Appendix 8A.3 Receiving and Source Cask Mating Subsystem

This appendix describes the calculations performed to ensure that the Receiving and Source Cask Mating Subsystem functions safely. The only portion of the Cask Mating Subsystem which is important to safety is the lifting of the cask lid, through the use of the overlid. Calculations are presented which evaluate the thickness of the overlid pintle, the thickness of the shield plug pintle, and the size of the overlid gripping device.

The source cask lid pintle and the shield plug pintle are identical. The grapple for the source cask lid and the grapple for the shield plug are also identical. Since the source cask lid is lighter than the shield plug, the analysis is performed on the shield plug pintle.

The forces are taken from the ANSYS analysis of the upper crane presented in Appendix 8A4. There are 4 fingers on each grapple. Any two opposing fingers can accommodate the entire load. The vertical force Fz is taken from the ANSYS model and is 150,000 N. This is the maximum force at the finger location for all positions analyzed. The mass used in the ANSYS analysis is 7000 kg.

The following masses are taken into account:

m_p = 3000 kg = mass of the shield plug
m_o = 1500 kg = mass of the overlid

The fingers, pintle and axis are all made from A36 forged carbon steel, with the following minimum properties:

yield strength, σ_y	36 ksi (248 MPa)
ultimate strength, σ_u	58 ksi (399 MPa)

The mass of the plug and overlid is less than that used in the ANSYS analysis. Therefore, the force is corrected below.

$$F_z = F_z(\text{computed}) \times m/m_T$$

where m is the mass of the system and m_T is the mass used in the analysis (7000 kg).

Pintle of the plug

The maximum force on the pintle of the plug due to seismic loading is:

$$F_z = 150{,}000 \times m_p/m_T = 150{,}000 \times 3000/7000 = 64{,}300 \text{ N} = 14{,}454 \text{ lbs}$$

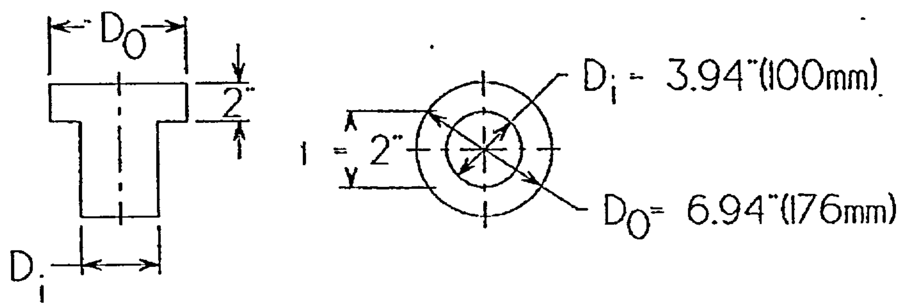
The maximum force in the static case (including a factor of 6 to yield for a nonredundant lift system) is:

$F = 3000 \times 9.81 \times 6.0 = 1.77 \times 10^5$ N = 39,654 lbs

Therefore the static case is limiting. The pintle of the plug is shown below:

FIGURE 8A.3-1

PINTLE OF THE PLUG



Using the loading from the static analysis, the force on one finger is:

$T = F_z/2 = 19{,}827$ lbs

The contact length t is the width of the finger, 2" (50 mm). The modulus of inertia of the bending resistant section is:

$S = te^2/6$ where e is the thickness of the pintle, 2" (50 mm) and t is the width of the finger

$S = 2 \times 2^2/6 = 1.33$ in^3

The bending moment is $M = Td = 19{,}827 \times 1.5 = 29{,}741$ in- lbs

The bending stress is:

$\sigma = M/S = 29741/1.33 = 22{,}362$ psi _ 36,000 psi (6 to yield strength)

$\sigma = 22{,}362 \times 10/6 = 37{,}270$ psi _ 58,000 psi (10 to tensile strength)

Fingers and axis of the overlid

The axis of the grapple is 1 in. (25 mm).
The cross sectional area is therefore $A = 0.785\ in^2$ (491 mm^2). The shear force in the pin for the static loading is:

$$F = 19{,}827 \text{ lbs}$$

The shear stress is:

$$\tau = T/2A = 19{,}827/2 \times 0.785 = 12{,}629 \text{ psi} \_ 36{,}000 \text{ psi}$$

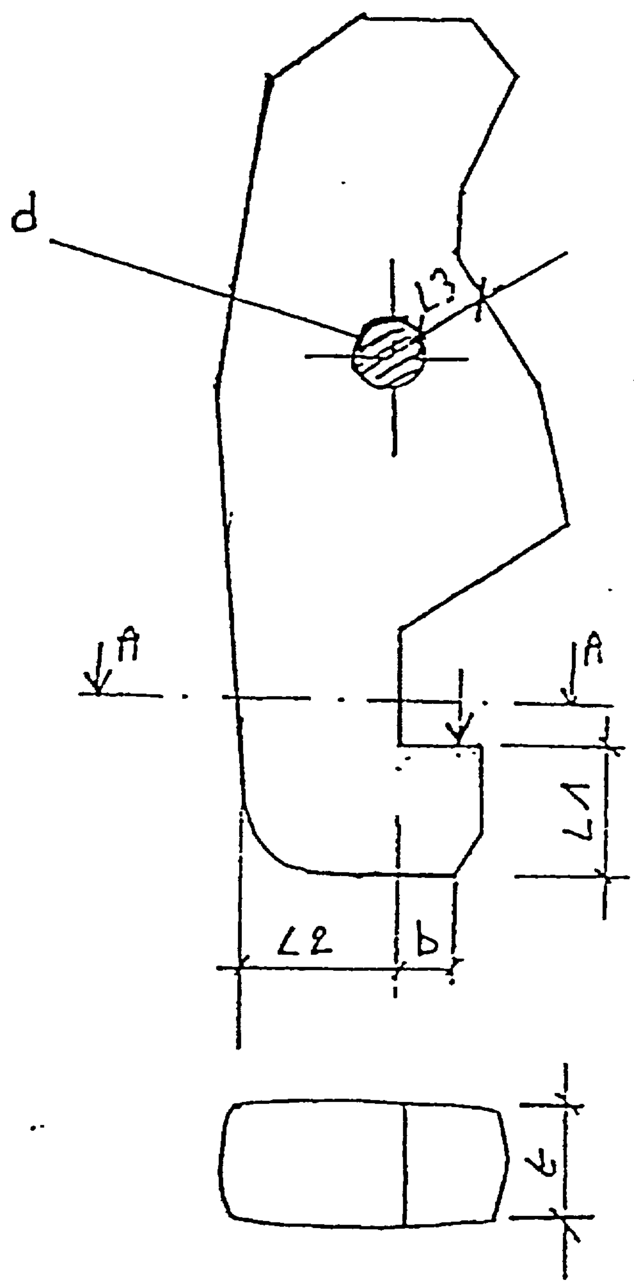
$$\tau = 12{,}629 \times 10/6 = 21{,}048 \text{ psi} \_ 58{,}000 \text{ psi}$$

A sketch of a finger is shown below. The following dimensions are used for the finger:

L2 = 60 mm = 2.36 in
L1 = 50 mm = 2.0 in.
L3 = 20 mm = 0.8 in.
t = 50 mm = 2.0 in.
b ≈ 20 mm =0.8 in.
d = 25 mm = 1.0"

FIGURE 8A.3-2

FINGER



The shear stress in the L1 section is:

$\tau = T/L_1t = 19{,}827/2{\times}2 = 4{,}957$ psi _ 36,000 psi

$\tau = 4{,}957 \times 10/6 = 7{,}828$ psi _ 58,000 psi

The shear stress in the L3 section is:

$\tau = T/L_3t = 19{,}827/0.8 \times 2 = 12{,}392$ psi _ 36,000 psi

$\tau = 12{,}392 \times 10/6 = 20{,}653$ psi _ 58,000 psi

The tensile and bending stress in the L2 section is:

$\sigma = T/L_2t + M/S$

where $M = T(b + L_2/2) = 19{,}827\ (0.8 + 2.36/2) = 39{,}257$ psi

and $S = tL_2^2/6 = 2 \times 2.36^2/6 = 1.86\ in^3$

Then $\sigma = 19{,}827/2.36 \times 2 + 39{,}257/1.86 = 4{,}200 + 21{,}106 = 25{,}306$ psi _ 36,000 psi

$\sigma = 25{,}306 \times 10/6 = 42{,}176$ psi _ 58,000 psi

<u>Pintle of the Overlid</u>

The maximum force based on the seismic analysis is:

$F_z = 150{,}000(m_p + m_o)/m_T = (150000)(4500)/7000 = 96{,}429$ N = 21,677 lbs

The maximum force due to the static case using a safety factor of 6 for nonredundant loading is:

$F = 4500 * 9.81 * 6 = 2.65 \times 10^5$ N = 59,572 lbs

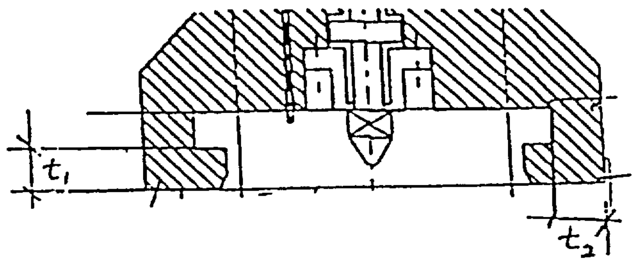
We conservatively assume that the load is handled by 2 fingers only. Then the maximum force applied to each finger is:

$T = F_z/2 = 29{,}786$ lbs

The pintle on the overlid is shown below:

FIGURE 8A.3-3

PINTLE ON THE OVERLID



t_1 = 40 mm = 1.6 in.
t_2 = 40 mm = 1.6 in.

The bending stress is:

$\sigma = M/S = 6T/\pi t_1^2 = 6 \times 29{,}786 / \pi \times 1.6^2 = 22{,}220$ psi i _ 36,000 psi

$\sigma = 22{,}220 \times 10/6 = 37{,}033$ psi _ 58,000 psi

The stress at t_2 is equal to the stress at t_1.

Summary of Results

The summary of the stresses in the cask mating subsystem are shown below.

Part	**Load**	**Allowable Value (ksi)**	**Calculated Value(ksi)**	**Calculated Size**
Axis for finger of the overlid diameter	Static	36 (yield) 58 (tensile)	12.6 (shear) 21.0 (shear)	25 mm (1.0 in)
Overlid finger thickness	Static	36 (yield) 58 (tensile)	25.3(bending) 42.2(bending)	50 mm (2 in.)
Plug Pintle thickness	Static	36 (yield) 58 (tensile)	22.3(bending) 37.2(bending)	50 mm (2 in.)
Overlid Pintle Thickness	Static	36 (yield) 58 (tensile)	22.2(bending) 37.0(bending)	40 mm (1.6 in.)

The stresses in the above table have been derived based on the Maximum Credible Critical Load equal to the shield plug weight and/or the shield plug weight plus the over-lid weight, as applicable, not including dynamic loads. Dynamic loads, resulting from the seismic load combinations, have been evaluated but not reported. This is because the static case stresses govern the design, based on the static acceptance criteria of 1/6th of yield stress and 1/10th of ultimate stress vs. the seismic acceptance criteria of 3/4th of yield stress. The above static acceptance criteria, based on the Maximum Credible Load without consideration for dynamic (impact) effects, though not specifically stated in NOG-1, is consistent with the criteria of NOG-5425.1 for hoist cables. It is also consistent with the acceptance criteria of ANSI N14.6-1993 "Special Lifting Devices for Shipping Containers Weighing 10,000 Pounds (4500 kg) or More".

Appendix 8A.4 Shield Plug and Source Cask Lid Handling Subsystem Analysis

This appendix describes the analysis performed on the upper crane, TC port covers and upper shield port covers. The upper crane has been analyzed using the finite element analysis program ANSYS 4.4. Certain components of the crane, such as the grapple, have been evaluated using hand calculations.

The seismic analysis is performed on the crane to ensure retention of the load and the prevention of any component from becoming a missile that would be detrimental to the DTS's safety related equipment. Seismic evaluation is performed with and without the rated load.

8A.4.1 Positions Evaluated

The shield plug/lid handling subsystem has been evaluated in three locations: over each of the casks with the rated loads of the crane, and at the mid-span of the crane rail with no load. The maximum stresses on the system will occur at one of these three locations, during both the normal operating conditions and during a seismic event. The seismic calculations were performed with the loaded grapple located at a cable length whose fundamental frequency corresponds to the frequency of peak vertical response on the spectrum. This position is more severe than the position with the hook in the full up or full down positions. Since the crane is located in the reinforced concrete building, the shield plug/lid handling subsystem will not be affected by a tornado. In the event of an accident or emergency, the crane can be stopped in any position along the crane rails. Therefore, the three postulated positions will bound any accident event combined with an unexpected seismic event.

The locking pins for the TC port covers and upper shield port covers have been analyzed to withstand forces created during a seismic event. This will be the worst condition for these components.

8A.4.2 Load Combinations

The following loads are used for the seismic evaluation. The symbols and nomenclature are taken from NOG-1.

P_{dt} = the trolley dead load
P_{db} = frame and rail dead load
P_{lr} = the rated load of the crane
P_{cs} = the credible critical load with safe shutdown earthquake
$P_{e'}$ = safe shutdown earthquake load

Note that the rated load of the crane is equal to the credible critical load, $P_{cs} = P_{lr}$.

The following load combinations were evaluated for the seismic event, as specified in NOG-4140(d):

$P_{c10} = P_{dt} + P_{db} + P_{cs} + P_{e'}$ (evaluated with trolley positioned over a cask - Load Combination 1)

$P_{c11} = P_{dt} + P_{db} + P_{e'}$ (evaluated with the trolley at mid-span - Load Combination 2)

$P = P_{dt} + P_{lr}$ (evaluated with trolley positioned over a cask -Load Combination 3)

$P = P_{dt}$ (evaluated with the trolley at mid-span - Load Combination 4)

The force in the cable is obtained from Load combination 1. The stresses in the supporting structure of the compensator and the support of pulleys #1 and #6 are obtained from this cable force. This is load combination 5.

Load combination 1 and 5 are combined to take into account the forces in the trolley induced by the cables in the seismic calculation. This is load combination 6.

Load combinations 2 and 6 are used to analyze the crane during a seismic event. Load combination 6 is used to analyze the supporting structure of the compensator and the support of pulleys #1 and #6 during a seismic event. Combinations 3 and 4 are used to verify the girder deflection.

8A.4.3 Material Properties

The properties for the structural components of the crane were taken from Tables NOG-4211-1 and NOG-4221-1 of NOG-1, and are summarized below:

The plates and beams will be constructed from A36 Steel, with a minimum yield strength of 36 ksi (248 MPa) and a minimum tensile strength of 58 ksi (399 MPa).

The structural connections will be constructed from A193 Grade B7, with a minimum yield strength of 75 ksi (517 MPa) and a minimum tensile strength of 100 ksi (689 MPa).

The cable minimum ultimate strength used in the analytical model is 256.7 ksi (1770 MPa). A shape factor including the strand factor of 0.57 is used in the analysis.

8A.4.4 Design Criteria

The design criteria for the crane are taken from NOG-4300 and are repeated following.

Allowable Stresses in the beams

For compression members with an equivalent slenderness ratio:

$$kl/r < C_c = \sqrt{(2\pi^2 E/\sigma_y)} \qquad (6)$$

where E = modulus of elasticity
σ_y = the yield point
k = effective length factor
l = length of compression member
r = radius of gyration of member
and C_c = column slenderness ratio separating elastic and inelastic buckling

The allowable axial compression stress shall not exceed the value:

$$\sigma_a = (1-((kl/r)^2 / 2C_c^2))(\sigma_y / FS) \qquad (7)$$

where FS = factor of safety and the other variables are as noted above.

The required factor of safety is equal to:

$$FS = N\{5/3 + (3/8)((kl/r)/C_c) - (1/8)((kl/r)/C_c)^3\} \quad (8)$$

For severe environmental loads, the value of N is 0.67. For compression members with an equivalent slenderness ratio $kl/r > C_c$, the allowable axial compression stress shall not exceed the value:

$$\sigma_a = 12\pi^2 E / (23N(kl/r)^2) \qquad (9)$$

Members subjected to both axial compression and bending stresses shall satisfy the following requirements:

$$\sigma / \sigma_a + C_{mx}\sigma_{bx} / ((1 - \sigma/\sigma'_{ex})\sigma_{abx}) + C_{my}\sigma_{by} / ((1- \sigma/\sigma'_{ey})\sigma_{aby}) \leq 1.0 \qquad (10)$$

$$\sigma / \sigma_{ac} + \sigma_{bx} / \sigma_{abx} + \sigma_{by} / \sigma_{aby} \leq 1.0 \qquad (11)$$

where $\sigma'_e = 12\pi^2 E / (23N(kl/r)^2)$ (12)

The subscripts x and y, combined with subscripts b, m, and e, indicate the axis of bending about which a particular stress or design property applies; and σ_a , σ_{ab} are the allowable axial and bending stresses respectively.

The l is the actual unbraced length in the plane of bending, r is the corresponding radius of gyration, K is the effective length factor in the plane of bending and N is the loading condition factor, 0.67 for extreme environmental loading.

C_m is a coefficient whose value is:

(a) C_m = 0.85 for compression members in frames subject to joint translation;

(b) $C_m = 0.6 - 0.4 (M_1 / M_2)$ but not less than 0.4 for restrained compression members in frames braced against joint translation and not subject to transverse loading between their supports in the plane of bending. M_1 / M_2 is the ratio of the smaller to the larger moments at the ends of that portion of the member unbraced in the plane of bending under consideration.

(c) For compression members in frames braced against joint translation in the plane of loading and subjected to transverse loading between their supports, $C_m = 0.85$ for members whose ends are restrained, and $C_m = 1.0$ for members whose ends are unrestrained.

If $\sigma / \sigma_a \leq 0.15$, then only equation (11) needs to be evaluated.

Members subjected to both axial tension and bending stresses shall satisfy equation (11). The computed bending tensile stress, taken alone, shall not exceed the $0.9\sigma_y$.

The maximum allowable shear stress under seismic load is $0.5\ \sigma_y$.

An additional factor of 1.2 is applied to all stresses to account for uncertainties since the loading may change from site to site.

For the beams, which are made from A36 steel:

The tensile stress allowable is:

$$F/A + M_{bx}x/ I_x + M_{by}y/ I_y < 0.9\ \sigma_y/1.2 = 186 \text{ MPa} = 27.0 \text{ ksi} \qquad (13)$$

The shear stress allowable is $0.5\sigma_y /1.2 = 103$ MPa = 15 ksi.

Allowable stresses in Bolts

The allowable stresses in the bolts are taken from NOG-4513. For seismic loading, the maximum allowable tensile load is $0.5\ \sigma_y$, and the maximum allowable shear stress is $0.26\ \sigma_y$. For bearing type joints, the stresses shall meet the following criteria:

$$\sigma \leq 0.6\ \sigma_y R - 1.6\ \tau \qquad (14)$$

The maximum allowable tensile stress due to seismic loading, assuming an additional safety factor of 1.2 is therefore 41.6 ksi (287 MPa). The maximum allowable shear stress, assuming an additional safety factor of 1.2 is 21.6 ksi (149 MPa).

Allowable Deflections

The deflection and camber in the components of the upper crane shall not exceed limits imposed in ASME NOG-1, Section NOG-4340.

Allowable stress for the Cables.

The maximum allowable stresses in the cables is governed by NOG-5425.1. The maximum critical load (without impact), plus the weight of the load block divided by the total number of parts of rope per system, shall not exceed 10% of the manufacturer's published breaking strength on the total system. The seismic load with all parts of rope intact shall not exceed 40% of the manufacturer's published breaking strength.

For the cables, $\sigma_u = 1770$ MPa = 256.7 ksi. For the static case,

$$F/KA < \sigma_u / 10 = 177 \text{ MPa} = 25.6 \text{ ksi} \qquad (15)$$

K is the shape coefficient, which is taken as 0.57. $A = \pi d^2/4$.

Then:

$$d_{MIN} = \sqrt{(40F/K\pi\sigma_u)} \qquad (16)$$

and

$$F = P_{cl} / n\eta \qquad (17)$$

where P_{cl} = the credible critical load and the weight of the load block
n = the number of parts of the rope
η = the efficiency, which is taken as 0.94 to start.

8A.4.5 Component Weights

The following masses were used in the model of the upper crane:

Live load:	7,000 kg (lifting capacity and grapple)
Trolley:	2,000 kg

8A.4.6 Upper Crane Model

A model of the upper crane was made to evaluate it under seismic loading. The response spectrum method was used according to the requirements of NOG 4153.1. The response of the crane to the input response spectra in three directions was determined on a modal basis. An ANSYS model was used to perform the analysis. The program searches the frequency and the modal participation factor up to the cutoff frequency (around 33 Hz). If the sum of the participation of the mass is less than 90% in a direction, the program is completed with the equivalent static component in this direction. The residual mass is affected with the acceleration of the cutoff frequency in this direction.

The dynamic responses of the structure are combined using the "grouping method" in accordance with NOG 4153.10. The three directional components of the earthquake motion are combined by taking the square root of the sum of the squares of the maximum representation values of the codirectional responses caused by each of the three components of earthquake motion at each mode of the crane mathematical model.

The model consists of:

- a plate for the mezzanine and its beams
- a left support for the pulleys
- a right support for the pulleys
- a trolley with a cable and a mass
- rails and poles.

The finite element required 1,350 elements and 1,178 nodes.

Trolley and Cable Model

The trolley is represented by STIF 4 beams with corrected densities to simulate the weight of the trolley. A sketch of the trolley model is shown in Figure 8A.4-1. The dotted lines are rigid beams with nearly no mass (material density of 0.1×10^{-11} kg/m^3). The single solid lines represent rectangular structural tubing 12 in. x 18 in x 1/2 in with a density of 0.55×10^{-7} kg/mm^3. The double solid lines represent rectangular structural tubing 16 in. x 12 in. x 1/2 in. with a density of 0.347×10^{-7} kg/mm^3. These corrected densities give a total mass of 2.67 metric tons or 5,732 lbs.

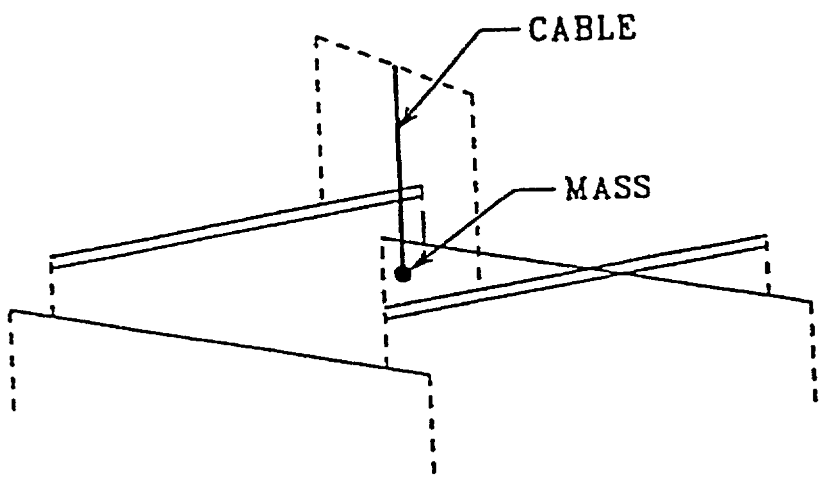
The cable is modeled as a spar element (LINK 8 of ANSYS) with a stiffness and a length which provides a vertical frequency of 10 Hz:

$$F = (1/2\pi)\sqrt{k/m} = 10 \text{ Hz}$$

The spring constant $k = EA/L$

Figure 8A.4-1

ANSYS Trolley Model



The truss element area and length are chosen to provide resonance at the spectrum peak of 10 Hz. The actual cable stiffness is much less than a truss. However, we are only interested in resonance at 10 Hz in order to obtain a peak load from the truss.

where E = Young's Modulus = 201,000 MPa
A = cross sectional area
L = length of the cable = 1 m
m = mass = 7,000 kg

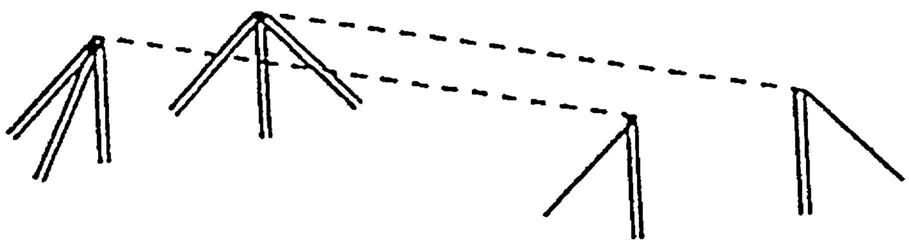
Solving for k: $k = (2\pi F)^2 m = 2.77 \times 10^7$ N/m
Then solving for A = 137.8 mm^2

Model of Rails and Poles

The rails and poles are modeled as beam elements (ANSYS STIF 4). A sketch of the model is shown in Figure 8A.4-2. The dotted lines represent W 10 x 60 beams with 2 lateral shells reinforcing them. The double lines represent W10 x 60 beams. The single lines represent W 6 x 25 beams. The density used for the beams is 7,850 kg/m^3. All beams are made from A36 steel.

Figure 8A.4-2

Model of Rails and Poles



Link Between the Trolley and the Rails

The link between the trolley and the rails is shown in Figure 8A.4-3. STIF 14 spring dampers with a high degree of stiffness are used to model the coupled nodes. The node constraints are summarized in Table 8A.4-1.

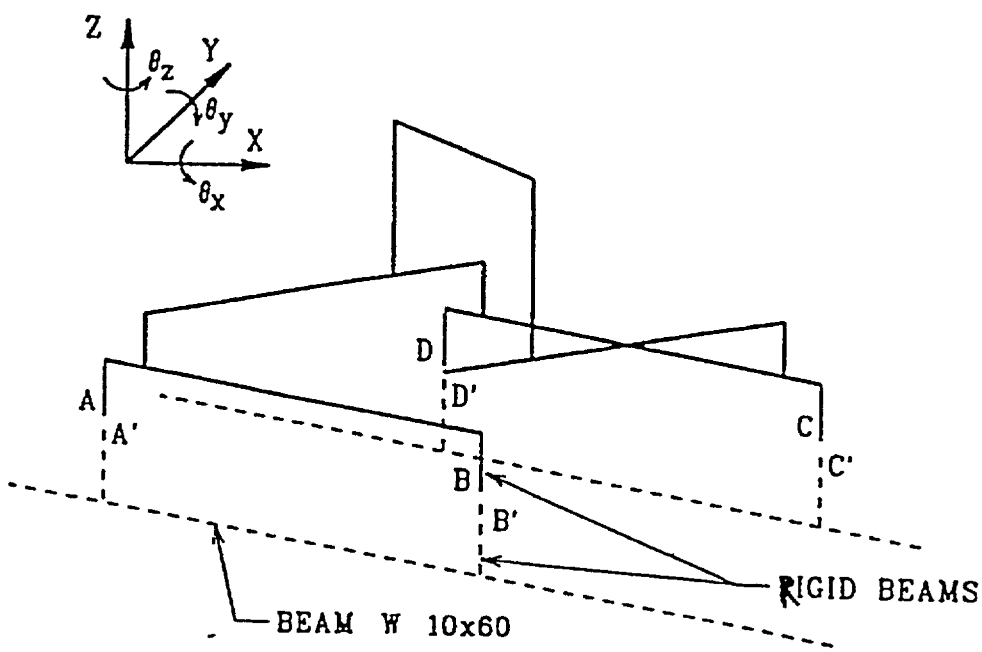
Table 8A.4-1

Node Constraints

	Translation			Rotation		
Nodes	X	Y	Z	θ_x	θ_y	θ_z
AA'	Free	Coupled	Coupled	FREE		
BB'	Coupled	Coupled	Coupled			
CC'	Coupled	Coupled	Coupled			
DD'	Free	Coupled	Coupled			

Figure 8A.4-3

Links Between the Trolley and the Rails

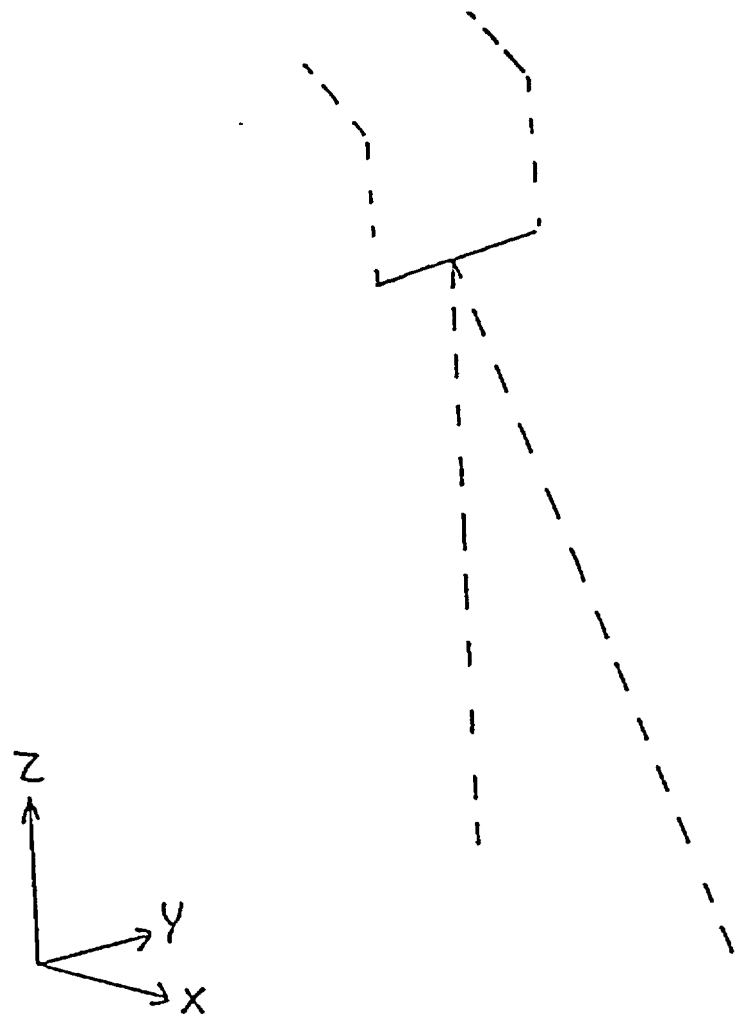


Left Support of the Pulleys

The left support of the pulleys is a beam structure modeled as shown in Figure 8A.4-4. The dotted lines represent W 10 x 60 beams (STIF4 ANSYS). The solid lines represent W10 x 60 beams reinforced by two lateral plates. The beams are made from A36 carbon steel, with a density of 7850 kg/m^3.

Figure 8A.4-4

Left Pulley Support

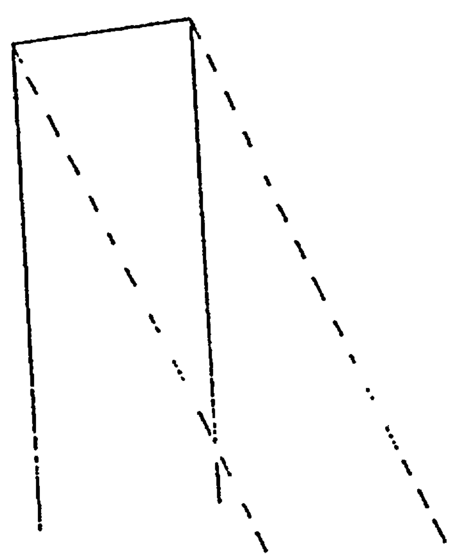


Right Support of the Pulleys

The right support of the pulleys is a beam structure modeled as shown in Figure 8A.4-5. The solid lines represent W 8 x 35 beams, and the dotted lines represent W6 x 25 beams. The beams are made from A36 carbon steel with a density of 7,850 kg/m^3.

Figure 8A.4-5

Right Pulley Support



Roof Plate

The roof plate is modeled using ANSYS shell element 43. The analysis was made using a 4 inch thick plate. Since the analysis was performed, the plate was increased to 7 inches to provide additional shielding. This analysis is expected to be conservative. The plate is made from A36 steel with a density of 7,850 kg/m^3. The plate is reinforced by 5 W14 x 550 beams.

The plate consists of 4 shells which are attached by bolts at the level of the fillets A, B and C. The boundary conditions are shown in Table 8A.4-2.

Table 8A.4-2
Restraint Conditions - Roof Plate

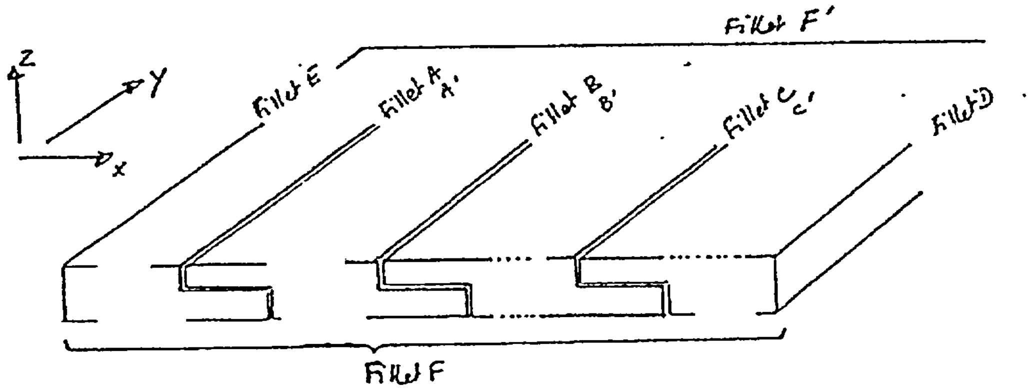
	Translation			Rotation		
Fillet	**X**	**Y**	**Z**	θ_x	θ_y	θ_z
AA'	Coupled	Free	Coupled		FREE	
BB'	Coupled	Free	Coupled			
CC'	Coupled	Free	Coupled			
E	Fixed	Free	Fixed			
F	Free	Fixed	Fixed			
D	Free	Free	Fixed			
F'	Free	Free	Fixed			

The coupling conditions between the 2 fillets are realized by coupled set equations. The fixed degrees of freedom are imposed by displacement constraints. (No displacement in the given degree of freedom).

The W14 x 550 beams are welded to the plates. Therefore, the nodes are coupled in all directions. For conservatism, the neutral axis of the beams are set coincident with those of the plate as shown in Figure 8A.4-6.

Figure 8A.4-6

W14 x 550 Beams and Roof Plate



Protective Cover

The protective cover is considered as a mass. The weight of the protective cover used in the analysis is 16 metric tons, or 35,274 lbs. The mass is uniformly distributed on the intersection of the plate and the protective cover. ANSYS mass elements 21 are used to represent the protective cover.

Link Between the Roof Plate and the Crane Supports

The crane supports and the roof plate are shown in Figure 8A.4-7. The node restraints are summarized in Table 8A.4-3.

Figure 8A.4-7

Upper Plate and Crane Supports

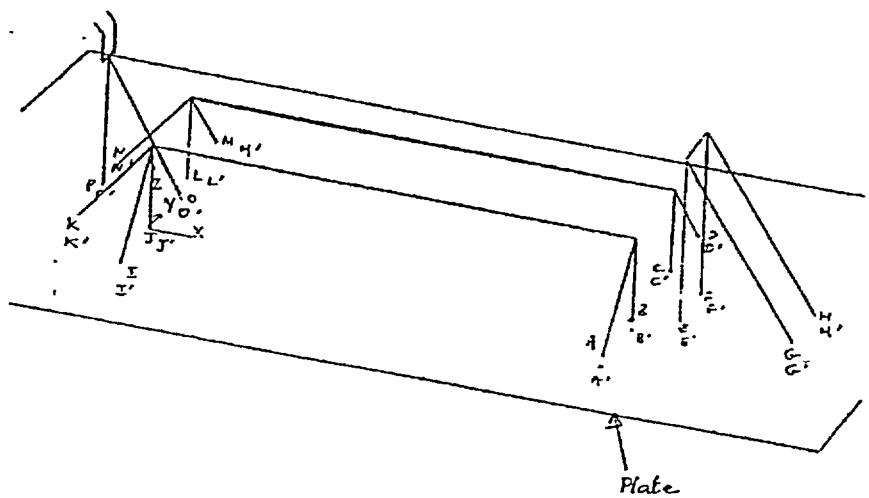


Table 8A.4-3

Restraint Conditions between the Roof Plate and the Crane Supports

	Translation			Rotation		
Nodes	**X**	**Y**	**Z**	θ_x	θ_y	θ_z
AA'		Coupled			Coupled	
BB'					Coupled	
CC'					Coupled	
DD'					Coupled	
EE'				Coupled	Free	Coupled
FF'				Coupled	Free	Coupled
GG'				Coupled	Free	Coupled
HH'				Coupled	Free	Coupled
II'				Free	Coupled	Coupled
JJ'				Coupled	Coupled	Coupled
KK'				Coupled	Free	Coupled
LL'				Coupled	Coupled	Coupled
MM'				Free	Coupled	Coupled
NN'				Coupled	Free	Coupled
OO'					Coupled	
PP'					Coupled	

The ANSYS model is shown in Figures 8A.4-8 through 8A.4-13.

Figure 8A.4-8

Model of Crane Supports

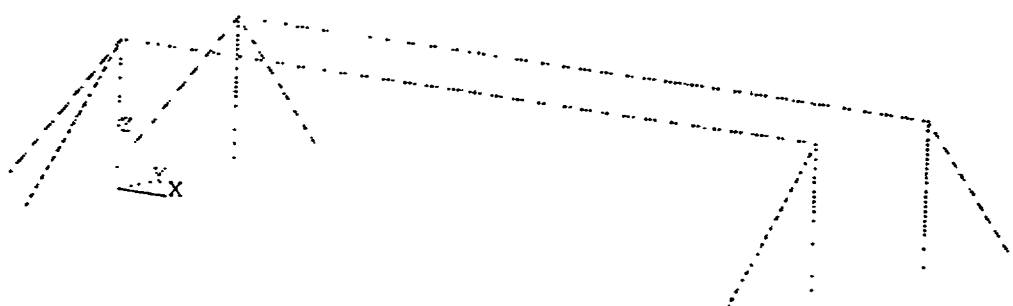


Figure 8A.4-9

Model of Left Pulley Support

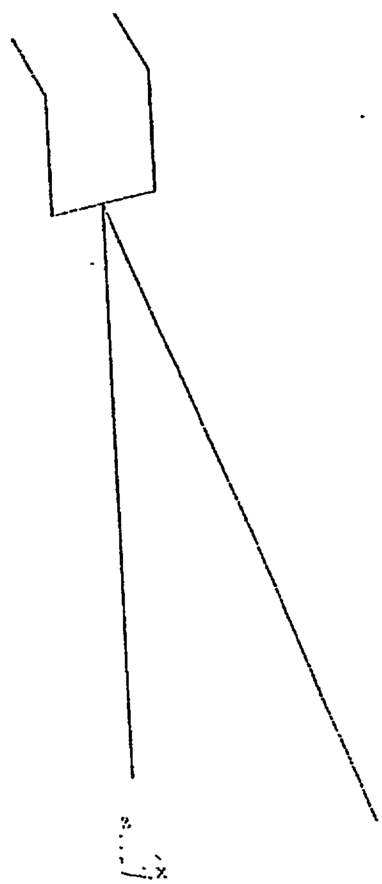


Figure 8A.4-10

Model of Right Pulley Support

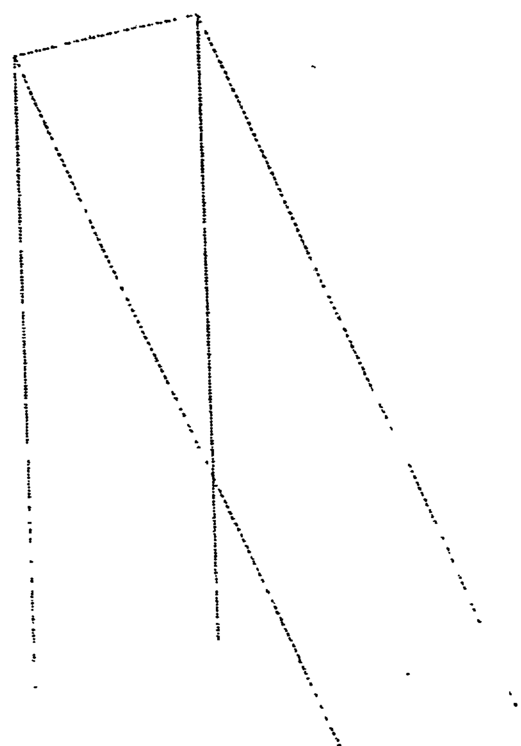


Figure 8A.4-11

Model of Trolley

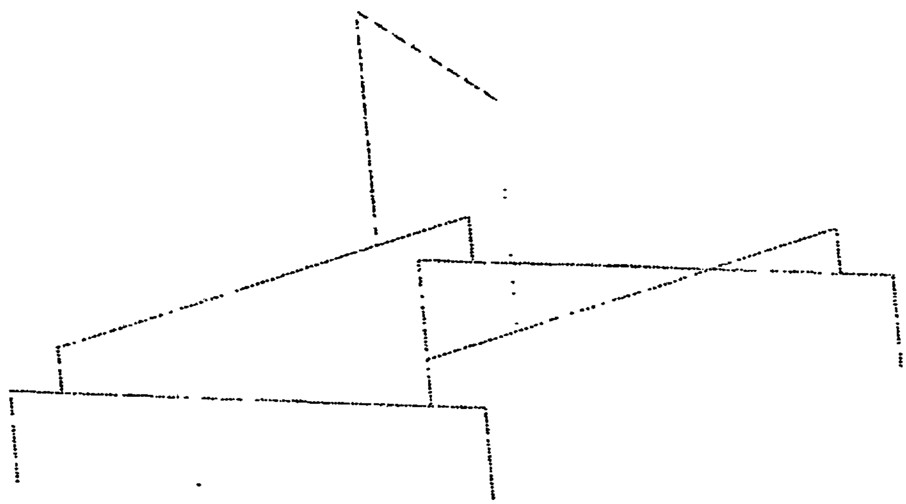


Figure 8A.4-12

Model of Trolley with Cable and Mass

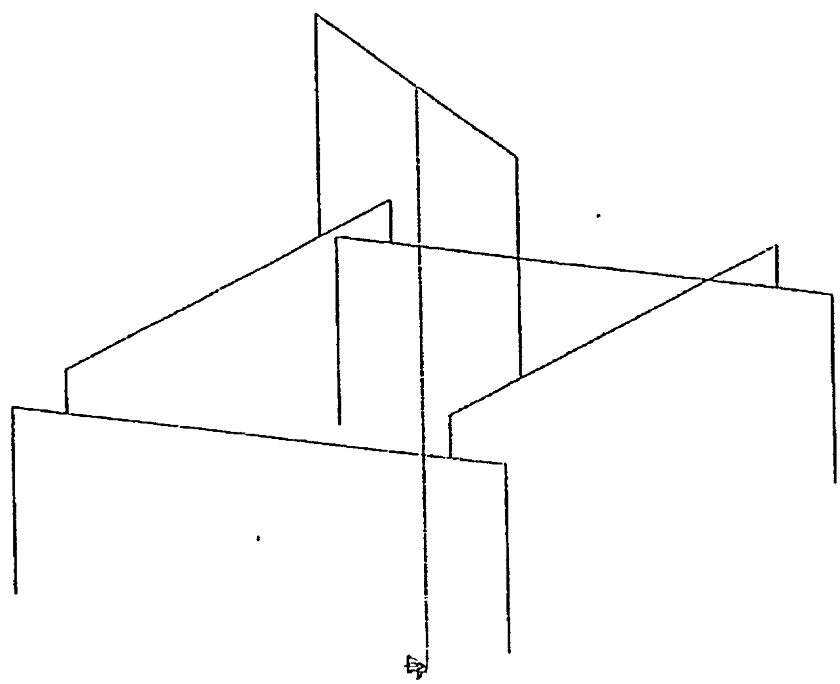
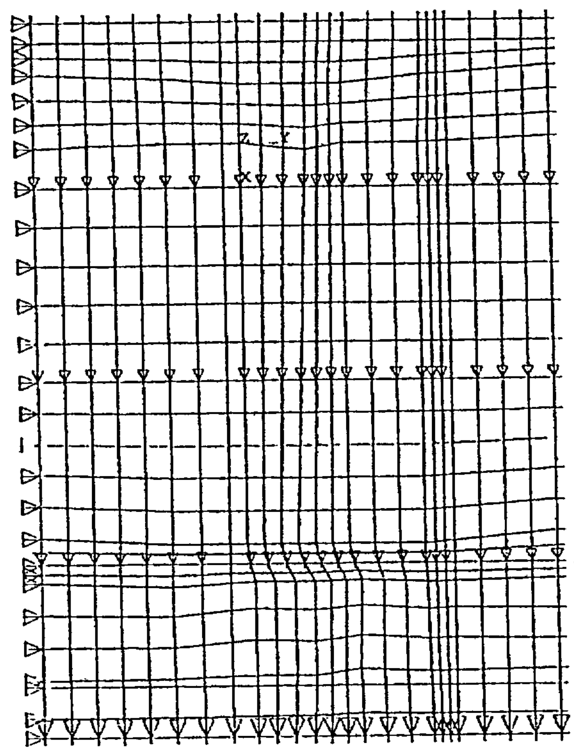


Figure 8A.4-13

Model of Roof Plate



8A.4.7 Input Spectra

The spectra is presented in Figures 8A.4-14 and 8A.4-15. The spectrum is based on a hard rock site (a basemat founded on competent bedrock with shear wave velocity > 1100 m/s. It is not valid for other site conditions such as sands, gravel, silt or clay. Note that the spectrum used for this analysis is slightly different from the spectrum determined in Appendix 8A.1. This analysis will be redone when a site location is determined with actual site spectrum. This analysis is only used to size the equipment and to be representative of the expected spectrum at the various potential DTS locations.

Figure 8A.4-14

Secondary Response Spectra, 46' Level, Y Direction

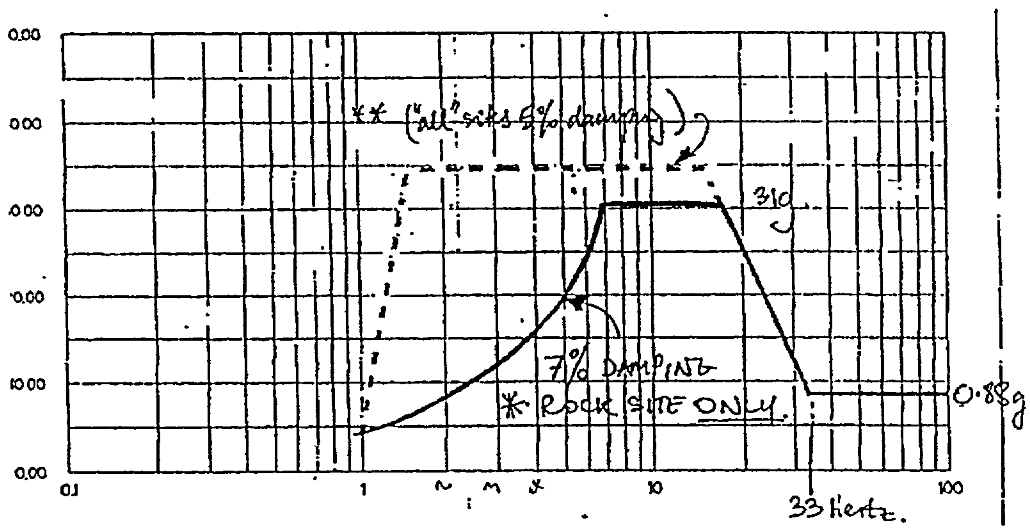
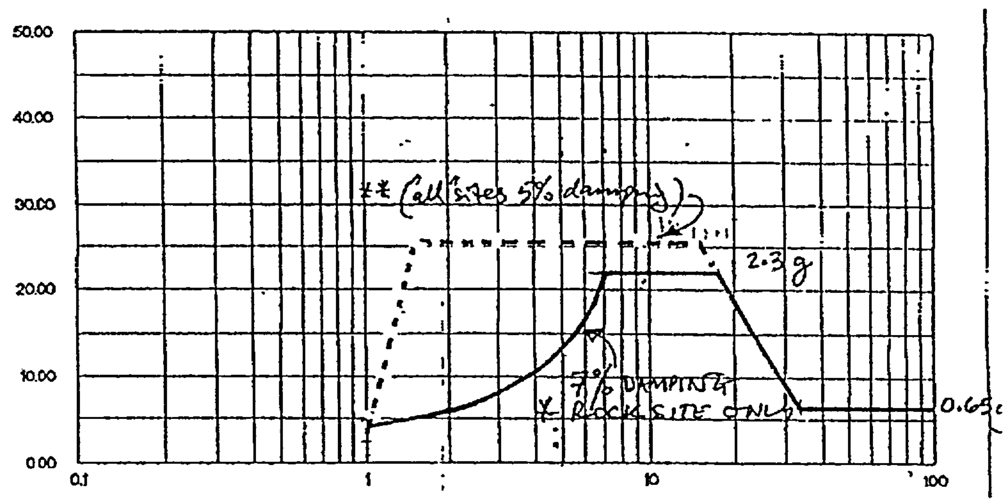


Figure 8A.4-15

Secondary Response Spectra, 46' Level, X Direction



8A.4.8 Seismic Results

The maximum stresses in the beams and plates due to load combination 1 are summarized in Table 8A.4-4. All the stresses are well below the allowable stress.

Table 8A.4-4

Seismic Stresses
Load Combination 1

Component	Maximum Tension		Maximum Shear	
	Calculated	Allowable	Calculated	Allowable
W10 x 60 with shell	25.5 MPa 3.7 ksi	186 MPa 27 ksi	18.6 MPa 2.7 ksi	103 MPa 15 ksi
W10 x 60	26 MPa 3.8 ksi	186 MPa 27 ksi	16 MPa 2.3 ksi	103 MPa 15 ksi
300 x 200 x 10	13.2 MPa 1.9 ksi	186 MPa 27 ksi	25.3 MPa 3.6 ksi	103 MPa 15 ksi
400 x 200 x 10	10.6 MPa 1.54 ksi	186 MPa 27 ksi	10.7 MPa 1.55 ksi	103 MPa 15 ksi
W 8 x 35	13.3 MPa 1.9 ksi	186 MPa 27 ksi	2.15 MPa 0.3 ksi	103 MPa 15 ksi
W 6 x 25	6.15 MPa 0.9 ksi	186 MPa 27 ksi	0.97 MPa 0.14 ksi	103 MPa 15 ksi
W14 x 550	18.7 MPa 2.7 ksi	186 MPa 27 ksi	2.5 MPa 3.5 ksi	103 MPa 15 ksi

The maximum stresses in the beams and plates due to load combination 2 are summarized in Table 8A.4-5. All the stresses are well below the allowable stress.

Table 8A.4-5

Seismic Stresses
Load Combination 2

Component	Maximum Tension		Maximum Shear	
	Calculated	Allowable	Calculated	Allowable
W10 x 60 with shell	53 MPa 7.62 ksi	186 MPa 27 ksi	8.88 MPa 1.3 ksi	103 MPa 15 ksi
W10 x 60	26 MPa 3.8 ksi	186 MPa 27 ksi	16 MPa 2.3 ksi	103 MPa 15 ksi
300 x 200 x 10	5.6 MPa 0.81ksi	186 MPa 27 ksi	11.3 MPa 1.64 ksi	103 MPa 15 ksi
400 x 200 x 10	5.22 MPa 0.75 ksi	186 MPa 27 ksi	2.56 MPa 0.37 ksi	103 MPa 15 ksi
W 8 x 35	12.9 MPa 1.87 ksi	186 MPa 27 ksi	2.07 MPa 0.3 ksi	103 MPa 15 ksi
W 6 x 25	5.96 MPa 0.86 ksi	186 MPa 27 ksi	0.94 MPa 0.13 ksi	103 MPa 15 ksi
W14 x 550	18.4 MPa 2.67 ksi	186 MPa 27 ksi	2.47 Pa .36 ksi	103 MPa 15 ksi

Combination 5 is obtained by applying the cable force from combination 1(150,000 N) to the 4 top nodes of the right and left pulley supports. These results are combined with load combination 1 to form load combination 6.

The maximum stresses in the beams and plates due to load combination 6 are summarized in Table 8A.4-6. All the stresses are well below the allowable stress.

Table 8A.4-6

Seismic Stresses
Load Combination 6

Component	Maximum Tension		Maximum Shear	
	Calculated	Allowable	Calculated	Allowable
W10 x 60 with shell	19.8 MPa 2.87 ksi	186 MPa 27 ksi	19.8 MPa 2.87 ksi	103 MPa 15 ksi
W10 x 60	39 MPa 5.6 ksi	186 MPa 27 ksi	17.1 MPa 2.48 ksi	103 MPa 15 ksi
300 x 200 x 10	13.9 MPa 2 ksi	186 MPa 27 ksi	28 MPa 4 ksi	103 MPa 15 ksi
400 x 200 x 10	10.33 MPa 1.5 ksi	186 MPa 27 ksi	4.09 MPa 0.6 ksi	103 MPa 15 ksi
W 8 x 35	21.5 MPa 3.1 ksi	186 MPa 27 ksi	2.2 MPa 0.32 ksi	103 MPa 15 ksi
W 6 x 25	21.6 MPa 3.1 ksi	186 MPa 27 ksi	0.96 MPa 0.14 ksi	103 MPa 15 ksi
W14 x 550	21 MPa 3 ksi	186 MPa 27 ksi	2.77 MPa 3.4 ksi	103 MPa 15 ksi

8A.4.9 Rail Deflection

The maximum deflection in the rails is obtained from combination 3 and 4. The maximum deflection with the trolley over a cask due to the trolley dead load and rated load (combination 3) is 1.063 mm. The maximum deflection from the trolley dead load only with the trolley positioned at midspan 0.08 mm. The allowable deflection, from NOG 4341 is 1/1000 of the length of the girder, or 4.9 mm. Therefore, the rail deflection is acceptable.

8A.4.10 Modal analysis

The results of the modal analysis are presented in the two following tables. Two cases are presented: the trolley at midspan and the trolley positioned over a cask.

The following information is provided:

- The first frequencies below the critical frequency
- The associated acceleration of the mode
- The dragged mass

TABLE 8A.4-7

TROLLEY WITH A MASS
(TROLLEY OVER A CASK)

Total Weight : 101.000

Nodes Reading (Direction X)

Load Step Number 1

MODE	FREQ.	ACCEL	WEIGHT	% WEIGHT CUM
	Hz	m.s-2	kg	
1	7.80	23.00	0.01	0.00
2	9.44	23.00	1.19	0.00
3	20.87	15.56	61.51	0.06
4	24.97	11.06	0.00	0.00
5	33.08	6.50	118.76	0.12
6	36.07	6.50	1280.14	1.27
7	41.55	6.50	1153.54	1.14

TABLE 8A.4-7 (Continued)

TROLLEY WITH A MASS
(TROLLEY OVER A CASK)

Total Weight : 101.000

Nodes Reading (Direction Y)

Load Step Number 2

MODE	FREQ.	ACCEL	WEIGHT	% WEIGHT CUM
	Hz	m.s-2	kg	
1	7.80	31.00	300.29	0.30
2	9.44	31.00	0.05	0.00
3	20.87	21.00	0.07	0.00
4	24.97	14.94	341.31	0.34
5	33.08	8.80	3500.60	3.47
6	36.07	8.80	42.21	0.05
7	41.55	8.80	24.29	0.02

TABLE 8A.4-7 (Continued)

TROLLEY WITH A MASS
(TROLLEY OVER A CASK)

Total Weight : 101.000

Nodes Reading (Direction Z)

Load Step Number 3

MODE	FREQ. Hz	ACCEL m.s-2	WEIGHT kg	% WEIGHT CUM
1	7.80	8.80	0.05	0.00
2	9.44	8.80	12103.00	11.98
3	20.87	4.99	61136.90	60.53
4	24.97	3.40	5.30	0.01
5	33.08	2.00	7.40	0.01
6	36.07	2.00	9.50	0.01
7	41.55	2.00	215.96	0.21

TABLE 8A.4-8

TROLLEY WITHOUT MASS
(TROLLEY AT MID-SPAN)

Total Weight : 94.002

<u>Nodes Reading (Direction X)</u>

Load Step Number 1

MODE	FREQ.	ACCEL	WEIGHT	% WEIGHT CUM
	Hz	m.s-2	kg	
1	7.80	23.00	0.00	0.00
2	16.49	23.00	0.00	0.00
3	19.63	17.49	31.62	0.03
4	24.97	11.06	0.02	0.00
5	27.34	9.30	46.23	0.05
6	29.40	8.10	1.63	0.00
7	38.76	6.50	84.29	0.09

TABLE 8A.4-8 (Continued)

TROLLEY WITHOUT MASS
(TROLLEY AT MID-SPAN)

Total Weight : 94.002

Nodes Reading (Direction Y)

Load Step Number 2

MODE	FREQ.	ACCEL	WEIGHT	% WEIGHT CUM
	Hz	m.s-2	kg	
1	7.80	31.00	300.61	0.32
2	16.49	31.00	3875.72	4.12
3	19.63	23.00	0.09	0.00
4	24.97	14.94	315.64	0.34
5	27.34	12.57	0.45	0.00
6	29.40	10.96	55.28	0.06
7	38.76	8.80	0.09	0.00

TABLE 8A.4-8 (Continued)

TROLLEY WITHOUT MASS
(TROLLEY AT MID-SPAN)

Total Weight : 94.002

Nodes Reading (Direction Z)

Load Step Number 3

MODE	FREQ.	ACCEL	WEIGHT	% WEIGHT CUM
	Hz	m.s-2	kg	
1	7.80	8.80	0.01	0.00
2	16.49	8.25	0.50	0.00
3	19.63	5.69	61370.60	65.29
4	24.97	3.40	0.99	0.00
5	27.34	2.80	4682.92	4.98
6	29.40	2.40	34.02	0.04
7	38.76	2.00	19.09	0.02

8A.4.11 Evaluation of the Cables and Pulleys

There are 8 parts to the cable.

The static load is the limiting case, due to the safety factor of 10 on ultimate strength. The maximum credible critical load, $P_{cl} = Mg = 70{,}000$ N.

The rope efficiency, η, is 0.94.

The number of parts to the rope is 2 x 4 = 8. The force on the rope is therefore:

$F = P_{cl} / n\eta = 9{,}308$ N
k = the shape factor = 0.57
$\sigma_u = 1770$ MPa
The minimum required cable diameter is:

$$d_{min} = \sqrt{(10F/(k\pi\sigma_u/4)} = \sqrt{(93{,}080)/((0.57)(1770)\ \pi/4)} = 10.7 \text{ mm}$$

The cable is 12 mm in diameter. Therefore, the cable is acceptable.

From NOG-5427.1, the pitch diameter of all sheaves except equalizer sheaves shall be not less than 24 times the diameter of the hoist rope. The sheave diameter is 300 mm (11.9 in) which is > 24 x 12 = 288. Therefore the sheave diameter is acceptable.

The allowable force in the cable $P = P_{cl}\,(12/10.7)^2 = 88{,}042$ N

The safety factor is:

$SF = P/P_{cl} = 1.25$

8A.4.12 Wheel Analysis

The wheels are sized using the static case plus the impact load during lifting. The bridge rail dimensions are shown in Figure 8A.5-16. The effective width of the rail head is 37 mm (1.45 in.) The diameter of the wheel is 139 mm (5.5 in.) The allowable wheel load is taken from from NOG-5452.3:

$$P_a = KbD \text{ (lbs)} \qquad (18)$$

where $K = 1300\,(BHN/260)^{0.333} = 1393$
b = the effective width of the rail head
D = diameter of the wheel.

Therefore $P_a = (1393)(1.45)(5.5) = 11{,}109$ lbs.

The actual load is $P = (M_t + 1.15\ M_l)g$ (19)

where M_t is the mass of the trolley and M_l is the mass of the rated load. G is 9.81 m/s^2.

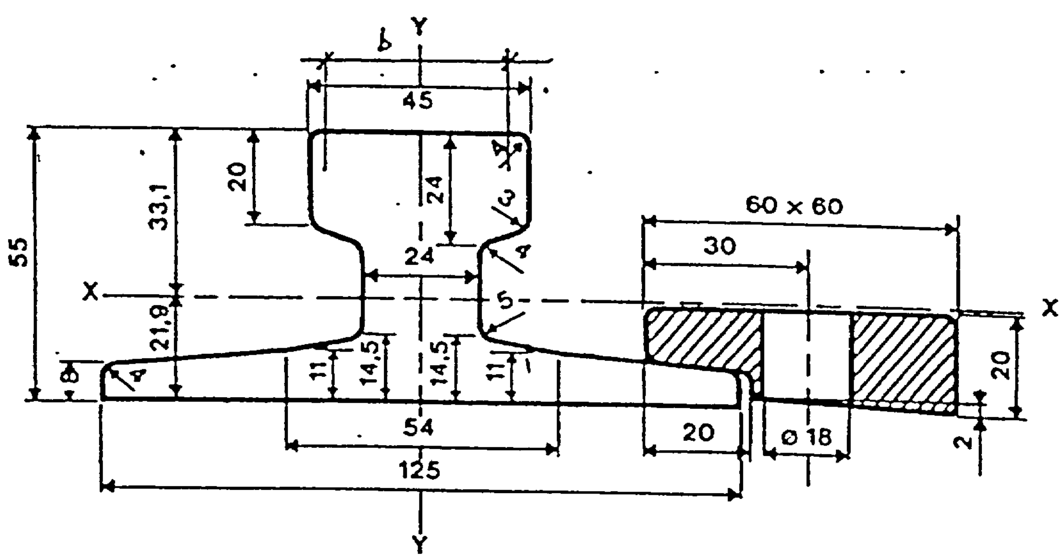
Then P = 100,500 N = 22,157 lbf.

The operational load is equally distributed between the four wheels. Therefore each wheel takes a load of P/4 = 25,125 N = 5,540 Lbf.

The safety factor is therefore 11,109/5,540 = 2.

Figure 8A.4-16

Rails BURBACH KS22-A45



8A.4.13 Evaluation of Guidance Rollers

The purpose of the guidance rollers is to prevent the upper crane trolley from derailing in the event that it begins to misalign transversely with the rails during normal operation. There are two sets of guidance rollers with each set adjacent to each trolley wheel on one rail. Conservatively (since the wheels are sliding and rolling simultaneously), the transverse load (F_y) required to maintain the trolley on track can be assumed to be equal to the dead load of the trolley plus the rated load multiplied by the coefficient of sliding friction (f_z).

The transverse load on each guidance roller is:

$$F_y = (M_t + M_l) g\, f_z / 2 = 11{,}360 \text{ N} = 2555 \text{ lbf}$$

where: M_t = Mass of the trolley = 2650 kg
M_l = Mass of the rated load = 7000 kg
g = Acceleration of gravity = 9.81 m/sec^2
f_z = 0.24 for a steel wheel on a steel rail
(Reference 8-17, Mark's Standard Handbook for Mechanical Engineers)

Therefore, utilize a standard McGill (or equivalent) CF-2-B stud type cam follower with a roller diameter of 2.00 in., roller width of 1.25 in. and a maximum static rated capacity of 10,570 lbf. The safety factor is SF = 10,570/2555 = 4.1

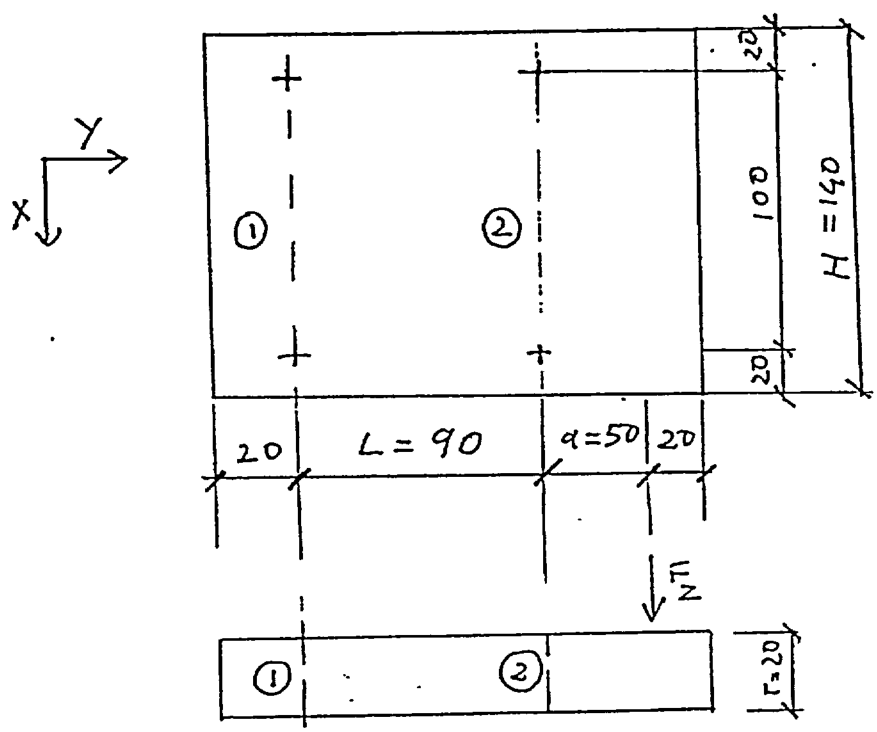
Since the transverse derailing load of 11,360 N is significantly less than the seismic transverse derailing load of 59,848 N, the trolley anti-derailing device is structurally adequate as the normal operation anti-derailing device per the analysis of Section 8A.4.15. Hence the guidance rollers need not be classified as SSCs important to safety.

8A.4.14 Evaluation of the Anti-Taking Off Device (of the Bridge)

To evaluate the anti-taking off devices, the static and seismic reactions must be added. The maximum reaction force from the seismic analysis is used. This occurs for the load combination with the trolley above a cask opening. The force F_z = 3,731 N (Node 439). The maximum bending moment in the plate occurs along the plane 2-2 in Figure 8A.4-17. The bending moment = $F_z a$ = (3,731)(50 mm) = 187 N-m. The maximum bending moment in the plate is at the plane 2-2.

Figure 8A.4-17

Dimensions of Anti-Taking Off Device



The maximum bolt tension is on the two bolts at 2. The bolts are M16, made from A193 Gr B7 steel. The cross sectional area of each bolt is 157 mm^2. The force in each bolt is F_b:

$$F_b = F_z (L+a)/2L = (3,731)(140)/180 = 2,902 \text{ N}$$

The tensile stress in the bolt is therefore:

$$\sigma = F_b / A_b = 2902/157 = 19 \text{ MPa} \leq 0.5\ \sigma_u /1.2 = 287 \text{ MPa} = 41.6 \text{ ksi}$$

The safety factor is SF = 287/19 = 15.

The section modulus of the plate is: $S = (H-2*18)t^3/6t = 6,900$ mm^3 where the thickness of the plate, t = 20 mm = 0.8 in.

The bending stress is $\sigma = M/S =$ 187 mN/6,900 mm^3 = 27 MPa = 3.9 ksi. This is well below the allowable stress of 186 MPa. The safety factor is 186/27 = 6.8.

8A.4.15 Evaluation of the Anti-Derailing Devices

The anti-derailing device is the lateral stop on the rail and is fixed to the trolley. There are four anti-derailing devices on the trolley. To calculate the stresses on the anti-derailing device, the maximum lateral force is needed. This is obtained from the seismic analysis. The lateral force is extracted from the ANSYS output.

The maximum force is F_y = 59,848 lbs and is obtained from load combination 1 with the trolley positioned above the cask, at node 1178.

A sketch of the anti-derailing device is shown in Figure 8A.4-18.
The static equations are as follows:

$$R_A = F_Y$$
$$R_A (15/2) + F_Y * C - R_B*a/2 = 0 \quad \text{(Summing moments about 0')}$$

Therefore:

$$R_C = R_B = F_Y (C + 15/2)/(a/2) = 67,329 \text{ N for } C = 60 \text{ mm}$$

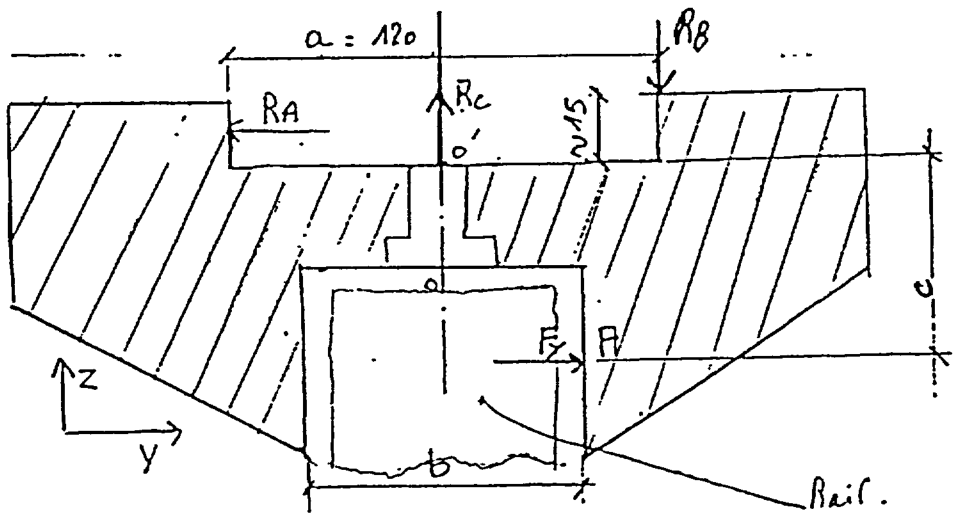
Two M16 bolts hold the anti-derailing device in place. The tensile force in each bolt is

$$F_b = R_C /2 = 33,665 \text{ N}$$

The tensile stress in each bolt is $\sigma_b = F_b/A_b$ = 215 MPa = 31.1 ksi < 287 MPa = 41.6 ksi. The cross sectional area of each bolt is 157 mm^2. The safety factor is 287/215 = 1.3.

Figure 8A.4-18

Anti-Derailing Device



8A.4.16 Evaluation of the Fingers and Axis of the Grapple

Seismic Loads

The forces are taken from the ANSYS seismic analysis. For conservatism, the force is assumed to be carried by only two of the four fingers. The vertical force Fz is taken from the ANSYS model and is 150,000 N. This is the maximum force at the finger location for all positions analyzed. The mass used in the ANSYS analysis is 7000 kg.

The following masses are taken into account:

m_p = 3000 kg = mass of the shield plug
m_o = 1500 kg = mass of the overlid

The fingers and axis are all made from A36 forged carbon steel, with the following minimum properties:

yield strength, σ_y	36 ksi (248 MPa)
ultimate strength, σ_u	58 ksi (399 MPa)

The allowable stress is 0.9 $\sigma_y/1.2$ = 186 MPa = 27 ksi. Note that an additional safety factor of 1.2 has been added to allow for uncertainties in the dimensions. The shear stress allowable is 0.5 $\sigma_y/1.2$ = 103 MPa = 15 ksi.

The mass of the plug and overlid is less than that used in the ANSYS analysis. Therefore, the force is corrected below.

$$F_z = F_z(\text{computed}) \times m/m_T$$

where m is the mass of the system and m_T is the mass used in the analysis (7000 kg).

Pintle of the plug

The maximum force on the pintle of the plug due to seismic loading is:

$$F_z = 150{,}000 \times m_p/m_T = 150{,}000 \times 4500/7000 = 96{,}429 \text{ N}$$

Static Load

For a nonredundant lift, a safety factor of 6 to yield and 10 to ultimate is used. For this component, the ultimate strength is limiting.

The maximum force in the static case including a factor of 10 to ultimate strength for a nonredundant lift is:

$F = 4500 \times 9.81 \times 10 = 4.41 \times 10^5$ N

Using the loading from the seismic analysis, and assuming that the load is handled by 2 fingers, the force on one finger is:

$T = F_z / 2 = 2.2 \times 10^5$ N

The axis of the grapple is 30 mm.
The cross sectional area is therefore 707 mm^2. The shear force in the pin is:

$F = T/2 = 1.1 \times 10^5$ N (because the axis is a rod supported at the ends)

The shear stress is:

$\tau = F/A = 1.1 \times 10^5 / 707 = 156$ MPa = 22.6 ksi $\leq$ 200 MPa = 29 ksi

The safety factor is SF = (200/156)*10 = 12.8

A sketch of a finger is shown below. The following lengths are used for the finger:

L2 = 60 mm = 2.4 in
L1 = 30 mm = 1.2 in.
L3 = 30 mm = 1.2 in.
t = 60 mm = 2.4 in.
b $\approx$ 20 mm = 0.8 in.

The shear stress in the L1 section is:

$\tau = T/L_1t = (2.2 \times 10^5)/(30*50) =$ 147 MPa = 21 ksi $\leq$ 200 MPa = 29 ksi

The shear stress in the L3 section is:

$\tau = T/L_3t = (2.2 \times 10^5)/(30*50) =$ 147 MPa = 21 ksi $\leq$ 200 MPa = 29 ksi

The tensile and bending stress in the L2 section is:

$\sigma = T/L_2t + M/S$

where $M = T(b + L_2/2) = (2.2 \times 10^5)(20 + 30) = 1.1 \times 10^4$ mN

and $S = tL_2^2/6 = (60)(60)^2/6 = 36$ cm^3

Then $\sigma = (2.2 \times 10^5)/(60*60) + 1.1 \times 10^4 / 36 =$ 367 MPa = 53.2 ksi $\leq$ 399 MPa = 58 ksi

The safety factor on the maximum stress is:

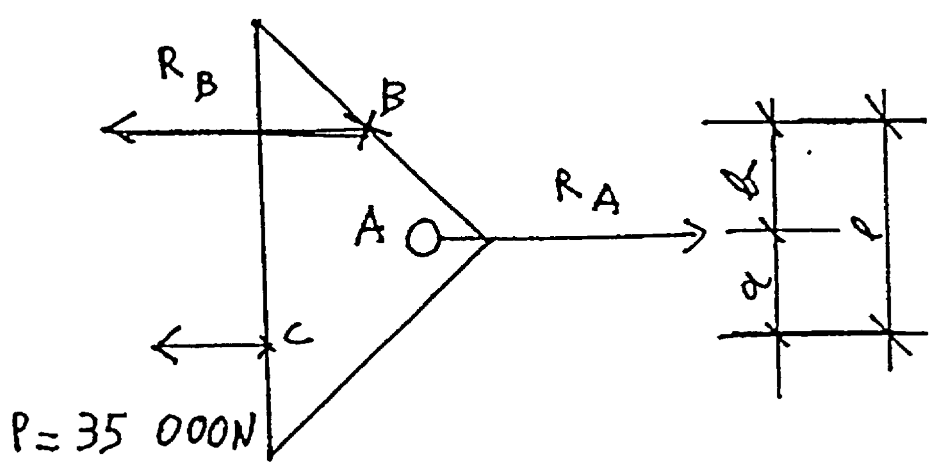
SF = 399 x 10 / 367 = 10.9

8A.4.17 Compensator Axis Analysis

The maximum force on the compensator axis occurs in the event of a cable breaking combined with the seismic load. The compensator is shown conceptually in Figure 8A.4-18.

R_A is the reaction on the compensator axis. R_B is the reaction at point B. P is the maximum force on the cable. It is exerted only at point C. The compensator is supported on B on the frame of the structure.

Figure 8A.4-19
Sketch of Compensator



Summing the forces:

$$R_A + R_B = P$$

Summing the moments:

$$P(a + b) - R_A b = 0$$

Then, $R_A = P(a + b)/b$

For the case of the broken cable:

P = Mg/2 = 35,000 N
where M is the mass of the rated load = 7,000 kg
$g = 10\ m/sec^2$

Then R_A = 105,000 N = 23,147 lbf.

The diameter of the compensator axis D = 40 mm = 1.6 in.
The cross sectional area of the axis is 1,256 mm^2.

There are two shear areas on the axis. Therefore the shear stress is:

$$\tau = R_A/2S = 42\ MPa = 6.1\ ksi \leq 0.45\sigma_y/1.2 = 93\ MPa = 13.5\ ksi$$

The safety factor is SF = 93/42 = 2.2.

The force taken from the seismic analysis is 75,000N. Therefore, the static case is limiting.

8A.4.18 Analysis of the Locking Pins

Locking Pins of the Trolley

The maximum force on the locking pin is taken from the seismic analysis. The maximum force is from load combination 1 at node 1123, where F_x = 15,600 N and at node 1178, where F_x= 17,045 N. The force on the pin is the sum of the two reactions.

$$F_p = 15,600 + 17,045 = 32,645\ N.$$

The diameter of the pin is D = 30 mm = 1.2 in.
The cross sectional area is A = 707 mm^2.
The shear stress is $\tau = F/A = 47\ MPa = 6.82\ ksi < 0.5\sigma_y/1.2 = 103\ MPa = 15\ ksi$.
The safety factor is SF = 103/47 = 2.2.

Locking Pins of the Port Covers

The pin is used to stop the port cover in the direction of the port cover railway. The covers are assumed to be rigid. The horizontal acceleration in the Y direction is $a_y = 0.74 \times 9.81 \times 1.5 = 10.9$ m/sec^2 at the 27' level and $a_y = 0.88 \times 9.81 \times 1.5 = 13$ m/sec^2 at the 46' level. The forces in the Y direction due to seismic loading are shown in Table 8A.4-9.

Table 8A.4-9

Forces on the Locking Pins

	Mass		F_y	
	US Units	Metric Units	US Units	Metric Units
Upper Shield Port Cover	1.9 tons	1700 kg	4873 lbf	22,100 N
Receiving Cask TC Port Cover	9.3 tons	9500 kg	20426 lbf	92,650 N
Source Cask TC Port Cover	6 tons	5500 kg	13217 lbf	59,950 N

The locking pins are selected such that the distance between the lower part of the port cover and the plate is less than D/2 to ensure that there is no bending moment on the pin.

Upper Shield Port Cover

The diameter of the pin D = 24 mm = 0.95 in. The cross sectional area A = 452 mm^2. Therefore, the shear stress τ = F/A = 49 MPa = 7.1 ksi. The safety factor is SF = 103/49 = 2.1.

Receiving Cask TC Port Cover

The diameter of the pin D = 40 mm = 1.6 in. The cross sectional area A = 1256 mm^2. Therefore, the shear stress τ = F/A = 48 MPa = 7 ksi. The safety factor is SF = 103/48 = 2.1.

Source Cask TC Port Cover

The diameter of the pin D = 50 mm = 2 in. The cross sectional area A = 1963 mm^2. Therefore, the shear stress τ = F/A = 47 MPa = 6.85 ksi. The safety factor is SF = 103/47 = 2.2.

8A.4.19 Summary of Results

A summary of the analysis results on the Shield Plug and Source Cask Handling Subsystem is presented in Table 8A.4-10 below:

Table 8A.4-10

Summary of Results

Component	Load	Allowable Value	Calculated Value	Size	Safety Factor
Cable Diameter	Static	88,042 N	70,000 N	12 mm (0.48 in.)	1.25
Trolley Wheel Diameter	Static	11,109 lbf	5,540 lbf	139 mm (5.5 in.)	2
Rail Width	Static	11,109 lbf	5,540 lbf	37 mm (1.45 in)	2
Guidance Roller Diameter	Static	10,570 lbf	2555 lbf	D = 50.8 mm (2.00 in)	4.1
Anti-Taking Off Device Bolt	Seismic	287 MPa	19 MPa	16 mm dia. (0.63 in)	15
Anti-Taking Off Device Plate Thickness	Seismic	186 MPa	27 MPa	20 mm (0.8 in)	6.8
Anti-Seismic Bumper Bolt Diameter	Seismic	287 MPa	215 MPa	16 mm dia. (0.63 in)	1.3
Finger of grapple axis diameter	Static	200 MPa	15.6 MPa	30 mm (1.2 in)	12.8

Table 8A.4-10 (Continued)

Summary of Results

Component	Load	Allowable Value	Calculated Value	Size	Safety Factor
Grapple finger thickness	Static	399 MPa	36.7 MPa	60 mm (2.4 in)	10.9
Compensator axis diameter	Cable Breaking	93 MPa	42 MPa	40 mm (1.6 in.)	2.2
Trolley locking pin diameter	Seismic	103 MPa	47 MPa	30 mm (1.2 in)	2.2
Upper Shield Port locking pin diameter	Seismic	103 MPa	49 MPa	24 mm (1 in)	2.1
Receiving Cask TC port cover locking pin diameter	Seismic	103 MPa	48 MPa	40 mm (1.6 in.)	2.1
Source Cask TC port cover locking pin diameter	Seismic	103 MPa	47 MPa	50 mm (2 in)	2.2

Appendix 8A.5 Fuel Handling Crane Analysis

The fuel handling crane has been analyzed using the finite element analysis program ANSYS 4.4. Certain components of the crane, such as the grapple, have been evaluated using hand calculations.

The seismic analysis is performed on the crane to ensure retention of the load and the prevention of any component from becoming a missile that would be detrimental to the DTS's safety related equipment. Seismic evaluation is performed with and without the rated load.

8A.5.1 Positions Evaluated

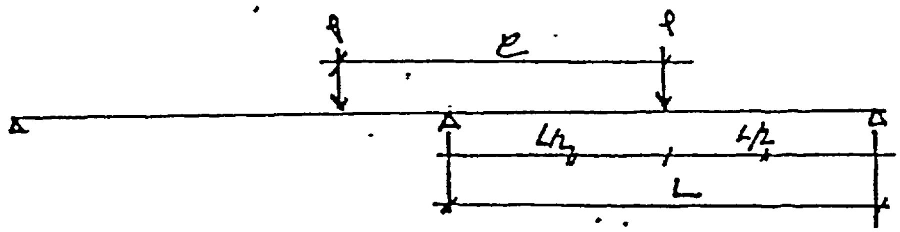
The fuel-handling crane has been analyzed for a number of positions. As outlined in detail in Section A, the bridge is analyzed with one wheel located at mid-span (to generate the maximum bending moment in the bridge) and the other wheel, in the vicinity of the supports (to give maximum force on the rail support). The trolley was analyzed in two positions. The maximum bending stress in the bridge occurs when the wheel is located 0.55 meters from the end of the rail, and the maximum force on the rail support occurs when the wheel is at the end of the rails. The calculations were performed with the loaded grapple located at a cable length, whose fundamental frequency corresponds to the frequency of peak vertical response on the spectrum. Five load combinations have been evaluated with the crane in the above positions, as described in Section 8A.5.

A. Bridge Position

The bridge rails are each simply supported by three equally spaced supports, one on each end and one at the center of the beam. The position of the bridge which results in the maximum bending moment in the bridge rails is where one of the two bridge wheels is located at mid span between an end support and the center support. (See Figure 8A.5-1). This is also the position which results in the maximum force on the rail support. This position is possible provided that the distance between the 2 wheels of the bridge along the X-axis, e, is greater than or equal to 0.586L, where L is the span. For the DTS, e = 2400 mm and L = 2000 mm. Therefore, $e \geq 0.586L = 1{,}172$ mm. Therefore, the bridge is analyzed with one wheel at mid-span.

Figure 8A.5-1

Position of the Bridge Resulting in Maximum Bending



L = span

e = distance between the 2 wheels of the bridge along the X axis

B. Trolley Position

The beams supporting the trolley on the bridge are simply supported on two supports of span L. The distance between the two wheels of the trolley is e. A sketch of the forces imposed by the trolley on the beam is provided in Figure 8A.5-2. The forces applied by the trolley in any direction are approximately equally distributed. Then if e < 0.586 L, for a < b, the maximum bending moment is at M2, where:

$$a = L/4(2-3e/L) \qquad (1)$$

and

$$M_{max} = (PL/2)(1-e/2L)^2 \qquad (2)$$

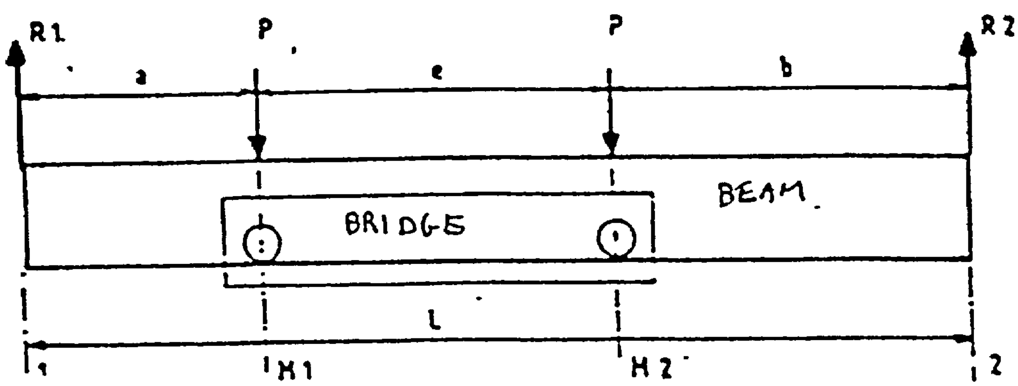
The distance between trolley wheels is e = 2.4 m = 94.5 inches. The span, L = 4.7 m = 185 in. Therefore, a = 0.55 m = 21.6 inches. The position which results in the maximum bending moment is at the position b = L - a - e = 1.75 m = 68.9 in.

The position which results in the maximum force at a support is where one wheel is at the end of the span.

Therefore, two positions of the trolley have been analyzed: a = 0.55 m = 21.6 in. and a = 0 (end of span).

Figure 8A.5-2

Forces Applied to the Trolley



C. Cable Position

The length of the cable, L, is selected such that the cable under load will have the first vertical frequency at the peak of the spectrum. This cable length will result in higher stresses than would occur if the hook were in the full up or full down position. The peak acceleration during the seismic event occurs at around 10 Hz. The weight of the load on the cable is 1500 kg = 3,300 lbs. The spring constant of the cable which would result in a natural frequency of 10 Hz is derived below:

$$f = \frac{1}{2\pi}\sqrt{\frac{K}{M}} \quad (3)$$

$$K = (2\pi f)^2 M = 5.92 \times 10^6 \text{ N/m} \quad (4)$$

The length of the cable, L, which results in the first vertical frequency at 10 Hz is:

$$L = EA/K \quad (5)$$

where E = the modulus of elasticity = 201,000 MPa = 29.2 x 10^6 psi and A = the cross sectional area of the cable. The cable is modeled as a spar element of length = 1 meter. To get a natural frequency of 10 Hz, the area of the spar is input as A = 29.46 mm^2 = 0.046 in^2.

8A.5.2 Load Combinations

The following loads are used for the seismic evaluation. The symbols and nomenclature are taken from NOG-1.

P_{dt} = the trolley dead load
P_{db} = the bridge dead load
P_{lr} = the rated load of the crane
P_{cs} = the credible critical load with safe shutdown earthquake
$P_{e'}$ = safe shutdown earthquake load

Note that the rated load of the crane is equal to the credible critical load, $P_{cs} = P_{lr}$.

The following load combinations were evaluated for the seismic event, as specified in NOG-4140(d):

$P_{c10} = P_{dt} + P_{db} + P_{cs} + P_{e'}$ (evaluated with the trolley at 0.55 m (21.6 in.) from the end and under load - Load Combination 1)

$P_{c10} = P_{dt} + P_{db} + P_{cs} + P_{e'}$ (evaluated with the trolley at the end under load - Load Combination 2)

$P_{c11} = P_{dt} + P_{db} + P_{e'}$ (evaluated with the trolley at 0.55 m (21.6 in.) from the end and no load - Load Combination 3)

$P_{c11} = P_{dt} + P_{db} + P_{e'}$ (evaluated with the trolley at the end with with no load - Load Combination 4)

The calculations were performed with the following:

- The length of the cable was fixed to have the vertical frequency at the peak of the spectrum.
- The position of the bridge for all cases was with one wheel at mid-span.

Additionally, the girder deflection was evaluated with the trolley at 0.55 m (21.6 in.) under the maximum rated load using the following load:

$$P = P_{dt} + P_{lr} \qquad \text{(Load Combination 5)}$$

8A.5.3 Material Properties

The properties for the structural components of the crane were taken from Tables NOG-4211-1 and NOG-4221-1 of NOG-1, and are summarized below:

The plates and beams will be constructed from A36 Steel, with a minimum yield strength of 36 ksi (248 MPa) and a minimum tensile strength of 58 ksi (399 MPa).

The structural connections will be constructed from A193 Grade B7, with a minimum yield strength of 75 ksi (517 MPa) and a minimum tensile strength of 100 ksi (689 MPa).

The cable minimum ultimate strength used in the analytical model is 256.7 ksi (1770 MPa). A shape factor including the strand factor of 0.57 is used in the analysis.

8A.5.4 Design Criteria

The design criteria for the crane are taken from NOG-4300 and are repeated following.

Allowable Stresses in the beams

For compression members with an equivalent slenderness ratio:

$$kl/r < C_c = \sqrt{(2\pi^2 E/\sigma_y)} \qquad (6)$$

where E = modulus of elasticity
σ_y = the yield point
k = effective length factor
l = length of compression member
r = radius of gyration of member
and C_c = column slenderness ratio separating elastic and inelastic buckling

The allowable axial compression stress shall not exceed the value:

$$\sigma_a = (1-((kl/r)^2 / 2C_c^2))(\sigma_y / FS) \qquad (7)$$

where FS = factor of safety and the other variables are as noted above.

The required factor of safety is equal to:

$$FS = N\{5/3 + (3/8)((kl/r)/C_c) - (1/8)((kl/r)/C_c)^3\} \qquad (8)$$

For severe environmental loads, the value of N is 0.67. For compression members with an equivalent slenderness ratio $kl/r > C_c$, the allowable axial compression stress shall not exceed the value:

$$\sigma_a = 12\pi^2 E / (23N(kl/r)^2) \tag{9}$$

Members subjected to both axial compression and bending stresses shall satisfy the following requirements:

$$\sigma / \sigma_a + C_{mx} \sigma_{bx} / ((1 - \sigma/\sigma'_{ex})\sigma_{abx}) + C_{my}\sigma_{by} / ((1- \sigma/\sigma'_{ey})\sigma_{aby}) \leq 1.0 \tag{10}$$

$$\sigma / \sigma_{ac} + \sigma_{bx} / \sigma_{abx} + \sigma_{by} / \sigma_{aby} \leq 1.0 \tag{11}$$

where $\sigma'_e = 12\pi^2 E / (23N(kl/r)^2)$ (12)

The subscripts x and y, combined with subscripts b, m, and e, indicate the axis of bending about which a particular stress or design property applies; and σ_a, σ_{ab} are the allowable axial and bending stresses respectively.

The l is the actual unbraced length in the plane of bending, r is the corresponding radius of gyration, K is the effective length factor in the plane of bending and N is the loading condition factor, 0.67 for extreme environmental loading.

C_m is a coefficient whose value is:

(a) $C_m = 0.85$ for compression members in frames subject to joint translation;

(b) $C_m = 0.6 - 0.4 (M_1/M_2)$ but not less than 0.4 for restrained compression members in frames braced against joint translation and not subject to transverse loading between their supports in the plane of bending. M_1/M_2 is the ratio of the smaller to the larger moments at the ends of that portion of the member unbraced in the plane of bending under consideration.

(c) For compression members in frames braced against joint translation in the plane of loading and subjected to transverse loading between their supports, $C_m = 0.85$ for members whose ends are restrained, and $C_m = 1.0$ for members whose ends are unrestrained.

If $\sigma/ \sigma_a \leq 0.15$, then only equation (11) needs to be evaluated.

Members subjected to both axial tension and bending stresses shall satisfy equation (11). The computed bending tensile stress, taken alone, shall not exceed the $0.9\sigma_y$.

The maximum allowable shear stress under seismic load is $0.5\ \sigma_y$.

An additional factor of 1.2 is applied to all stresses to account for uncertainties since the loading may change from site to site.

For the beams, which are made from A36 steel:

The tensile stress allowable is:

$$F/A + M_{bx}x/ I_x + M_{by}y/ I_y < 0.9\ \sigma_y/1.2 = 186 \text{ MPa} = 27.0 \text{ ksi} \qquad (13)$$

The shear stress allowable is $0.5\sigma_y /1.2 = 103$ MPa = 15 ksi.

Allowable stresses in Bolts

The allowable stresses in the bolts are taken from NOG-4513. For seismic loading, the maximum allowable tensile load is 0.5 σ_u , and the maximum allowable shear stress is 0.26 σ_u. For bearing type joints, the stresses shall meet the following criteria:

$$\sigma \leq 0.6\ \sigma_y R - 1.6\ \tau \qquad (14)$$

The maximum allowable tensile stress due to seismic loading, assuming an additional safety factor of 1.2 is therefore 41.6 ksi (287 MPa). The maximum allowable shear stress, assuming an additional safety factor of 1.2 is 21.6 ksi (149 MPa).

Allowable Deflections

The deflection and camber in the components of the fuel-handling crane shall not exceed limits imposed in ASME NOG-1, Section NOG-4340.

Allowable stress for the Cables.

The maximum allowable stresses in the cables is governed by NOG-5425.1. The maximum critical load (without impact), plus the weight of the load block divided by the total number of parts of rope per system, shall not exceed 10% of the manufacturer's published breaking strength on the total system. The seismic load with all parts of rope intact shall not exceed 40% of the manufacturer's published breaking strength.

For the cables, σ_u= 1770 MPa = 256.7 ksi. For the static case,

$$F/KA < \sigma_u / 10 = 177 \text{ MPa} = 25.6 \text{ ksi} \qquad (15)$$

K is the shape coefficient, which is taken as 0.57. $A = \pi d^2/4$.

Then:

$$d_{MIN} = \sqrt{(40F/K\pi\sigma_u)} \qquad (16)$$

and

$$F = P_{cl} /n\eta \qquad (17)$$

where P_{cl} = the credible critical load and the weight of the load block
n = the number of parts of the rope
η = the efficiency, which is taken as 0.94 to start.

8A.5.5 Component Weights

The following loads were used in the model of the fuel handling crane:

Beams and Rails	4000 kg	4.4 tons
Bridge	4000 kg	4.4 tons
Trolley	1500 kg	1.7 tons
Rotating Platform + Roller	4000 kg	4.4 tons
Crane Rated Load	1500 kg	1.7 tons
Total load	**15,000 kg**	**16.6 tons**

8A.5.6 Fuel Handling Crane Model

A model of the fuel handling crane was made to evaluate the crane under seismic loading. The response spectrum method was used according to the requirements of NOG 4153.1. The response of the crane to the input response spectra in three directions was determined on a modal basis. An ANSYS model was used to perform the analysis. The program searches the frequency and the modal participation factor up to the cutoff frequency (around 33 Hz). If the sum of the participation of the mass is less than 90% in a direction, the program is completed with the equivalent static component in this direction. The residual mass is affected with the acceleration of the cutoff frequency in this direction.

The dynamic responses of the structure are combined using the "grouping method" in accordance with NOG 4153.10. The three directional components of the earthquake motion are combined by taking the square root of the sum of the squares of the maximum representation values of the codirectional responses caused by each of the three components of earthquake motion at each mode of the crane mathematical model.

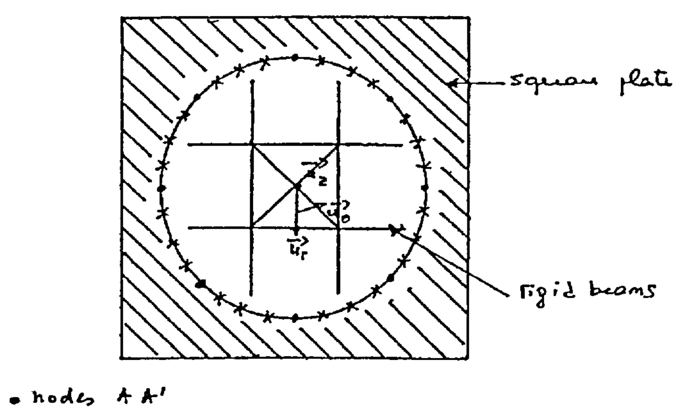
The model consists of 900 elements and 680 nodes. The model is made up of a trolley, a vertical beam with a cable and a mass, a bridge, and rails.

Trolley Model

The trolley is made up of frame of beams W12 x 12 x 0.5 linked with rigid beams to a square plate with a circular centered hole receiving a rotating circular plate. See Figure 8A.5-3. The link between the circular plate and the square one is made with spring elements as shown in the figure. The circular plate is reinforced by rigid beams.

The nodes identified as AA' are coupled in the radial and vertical directions, and are free in the rotational direction. The nodes identified as BB' are coupled in the radial direction, and free in all other directions. The square plate is 3.0 inches thick and the circular plate is 3.0 inches thick.

Figure 8A.5-3
Trolley Model



Vertical Beam

The vertical beam is a square beam of 400 x 400 x 15 mm (15.75 in x 15.75 in. x 0.6 inch). It is linked with the circular plate in all degrees of freedom. The additional weight of the equipment supported by the vertical beam (crud catcher, pulleys, etc. are modeled by mass elements all along the length of the beam to get a total weight of 1.5 tons in the x and y directions. The model consists of 25 mass elements, each 57.7 kg.)

A cable with a mass of 1.5 metric tons is fixed to the beam. Since we want the cable and the mass to have a vertical frequency of 10 Hz, we model the cable using a spar element with a length of 1 meter. The cross sectional area is calculated below:

$$F = (1/2\pi)\sqrt{(k/m)} = 10 \text{ Hz} \qquad (18)$$

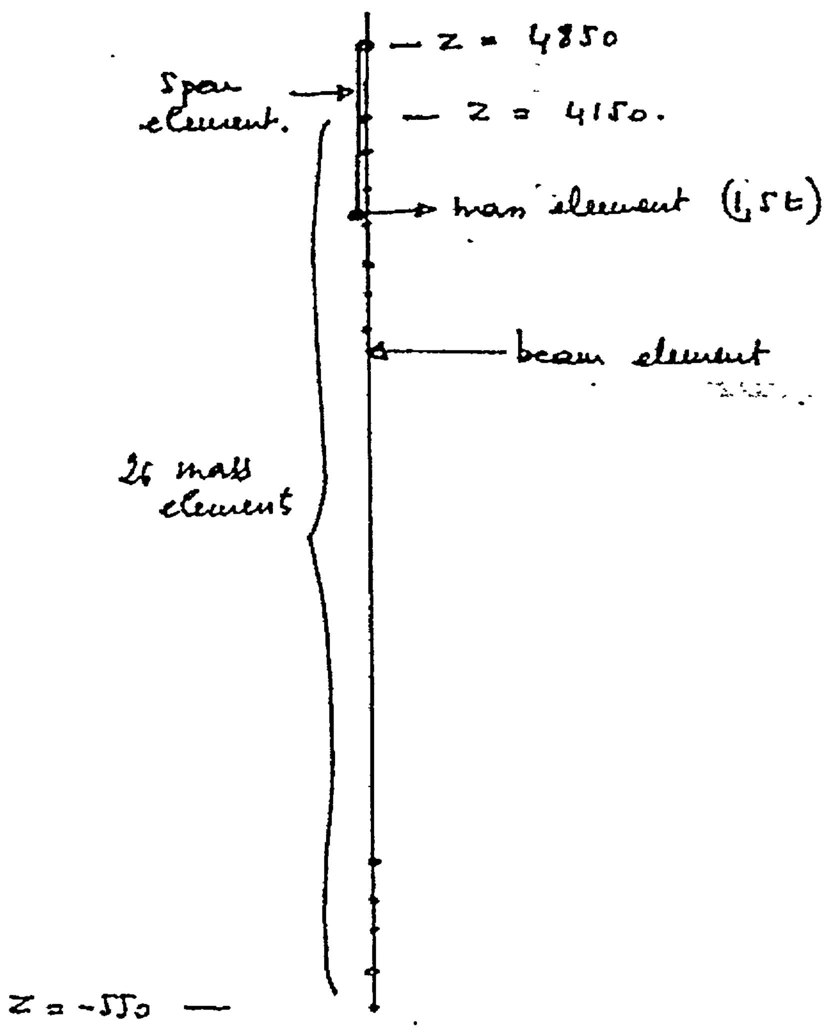
where k = EA/L
E is the modulus of elasticity of the cable
A is the cross sectional area
L is the length of the cable
and m is the mass = 1.5 metric tons
Solving equation (18) for k results in $k = 5.922 \times 10^6$ kg.

The cable has an elastic modulus, E of 201,000 MPa. Therefore the cross sectional area which results in a frequency of 10 Hz is 29.46 mm^2.

The model of the vertical beam is shown in Figure 8A.5-4.

Figure 8A.5-4

Model of Vertical Beam



Bridge

The bridge is modeled by two kinds of beams (W12 x 8 x 0.5 and W14 x 82) reinforced by 2 lateral shells.

Rails

The rails are modeled by W 12 x 96 beams reinforced by 2 lateral shells.

Material Densities

The material densities used in the model are corrected to have the following mass:

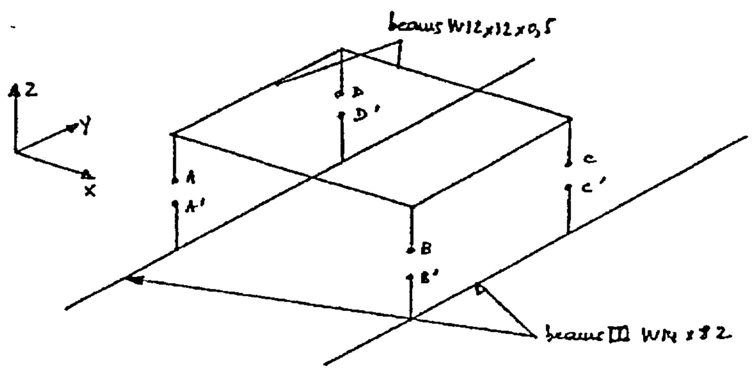
Component	mass (kg)
4 bridge beams	4000
Cable	negligible
Frame of the trolley	1500 kg
Rails	4000 kg
Plates (circular and square)	2000 kg
Vertical Beam	2000 kg
Mass elements	1500 kg.
Total mass	15000 kg

8A.5.7 Boundary Conditions

The bridge rails are supported by brackets. The rail nodes which contact the bracket are fixed in the x, y z and Θ_x directions. To ensure that there is no instability, the mass element at the end of the cable is fixed in the x and y directions. The connection between the trolley and bridge is shown in Figure 8A.5-5.

Figure 8A.5-5

Link Between Trolley and Bridge



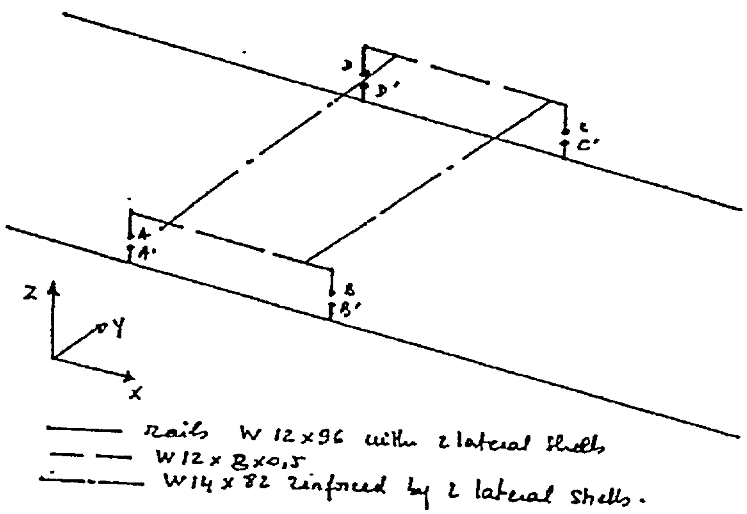
The coupled degrees of freedom are provided below:

Restraint Conditions - Trolley and Bridge Connection						
Nodes	X	Y	Z	θ_x	θ_y	θ_z
AA'	Coupled	Coupled	Coupled	Free	Free	Free
BB'	Coupled	Coupled	Coupled	Free	Free	Free
CC'	Coupled	Free	Coupled	Free	Free	Free
Free	Coupled	Free	Coupled	Free		Free

The connection between the bridge and the rails is shown in Figure 8A.5-6.

Figure 8A.5-6

Link Between Bridge and Rails



The node coupling between the bridge and the rails is summarized below:

Restraint Conditions - Bridge and Rail Connection						
Nodes	X	Y	Z	θ_x	θ_y	θ_z
AA'	Free	Coupled	Coupled	Free	Free	Free
BB'	Coupled	Coupled	Coupled	Free	Free	Free
CC'	Coupled	Free	Coupled	Free	Free	Free
DD'	Free	Free	Coupled	Free	Free	Free

The model and boundary conditions of the trolley positioned at 550 mm is shown in Figures 8A.5-7 and 8A.5-11. The model of the trolley positioned at the end is shown in Figures 8A.5-12 through 8A.5-14. The boundary conditions for this case are identical to those for the trolley positioned at 550 mm.

The accelerations due to the seismic event used for evaluation of the fuel handling crane are presented in Figures 8A.5-15 and 8A.5-16. The spectrum is based on a hard rock site (a basemat founded on competent bedrock with shear wave velocity > 1100 m/s. It is not valid for other site conditions such as sands, gravel, silt or clay. Note that the spectrum used for this analysis is slightly different from the spectrum determined in Appendix 8A1. The analysis will be redone when a site location is determined with actual site spectrum. This analysis is only used to size the equipment and to be representative of the expected spectrum at the various potential DTS locations.

Figure 8A.5-7
ANSYS Model & Boundary Conditions Trolley Positioned at 550 mm
Top View

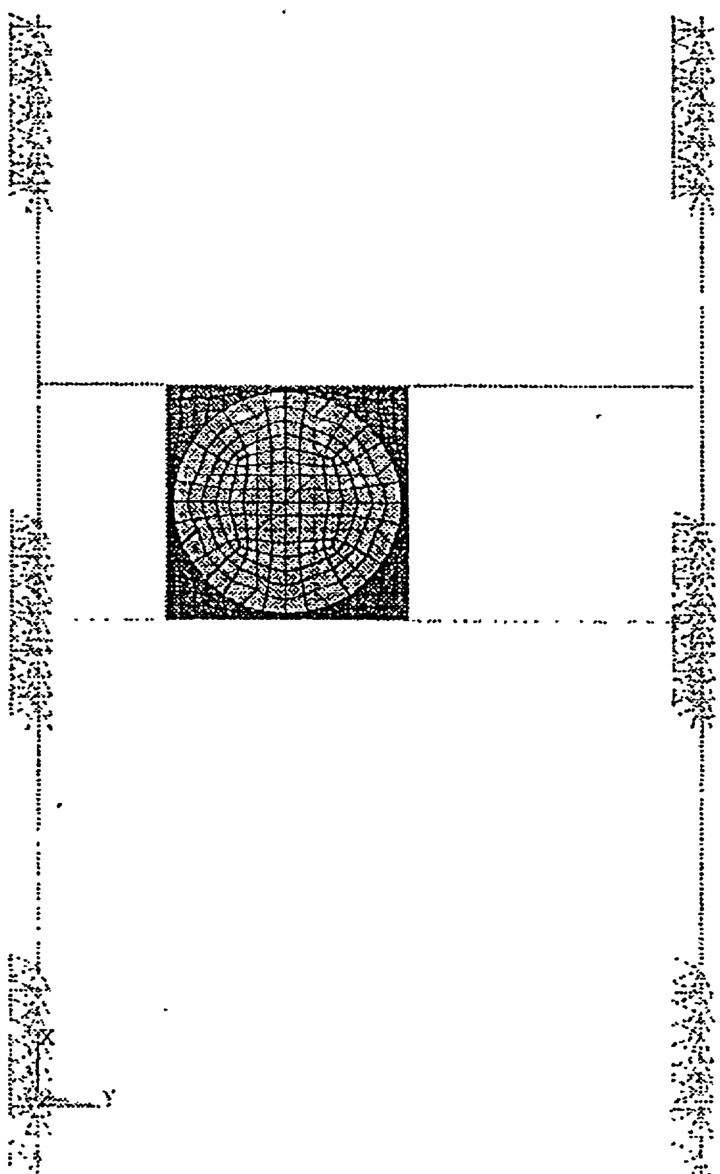


**Figure 8A.5-8
ANSYS Model & Boundary Conditions
Trolley Positioned at 550 mm
Isometric View**

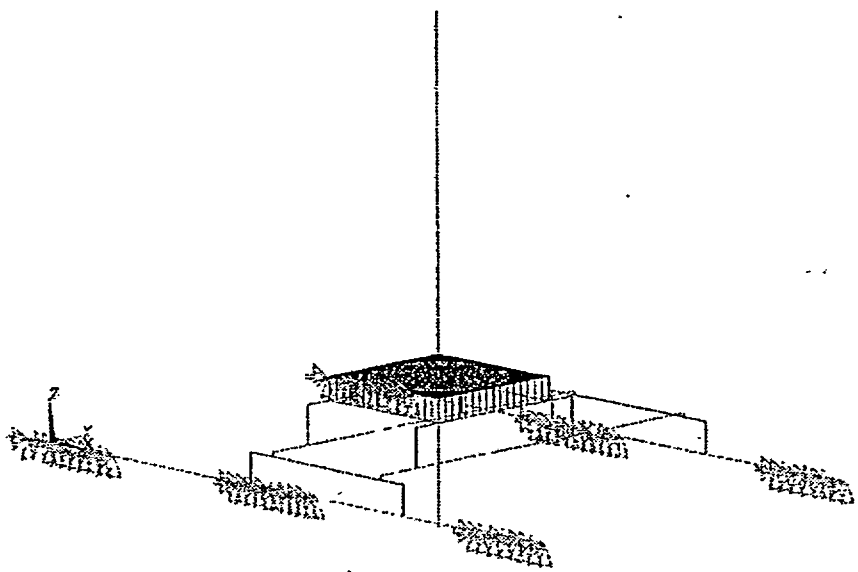


Figure 8A.5-9
ANSYS Model & Boundary Conditions
Trolley Positioned at 550 mm
SideView

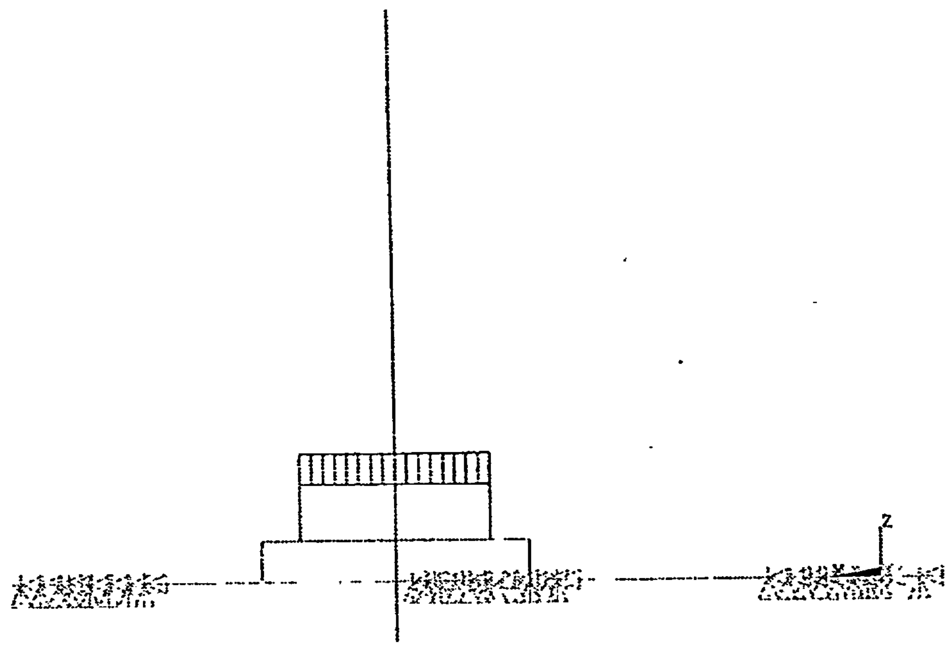


Figure 8A.5-10
ANSYS Model & Boundary Conditions
Trolley Positioned at 550 mm
End View

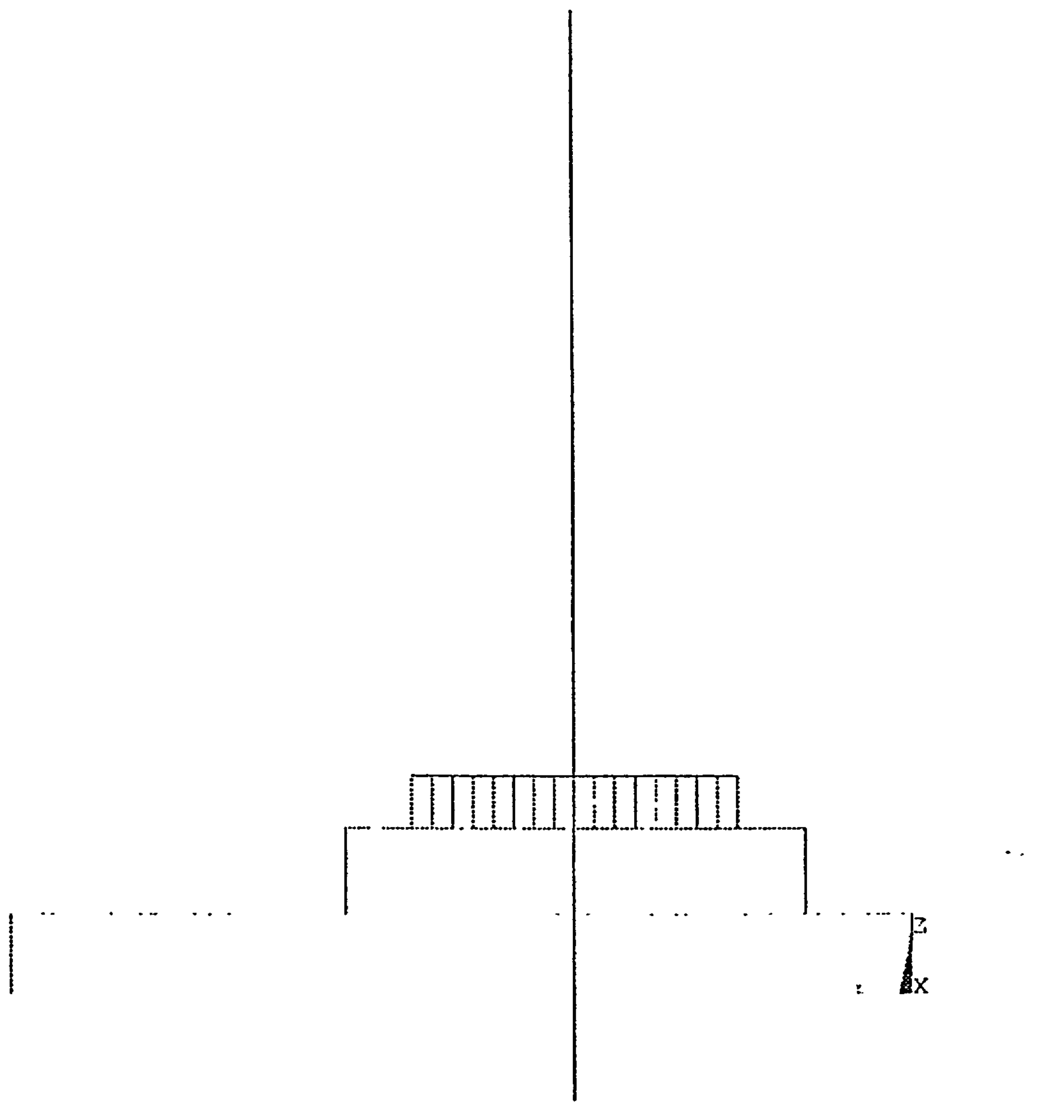


Figure 8A.5-11
ANSYS Model & Boundary Conditions
Trolley Positioned at 550 mm
Second Isometric View

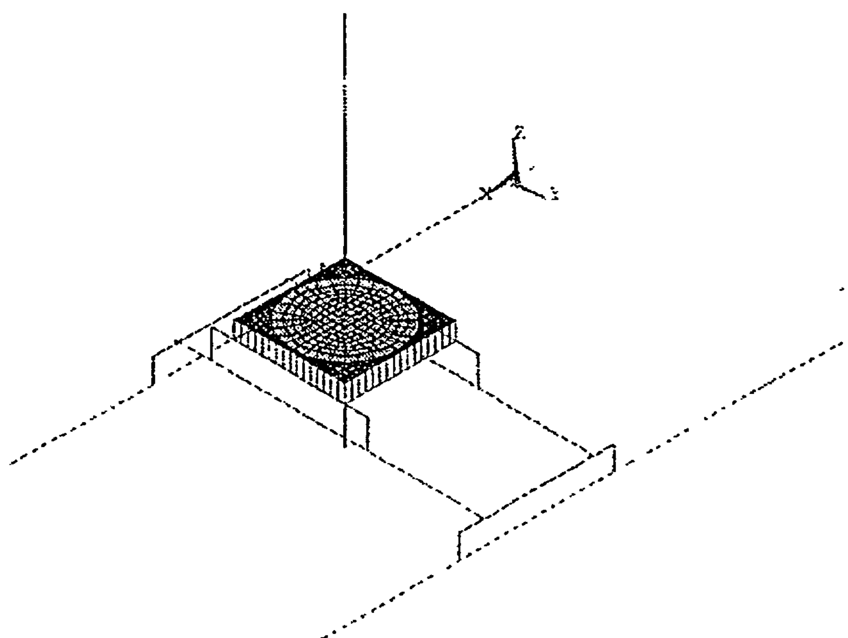


Figure 8A.5-12
ANSYS Model
Trolley Positioned at End
Isometric View from Top

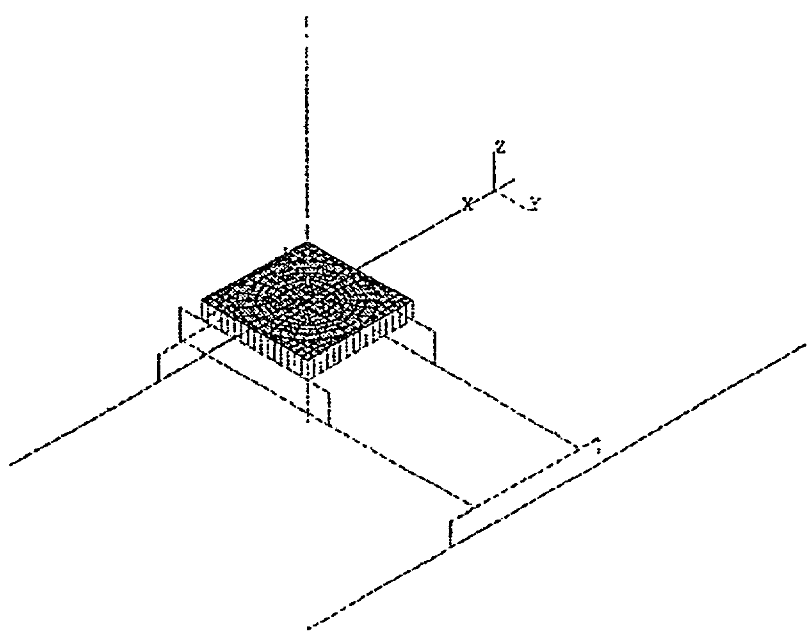


Figure 8A.5-13
ANSYS Model
Trolley Positioned at End
Isometric View from Side

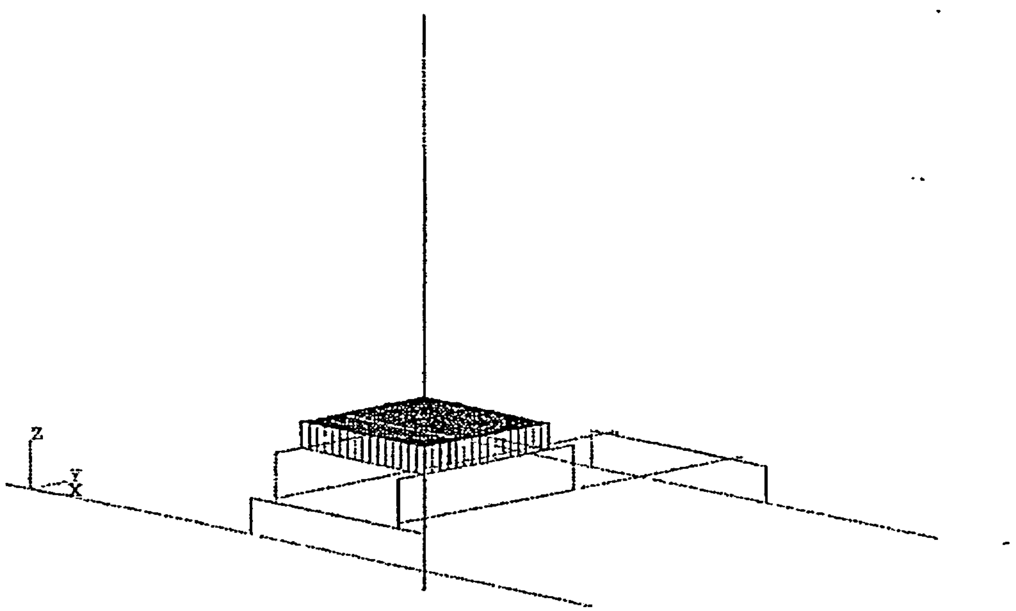


Figure 8A.5-14
ANSYS Model & Boundary Conditions Trolley Positioned at End
End View

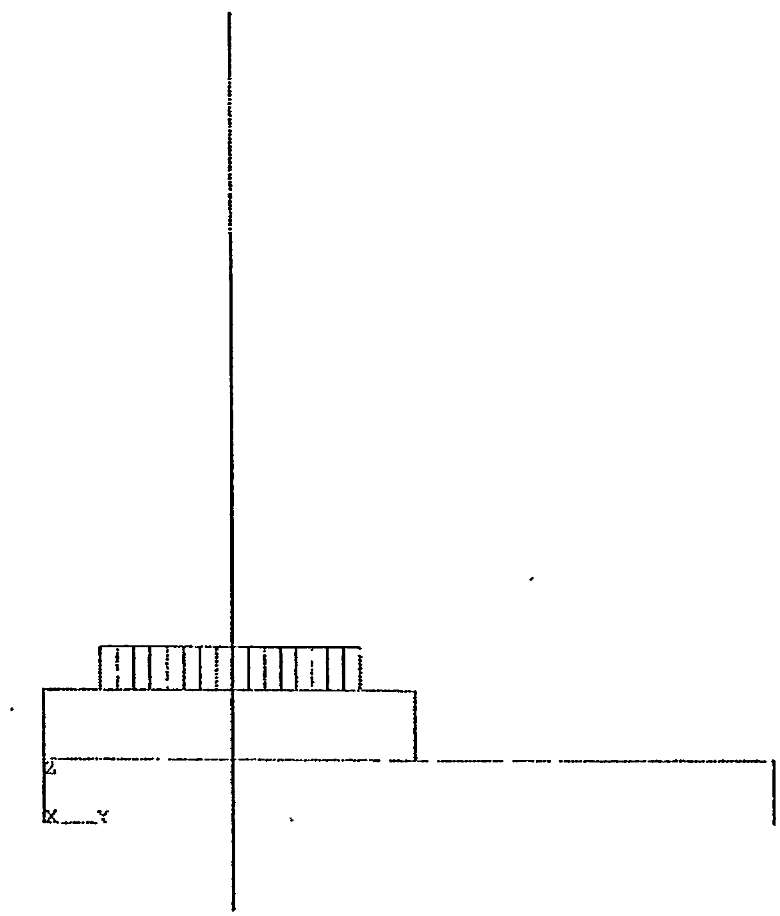


Figure 8A.5-15
Secondary Response Spectra
27" 0" Level, Y direction 7% Damping

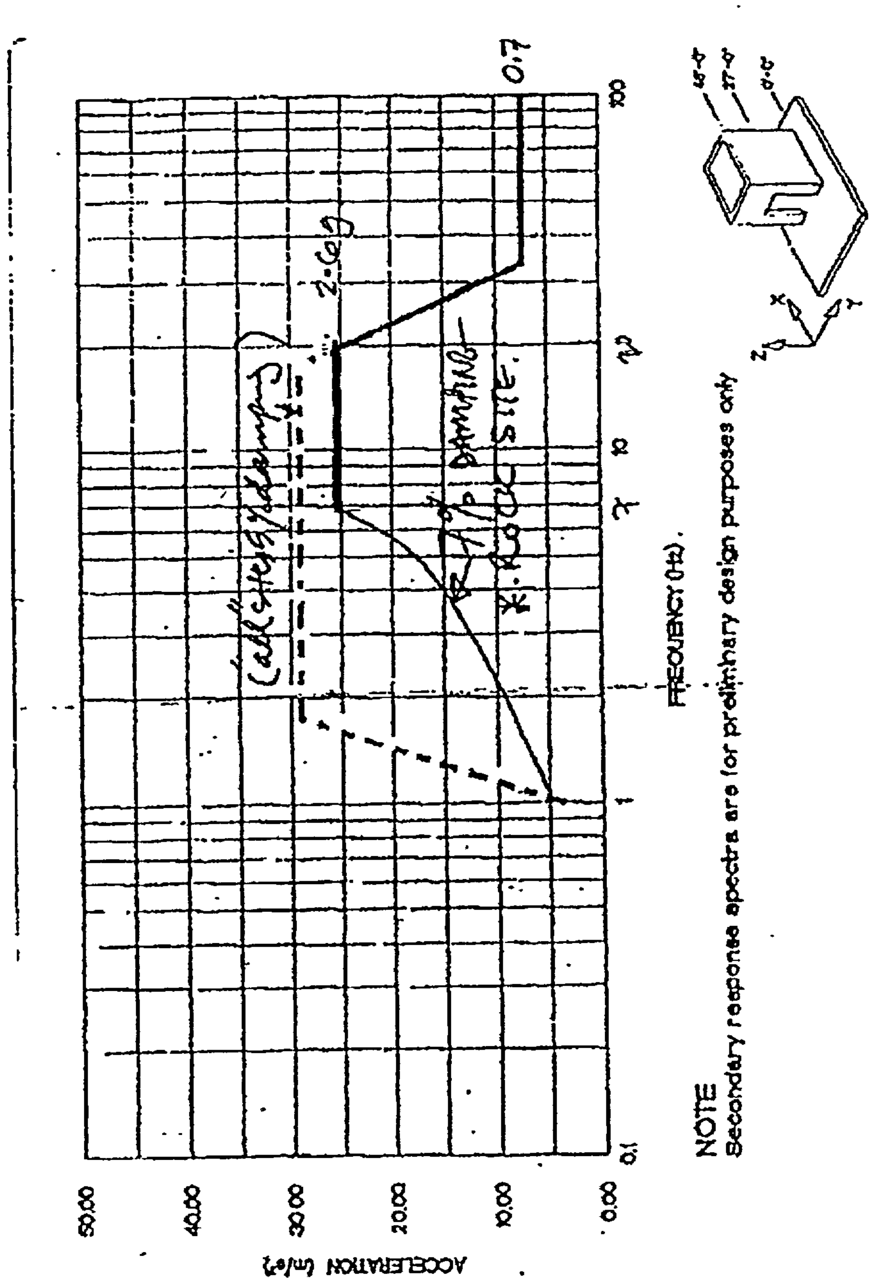
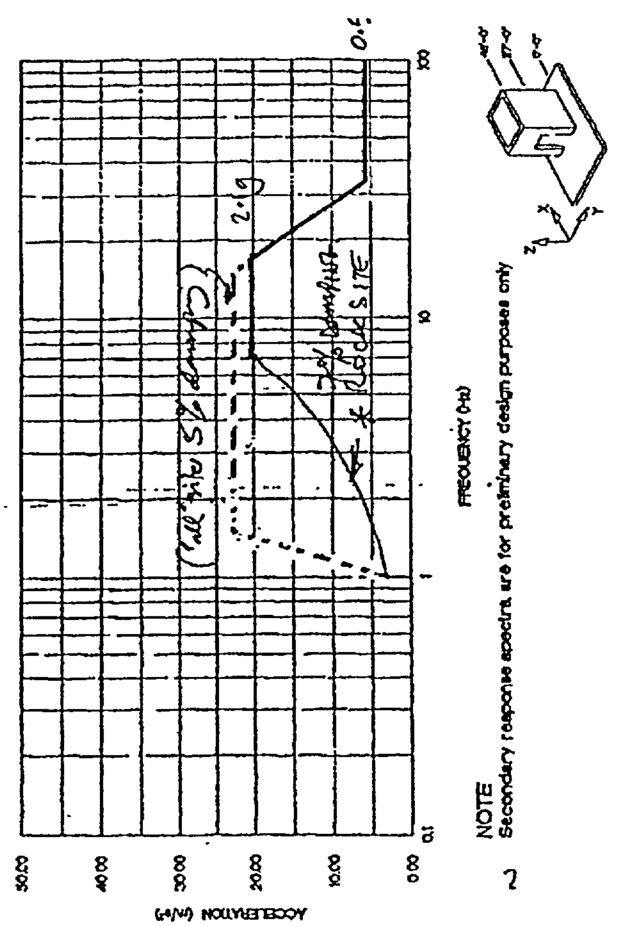


Figure 8A.5-16
Secondary Response Spectra
27" 0" Level, X direction 7% Damping



8A.5.8 Results

The stresses in the main beams due to load combination 1 are presented below in Table 8A.5-1:

Table 8A.5-1

Beam Stresses Load Combination 1
(Seismic Analysis)

Beams	**Maximum Tension**		**Maximum Shear**		**Conclusion**
	Calculated	Allowable	Calculated	Allowable	
W 14 x 82 with shell (bridge)	48.2 MPa 7 KSI	186 MPa 27 KSI	20.5 MPa 3 KSI	103 MPa 15 KSI	Acceptable
W 12 x 96 with shell (rails)	34.8 MPa 5 KSI	186 MPa 27 KSI	9.8 MPa 1.4 KSI	103 MPa 15 KSI	Acceptable
12 x 8 x 0.5 (bridge)	62 MPa 9 KSI	186 MPa 27 KSI	35.8 MPa 5.2 KSI	103 MPa 15 KSI	Acceptable
12 x 12 x 0.5 (trolley)	32.8 MPa 4.7 KSI	186 MPa 27 KSI	23.1 MPa 3.3 KSI	103 MPa 15 KSI	Acceptable
400 x 400 x 15 (fuel tube)	65.6 MPa 9.52 KSI	186 MPa 27 KSI	5 MPa 0.7 KSI	103 MPa 15 KSI	Acceptable

As shown in the Table, the stresses in the beams are well below the allowable stresses.

The forces in the links are presented in Section 8A.5.9-1. All units are metric.

The maximum stress in the plates (both the rotational table and the trolley plates) is 101 MPa (14.4 ksi). This value is well below the allowable stress of 186 MPa (27 ksi). A plot of the stresses in the plates is shown in Figures 8A.5-17 through 8A.5-20. The stresses are plotted in metric (MPa).

The reaction forces at the brackets are presented in Section 8A.5.10-1. Metric units are used. In Section 8A.5.11, the first frequencies below the critical frequency are presented.

Figure 8A.5-17

Plate Stresses
Top of Plate
Load Combination 1
Primary + Secondary Stresses

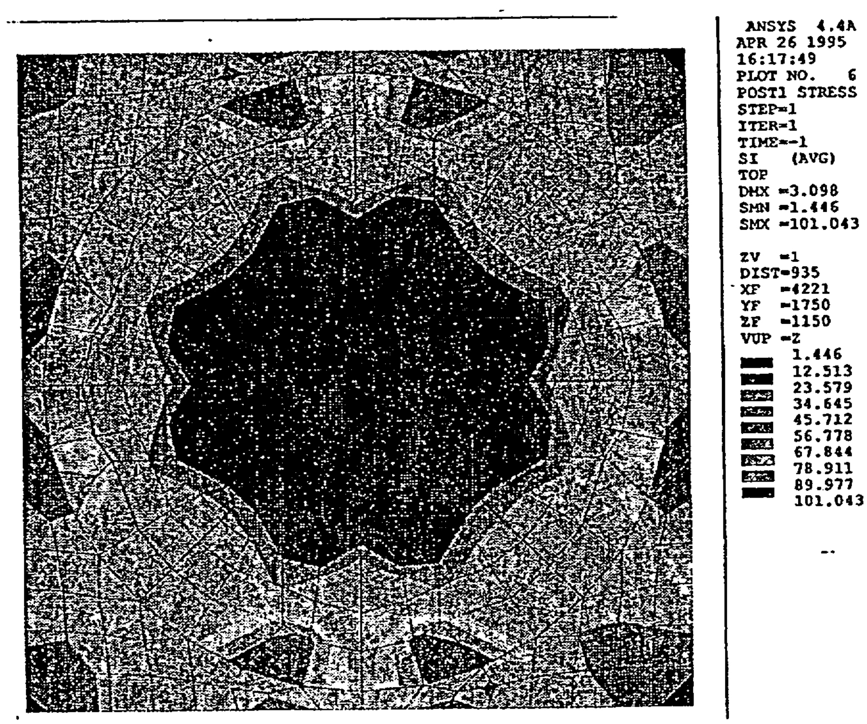


Figure 8A.5-18

Plate Stresses
Middle of Plate
Load Combination 1
Primary + Secondary Stresses

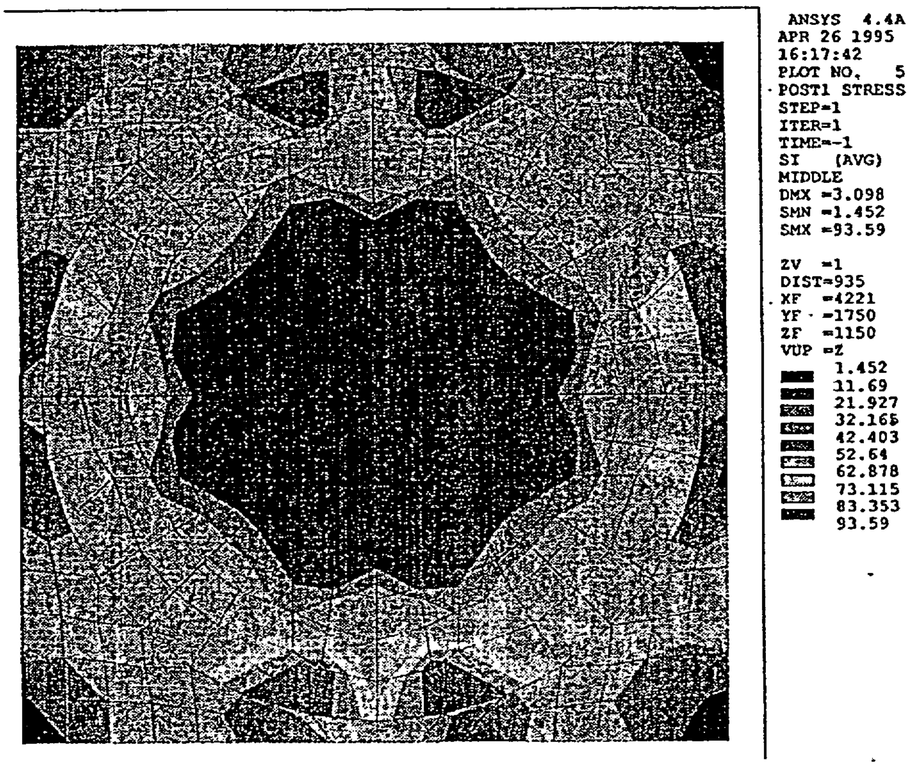


Figure 8A.5-19

Plate Stresses
Middle of Plate
Load Combination 1
Primary - Secondary Stresses

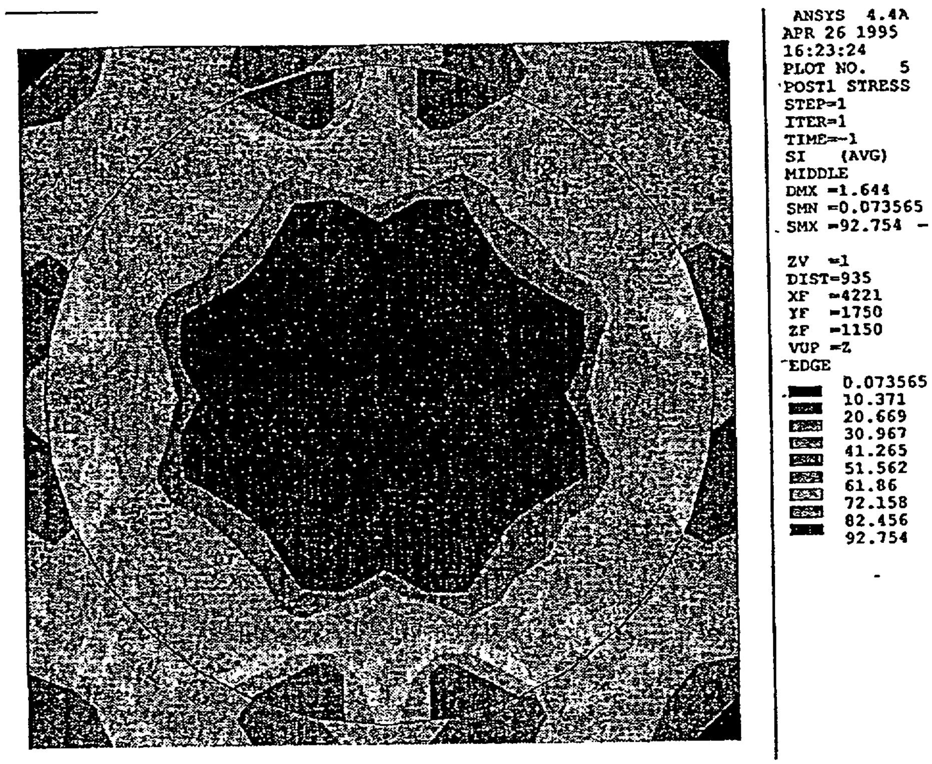
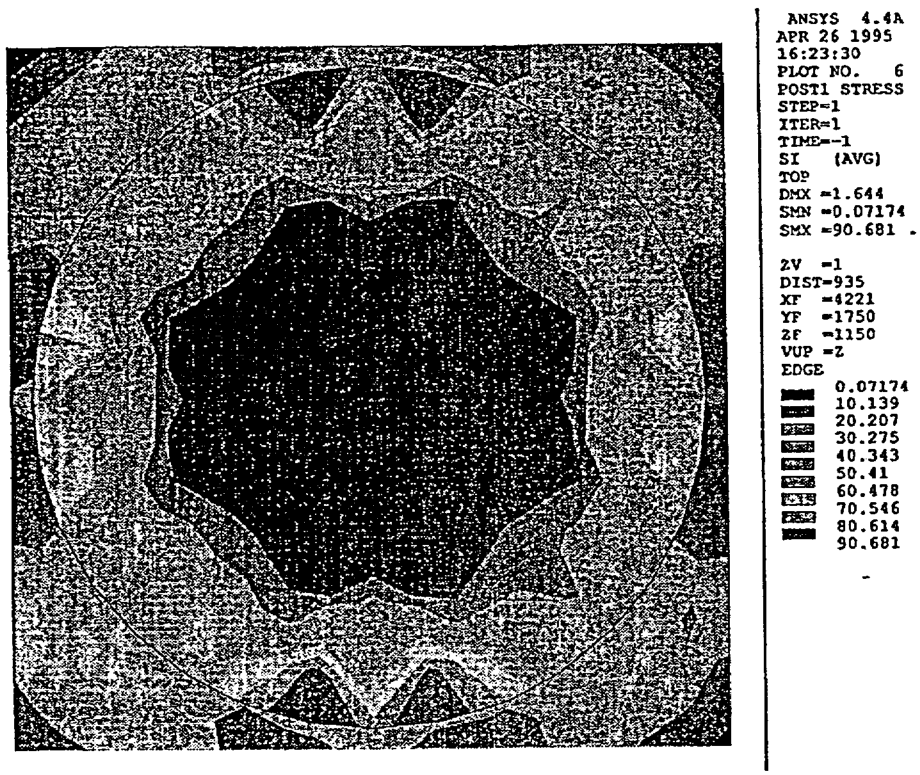


Figure 8A.5-20

Plate Stresses
Top of Plate
Load Combination 1
Primary - Secondary Stresses



The stresses in the beams due to load combination 2 are presented in the table 8A.5-2 below.

Table 8A.5-2

Beam Stresses Load Combination 2 (Seismic Analysis)

Beams	Maximum Tension		Maximum Shear		Conclusion
	Calculated	Allowable	Calculated	Allowable	
W 14 x 82 with shell (bridge)	50.7 MPa 7.35 KSI	186 MPa 27KSI	6.4 MPa 0.92 KSI	103 MPa 15 KSI	Acceptable
W 12 x 96 with shell (rails)	33.3 MPa 4.83 KSI	186 MPa 27 KSI	9.5 MPa 1.37 KSI	103 MPa 15 KSI	Acceptable
12 x 8 x 0.5 (bridge)	61.8 MPa 8.96 KSI	186 MPa 27 KSI	36.2 MPa 5.2 KSI	103 MPa 15 KSI	Acceptable
12 x 12 x 0.5 (trolley)	35.1 MPa 5.1 KSI	186 MPa 27 KSI	23.5 MPa 3.4 KSI	103 MPa 15 KSI	Acceptable
400 x 400 x 15 (fuel tube)	78MPa 11.3 KSI	186 MPa 27 KSI	5.9 MPa 0.8 KSI	103 MPa 15 KSI	Acceptable

As shown in the Table, the stresses in the beams are well below the allowable stresses.

The forces in the links are presented in Section 8A.5.9-2. All units are presented in metric.

The reaction forces at the brackets are presented in Section 8A.5.10-2.

In Section 8A.5.11, the first frequencies below the critical frequency are presented. The maximum stress in the plates (both the rotational table and the trolley plates) is 102 MPa (14.8 ksi). This value is well below the allowable stress of 186 MPa (27 ksi). A plot of the stresses in the plates due to this load is shown in Figures 8A.5-21 through 8A.5-24.

The maximum deflection of the bridge rails under normal loads (Load combination 5) is 1.065 mm. This is below the allowable deflection of 1/1000 (span) = 1/1000 x 4700 mm = 4.7 mm. Therefore the deflection is acceptable.

Figure 8A.5-21

Plate Stresses
Top of Plate
Load Combination 2
Primary + Secondary Stresses

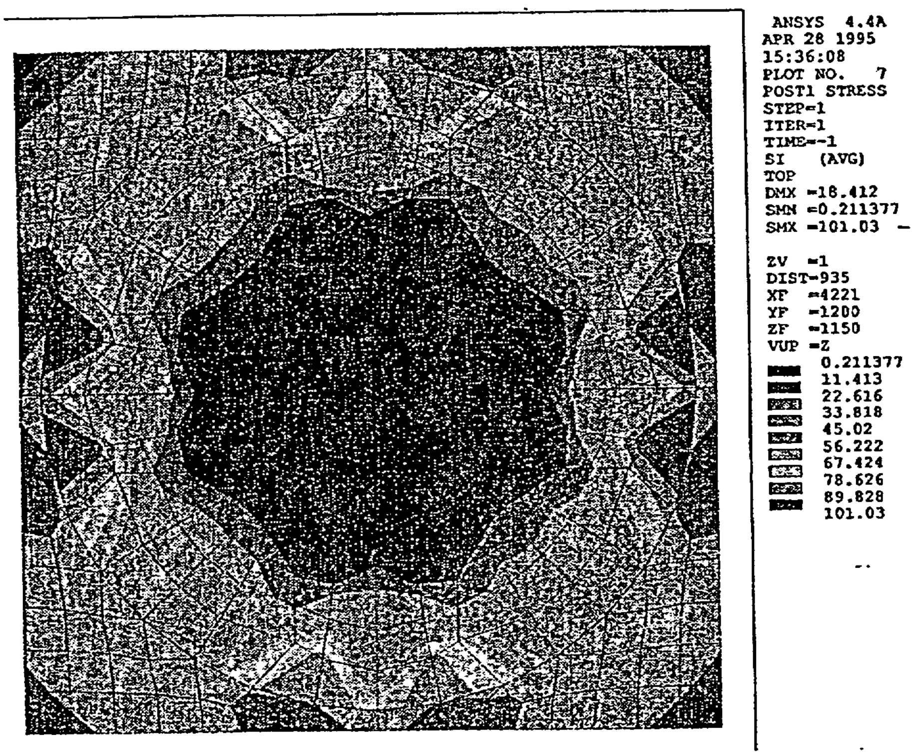


Figure 8A.5-22

Plate Stresses
Middle of Plate
Load Combination 2
Primary + Secondary Stresses

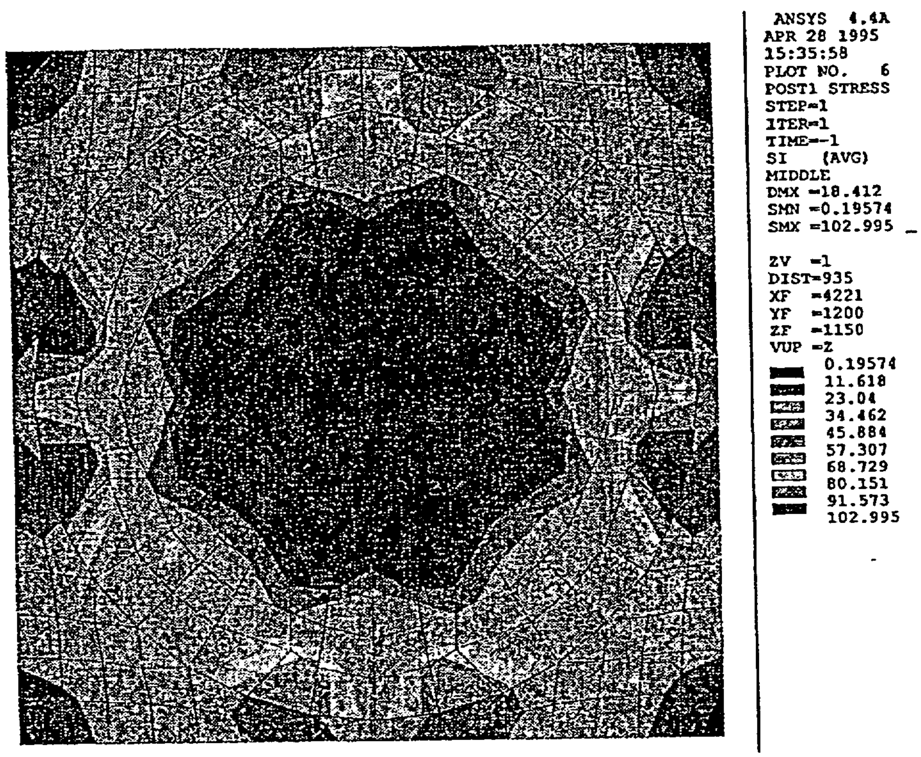


Figure 8A.5-23

Plate Stresses
Middle of Plate
Load Combination 2
Primary - Secondary Stresses

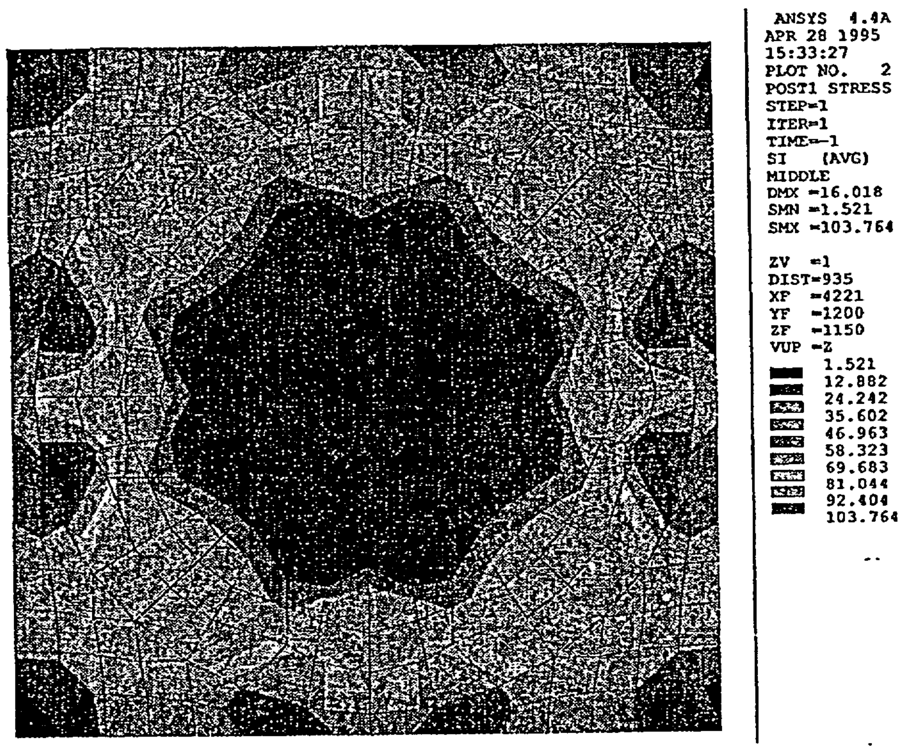
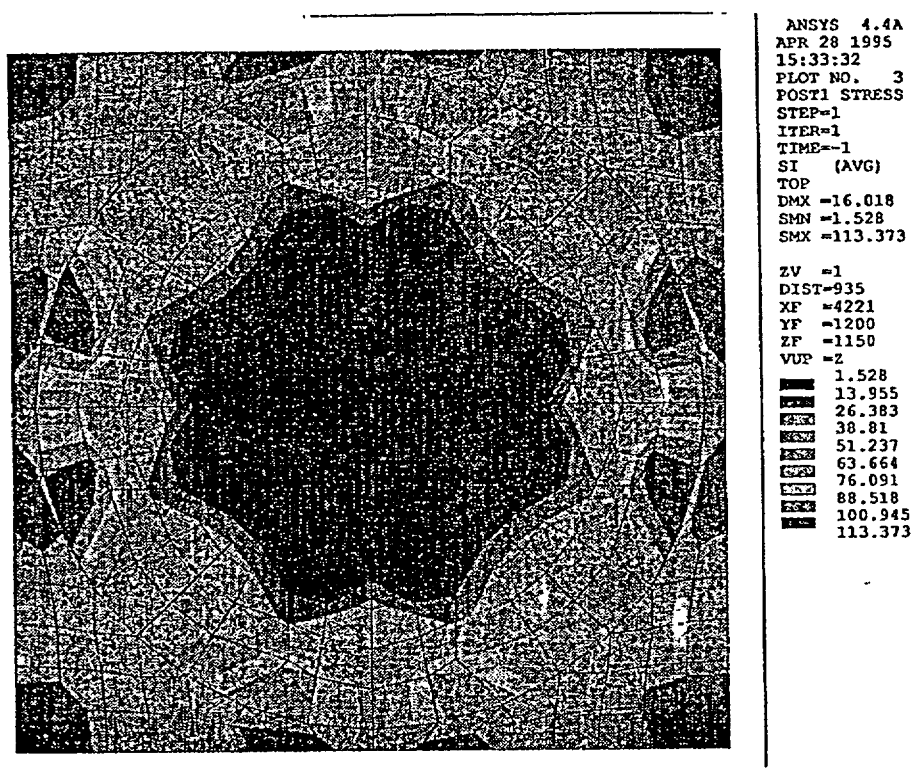


Figure 8A.5-24

Plate Stresses
Top of Plate
Load Combination 2
Primary - Secondary Stresses



8A.5.9 Reaction Forces

The reaction forces for Load Combinations 1 and 2 are provided in the following pages. All units are metric.

8A.5.10 Static Calculations

Cables and Pulleys

A cable with a minimum diameter of 12 mm (0.48 inches) and an ultimate strength of 1770 MPa (256.7 ksi) has been selected. A factor of 10 is required on breaking strength. Therefore the maximum credible load is 10 x the lifting load. Using an efficiency factor $\eta = 0.94$ and 2 rope parts, the force on the rope is:

F = 15000 N/(0.94*2) = 7979 N

The allowable force on the cable is $P = P_{cl}$ (12/1904)2 = 21,428 N

Therefore the safety factor is $P/P_{cl} = 1.4$.

The sheave to rope ratio is 24 in accordance with NOG-5427.1. The minimum sheave diameter is therefore 24 x 12 = 288 mm. A sheave diameter of 300 mm has been selected.

Wheels of the Bridge

The wheels are sized using the static case plus the impact load during lifting. The bridge rail dimensions are shown in Figure 8A.5-25. The effective width of the rail head is 37 mm (1.45 in.) The diameter of the wheel is 153 mm (6.1 in.) The allowable wheel load is taken from from NOG-5452.3:

P_a = KbD (lbs)
where $K = 1300 (BHN/260)^{0.333} = 1393$
b = the effective width of the rail head
D = diameter of the wheel.

Therefore P_a = (1393)(1.45)(6.1) = 12,321 lbs.

The actual load P = ((Mt + Mb + Mr) + 1.15 Ml)g
where Mt is the mass of the trolley, Mb is the mass of the bridge, Mr is the mass of the rotating platform and Ml is the mass of the rated load. G is the 9.81 m/s^2.

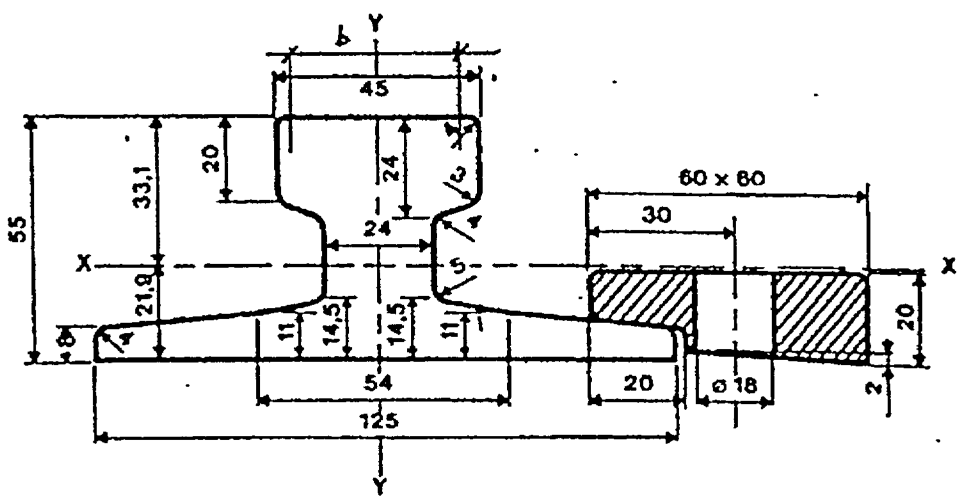
Then P = 220,228 N = 24,278 lbf.

The operational load is equally distributed between the four wheels. Therefore each wheel takes a load of P/4 = 27,530 N = 6,070 Lbf.

The safety factor is therefore 12321/6070 = 2.03

Figure 8A.5-25

Bridge Rails BURBACH KS22-A45



Wheels of the Trolley

The wheels are sized using the static case plus the impact load during lifting. The trolley rails are identical to the bridge rails. The effective width of the rail head is 37 mm (1.45 in.) The diameter of the wheel is 99 mm (3.9 in.) The allowable wheel load is taken from from NOG-5452.3:

$$P_a = KbD \text{ (lbs)}$$

where $K = 1300\,(BHN/260)^{0.333} = 1393$
b = the effective width of the rail head
D = diameter of the wheel.

Therefore $P_a = (1393)(1.45)(3.9) = 7878$ lbs.

The actual load $P = ((M_t + M_r) + 1.15\,M_l)g$

where M_t is the mass of the trolley, M_r is the mass of the rotating platform and M_l is the mass of the rated load. G is the 9.81 m/s^2.

Then P = 70 N = 24,278 lbf.

The operational load is equally distributed between the four wheels. Therefore each wheel takes a load of P/4 = 27,530 N = 6,070 Lbf.

The safety factor is therefore 12321/6070 = 2.03

Evaluation of Guidance Rollers

The purpose of the guidance rollers is to prevent the fuel handling crane bridge and trolley from de-railing in the event that it begins to mis-align transversely with the rails during normal operation. The bridge and trolley each have two sets of guidance rollers with one set adjacent to each wheel along one rail. The bridge and trolley guide rollers are identical. Conservatively (since the wheels are sliding and rolling simultaneously), the transverse load (F_y) required to maintain the bridge or trolley on track can be assumed to be equal to the dead load plus the load plus the rated load multiplied by the coefficient of sliding friction (f_z).

The transverse load on each guidance roller is:

$$F_y = (M_b + M_t + M_r + M_l)g\, f_z/2 = 12{,}950 \text{ N} = 2911 \text{ lbf}$$

where: M_b = Mass of the bridge = 4000 kg
M_t = Mass of the trolley = 1500 kg
M_r = Mass of the rotating platform = 4000 kg
M_l = Mass of the rated load = 1500 kg
g = Acceleration of gravity = 9.81 m/sec^2
f_z = 0.242 for a steel wheel on a steel rail
(Reference 8-17, Mark's Standard Handbook for Mechanical Engineers)

Therefore, utilize a standard McGill (or equivalent) CF-2-B stud type cam follower with a roller diameter of 2.00 in., roller width of 1.25 in. and a maximum static rated capacity of 10,570 lbf. The safety factor is SF = 10,570/2911 = 3.63

Since the transverse derailing load of 12,950 N is significantly less than the worst case (trolley) seismic transverse derailing load of 62,886 N, the bridge and trolley anti-seismic transverse bumpers are structurally adequate as the normal operation anti-derailing device per the analysis for the bumpers. Hence the bridge and trolley guidance rollers need not be classified as SSCs important to safety.

Evaluation of the Anti-Taking Off Device (of the Bridge)

To evaluate the anit-taking off devices, the static and seismic reactions must be added. The maximum reaction force from the seismic analysis is used. This occurs for the load combination with the trolley at 550 mm. The force $F_z = 35{,}638$ N (Node 526). The maximum bending moment in the plate occurs along the plane 2-2 in Figure 8A.5-26. The beinding moment = $F_z a$ = (35,638)(50 mm) = 1782 N-m.

The two bolts on the plane 2-2 see the maximum tension. The cross sectional area of each bolt is 157 mm^2. The Tensile force in each bolt is:

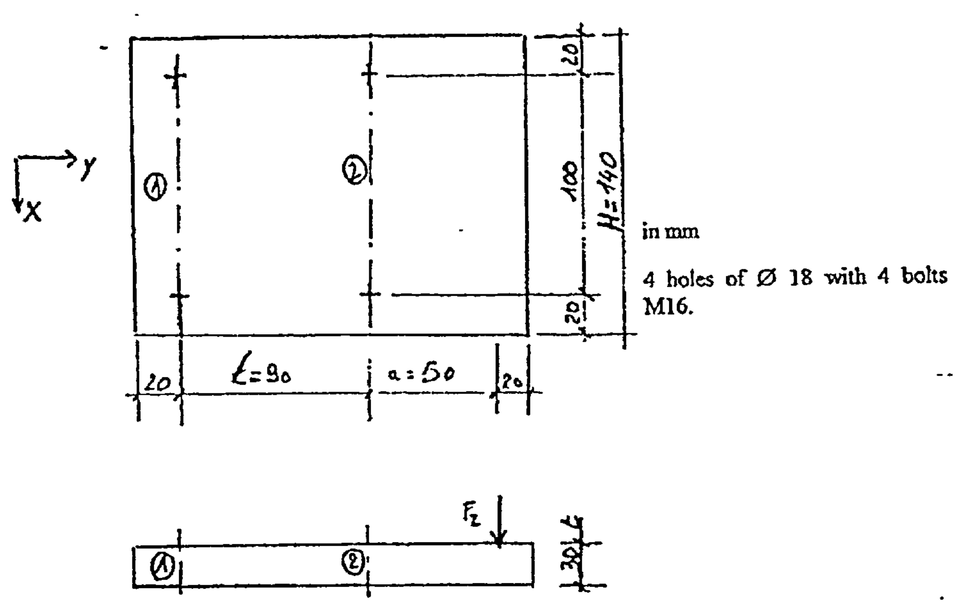
$F_b = F_z(L+a)/2L = 27{,}719$ N per bolt.

This results in a tensile stress in each bolt of $\sigma = F_b/A = 177$ MPa. The bolt allowable stress is 287 MPa. Therefore the safety factor is SF = 287/177 = 1.6.

The plate stress is evaluated below. The section modulus = $S = (H\text{-}2x18)t^3/6t = 15{,}600\ mm^3$. The bending stress is $\sigma = M/S = 1782\ mN/15{,}600\ mm^3 = 114$ MPa = 16.6 ksi. This is well below the allowable stress of 189 MPa. The safety factor is 186/114 = 1.6.

Figure 8A.5-26

Dimensions of Bridge Anti-Taking Off Device



Evaluation of the anti-taking off of the trolley

The trolley anti-taking off device is identical to the bridge anti-taking off device shown in Figure 8A.5-26. The maximum reaction force from the seismic analysisis taken from the case with the trolley at the end. The maximum force $F_z = 46{,}973$ N (Node 439). The maximum bending moment in the plate occurs along the plane 2-2 in Figure 8A.5-26. The bending moment $= F_z a = (46{,}973)(50\text{ mm}) = 2{,}349$ N-m.

The two bolts on the plane 2-2 see the maximum tension. The cross sectional area of each bolt is 157 mm^2. The tensile force in each bolt is:

$F_b = F_z(L+a)/2L = 36{,}535$ N per bolt.

This results in a tensile stress in each bolt of $\sigma = F_b/A = 233$ MPa. The bolt allowable stress is 287 MPa. Therefore the safety factor is SF = 287/233 = 1.2.

The plate stress is evaluated below. The section modulus = $S = (H\text{-}2x18)t^3/6t = 15{,}600\ mm^3$. The bending stress is $\sigma = M/S = 2349\text{ mN}/15{,}600\ mm^3 = 150$ MPa = 21.8 ksi. This is below the allowable stress of 189 MPa. The safety factor is 186/150 = 1.2.

Anti-Taking Off device of the Rotating Platform

The anti-taking off device of the rotating platform is shown in figure 8A.5-27. The vertical force is taken from the results of the ANSYS analysis. The maximum vertical force is 41,445 N (element 396) and occurs with the trolley at 550 mm.

The cross sectional area of each bolt is 157 mm^2. The Tensile force in each bolt is:

$F_b = F_z(C\text{-}A/2)/2A = 20{,}728$ N per bolt.

A = 200 mm
B = 200 mm
C= 300 mm
Bolt cross sectional area = 157 mm^2

This results in a tensile stress in each bolt of $\sigma = F_b/A = 132$ MPa. The bolt allowable stress is 287 MPa. Therefore the safety factor is SF = 287/132 = 2.1.

The plate stress is evaluated below. The plate thickness , t, is 25 mm, and section modulus = S $= \pi dt^3/6t = 13.08\ cm^3$.

Figure 8A.5-27a

Rotating Platform Anti-Taking Off Device

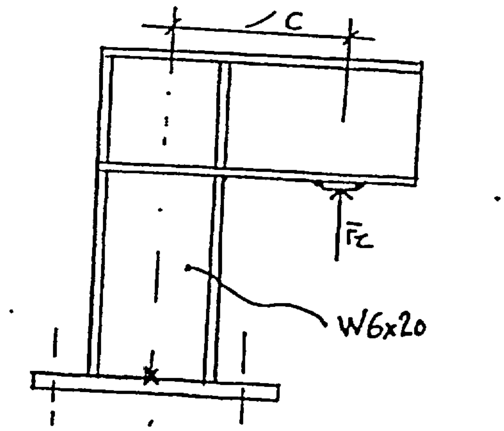
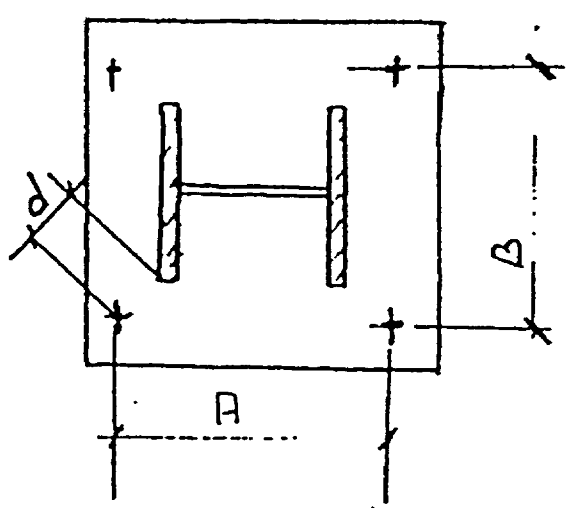


Figure 8A.5-27b
Rotating Platform Anti-Taking Off Device

Four bolts M16.



The bending moment on the plate is M = Fd = 829 mN. The bending stress is therefore

$$\sigma = M/S = 64 \text{ MPa} = 9.2 \text{ ksi} \leq 0.5\ \sigma_u / 1.2 = 186 \text{ MPa} = 27 \text{ ksi}$$

The safety factor SF = 186/64 = 2.9.

The bending moment in the W 6 x 20 beams is

$$F_z\, C = M = 12{,}437 \text{ mN}$$

The section modulus of inertia of the beam is 219 cm^3. The cross sectional area A = 37.8 cm^2. The tensile stress in the beam is therefore:

$$\sigma = (F_z/A + M/S) = 68 \text{ MPa} = 9.9 \text{ ksi} < 0.9 \text{ vy}/2 = 186 \text{ MPa} = 27 \text{ Ksi}$$

The safety factor is SF = 186/68 = 2.7.

Anti-Seismic Transverse Bumpers

Thc transverse bumpers are the lateral end stops on the rails. They are fixed on the bridge and the trolley. There are four bumpers on the bridge and four bumpers on the trolley. The lateral forees exerted due to the seismic event, taken from the ANSYS runs are used for this analysis.

Bridge Anti-Seismic Transverse Bumpers

The anti-seismic bumpers used on the bridge and trolley are shown in Figure 8A.5-28. They are made of A36 steel and held in place using two A193 Gr B7 bolts. The maximum transverse force due to the seismic loading, F_y is taken from node 526 from the case with the trolley located at 550 mm.

The equations of static equilibrium are:

$R_A = F_y$ and

$R_A \times 15/2 + F_y \times C - R_B \text{ X } a/2 = 0$ (at o')

Solving the equations $R_C = R_B = F_y (C + 15/2)/ (a/2) = 69{,}964$ N with C = 60 mm

The tensile force on cach of the two bolts is $F_{bolt} = R_c / 2 = 34{,}982$ N

The bolt diameter is 16 mm = 0.63 in. Therefore A = 157 mm^2.

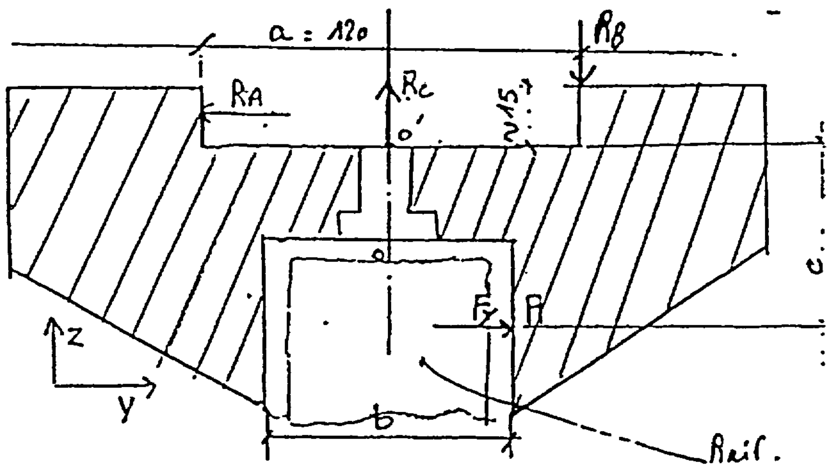
The tensile stress in each bolt is therefore:

$a = F_{bolt}/A = 223$ MPa= 31.1 ksi $< 0.5\ \sigma_u / 1.2 = 287$ MPa = 41.6 ksi

The safety factor is SF = 287/223 = 1.2.

Figure 8A.5-28

Anti-Seismic Transverse Bumpers



Trolley Anti-Seismic Transverse Bumpers

The bumpers on the trolley are identical to those used on the bridge. The maximum transverse loading on the trolley due to the seismic event is F_x = 62k,886 N taken from node 442 from the case where the trolley is located at the end.

The equations of static equilibrium are:

$R_A = F_x = 62{,}886$ N and

$R_A \times 15/2 + F_x \times C - R_B \times a/2 = 0$ (at o')

Solving the equations $R_C = R_B = F_x\,(C + 15/2)/(a/2) = 70{,}747$ N with $C = 60$ mm

The tensile force on each of the two bolts is $F_{bolt} = R_C/2 = 35{,}374$ N

The bolt diameter is 16 mm = 0.63 in. Therefore $A = 157\ mm^2$.

The tensile stress in each bolt is therefore:

$\sigma = F_{bolt} / A = 226$ MPa = 32.7 ksi $< 0.5\ \sigma_u / 1.2 = 287$ MPa = 41.6 ksi

The safety factor is SF = 287/226 = 1.2.

Grapple, Axis, Pins and Head

For a mass of M = 1500 kg, the maximum force on the cables during a seismic event is F_z = 43,580 N. There will be four fingers on each grapple for a PWR and 2 fingers on each grapple for a BWR. Therefore, for the following calculations, the force F_z is exerted on 2 fingers on the PWQR and one finger on the BWR.

The vertical force F_z is taken from the output of the ANSYS seismic analysis. It is the maximum vertical force for all load comibinations.

PWR Grapple

The mass for a PWR fuel assembly is M_F = 780 kg. The grapple pivot axis, fingers and pintle will be made from A36 forged carbon steel. The properties of this material are provided below:

Yield Strength, σ_y	36 ksi	348 MPa
Tensile Strength, σ_u	58 ksi	399 MPa

The weight of the fuel assembly is less than the nu,mber used to evaluate the seismic event using ANSYS. (M_T = 1500 kg was used for the ANSYS analysis). Therefore the force exerted on the grapple (corrected) is:

$F_z = F_z$(computed) x M_F/M_T = 43,580 x 780/1500 = 22,661 N = 5,094 lbs.

The maximum force in the static case (including a factor of 6 to yield for a nonredundant lift system) is:

F_z = 780 x 6 = 4680 kg = 10,317 lbs.

Therefore the maximum stress is found from the static case:

F(per finger) = 10,317/2 = 5,159 lbs.

Stresses on the Pivot Axis

The diameter of the pivot axis is 18 mm = 0.7 in.

The cross sectional area is 254 mm^2 (0.385 in^2)

The shear force is T = 5,159 lbs.

The shear stress is τ = T/2A = 5159/(2 x 0.385)= 6,700 psi < 36,000 psi (6 to yield strength)

or τ = 6,700 x 10/6 = 11,170 psi < 58,000 psi (10 to Ultimate Strength)

Stresses in the Grapple Finger

The grapple finger is shown in Figure 8A.5-29. The shear stress in the L1 section is:

$\tau = F/(L_1t)$ = 5159/(0.6x 0.8) = 10,748 psi < 36,000 psi

$\tau = F/(L_1t)$ = 10,748 x 10/6 = 17,913 psi < 58,000 psi

The horizontal force F_x at the pivot point is $F_x = FH_2/H_1$

Since $H_2 < H_1$, , $F_x < F$. Then the shear stress in the L3 section is

$$\tau = F/(L_3 t) = 5159/(0.4 \times 0.8) = 16{,}122 \text{ psi} < 36{,}000 \text{ psi}$$

$$\tau = F/(L_3 t) = 16{,}122 \times 10/6 = 26{,}870 \text{ psi} < 58{,}000 \text{ psi}$$

The tensile and bending stress in the L2 section is

$$\sigma = F/(L_2 t) + M/S$$

where $M = F(b + L_2/2) = 5{,}159\ (0.4 + 1.25/2) = 5{,}288$ in-lbs

and $S = tL_2^2/6 = 0.8(1.25)^2/6 = 0.2083$ in^3

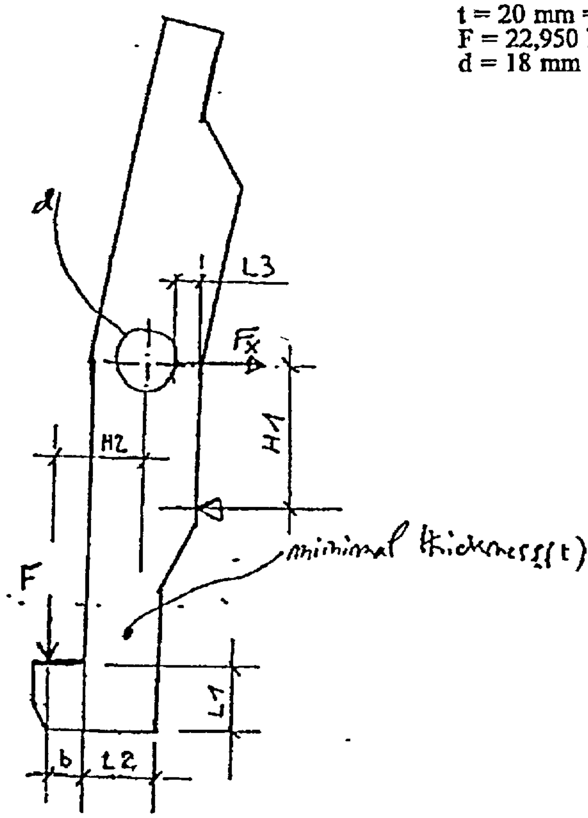
then $\sigma = 5150/(1.25 \times 0.8) + 5288/0.2083 = 30{,}545$ psi < 36,000 psi to yield strength

and $\sigma = 30545 \times 10/6 = 50{,}908$ psi < 58,000 psi to ultimate strength

Figure 8A.5-29

Grapple Finger

The following lengths are used in the analysis:
L2 = 32 mm = 1.25 in.
L1 = 15 mm = 0.6 in.
L3 = 10 mm = 0.4 in.
b = 10 mm = 0.4 in.
t = 20 mm = 0.8 in.
F = 22,950 N = 5,159 lbs.
d = 18 mm = 0.7 in.



BWR Grapple

The mass for a BWR fuel assembly is $M_F = 330$ kg. The grapple pivot axis, fingers and pintle will be made from A36 forged carbon steel. The properties of this material are provided below:

Yield Strength, σ_y	36 ksi	348 MPa
Tensile Strength, σ_u	58 ksi	399 MPa

The weight of the fuel assembly is less than the nu,mber used to evaluate the seismic event using ANSYS. ($M_T = 1500$ kg was used for the ANSYS analysis). Therefore the force exerted on the grapple (corrected) is:

$F_z = F_z$(computed) x M_F/M_T = 43,580 x 330/1500 = 9,588 N = 2,155 lbs.

The maximum force in the static case (including a factor of 6 to yield for a nonredundant lift system) is:

F_z = 330 x 6 = 1,980 kg = 4,365 lbs.

Therefore the static case is limiting. The force per finger is 4,365 lbs (The force is exerted on one finger only).

Stresses on the Pivot Axis

The diameter of the pivot axis is 18 mm = 0.7 in.

The cross sectional area is 254 mm^2 (0.385 in^2)

The shear stress is τ = T/2A = 4365/(2 x 0.385)= 5,670 psi < 36,000 psi (6 to yield strength)

or τ = 5,670 x 10/6 = 9,450 psi < 58,000 psi (10 to Ultimate Strength)

Stresses in the Grapple Finger

Since the forces are lower in the BWR case than in the PWR case, the stresses are acceptable.

8A.5.11 Summary of Results

The results of the analyses on the Fuel Handling Crane are summarized in Table 8A.5-3. All the stresses are below the allowable stresses, and are therefore acceptable.

Table 8A.5-3

Fuel Handling Crane Results

Part	Load	Allowable Value	Calculated Value	Calculated Size	Safety Factor
Cable Diameter	Static	21,420 N	15,000 N	12 mm (0.48 in.)	1.4
Bridge wheel diameter	Static	12,321 lbf	6,070 lbf	153 mm (6.1 in.)	2
Bridge Rail Width	Static	12,321 lbf	6,070 lbf	37 mm (1.45 in)	2
Trolley Wheel Diameter	Static	7,878 lbf	3,906 lbf	99 mm (3.9 in)	2
Trolley rail width	Static	7,878 lbf	3,906 lbf	37 mm (1.45 in.)	2
Bridge/Trolley Guidance roller	Static	10,570 lbf	2911 lbf	D = 50.8 mm (2.00 in)	3.63
Bolt of Bridge anti-taking off device	Seismic	287 MPa	177 MPa	16 mm (0.63 in)	1.6
Plate of Bridge anti-taking off Device	Seismic	186 MPa	114 MPa	t = 30 mm (1.2 in.)	1.6

Table 8A.5-3 (Continued)

Fuel Handling Crane Results

Part	Load	Allowable Value	Calculated Value	Calculated Size	Safety Factor
Bolt of Trolley anti-taking off Device	Seismic	287 MPa	233 MPa	16 mm (0.63 in.)	1.2
Plate of Trolley anti-Taking Off Device	Seismic	186 MPa	150 MPa	t= 30 mm (1.2 in)	1.2
Bolts of Rotating Platform anti-taking Off Device	Seismic	287 MPa	1321 MPa	16 mm (0.63 in.)	2.1
Plate of Rotating Device Anti-Taking Off Device	Seismic	186 MPa	64 MPa	t = 25 mm (1 in)	2.9
W 6 x 20 Beam of the Platform Anti-taking Off Device	Seismic	186 MPa	68 MPa	W 6 x 20	2.7
Bolts of Bridge anti-seismic bumper	Seismic	287 MPa	226 MPa	16 mm dia. (0.63 in)	1.2

Table 8A.5-3 (Continued)

Fuel Handling Crane Results

Part	Load	Allowable Value	Calculated Value	Calculated Size	Safety Factor
Bolts of Trolley anti-seismic bumper	Seismic	287 MPa	226 MPa	16 mm dia (0.63 in.)	1.2
PWR Grapple Finger Axis	Static	36 ksi yield 58 ksi tensile	6.7 ksi (shear) 11.2 ksi (shear)	18 mm dia. (0.7 in.)	>6 to yield >10 to ultimate
BWR Grapple Finger Axis	Static	36 ksi yield 58 ksi tensile	5.7 ksi (shear) 9.4 ksi (shear)	18 mm dia. (0.7 in)	>6 to yield >10 to ultimate
Grapple Finger (PWR and BWR)	Static	36 ksi yield 58 ksi tensile	30.5 ksi (bending) 50.9 ksi (bending)	t = 20 mm (0.8 in)	>6 to yield >10 to ultimate

Appendix 8A.6 Dose Assessment from Accident Conditions

8A.6 .1 Introduction

For the dose assessment for accident conditions, the scenario considered (which is not considered credible) is that the HEPA filters are inoperable during a fuel drop accident. If a fuel assembly were to drop while in the transfer tube, it would fall straight down, (the top of the assembly would remain within the tube given that a PWR assembly is approximately 14 feet in length.). A worst case scenario is that it could fall on the corner of four adjacent fuel assemblies in the cask. The conservative assumption is made that 100% of the fuel rods rupture on five fuel assemblies, (the assembly dropped plus the four it is dropped on). This condition exists over a 30 day period.

8A.6.2 Source Evaluation

The B&W 15 x 15 assembly characteristics provided in Table 7.2-1a are used for the model. The assembly is assumed to have a 3.75 w% enrichment. The fuel is irradiated with a typical specific power of 37.5 MW/MTU to a total burnup of 40,000 MWD/MTU. Three cycles will be used with a down time of 30 days between cycles. The SAS2H / ORIGEN-S modules of the SCALE4.3 (Ref 8A.6-10) was used for this analysis.

The fuel hardware data (top fitting zone, plenum zone, fuel zone and bottom fitting zone) is separated by element. The material from the fuel hardware is taken from Reference 8A.6-2 for a Westinghouse 17x17 assembly since hardware data is not available for the B&W 15x15 assembly. In addition, this calculation is mainly interested in the gas, volatiles and fines inventory of the fuel which is not readily affected by the activated hardware.

Material compositions for the activated hardware are taken from Reference 8A.6-2. Of particular interest is the amount of Co-59 in each material. From Table 4.3:

Zr-4	0.001 w%
Inconel-718	0.4694 w%
SS304	0.08 w%

For the irradiation of the materials outside of the fuel region, the methodology of Ref 8A.6-11 is used; i.e., to account for the axial flux variation and the neutron spectrum, the flux and material quantities are modified as follows. The flux for the top end fitting, plenum and bottom end fitting are multiplied by 0.1, 0.2 and 0.2, respectively.

Materials (Reference 8A.6-2, Table 4.4)

Region	Material	Kg/MTU
Fuel Zone		
Cladding	Zircaloy-4	223.0
Grid Spacers & Springs	Inconel 718	12.8
Grid Brazing	Nicrobraze 50	2.6
Miscellaneous	SS 304	9.9
Plenum Zone		
Cladding	Zircaloy-4	12.0
Spring	SS 302	4.2
End Fitting Zone		
Top Fitting	SS 304	14.8
Bottom Fitting	SS 304	12.4

As previously mentioned, the elemental compositions of each of the materials listed above is taken from Table 4.3 of Reference 8A.6-2, as modified in the plenum and end zones.

From the SAS2H/ORIGEN-S run, radionuclides were selected based on the methodology of ISG-5 (Ref 8A.6-12). Table 8A.6-1 presents the radionuclide inventory for the B&W 15x15 assembly.

Table 8A.6-1

Radionuclide Inventory
(Curies/assembly)
B&W 15 x 15, 3.75 wt% U-235, 40,000 MWD/MTU, 5 year cooled

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8A.6.3 Accident Release Analysis

The concentration of gaseous nuclides at a given distance from the DTS is determined by the method of Reference 8A.6-3, Section 1.3, assuming air is being exhausted through the HEPA filters and out the stack, and 100% of rods have failed on five fuel assemblies Stability category F and 1 m/s wind speed is used for this analysis.

This method provides short term relative concentrations (χ/Q) for releases at a low height above ground level. Unlike stack releases, ground level release relative concentration declines monotonically with distance from the release point; so a maximum need not be found. Short term relative concentrations are conservative because they do not account for the fluctuations in wind speed and direction and atmospheric conditions which occur over a longer time.

8A.6.4 Air Dispersion Evaluation

Two distances from DTS are considered; 100 m (minimum controlled boundary distance) and 500 m.

χ/Q Calculation

The atmospheric diffusion from vents and other building penetrations at 100 meters (Reference 8A.6-3, Section 1.3.1) is calculated below:

$$\frac{\chi}{Q} = \frac{1}{U(\pi \sigma_y \sigma_z + \frac{A}{2})} \qquad (1)$$

$$\frac{\chi}{Q} = \frac{1}{U(3\pi \sigma_y \sigma_z)} \qquad (2)$$

$$\frac{\chi}{Q} = \frac{1}{U \pi \Sigma_y \sigma_z} \qquad (3)$$

where:

χ/Q is the relative concentration, in sec/m^3

U is wind speed at 10 meters above plant grade, in m/sec

σ_y is lateral plume spread , in m, a function of atmospheric stability and distance (see Figure 1 from Regulatory Guide 1.145)

σ_z is the vertical plume spread, in m, a function of atmospheric stability and distance (see Figure 2 from Regulatory Guide 1.145)

M Correction factors for σ_y values by atmospheric stability class (see Figure 3 from Regulatory Guide 1.145)

Σ_y is lateral plume spread with meander and building wake effects, in m, a function of atmospheric stability, wind speed, U, and distance. $\Sigma_y = M\sigma_y$ for distances less than 800 meters.

A is the smallest vertical-plane cross-sectional area of the DTS building, in m^2.

Calculating:

$$A = (280x668) + (170x459)\ in^2 = 171\ m^2$$

From Regulatory Guide 1.145, Figure 1

σ_y at 100 meters, Pasquill Stability Category F = 4 meters

σ_y at 500 meters, Pasquill Stability Category F = 20 meters

From Regulatory Guide 1.145, Figure 2

σ_z at 100 meters, Pasquill Stability Category F = 2.3 meters

σ_z at 500 meters, Pasquill Stability Category F = 8.4 meters

From Regulatory Guide 1.145, Figure 3

M at U = 1 m/sec, Pasquill Stability Category F = 4

therefore, Σ_y at 100 meters, Pasquill Stability Category F = 4 * 4 m = 16 m

therefore, Σ_y at 500 meters, Pasquill Stability Category F = 4 * 20 m = 80 m

For 100 m, substituting into Equations (1), (2), and (3) yields:

1. $\chi/Q = 1 / 1 (\pi \times 4 \times 2.3 + 171/2) = 8.74E\text{-}03 \text{ sec/m}^3$
2. $\chi/Q = 1 / 1 (\pi \times 3 \times 4 \times 2.3) = 1.15E\text{-}02 \text{ sec/m}^3$
3. $\chi/Q = 1 / 1 (\pi \times 16 \times 2.3) = 8.65E\text{-}03 \text{ sec/m}^3$

Choosing the larger of calculations (1) and (2), and the lesser of that selection and (3) yields:

$\underline{\chi/Q = 8.65E\text{-}3 \text{ sec/m}^3}$, which includes wake and meander effects.

Similarly, substituting for 500 meters

(1) $\chi/Q = 1 / 1(\pi *20 *8.4 + 98.1/2) = 1.73E\text{-}03 \text{ sec/m}^3$
(2) $\chi/Q = 1 / 1(\pi * 3 *20*8.4) = 6.32E\text{-}04 \text{ sec/m}^3$
(3) $\chi/Q = 1 / 1(\pi *80*8.4) = 4.74E\text{-}04 \text{ sec/m}^3$

Choosing the larger of calculations (1) and (2), and the lesser of that selection and (3) yields:

$\underline{\chi/Q = 4.74E\text{-}04 \text{ sec/m}^3}$, which includes wake and meander effects.

8A.6.5 Radioactive Gas Inventory

The radioactive gas inventory was taken from the SAS2H/ORIGEN-S results. From References 8A.6-13 and 8A.6-14, the release fractions applied to the source term are provided below:

Table 8A.6-2
Release Fractions

Variable	Off-Normal Conditions	Accident Conditions
Fraction of crud that spalls off rods, f_C	0.15	1.0
Fraction of Rods that develop cladding breaches, f_B	0.10*	1.0
Fraction of Gases that are released due to a cladding breach, f_G	0.3	0.3
Fraction of Fines that are released due to a cladding breach, f_F	3×10^{-6}**	3×10^{-6}**
Fraction of Volatiles that are released due to a cladding breach, f_V	2×10^{-4}	2×10^{-4}

* For off normal conditions, this value is taken from Ref 8A.6-13, Section 7.V.4.b, page 7-6.

** Per Ref 8A.6-14, 3×10^{-5} of the fines are released during a cladding breach. Per Ref 8A.6-15, page IV-7, of the 3×10^{-5} of the fines released recommends that only 10% of the fuel fines ejected remain airborne.

Based on the radionuclide inventory and the release fractions, the releasable source term from the DTS under accident conditions is provided below

Table 8A.6-3
DTS Releasable Source Term For Accident Conditions

	Isotope	A Ci/assembly	Fb[1]	Fv / Fg / Fr / Fc	Na	Q[2] (uCi/yr)	/Q (sec/m^3)	(uCi/m^3)
gas	h 3	2.03E+02	1.00E+00	0.30	5	3.05E+08	8.65E-03	8.35E-02
crud[3]	Co 60	2.01E+01	2.70E-05	1.00E+00	5	2.71E+03	8.65E-03	7.44E-07
fine	pu238	1.83E+03	3.00E-04	3.00E-06	5	8.24E+00	8.65E-03	2.26E-09
fine	pu239	1.64E+02	3.00E-04	3.00E-06	5	7.38E-01	8.65E-03	2.02E-10
fine	pu240	2.37E+02	3.00E-04	3.00E-06	5	1.07E+00	8.65E-03	2.93E-10
fine	pu241	5.96E+04	3.00E-04	3.00E-06	5	2.68E+02	8.65E-03	7.36E-08
fine	am241	6.09E+02	3.00E-04	3.00E-06	5	2.74E+00	8.65E-03	7.52E-10
fine	cm244	1.33E+03	3.00E-04	3.00E-06	5	5.99E+00	8.65E-03	1.64E-09
gas	kr 85	3.62E+03	1.00E+00	0.30	5	5.43E+09	8.65E-03	1.49E+00
volatile	sr 90	3.81E+04	3.00E-04	2.00E-04	5	1.14E+04	8.65E-03	3.14E-06
fine	y 90	3.81E+04	3.00E-04	3.00E-06	5	1.71E+02	8.65E-03	4.70E-08
volatile	ru106	9.75E+03	3.00E-04	2.00E-04	5	2.93E+03	8.65E-03	8.02E-07
fine	rh106	9.75E+03	3.00E-04	3.00E-06	5	4.39E+01	8.65E-03	1.20E-08
fine	sb125	1.21E+03	3.00E-04	3.00E-06	5	5.45E+00	8.65E-03	1.49E-09
fine	te125m	2.97E+02	3.00E-04	3.00E-06	5	1.34E+00	8.65E-03	3.67E-10
gas	I129	1.77E-02	1.00E+00	0.30	5	2.66E+04	8.65E-03	7.28E-06
volatile	cs134	1.73E+04	3.00E-04	2.00E-04	5	5.19E+03	8.65E-03	1.42E-06
volatile	cs137	5.40E+04	3.00E-04	2.00E-04	5	1.62E+04	8.65E-03	4.44E-06
fine	ba137m	5.10E+04	3.00E-04	3.00E-06	5	2.30E+02	8.65E-03	6.29E-08
fine	ce144	6.99E+03	3.00E-04	3.00E-06	5	3.15E+01	8.65E-03	8.63E-09
fine	pr144	6.99E+03	3.00E-04	3.00E-06	5	3.15E+01	8.65E-03	8.63E-09
fine	pm147	2.29E+04	3.00E-04	3.00E-06	5	1.03E+02	8.65E-03	2.83E-08
fine	eu154	4.29E+03	3.00E-04	3.00E-06	5	1.93E+01	8.65E-03	5.30E-09
fine	eu155	2.14E+03	3.00E-04	3.00E-06	5	9.63E+00	8.65E-03	2.64E-09

Notes:
1- assumes 0.03% of crud & fines passes HEPA filters.
2- assumes released over one year
3- Calculation of Co-60 inventory from surface area of fuel rods using the methodologyof NUREG/CR 6487(Reference 8A.6-12). Assumes 15% spalls off of rods during handling, 90% of the crud that spalls falls into the cask and 10% becomes airborne, 10% of the airborne crud plates out. In the DTS, thus 1.35% of the crud activity gets to the HEPA filters

8A.6.6 Exposure to Dose Conversion Factors

The exposure-to-dose conversion factors for inhalation effects are taken from Reference 8A6-5 and for air immersion are taken from Reference 8A6-6.

8A.6.7 Dose Calculation

Committed Doses

Knowing the radioactive inventory, the leak rate from the DTS, the χ/Q, and the DCFs, the airborne dose from the DTS can be calculated. The methodology of Regulatory 1.109, is applied. For doses from inhalation the following equation is used:

$$Dose_{inhalation} = R \times \chi/Q \times Q \times DCF_{inhalation}$$

Where:
R = Inhalation Rate = 8,000 m^3/year = 2.54E-04 m^3/sec
χ/Q = Short term average centerline value of atmospheric diffusion for a ground level release (sec/m^3)
Q = amount of material released (μCi/sec)
$DCF_{inhalation}$ = Exposure Dose Conversion Factor (mrem/μCi), from reference 2.3

The internal committed dose is provided in Table 8A.6-4.

Deep Dose Equivalent

Knowing the radioactive inventory, the leak rate from the DTS, the χ/Q and the DCFs, the deep dose equivalent from the DTS can be calculated. The basic methodology of Regulatory Guide 1.109 for air immersion is applied. For doses from air immersion the following equation is used:

$$Dose_{air\ immersion} = \chi/Q \times Q \times DCF_{air\ immersion}$$

Where:
χ / Q = Short term average centerline value of atmospheric diffusion for a ground level release (sec/m^3)
Q = amount of material released (μCi/sec)
$DCF_{immersion}$ = Exposure Dose Conversion Factor (mrem/year per $\mu Ci/cm^3$), from ref 2.4

The external deep doses are provided in Table 8A.6-5.

Table 8A.6-4
Accident Conditions- Airborne Doses – 100 m
Committed Doses (Internal mrem/30 days)

Isotope	Gonad	Breast	Lung	R. Marrow	B. Surface	Thyroid	Remainder	Effective
h 3	3.52E+00	3.52E+00	3.52E+00	3.52E+00	3.52E+00	3.52E+00	3.52E+00	3.52E+00
Co 60	8.63E-03	3.34E-02	6.26E-01	3.12E-02	2.45E-02	2.94E-02	6.53E-02	1.07E-01
pu238	1.54E-01	5.50E-06	1.76E+00	8.36E-01	1.05E+01	5.29E-06	3.86E-01	5.83E-01
pu239	1.57E-02	4.55E-07	1.59E-01	8.33E-02	1.04E+00	4.45E-07	3.73E-02	5.72E-02
pu240	2.27E-02	6.78E-07	2.30E-01	1.20E-01	1.50E+00	6.45E-07	5.39E-02	8.27E-02
pu241	1.22E-01	5.48E-06	5.70E-01	6.02E-01	7.53E+00	2.22E-06	2.35E-01	4.00E-01
am241	5.95E-02	4.89E-06	3.37E-02	3.19E-01	3.97E+00	2.93E-06	1.43E-01	2.20E-01
cm244	6.36E-02	4.16E-06	7.72E-02	3.75E-01	4.68E+00	4.04E-06	1.91E-01	2.68E-01
kr 85	0 00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
sr 90	2.02E-02	2.02E-02	2.85E-02	2.57E+00	5.55E+00	2.02E-02	2.57E-02	2.68E+00
y 90	1.09E-06	1.09E-06	1.07E-03	3.20E-05	3.18E-05	1.09E-06	4.43E-04	2.61E-04
ru106	2.70E-02	2.68E-02	2.03E+00	2.68E-02	2.68E-02	2.68E-02	3.30E-02	2.52E-01
rh106	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
sb125	1.31E-06	1.51E-06	7.89E-05	2.36E-06	9.93E-06	1.18E-06	5.28E-06	1.20E-05
te125m	1.11E-07	9.56E-08	9.29E-06	2.69E-06	2.87E-05	8.87E-08	6.03E-07	1.76E-06
i129	1.54E-03	3.71E-03	5.57E-03	2.48E-03	2.45E-03	2.77E+01	2.09E-03	8.32E-01
cs134	4.51E-02	3.75E-02	4.09E-02	4.09E-02	3.81E-02	3.85E-02	4.82E-02	4.33E-02
cs137	9.48E-02	8.49E-02	9.55E-02	8.98E-02	8.59E-02	8.58E-02	9.87E-02	9.34E-02
ba137m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ce144	4.06E-05	4.14E-05	1.66E-02	5.61E-04	9.54E-04	3.95E-05	2.16E-03	2.12E-03
pr144	5.07E-11	2.21E-10	1.98E-06	1.70E-09	2.84E-09	1.78E-10	2.94E-08	2.46E-07
pm147	1.29E-09	2.48E-09	5.33E-03	5.62E-04	7.02E-03	1.36E-09	4.06E-04	7.30E-04
eu154	1.51E-04	2.00E-04	1.02E-03	1.37E-03	6.75E-03	9.21E-05	1.46E-03	9.97E-04
eu155	2.29E-06	3.95E-06	7.66E-05	9.20E-05	9.78E-04	1.54E-06	7.14E-05	7.21E-05
Total	4.15E+00	3.73E+00	9.20E+00	8.62E+00	3.84E+01	3.14E+01	4.84E+00	9.14E+00

Table 8A.6-5
Accident Conditions – Airborne Doses - 100 m
Deep Doses (External mrem/30 days)

Isotope	Gonad	Breast	Lung	R. Marrow	B. Surface	Thyroid	Remainder	Effective	Skin
h 3	0.00E+00	0.00E+00	2.20E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.65E-04	0.00E+00
Co 60	8.79E-04	9.93E-04	8.86E-04	8.79E-04	1.27E-03	9.07E-04	8.57E-04	9.00E-04	1.04E-03
pu238	1.42E-10	2.75E-08	2.30E-11	3.64E-11	2.02E-10	8.70E-11	4.32E-11	1.06E-10	8.87E-10
pu239	9.41E-12	1.47E-11	5.15E-12	5.19E-12	1.84E-11	7.54E-12	5.56E-12	8.24E-12	3.61E-11
pu240	1.79E-11	3.45E-11	3.06E-12	4.63E-12	2.60E-11	1.10E-11	5.50E-12	1.33E-11	1.10E-10
pu241	5.08E-11	6.12E-11	4.58E-11	3.98E-11	1.55E-10	4.93E-11	4.30E-11	5.12E-11	8.26E-11
am241	6.19E-09	7.72E-09	4.86E-08	3.76E-09	2.07E-08	5.65E-09	4.58E-09	5.90E-09	9.24E-09
cm244	1.09E-10	2.10E-10	1.12E-11	2.30E-11	1.39E-10	6.60E-11	2.85E-11	7.74E-11	6.16E-10
kr 85	1.67E+00	1.92E+00	1.63E+00	1.56E+00	3.15E+00	1.69E+00	1.56E+00	1.70E+00	1.89E+02
sr 90	2.34E-07	2.86E-07	1.94E-07	1.64E-07	6.86E-07	2.21E-07	1.84E-07	2.27E-07	2.77E-04
y 90	8.53E-08	9.93E-08	7.99E-08	7.31E-08	2.00E-07	8.44E-08	7.58E-08	8.58E-08	2.82E-05
ru106	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
rh106	1.17E-06	1.34E-06	1.17E-06	1.13E-06	1.99E-06	1.19E-06	1.11E-06	1.20E-06	1.26E-05
sb125	2.84E-07	3.25E-07	2.80E-07	2.68E-07	5.06E-07	2.88E-07	2.67E-07	2.90E-07	3.80E-07
te125m	2.10E-09	2.98E-09	7.85E-10	6.55E-10	4.29E-09	1.63E-09	9.11E-10	1.59E-09	6.83E-09
i129	3.38E-05	4.66E-05	1.50E-05	1.15E-05	7.69E-05	2.70E-05	1.61E-05	2.66E-05	7.69E-05
cs134	1.01E-03	1.15E-03	1.01E-03	9.83E-04	1.64E-03	1.03E-03	9.65E-04	1.03E-03	1.29E-03
cs137	3.40E-07	4.12E-07	2.85E-07	2.43E-07	9.77E-07	3.22E-07	2.70E-07	3.30E-07	3.68E-04
ba137m	1.71E-05	1.95E-05	1.69E-05	1.65E-05	2.80E-05	1.74E-05	1.62E-05	1.74E-05	2.25E-05
ce144	7.07E-08	8.37E-08	6.37E-08	5.53E-08	2.06E-07	6.90E-08	5.99E-08	7.07E-08	2.43E-07
pr144	1.57E-07	1.78E-07	1.57E-07	1.55E-07	2.48E-07	1.62E-07	1.52E-07	1.62E-07	6.98E-06
pm147	2.03E-10	2.59E-10	1.48E-10	1.21E-10	5.92E-10	1.83E-10	1.43E-10	1.88E-10	2.20E-07
eu154	3.05E-06	3.46E-06	3.04E-06	2.98E-06	4.79E-06	3.13E-06	2.92E-06	3.12E-06	4.21E-06
eu155	6.31E-08	7.48E-08	5.63E-08	4.69E-08	2.05E-07	6.11E-08	5.25E-08	6.31E-08	8.60E-08
	1.67E+00	1.92E+00	1.63E+00	1.56E+00	3.15E+00	1.69E+00	1.56E+00	1.70E+00	1.89E+02

Doses from Hypothetical Accident Conditions

For the hypothetical accident conditions, the total effective dose equivalent at 100 and 500 meters is provided below. To determine the doses at 500 meters from the cask, the dose values are multiplied by 0.0548 (4.74E-04 / 8.65E-03).

	Dose (mrem/30 day)	
	100 meters	500 meters
Deep Dose (external)	1.70E+00	9.34E-02
Committed Dose Equivalent (internal)	9.14E+00	5.01E-01
TEDE	1.08E+01	5.94E-01

The committed dose equivalent to each organ plus the deep dose for a 30 day release is shown below:

	Dose at 100 meters (mrem/30 day)	Dose at 500 meters (mrem/30 day)
Deep Dose (total)	**1.70E+00**	**9.32E-02**
Gonad	4.15E+00	2.27E-01
Breast	3.73E+00	2.04E-01
Lung	9.20E+00	5.04E-01
Red Marrow	8.62E+00	4.72E-01
B. Surface	**3.84E+01**	**2.10E+00**
Thyroid	3.14E+01	1.72E+00
Remainder	4.84E+00	2.65E-01
Total - Deep Dose plus + Committed Dose Equivalent to Worst Organ (bone surface)	**4.01E+01**	**2.20E+00**
Skin	**1.89E+02**	**1.04E+01**

For hypothetical accident conditions, the criteria of 72.106 are met.

8A.6.8 References

8A.6-1 ORIGEN2 Users Manual

8A.6-2 Croff, et al, "Revised Uranium - Plutonium Cycle PWR and BWR Models for the ORIGEN Computer Code," ORNL/TM-6051, September 1978.

8A.6-3 Regulatory Guide 1.145, "Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants," Revision 1, 1983.

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CHAPTER 9

CONDUCT OF OPERATIONS

This chapter describes a proposed infrastructure and plan for the management, test, and operation of the Dry Transfer System (DTS). Proposed training and emergency plans are also described. The DTS will be procured for installation and operation at an existing site of a nuclear reactor owned and/or operated by the organization holding the license for the reactor. It is assumed that the organization holding the license for the reactor will be the applicant for the site-specific license for the DTS. The intent of this chapter is to provide sufficient information to enable the NRC Staff to make the determination that the proposed organization, plans and procedures will satisfy the regulatory requirements related to the facility's conduct of operations.

The site-specific license application by the organization will reference this TSAR and the NRC Staff's Safety Evaluation Report (SER). Any significant revision to the conduct of operation of the DTS from that described in the generic TSAR and SER would be identified and justified in the site-specific license application. The organization would commit to compliance with the content of this chapter and any SER requirements in the site-specific license application.

This TSAR provides:

- The plan for the conduct of operations that meets the requirement s of 10 CFR 72.24(h).
- The description of the program covering pre-operational testing and initial operations that meet the requirements of 10 CFR 72.24(p).
- The description of the technical qualification, including training and experience, for the organization to engage in the proposed activities that meet the requirements of 10 CFR 72.28(a).
- The description of the personnel training program that meets the requirements of 10 CFR 72, Subpart I. The description of the DTS organization, delegations of responsibility and authority, and the minimum skills and experience qualifications that meet the requirements of 10 CFR 72.28(c).
- The description of the DTS emergency plan that meets the requirements of 10 CFR 72.32(b).

9.1 Organizational Structure

9.1.1 Corporate Organization

The Corporate Organization ("Organization") applying for the site-specific license will provide the description of its corporate organization. The Organization will be the holder of a NRC license for the operation of the nuclear reactor that is located on the same site on which the DTS will be installed. Reference to this license will be provided in the site-specific license application.

The Organization will provide a demonstration of its financial qualifications in the site-specific license application.

9.1.1.1 Corporate Functions, Responsibilities, and Authorities

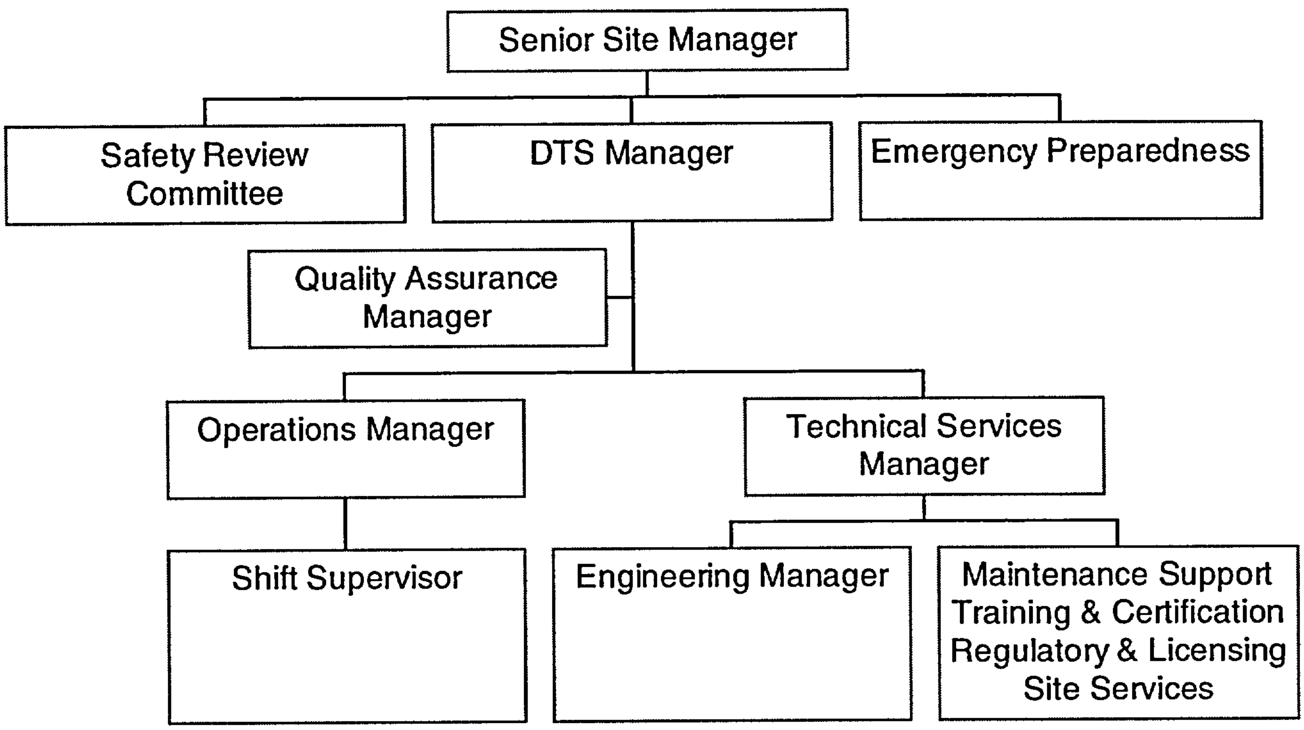
A description of the corporate functions, responsibilities and authorities will be provided in the site-specific license application. The relationship of the Corporate Officer responsible for the site, its facilities and operations with the site management will be described. Specific discussions will be provided that describe the management of the design and licensing activities prior to the turnover of the DTS to operations management, especially the quality assurance during design, construction, and testing of the DTS prior to startup. Included in this discussion will be descriptions of the management of the development of operating procedures, startup training, and other preoperational procedures. Descriptions will be provided of any contractors and the services that they will provide.

9.1.1.2 Site Organization for Operation of the DTS

Figure 9.1-1 shows the proposed Site Organization for operation of the DTS. Position titles are functional and may not correspond to the titles that will be provided in the site-specific license application. The positions shown will be located on site. Dedication of specific positions to the following phases of operation is discussed below.

Figure 9.1-1

DTS Operations Organization



Operation of the DTS is based on unloading/loading campaigns and intervening periods of inactivity when timely surveillance of the facility is required. This type of operation is staffed according to the operational requirements, as well as with consideration of the licensing requirements for staffing and for maintenance, for engineering, and for various surveillance activities. Therefore, assignment of the staff depends primarily on the operational need for specific functions. In order to define staff needs, the following Phases of DTS Operation are defined.

Phase 1: Unloading/Loading Operations
-Fuel transferred from pool or storage casks and loaded into transportable casks.

Phase 2: No Unloading/Loading Operations, but with provisions for Unscheduled Unloading/Loading
-Unloading a storage cask or transportable cask on an emergency basis.
-Surveillance and maintenance of contaminated facility.

Phase 3: Extended Periods of Inactivity
-Periods preceding initial operation of the facility during which only surveillance and maintenance are required

Phase 1 operations may be conducted on a rotating shift basis with full support services and maintenance staff available during the day shift. Support staff for maintenance, radiation protection, and quality assurance may be augmented by on-site or off-site staff or contractors during this Phase. Operations staff may be drawn from the on-site reactor or other reactors under Corporate management.

A minimum staff will be maintained during Phases 2 and 3 to ensure compliance with the NRC License requirements and to deal with abnormal events during Phase 2. Certain key positions will retain essential DTS responsibilities as described in the key position descriptions below.

The on-site staffing during the preparation for initial operation prior to the initial Phase 1 will be augmented by facility design and construction personnel and equipment design and fabrication personnel to support facility systems and equipment startup and any modifications that may be required. This augmented on-site staffing will not be required during subsequent operations.

The site specific approach to staffing for all three phases will be described in the site specific license application

The key positions for DTS Operations are described below:

A. DTS Manager

The DTS Manager reports to the Senior Site Manager responsible for the site, its facilities, and operations.

The DTS Manager has ultimate responsibility for the safe operation of the DTS during all phases of DTS Operations. The DTS Manager is responsible for: proper selection of the DTS staff for all key positions, as well as representation on the DTS Safety Review Committee. The DTS Manager is also responsible for: a) compliance with the requirements of the NRC License that governs the design and operation of the DTS, b) the interface with other site organizations including the site Emergency Response Organization, the site Radiological Safety Organization, the site Utility Organization, and c) the Management of other site facilities in so far as the operation of those facilities can impact the DTS and vice versa. The DTS Manager's responsibilities also include the interface with the Reactor Fuel Handling organization and any offsite organizations that support the DTS Operations.

The DTS Manager has management responsibility for the DTS Operations during all phases. The DTS Manager may be assigned additional responsibilities not related to the DTS operations.

B. DTS Quality Assurance Manager

The DTS Quality Assurance (QA) Manager reports to the DTS Manager, and has access to the DTS Manager regarding all matters affecting quality. In addition, the QA Manager has the authority and responsibility to directly contact the Senior Site Manager responsible for the site and its facilities and operations, with any QA concerns.

The QA Manager is responsible for providing guidance and direction for the implementation of the Quality Assurance Program, and providing oversight of quality affecting the work at the facility. These may include verification of quality achievement by the line organization during all phases through audits, surveillances, or other means of quality verification, as appropriate. These responsibilities may be implemented by assigning qualified staff to the DTS, as needed by operational requirements.

The QA Manager may be assigned other responsibilities in addition to his DTS responsibilities.

C. DTS Technical Services Manager

The Technical Services Manager reports to the DTS Manager.

The Technical Services (TS) Manager is responsible for training, radiation protection, licensing and regulatory compliance, and engineering. All changes proposed in the DTS facility or equipment design or operation, and new or changed procedures that could impact radiation safety, criticality safety, or environmental protection are reviewed by the TS Manager and approved in writing prior to implementation. The approval indicates compliance with NRC License and Corporate Policy requirements.

The TS Manager is responsible for training and certification of the DTS Staff. A description of a suggested training program is included in this TSAR Section 9.2. The site specific license application will describe the training and certification requirements of the site-specific applicant.

The TS Manager carries out the responsibilities for the DTS Operations during all phases of operation and assigns qualified staff to the various functions depending on operational requirements. The TS Manager may be assigned other duties in addition to the DTS duties.

D. DTS Engineering Manager

The Engineering Manager reports to the Manager of Technical Services, and is responsible for the implementation of facility and equipment modifications as well as for providing engineering services to support the operation and maintenance. The Engineering Manager may be assigned additional responsibilities not related to DTS operations.

E. DTS Operations Manager

The Operations Manager reports to the DTS Manager, and is responsible for the direction of day to day activities of the DTS in accordance with the NRC License and Corporate requirements. These activities include receipt of loaded spent fuel casks and empty receiving casks; unloading and transfer of spent fuel to the receiving cask; sealing of the receiving cask and canister (if applicable); operation of support systems, including the control system, the HVAC system, and the radiation detection system. The Operations Manager is also responsible for the collection and packaging of radioactive waste produced by the DTS Operation, and for periodic testing and surveillance of all systems.

The Operations Manager's time is dedicated to the DTS Operations during Phase 1, but the manager may be assigned other duties not related to DTS Operations during Phases 2 and 3.

F. DTS Safety Review Committee

The DTS Safety Review Committee (SRC) reports to the Senior Site Manager. The SRC has the authority and responsibility to directly contact the Corporate Officer responsible for the site, its facilities and operations, with any safety concerns.

The SRC provides technical and administrative review, approval, and audit of the DTS design and operations to assure compliance with safety and environmental requirements of the NRC License and the Corporate policies. The scope of the SRC includes the following:

- Radiation protection
- Criticality safety
- Industrial safety including fire protection
- Environmental protection
- ALARA policy implementation
- Facility or operations changes

The SRC approves all DTS procedures and facility modifications

The SRC will conduct at least one comprehensive facility/operations review per year, regardless of the DTS operations phase.

The SRC may be the same body as the reactor site safety committee. The following guidelines may be utilized for the composition of the SRC in the absence of a site safety committee:

> The SRC is composed of at least five members, including a Chairman. SRC members may be from on site or off site and may include contractors or consultants. The expertise represented shall include all safety disciplines, operations, and mechanical design. The SRC members will be appointed by the Senior Site Manager. Each shall have an engineering or physical science degree and at least 10 years of experience in work related to nuclear operational safety environment and the operations performed in a radioactive environment. Experience should include operations, design, or evaluations of spent fuel handling, storage, or shipment.

The SRC shall meet as necessary to carry out is responsibilities.

In addition, meetings of the SRC shall be conducted within 60 days of the occurrence of an incident that is reportable to the NRC. The SRC shall review the incident's causes, responses, and both specific and generic corrective actions to ensure resolution of the root cause. A written report of each meeting and review shall be forwarded to the DTS Manager with 30 days of the conclusion of the meeting and retained for at least 3 years.

The site specific license application shall describe the site's approach to the SRC.

I. Other Support Services

Other Support Services are required by the DTS, but these Services may be performed by on-site or off-site personnel who provide the same or similar services to other site operations. The site specific license application will provide details of the specific approach to providing these services. These Services include the following;

A. Maintenance

Support of maintenance of the DTS Facility and Equipment may be provided by the Site Maintenance Organization. This organization will work with the DTS Technical Services Manager to provide the required preventive maintenance and repair activities to ensure proper operation of the facility and equipment.

B. Emergency Preparedness Coordination

The Emergency Preparedness Coordination for the DTS may be performed by the Site Emergency Preparedness Manager. This function includes procedure development, training of on-site and off-site emergency organizations and their responders in accordance with the requirement of the DTS Operation, and the conduct of appropriate drills to maintain the response organization and personnel capability.

The coordinator reports to the DTS Manager.

C. Regulatory and Licensing

The function of the coordination of regulatory and licensing activities for the DTS may be provided by an on-site or off-site organization. This organization is responsible for coordinating activities to ensure compliance with NRC Requirements, including routine reporting and reporting of abnormal events to the NRC. This organization also monitors compliance with local, state, and federal environmental regulations.

This organization is responsible to the Manager of Technical Services.

D. Site Services

Safeguards, security, training, health and safety support, and administration for the DTS may be provided by an on-site or off-site organization(s). This organization is responsible to the DTS Manager of Technical Services.

9.1.1.3 DTS Technical Staff Qualifications

The suggested qualifications for key DTS staff are summarized below. Site Specific staff qualifications may differ from those below, but will be described in the site specific license application.

A. DTS Manager

The DTS Manager should be a graduate engineer or physical scientist with at least 10 years experience in positions involving responsibilities for spent fuel handling operations or design of handling equipment. Experience shall include management of related activities.

The DTS Manager may be the site individual responsible for dry spent fuel storage management.

B. DTS Quality Assurance Manager

The Quality Assurance Manager should have at least 7 years experience in the quality assurance of nuclear activities in a NRC licensed activity.

The DTS Quality Assurance Manager may be the senior site quality assurance representative.

C. DTS Operations Manager

The Operations Manager should have at least 10 years of lead or supervisory experience in spent fuel handling operations and shall be a certified fuel handler.

D. DTS Technical Services Manager

The Technical Services (TS) Manager should be a graduate engineer or physical scientist. The TS Manager should have at least 15 years of experience in a responsible position(s) in nuclear facilities. In addition, the TS Manager should have at least 5 years of supervisory or management experience in a related position.

E. DTS Engineering Manager

The Engineering Manager should be a graduate engineer with at least 10 years of experience in the design of equipment for nuclear facilities.

9.1.1.4 Operating Staff Functions

Typical DTS operating staff functions include the following. The site specific license shall describe the site specific positions, and applicable training and certification requirements.

Operations Shift Supervisor

The Operations Shift Supervisor reports to the DTS Operations Manager and is responsible for directing the receipt, preparation, unloading and loading of casks, cask movement, fuel transfers, sealing of canisters and casks, operation of all facility equipment and systems, all in compliance with approved written procedures.

The Operations Shift Supervisor is also responsible for determining the need for equipment and facility maintenance and for the conduct of equipment and system testing.

In addition, the Operations Shift Supervisor supervises the activities of the technicians described below.

- Control System Supervisor

  Responsible for Control Room Operations including the operation of the fuel assembly handling subsystem, the transfer confinement port cover handling subsystem, the receiving cask shield plug and source cask lid handling subsystem, the receiving and source cask mating subsystem, and the control subsystem. These operations are conducted from the remote control area.

- Control Room Operator

  Responsible for hands-on operation of the above subsystems.

- Cask Handling Supervisor

  Responsible for all operations outside the facility as well as within the PA (Preparation Area) and the LAA (Lower Access Area). The operations may require presence of operators in the LAA. These operations include: acceptance and preparation for unloading and loading of source and receiving casks, preparation for removal and shipment of casks, placement of casks on their conveyances, placement of cask on trolleys, movement of casks into and out of the LAA, support of cask mating as well as lid and shield plug removal and replacement, canister lid welding, and canister vacuum drying and back-filling.

- Cask Operator

  Responsible for hands-on operation to accomplish the above and for operation of the required equipment.

- Support Equipment Supervisor

  Responsible for the operation of the HVAC and the radiation detection subsystem, as well as for supporting the Control System Supervisor and the Cask Handling Supervisor, as required. Responsible for the cask decontamination and the collection and packaging of radioactive waste.

- Support Equipment Operator

  Responsible for hands-on operation of the above equipment and subsystems.

- Radiation Protection Technician

Responsible for all radiological surveys of the facility, equipment, and casks. Collects all sample media from the radiation detection subsystem, and monitors hands on operations related to the casks.

9.2 Preoperational Testing and Operation

9.2.1 Pre-Operational Testing and Operation

The testing program for the DTS is designed to ensure that plant structures, systems and components have been adequately designed and constructed, as well as meet regulatory and licensing requirements, are safe for workers and the public, and can be operated in a dependable manner. The testing shall prove compliance with the capabilities, features and parameters presented in this Topical Report and the site-specific design and specifications upon which approval of a specific installation is based. The testing program involves pre-operational tests, an operating startup plan, and plans for conducting an operational readiness review. All testing is performed by qualified personnel, and by using written test procedures that have been approved by the DTS site manager. The owners of the DTS are responsible for conducting or overseeing all tests.

9.2.1.1 Pre-Operational Testing Plan

Pre-operational tests are defined as tests that will be required to be completed on the DTS prior to fuel receipt, and are coordinated by the DTS operations manager. The constructor of the DTS is responsible for verifying correctness of the as-built drawings, purging/flushing, cleaning, pneumatic testing, HVAC system balancing and initial calibration of instruments. Pre-operational testing is performed on all systems important to safety to ensure that they are built and that they function as designed. The systems that are involved in the transfer of spent nuclear fuel will be tested by dry runs (i.e. cold-tests). For systems that are not important to safety, acceptance criteria for the tests are established only to ensure worker safety, efficient operation of the system and to demonstrate the performance of intended functions. Results of the pre-operational tests are evaluated, and changes to the DTS or procedures are made as necessary. Section 9.2 in Chapter 9 provides details of pre-operational tests to be completed on each subsystem.

9.2.1.2 Operating Startup Plan

Operating startup tests are performed on all components important to safety. These tests ensure that the DTS functions as designed, when loaded with spent fuel. The tests demonstrate that all operations are performed in a safe manner, and provide verification that the operating procedures are acceptable prior to normal operations. The operational startup plan will include confirmation of the procedures and the exposure times for systems involving radioactive sources, radiation monitoring and shielding of the casks, and for checking the effectiveness of the HVAC heat removal and particulate filtration systems. Results of the operating startup tests are evaluated, and changes to the DTS or the procedures are made if necessary.

9.2.1.3 Operational Readiness Review

An operational readiness review will be conducted to verify that the DTS is ready to transfer spent nuclear fuel.

This review will be based on the results of the pre-operational tests as well as operating start-up tests. The readiness will need to be approved by the NRC prior to first transfer of spent fuel. The operational readiness review will address as a minimum; radiological controls, nuclear safety, operations training and procedures, DTS construction, engineering controls, fire protection, maintenance, Quality Assurance, emergency preparedness, and security.

9.2.2 Subsystem Testing and Requirements

The anticipated off-normal operation scenarios shall be tested to validate operation safety and function.

The monitoring function of the Control Subsystem shall be validated during the system testing as well as all the interlocks between the equipment. Bypasses can be used to set equipment status or conditions linked indirectly with the control (HVAC with sliding door position for example). Bypasses can not be used to test alarms.

9.2.2.1 Structural Subsystem

The structural subsystem shall undergo the following testing:

Normal operations:

Test the opening and closing functions of the sliding door. Test the inflating of the seal. Process the locking operation.

The interface with the HVAC Subsystem (including sealing effectiveness) and the TC Cask Mating Subsystem (for HVAC) shall be tested during HVAC tests.

Interlock testing:

The opening of the sliding door is interlocked with the closed position of the two TC port covers and the radiation monitoring information. The TC port covers shall be placed in the "not closed" position to test the interlocks. The radiation monitoring interface shall be tested by manually generating a radiation alarm.

9.2.2.2 HVAC Subsystem

The following tests shall be performed on the HVAC Subsystem:

All components of the HVAC Subsystem shall be factory tested to ensure that design specifications are met. Prior to operation, the exhaust fans will be run to verify proper operation. The heat pump and cooling units will also be run to verify that they are operating properly.

The temperature monitoring equipment will be calibrated. The temperture sensors and alarms will be checked by locally cooling and heating the sensors.

The temperature of the DTS will be monitored for at least 96 hours to ensure that the system is operating properly.

Check the proper monitoring of the temperature in each room.

Pressure Differential Control:

Test the capability of the HVAC Subsystem to establish the pressure differential between the three areas. Check the proper monitoring of the pressure in each room. After establishment of the proper pressure differential between the three areas, bypass automatic damper and fan control and check that alarms corresponding to the incapability of the HVAC to maintain the proper pressure differential are generated.

Test the automatic switching from lead to backup fan by shutting off the lead exhaust fan power. Test the monitoring and alarms linked to this status. Shut off the backup exhaust fan (loss of double confinement). Check that proper alarms are activated. Check that in each case the damper associated with the fan is closed.

Check that each damper failure (detected by the equipment) triggers an alarm and that the failing equipment can be identified (monitoring display).

Interface with Sliding Door & Cask Mating Subsystem

With the sliding door closed, the source and receiving cask mated, the pressure differential between areas established, open the sliding door or disengage one or the other cask and check that in each case the exhaust fan speed is kept constant. Reestablish the conditions and check that the pressure differential is reestablished.
Bypasses can be used to change the conditions.

9.2.2.3 Cask Transfer Subsystem

Test the positioning of the transfer trolleys, generate off-normal operations activating different sensors (over travel, collision...) while the trolleys are running.

Test the locking operation. Check that the monitoring system displays the locking information.

9.2.2.4 Transfer Confinement Casks Mating Subsystem

Mating:

With the casks (or a mockup of a cask) in position, test the mating operations under normal conditions. Visually check the platform position.

Check that the vertical positioning of the three electrical jacks and the mating status are displayed in the Control Center.

Disengagement:

Verify that the Cask Mating Subsystem moves to the full up position without binding.

9.2.2.5 Transfer Confinement Port Covers

Positioning:

Test the positioning of each TC port cover. Check the proper alignment of the port covers with lines drawn on the mezzanine plate. Test off-normal operations (over travel).

Test the locking operation when the TC port cover is open. Test the time-out detection. Test inconsistencies between lock and port cover positions as shown in Tables 9.2-1 and 9.2-2.

Table 9.2-1
Receiving Cask TC Port Cover Instrumentation Logic Table

	Open	Closed	Off Centered	Locked	Unlocked
Open		X	X	O	O
Closed	X		X	X	O
Off Centered	X	X		X	O
Locked	O	X	X		X
Unlocked	O	O	O	X	

Table 9.2-2
Source Cask TC port cover instrumentation logic table

Information	Open	Closed	Locked	Unlocked
Open		X	O	O
Closed	X		X	O
Locked	O	X		X
Unlocked	O	O	X	

Test the interlocks between the positioning and locking operations.

Verify proper operation of manual backup system for TC port covers, including moving platforms from worst condition positions.

9.2.2.6 Source Cask Lid and Receiving Cask Shield Plug Handling Subsystem

The two upper shield port covers opening, closing and locking functions shall be tested independently.

Test the positioning of the upper shield port. Test off-normal operations (over travel).

Test the locking operation when the upper shield port is closed. Test the time-out detection. Test inconsistencies between lock and shield port positions as shown in Table 9.2-3.

Table 9.2-3
Source and Receiving Cask Upper Shield Ports Instrumentation Logic Table

Information	Open	Closed	Locked	Unlocked
Open		X	X	O
Closed	X		O	O
Locked	X	O		X
Unlocked	O	O	X	

Test the interlocks on the positioning and locking operations.

Preoperational testing of the upper crane shall be performed in accordance with NOG-7420. Inspections prior to performance testing shall be in accordance with NOG-7520. A load test of the hoist and grapple will be performed at 125% of the rated load in accordance with NOG-7523.

Perform an operation functional check on the hoist lowering and lifting. Verify that the positions of the hoist do not result in any interferences. Verify that the grapple engages and disengages properly. Verify that the gripping device engages and disengages properly. Verify that all sensors are functioning including verification of proper position and function of limit switches for positioning trolley and function of the over travel limit switches. Verify absolute positioning of the hoist with and without load. Verify functionality of all limit switches and associated instrumentation.

Verify that the load cell is reading correctly by lifting known loads.

Verify that the upper crane hoist can not operate of the lid/shield plug handling grapple is not stopped in its upper z position. Verify that the upper crane trolley can not be operated unless the upper shield ports are closed.

Verify that the upper shield ports cannot be closed unless the lid/shield plug grapple is in the upper z position or if the hoist is loaded.

Verify that the upper shield port covers cannot be opened if the opposite TC port cover is not closed.

Verify that the upper shield ports cannot be unlocked if the fuel handling system is in operation.

Verify that only one upper shield port can be open at one time.

Verify that the upper shield ports cannot be locked in the closed position.

Verify that motion of the hoist is stopped when the cables are under loaded during lowering.

Verify that the motion of the hoist is automatically stopped when the grapple reaches the upper position (with no load) and the position above the TC port cover when the cables are loaded.

Verify that the hoist cannot be operated unless the fuel assembly handling crane carriage is stopped in the parking position.

Verify that the hoist cannot be used for lifting unless the grapple is totally disengaged from the overlid or unless both the gripping device and grapple are fully engaged.

Verify that the grapple can not be disengaged if the cables are loaded or if the grapple is not in its proper z position.

9.2.2.7 Fuel Assembly Handling Subsystem

Inspections of the Fuel Handling Subsystem prior to performance testing shall be in accordance with NOG-7520. Preoperational testing of the upper crane shall be performed in accordance with NOG-7420 A load test will be performed on the system at 125% of the rated load in accordance with NOG-7523.

Perform a functional test to ensure that the crane carriage and the rotating platform can move to locate the fuel transfer tube above all locations in both the source and receiving casks.

Perform a complete checkout of the positioning system to ensure that the gross positioning is programmed correctly.

Verify that all operations can be monitored visually with the assistance of the CCTV's.

Verify that the crane carriage and the rotating platform will not move unless the fuel assembly grapple is in the upper z position.

Verify that the crane carriage and the rotating platform cannot be moved if the crud catcher is not closed.

Verify that the crane carriage cannot be moved unless the two upper shield ports are locked in the closed position. Verify that the crane carriage cannot be moved unless the two TC port covers are locked in the open position.

Verify that the crud catcher cannot be opened unless the crane carriage is stopped in both the x and y directions and the rotating platform is also stopped.

Verify that the crud catcher cannot be closed unless the grapple is in the upper z position.

Verify that the hoist operates properly under load and without load. Verify, using a dummy fuel assembly that the pass through to the fuel transfer tube is smooth and no binding results.

Verify that the grapple fully engages and disengages. Verify that disengagement will not occur if the cable is loaded or if the grapple is not stopped in the proper position.

Verify proper operation of all sensors including verification of grapple fingers closed and open and fuel assembly presence. Verify proper operation and readout of the load cell.

Verify proper operation of all manual backup positioning equipment and verify proper operation of all electrical backup equipment.

Verify proper operation of backup power supply.

9.2.2.8 Fire Suppression System

Verify proper operation of smoke and fire detection systems.

9.2.2.9 Radiation Monitoring System

The Radiation Monitoring System shall be calibrated and functionally tested prior to operation. It is expected that these tests will be incorporated into the reactor's instrumentation maintenance program.

9.2.2.10 Cameras and Lighting

Verify proper positioning of all cameras and lights. Verify that all operations which require visual monitoring can be seen using the cameras and monitors.

9.3 Training Program

The training program plans for the DTS are site specific and will be submitted with the site-specific license applications.

9.3.1 General

The Site-Specific License Applicant may provide a training program description in the License Application that is consistent with the Applicant's existing corporate and site-specific programs, provided that the program includes the elements described herein.

The training program for the DTS operation will include the General Training program, and the Continuing Training program. The main objective of the DTS training program will be to ensure that the facility is operated by personnel who have demonstrated that they have been properly trained and are qualified to complete their assigned tasks. Employees will be provided with formal training to gain knowledge of the DTS, as well as to obtain on-the-job training, in order to develop good work performance skills. Continuing Training is to be implemented, so that the workers maintain their proficiency and to continue to develop their skills.

The training program will ensure that the employees are sufficiently trained, as well as tested and certified (if required) to prepare them to operate the DTS facility in a safe, reliable, and efficient manner. Different levels of training will be available depending on the employees past experience, level of ability, and qualifications. Training requirements are applicable to all personnel with responsibilities for operation, safety, or quality operations or oversight, and maintenance of the DTS. Training sessions will be held on a regular basis to accommodate new employees or those requiring retraining.

The General Training program will include General Employee Training, Nuclear Safety Training, and Technical Training.

The training may consist of live, taped or filmed lectures, self-study, demonstrations, laboratories, work-shops, on-the-job and dry run training, and computer based training. Each module or training program will require that the employee pass a written, computer-based, oral, or practical examination. After successfully passing the exams with a score above a set passing grade, the employee will be authorized to work within the guidelines governed by the employee's level of training.

The training and certification programs will be monitored by the designated DTS personnel, and will be audited by the QA department. The training as well as the certification programs will be monitored by the designated site personnel. The Quality Assurance organization will audit the Training program. In addition, trainees and vendors may provide input concerning the training program effectiveness. Frequently conducted classes will be routinely evaluated, at a frequency that is adequate for evaluating the program effectiveness. Unacceptable performance will be reported to the DTS Manager.

9.3.2 General Employee Training

General Employee Training (GET) will include quality assurance, radiation protection, safety, emergency, and administrative procedures, the DTS licensing basis, as well as the technical specifications and the applicable regulations. The GET will also include Technical Training specific to each DTS job function. All personnel who are under the direct supervision of the DTS management will successfully participate in GET. Temporary contractors will only be required to receive training on aspects of the GET that are critical to the contractor, in executing the assigned work a safe and efficient manner. GET topics will include but are not limited to the following:

1. General administrative controls and procedure use
2. Quality Assurance policies and procedures
3. DTS systems and equipment design and operating procedures and records
4. Industrial safety and first aid
5. Emergency plan
6. Security
7. Fitness for Duty, FFD
8. Nuclear safety training
9. Fire protection
10. Licensing basis and technical specifications
11. Applicable regulations
12. Technical training

Nuclear Safety Training will be crucial to the assurance of radiological safety of the plant personnel and the public. All personnel assigned to the DTS will receive Nuclear Safety Training. Visitors who request unescorted access must receive formal Nuclear Safety Training at a level appropriate to their work scope. Based on radiation levels visitors can be escorted by a trained employee, without a need for them to successfully complete the Nuclear Safety Training. Topics that will be covered in the Nuclear Safety Training are listed below:

1. Notices, reports and instructions to workers
2. Plant access and visitor escort duties
3. Sources of radiation
4. Biological effects
5. Limits and guidelines
6. ALARA principles
7. Radiation dosimetry
8. Contamination control limits
9. Use of monitoring equipment
10. Donning and doffing protective clothing
11. Emergency plans and procedures
12. Waste Minimization
13. Decontamination
14. Criticality safety principles and limits

The Technical Training program will include in-depth training on the operation, pre-operational testing, maintenance and troubleshooting of each component of the DTS system. The Technical Training program shall include the following:

1. DTS fundamentals, including applicable licensing basis and technical specifications
2. Equipment design and operating characteristics
3. Instrumentation and controls
4. On-site cask transport systems
5. Procedures
6. Equipment maintenance
7. Subsystem manual operation training
8. Operator skills and certification

Some of the training may not be applicable for every employee. The job description will distinguish which training sections are necessary for an individual to be able to safely and efficiently work within the DTS. On-the -job training will take place in the work place and will involve a complete simulation of fuel transfer. The first group of employees selected to transfer fuel will be able to train on all of the equipment during dry run exercises, which are performed prior to receipt of spent fuel. Once the DTS is operational, future operators will be able to train on the equipment in between campaigns of fuel transfers while fuel is not present in the DTS. Special training may be required for individuals who will be performing non-routine work that is not directly covered under the modules of the Technical Training program.

Personnel involved in the operation of system and controls important to safety must be trained and certified. Certification training includes a minimum of GET, including Nuclear Safety Training, Technical Training, and on-the job training. Certification training will be job-specific, and will require the employee pass a written and practical examination prior to executing any task important to safety.

9.3.3 Continuing Training

The Continuing Training program will be designed to ensure that all employees maintain proficiency on the job. The training content will be based on safe operation information, past job performance, and improvements or revisions in maintenance and operational procedures, as well as lessons learned. The Continuing Training program content will include topics of the GET, the Nuclear Safety Training, and the Technical Training programs.

9.3.4 Administration and Records

The DTS Training program is the responsibility of the Technical Services Manager. Accurate records will be maintained of each employee's qualifications, experience, training and retraining. The employee's training file shall include records of all training conducted for the DTS operations. The employee's training file shall also contain records of any related training conducted by others. Accurate and retrievable training records are maintained for each individual. Training records are retained for two years after an individual's employment is terminated.

9.4 Normal Operations

9.4.1 Procedures

Detailed written procedures for all normal operating, maintenance, and testing procedures will be prepared and in effect prior to operation of the DTS. These procedures are briefly described in the following subsections.

These procedures will be expanded in detail, presented on a site specific format and included in the submission of the

9.4.1.1 Administrative Procedures

Administrative procedures will provide rules and instructions to DTS personnel to provide a clear understanding of operating philosophy and management policies. These procedures included instructions pertaining to personnel conduct and control, including consideration of job-related factors which influence the effectiveness of operating and maintenance personnel, e.g. work hours, entering and exiting the DTS, organization, and responsibility, etc.

9.4.1.2 Annunciator Response Guides

Annunciator response guides will provide information relative to each alarm annunciator which monitors cask and fuel parameters. The procedures will provide alarm set points and appropriate corrective action.

9.4.1.3 Radiation Protection Procedures

Radiation protection procedures are used to implement a radiation control program. The radiation control program will involve the acquisition of data and provision of equipment to perform necessary radiation surveys, measurements, and evaluations for the assessment and control of radiation hazards associated with the operation of the DTS. Procedures will be developed and implemented for: monitoring exposures of employees; radiation surveys of work areas; and radiation monitoring of maintenance activities.

Regularly scheduled surveillance will be required, but calculations show that dose received by personnel from anticipated activities are within the guidelines set forth in 10 CFR 20. There are no credible events during normal operations that could lead to high radiation releases. Accident analyses in Chapter 8 also show no credible event leading to high radiation releases.

9.4.1.4 Maintenance Procedures

Maintenance procedures will be established for performing preventative and corrective maintenance on the DTS equipment. Preventive maintenance will be performed on a periodic basis to preclude the degradation of DTS systems, equipment and components. Corrective maintenance is that performed to rectify any unexpected system, equipment, or component malfunction, and is initiated as necessary.

9.4.1.5 Operating Procedures

Operating procedures will provide instructions for the use of DTS subsystems.

9.4.1.6 Test Procedures

Periodic test procedures will be developed to ensure that DTS subsystems, equipment, and components are observed on a routine basis to verify operability.

9.4.1.7 Pre-operational Test Procedures

Pre-operational test procedures will be established to ensure that DTS structures, systems, and components satisfactorily perform their required functions. These test procedures will further ensure that the DTS has been properly designed and constructed and is ready to operate in a manner that will not endanger the health and safety of the public.

9.4.1.8 Quality Assurance Procedures

Quality assurance procedures will be established to ensure that the operation and maintenance of the DTS is performed in accordance with 10CFR72 Subpart G or 10CFR50 Appendix B, as applicable.

9.4.2 Records

Records will be maintained in accordance with the site specific program and will be described in the site specific license application.

9.5 Emergency Planning

The site specific Emergency Plan will describe the organization , assessment actions, conditions for activation of the emergency organization, notification procedures, emergency facilities and equipment, training, provisions for maintaining emergency preparedness, and recovery criteria used at the site utilizing the DTS.

Portions of the Emergency Plan and applicable implementing procedures will be modified to reflect the actions to be taken during off-normal and accident conditions. Design Event III will require the declaration of a Notification of Unusual Event. Design Event IV will require declaration of an Alert.

A comprehensive analysis of the DTS due to various accidents has been performed and is presented in Chapter 8. For each postulated accident, appropriate corrective action and recovery procedures, which would minimize the consequences of the accident, have been described.

Detailed emergency plans will rely heavily on the emergency services and organizations available at the on-site reactor. Details of how the DTS will be incorporated into the Emergency Plans will be provided by the utility applying for certification of a specific site.

9.6 Decommissioning Plan

The DTS is designed so that the major components can be disassembled and transported as LSA material to a new site for reuse. The concrete structure, interior walls and floor, can be decontaminated and disposed of as either low level waste, or preferably, as normal debris, minor equipment items will be disposed as low level waste.

9.6.1 Decommissioning Program

The DTS is designed to confine contamination within its three areas. After each completed dry transfer, equipment and structure surfaces of the DTS are decontaminated to levels that permit maintenance activities. The level of radiation and the contamination in the three areas is expected to be low. This approach facilitates decontamination at the termination of the DTS use.

All three areas will be vacuumed to remove any loose contamination. Each equipment item will be wiped with damp cloths, surveyed and removed to appropriate disposition. The only equipment which is expected to present high contamination levels is the fuel transfer tube and its associated crud catcher. Efforts will be taken to decontaminate the fuel transfer tube. If unsuccessful, the fuel transfer tube may be disposed of. All other major equipment which is decontaminated on site will be packed and transported to the next location. This equipment includes: upper crane, CCTV and lighting, fuel assembly handling, cask mating, upper shield cover, roof plate, cask mating, TC port cover handling, mezzanine plate, cask transfer, cask, lid handling, HVAC. Only the sliding door, the protective cover, and concrete structure will not be removed.

Once only the shell of the DTS remains, the inside walls of will be cleaned as required. The walls of the DTS are painted to facilitate decontamination and to prevent the need for scabbling the concrete.

No residual contamination is expected to be left behind outside the DTS. The rails and peripheral utility structure will be decommissioned when all equipment inside the DTS building is removed.

Decommissioning is estimated to use a 5 member crew and last for 60 days. Waste from decontamination and decommissioning will consist of cloths, protective clothing from workers, HEPA filters, and minor equipment.

9.6.2 Cost of Decommissioning

The amount of material expected to be disposed of as low level waste is expected to be negligible. The primary source of contamination is the spalled material from the fuel assembly (crud), however, the fuel assembly is enclosed by the transfer tube through most of the fuel transfer process. This tube is the only piece of equipment that potentially will not be decontaminated. All other major equipment items and the walls of the DTS will be decontaminated. The volume is estimated to be 20-40 55-gallon drums (Approximately, 2-4 55-gallon drums per week). These are expected to be easily incorporated into the waste streams from other site operations.

Demolition of the DTS structure is not included in this waste volume estimate. The DTS building is not expected to be contaminated following cleaning and it will be demolished and disposed of through standard construction methods.

9.6.3 Decommissioning Facilitation

The DTS is designed for its ease of decontamination. The fuel during the fuel transfer process is enclosed in a steel tube with a crud catcher. The majority of crud from a fuel assembly is expected to be captured by this crud catcher. When the fuel is lowered into the receiving cask, this spalled material is expected to fall into the receiving cask. Therefore, the amount of loose contamination in the DTS is expected to be minimal.

The concrete walls are coated with paint to eliminate the need to scabble the concrete. The painted walls will only require wiping with damp cloths or at most high pressure water cleaning for decontamination.

Due to the design features of the DTS, the amount of material requiring disposal generated from decontamination is minimal.

9.6.4 Recordkeeping of Decommissioning

Recordkeeping in support of decommissioning will consist of the source cask records, the receiving cask records, the fuel transferred records, and facility records (operating procedures, maintenance, incident reports, decontamination, etc.). These will be kept in a secure storage area at the host facility.

9.7 Physical Security and Safeguards and Contingency Plans

The physical security and safeguards and contingency plans are site specific and will be discussed in the site specific license applications.

10. OPERATING CONTROLS AND LIMITS

10.1 Proposed Operating Controls and Limits

The general areas where controls and limits are necessary for safe operations of the DTS system are shown in Table 10.1-1. The conditions and other items to be controlled have been selected based on the safety assessments for normal and accident conditions provided mainly in Chapter 8.

In addition to the operating controls and limits proposed herein, there will be specific operating controls related to welding of the receiving cask lids, inerting of the receiving cask, and site specific controls. These controls and limits will be specified in the site application.

Table 10.1-1
General Areas Where Controls and Limits are Necessary

AREAS FOR OPERATING CONTROLS AND LIMITS		CONDITIONS OR OTHER ITEMS TO BE CONTROLLED
1.	Cask Characteristics	Surface Dose Rates, Alignment with the TCS, Dimensional characteristics of lid opening, weight of lid and shield plug, compatibility with lifting pintle
2.	IFA Characteristics	Type and physical condition, burnup, initial enrichment, total weight, gamma source strength, neutron source strength, decay heat power, post irradiation time
3.	Cask Transfer Trolleys	Security of Load Locking Mechanism
4.	Upper Crane	Load testing Grapple operation Sensor operation
5.	Fuel Handling Subsystem	Load testing Sensor operation Operation of grapple Crud catcher operation
6.	Cask Mating Subsystem	Mating of Cask with Cask Mating Subsystem Sensor Operation Operation of gripping device
7.	Sliding Door	Interlocks
8.	Health Physics	Radiation Detection Radioactivity Detection Health Physics Surveys
9.	HVAC System	Operability Radioactivity Monitoring HEPA filter pressure differences HEPA filter testing

10.2 Development of Operating Controls and Limits

This section provides a description and discussion of the operating controls and limits specified in this Topical Report. These specifications cover generic issues associated with the operation of the DTS so as to ensure the protection of operators, the environment and the public's health and safety. Any additional operating controls and limits on site specific issues will be supplied by site license applicants.

10.2.1 Functional and Operational Limits, Monitoring Instruments and Limiting Control Settings

This category of operating controls and limits applies to operating variables that are observable and measurable during operation of the DTS.

10.2.1.1 Surface Dose Rate of Source Cask

Title: Surface Dose Rate of Source Cask

Specification: The source cask shall provide shielding for the design basis fuel at least as well as the design basis fuel. The maximum contact dose rate at axial midpoint on the top of the cask shall not exceed 250 mrem/hr. The maximum contact dose rate at the radial midpoint at the side of the cask shall not exceed 300 mrem/hr. (Gamma and Neutron)

Applicability: All source casks

Objective: Ensure that the operational dose rates to workers are within site acceptance criteria and ALARA.

Action: Casks with higher surface dose rates will not be permitted inside the DTS.

Surveillance: Surface dose rates on all incoming source casks will be surveyed.

Basis: The basis for the maximum specified dose rates of 250 mrem/hr and 300 mrem/hr (combined gamma and neutron) is the shielding analysis of Section 7.3.2. These dose rates were calculated assuming that the source cask is a generic transfer cask with a capacity of 4 design basis fuel assemblies. Appendix 7A.2.1 provides details of the dose rate determination.

These dose rates are expected to be conservative based on the assumptions of the analysis. The site specific license applicant will provide an analysis of the fuel and the source cask that is proposed by the specific license. The applicant will compare the results of the evaluation with maximum specified dose rates given in the TSAR.

10.2.1.2 Alignment of the Source Cask or Receiving Cask with the TCS

Title: Cask Alignment

Specification: All source casks and receiving casks must mate properly with the cask mating system.

Applicability: All casks.

Objective: Maintain confinement between the Lower Access Area and the TCS to minimize the spread of contamination and ensure proper alignment.

Action: If cask will not fitup properly, operators can investigate the cask mating system by entering the lower access area after verification that both casks are closed, and that radiation levels within the Lower Access Area are low enough to permit entry.

Surveillance: The operator in the control room visually verifies proper alignment between the cask mating subsystem and the cask by means of video cameras in the Lower Access Area. The load measurements from each screw jack will also be used to verify that the cask is properly mated with the annular platform. When so mated, the upper surface of the cask should not be visible and the annular platform should be relatively horizontal. If the annular platform appears to be cocked or tipped, then the cask mating subsystem may be misaligned. Shield plug or source cask lid removal will not be performed prior to verification of proper fitup.

Basis: ALARA

10.2.1.3 Cask Characteristics

Title: Cask Characteristics

Specification: All source casks and receiving casks must interface with the DTS to ensure proper operation.

Applicability: All casks.

Objective: Ensure that the DTS will properly function, and prevent operational interference.

Action: All cask designs shall be verified to ensure that the cask height, diameter, inside diameter, lid diameter, shield plug diameter, fuel cell opening, trunnion sizes and locations and pintle dimensions are acceptable for proper interface with the DTS.

Surveillance: Design verification.

Bases: Section 3.1.2

10.2.1.4 Spent Fuel Specifications

Title: Fuel Specifications

Specifications: Type Intact PWR fuel assemblies

Weight	1720 lbs. max.
Burnup	≤ 40,000 MWD/MTU
Initial Enrichment	≤ 3.75 w/o U-235
Cooling Time	minimum 5 years
Decay Heat / Fuel Assembly	≤ 0.74 kW
Neutron Source per assembly	≤ 2.4E+08 n/sec with spectrum bounded by Table 3.1-3
Gamma Source per assembly	≤ 7.8E15 photon/sec with spectrum bounded by Table 3.1-2

Applicability: All fuel.

Objective: To avoid exceeding the ranges for which the thermal, shielding, criticality and release calculations are valid.

Action: Spent Fuel which do not meet these specifications may not be transferred in the DTS.

Surveillance: Each spent fuel assembly will be demonstrated to meet these specifications by reactor staff, using site-specific procedures, before fuel transfer within the DTS.

Basis: The specified limits for burnup, initial erichment, cooling time, and decay heat were taken from U.S. DOE's "Mulitpurpose Canister (MPC) Subsystem Design Procurement Specification," DBG6000000-01717-6300-00001, Revision 04, Prepared by TRW Environmental Safety Systems, Inc., August 26, 1994. The fuel parameters developed for the MPC program were considered to be representative, however, site specific information (fuel type, burnup, initial enrichment, cooling time and decay heat) will need to be evaluated prior to use of the DTS.

10.2.1.5 Cask Transfer Trolley Locking

Title: Locking of Source Cask and Receiving Cask Trolleys in the Preparation Area and the Lower Access Area.

Applicability: Source Cask and Receiving Cask Trolleys

Objective: Prevention of inadvertent movement of the trolleys during a seismic event.

Action: The cask trolleys will be locked in place in the Preparation Area prior to removing the lid bolts of the source cask and prior to initiating closure operations on the receiving cask. Both cask trolleys will be locked in place in the Lower Access Area after positioning of the cask below the opening in the Mezzanine plate.

Surveillance: Interlock of locking pin and TC port cover opening.

Basis: Prevention of movement of the trolleys during a seismic event.

10.2.1.6 Tiedown of Casks on Trolleys

Title: Tiedown of Casks on Trolleys

Applicability: Source cask and receiving cask trolleys.

Objective: Prevention of cask tipover during tornado or seismic event.

Action: Cask shall be securely fastened to the trolley prior to movement of the trolley into the Preparation Area.

Surveillance: The procedure of fastening the casks to the trolleys is outlined in Chapter 5, Section 5.2.1. The procedure is identical for both the receiving and the source casks. Four centering guides bolted to the top of the trolley with generous lead angles allow for proper alignment of the cask onto the trolley. The cask can be misaligned up to four inches and still land on the trolley in the proper position. Two trunnions attached to the lower end of

the cask will fit into trunnion cradles which will be attached to the trolley. Tie-down covers will bolt to the top of the trunnion cradles by means of six torqued bolts which will capture the trunnions on the cask and fix it to the trolley. The trunnion cradles and their covers prevent the cask from being disengaged from the trolley during transportation, fuel transfer, and during a seismic event. Figure 5.2-1 in Chapter 5 illustrates the concept for the trunnion cradle. Surveillance steps for the cask tie-down procedure will include visual verification that the cask is properly positioned on the trolley, with the trunnions in the trunnion cradles. The torque on the six bolts fastening the trunnion cover to the trunnion cradle will also be verified.

Basis: Prevention of cask tipover due to tornado or seismic event.

10.2.1.7 Load Testing of Upper Crane and Fuel Handling Crane

Title: Pre-Operational Testing of Upper Crane and Fuel Handling Crane

Applicability: Cranes

Objective: Prevention of loss of load.

Action: Following initial installation, the "in-service" cranes shall be inspected and tested in accordance with NOG-7520 and NOG-7530 at the intervals specified in "Surveillance", below.

Surveillance: Testing and inspections shall be verified by appropriate site personnel. Documentation shall be in accordance with NOG-7600. Fuel handling crane operation will be continually checked during operation using video cameras to observe operation and through monitoring of the control system signals indicating proper sensor and mechanical equipment operation. Procedures will require visual inspection of the crane critical components designated for "frequent inspection" by direct entry into the TCA prior to beginning of each campaign of loading one receiving cask.. Frequent inspection items are those items generally as identified in ASME B30.2-1996, Paragraph 2-2.1.2 as applicable and expanded to the DTS application. Procedures will also require full inspection and maintenance operations to be performed on the crane during the scheduled 100-day periodic maintenance cycle. Full load tests at 125% of the design rated load of the crane are to be performed yearly (unless the crane is not in service during that period) and/or at every third maintenance cycle, whichever occurs first. Periodic inspection items shall generally be as identified in ASME B30.2-1996, Paragraph 2-2.1.3 as applicable and expanded to the DTS application. Full inspection, operational and load testing will be required after repair and after accident events.

Basis: Prevention of loss of load.

10.2.1.8 Operational Testing of Grapples and Gripping Devices

Title: Grapples and Gripping Devices Operational Testing

Applicability: Fuel Handling Crane Grapple, Cask Mating Subsystem Gripping Device and Upper Crane Grapple

Objective: Ensure grapples stay engaged while under load, can be easily disengaged with no load, and all sensors operate properly.

Action: Full check out of grapple and gripping device operations including operational testing of all sensors, load indicators, and grapple movements prior to first use and during each scheduled maintenance period.

Surveillance: Grapple operation will be continually checked during operation using video cameras to observe grappling action and through monitoring of the control system signals indicating grapple open/closed and load present conditions. Initially, procedures will require that all grapples be visually and functionally inspected directly by entry into the LAA and/or TCA prior to each campaign i.e. loading of each receiving cask. Certain gripping devices, such as the fuel transfer subsystem grapple, may be inspected on contact in between the unloading of each source cask if deemed necessary. Entrance into these areas will only be allowed when the monitored radiation levels are acceptable and proper surveys have been completed to locate contaminated and high radiation areas. Operation will be checked utilizing suitable fuel nozzle and pintle mockups. With operating experience on the reliability of the grapples, the interval of the direct inspections may be reduced to no less than one campaign (i.e. loading one receiving cask). Procedures will also require full inspection and maintenance operations to be performed during the scheduled 100 day periodic maintenance cycle (i.e. 10 campaigns). Full load tests at 125% of the design rated load of the grapple are to be performed at least yearly (unless the grapple is not in service during that period) and/or at every third maintenance cycle, whichever occurs first. Full inspection, operational testing, and load testing will be required after repair of grapples and after accident events.

Basis: Prevention of loss of load, and prevent need for maintenance on equipment located in high radiation environment.

10.2.1.9 Sensor Functional Testing

Title: Sensor Functional Testing

Applicability: Fuel Handling Crane, Cask Mating Subsystem, Shield Plug and Source Cask Lid Handling Subsystem, Cask Transfer Subsystems

Objective: Verification of proper function of all sensors.

Action:

1. All sensors and monitors are to be calibrated prior to being installed. Load cell calibration shall be checked after every complete campaign of filling a receiving cask. With operating experience on actual radiation dose levels and its effects on the load cells, the interval of the calibration checks may be reduced to 100 day cycles. The calibration and maintenance of temperature and pressure sensors associated with the HVAC system will be scheduled for maintenance after every 100 day cycle and will strictly follow the recommendations of the manufacturers. The limit switches and position sensors do not require any calibration or preventative maintenance after being placed in service. They only need replacing due to radiation or other damage as specified in the equipment replacement schedule, which will be developed by the owner of the DTS based on manufacturer's recommendations, or if they fail or prove faulty during operation.

2. Prior to first use of the DTS, all equipment shall go through complete system functional testing including verification of proper positioning of all sensors, proper indications, proper activation of interlocks, proper disengagement of interlocks through the use of bypasses. This shall include functional testing of all backup instrumentation.

3. During each scheduled maintenance period, all equipment shall be functionally checked to ensure that all instrumentation is in good working order.

Surveillance: See action above.

Basis: Assurance that operators and the control system are provided with accurate information from the equipment.

10.2.1.10 Port Cover Locking

Title: Port Cover Locking.

Applicability: Upper shield port cover locking in closed position and TC port cover locking in open position.

Objective: Upper shield port covers: Ensure that radiation dose rates on the roof of the DTS are within calculated values, thus ensuring that off-site dose rates are within allowable limits. Setting limits for the dose rates on the roof of the DTS facility will be a site specific requirement. The dose rates presented in this SAR are representative and further evaluation is necessary once site specific conditions are known. Allowable dose rates on the roof will be a function of the actual fuel being transferred (maximum burnup, initial enrichment, decay time) and the actual location of the site boundary and the nearest site resident.

TC port covers: Prevention of collision with fuel handling machine and ensuring that the opening to the casks is clear for fuel transfer.

Action: The upper shield port cover will be locked in the closed position during fuel transfer. The TC port covers will be locked in the open position during fuel transfer.

Surveillance: Verification that sensors and interlocks are working properly prior to first use and during scheduled maintenance periods. Verification of proper operation and fitup of locking devices prior to first use.

Basis: Shielding evaluation presented in Section 7 and proper operation.

10.2.1.11 Upper Crane Alignment

Title: Upper Crane Alignment

Specification: Upper crane must align with the lifting pintle on the cask mating subsystem.

Applicability: Upper Crane

Objective: Ensure proper fitup and operability of grapple and gripping device.

Action: Locate crane above each cask opening and engage and disengage with overlid pintle.

Surveillance: Verify proper engagement, disengagement and operation prior to first use and during scheduled maintenance periods.

Basis: Ensure that source cask lid and shield plug can be removed and replaced during operations.

10.2.1.12 Upper Crane Operations

Title: Upper Crane Vertical Positioning

Specification: Upper crane must be capable of proper positioning in full up position, above TC port cover with lid (or shield plug), above TC port cover with lid (or shield plug) disengaged, and at location of overlid gripping device in the cask mating subsystem.

Applicability: Upper Crane

Objective: Ensure proper fitup and operability of grapple and gripping device.

Action: Locate grapple in vertical orientation in positions specified in the operating procedures.

Surveillance: Preoperational testing of sensors and crane prior to first use.

Basis: Ensure proper functioning of crane hoist.

10.2.1.13 Fuel Handling Subsystem Operation

Title: Fuel Handling Subsystem Operation

Specification: Fuel Handling Subsystem must be able to safely lift one fuel assembly out of the source cask and place it into a specified location in the receiving cask.

Applicability: Fuel Handling Subsystem

Objective: Ensure safe handling of the fuel assembly.

Action: Demonstrate using a dummy fuel assembly that the fuel handling subsystem works properly prior to first use of the DTS. Full operational testing would include verification of crud catcher operation, full operation of bridge, trolley and rotating platform and all sensors. Verification of all computer assisted positioning.

Surveillance: Proper alignment and positioning is continuously checked during operation using video cameras. The operator visually monitors and verifies the rough positioning in the X and Y directions completed by the operating system. Fine positioning in the X, Y and θ is accomplished manually by using a joystick. All three directions of motion will be adjusted until the grapple will engage the fuel during lifting operations or

until the fuel assembly can be lowered into its position in the cask during lowering operations.

Basis: The fuel handling subsystem must transfer fuel from the source cask to the receiving cask.

10.2.1.14 Sliding Door

Title: Operation of Sliding Door

Specification: The sliding door must properly shield the preparation area from radiation during fuel transfer.

Applicability: Sliding Door

Action: Sliding Door must interlock with radiation monitoring system to ensure that door will not be opened during fuel transfer. Sliding door must provide adequate shielding during fuel transfer.

Surveillance: Continuous radiation monitoring in the Preparation Area during DTS operation. Check out of interlocks prior to first use of DTS, and periodic testing of interlocks during scheduled maintenance periods.

Basis: Radiation safety.

10.2.2 Limiting Conditions for Operation

Limiting conditions for operation of equipment, systems and components (in terms of lowest acceptable level of performance, minimum number of components available, etc.) will be concerned with operating systems.

Technical conditions and characteristics are provided in terms of allowable levels of operating variables which are measured before operation of the equipment is permitted. Also included in this section are interlocks which automatically inhibit operations unless certain conditions are met.

10.2.2.1 HVAC Subsystem Operational Checks

A. Ventilation System Pre-shift Checks

Title: Ventilation System Pre-shift Checks

Specification: Fans are running. Pressure differences across HEPA filters within range, typically 1-4 in. wg. Subatmospheric pressures in each of the DTS areas (TCA, Lower Access Area, and Preparation Area) are within ±20% the following values:

a. Preparation Area:	0.25 in. water less than ambient
b. Lower Access Area:	0.5 in. water less than ambient
c. TCS:	1.0 in. water less than ambient

Applicability: HVAC Subsystem

Objective: To minimize spread of contaminated material.

Action: If fans are not running, shift to backup system. Investigate cause of problem and repair. Adjust flow rates to ensure pressure differentials.

Surveillance: Check flows, pressure differentials and operation of fans before starting each shift. Replace filters when casks are moved out of Lower Access Area if required, and as part of scheduled maintenance.

Basis: HEPA filters are typically designed for pressure differentials of 1 - 4 in wg, depending on dust load and flow. Actual values are site-specific, depending on type and make of filters used. High pressure differences indicate filters need changing. Radiation levels in the Lower Access Area may also indicate need for filter change.

B. HEPA Filter Leak Detection

Title: HEPA filter leak detection

Specification: Filters must pass DOP, sodium flame or similar test.

Applicability: All HEPA filters

Objective: To ensure that exhaust air is adequately filtered.

Action: If filters fail test, change them. Also change filters as part of scheduled maintenance.

Surveillance: Perform test after installing filters.

Basis: Filters will be tested in accordance with ANSI/ASME N509.

C. Air Particulate Check

Title: Air Particulate Check

Specification: Air samples from the exhaust stack shall be monitored and meet site specific limits.

Applicability: This will be addressed in the site-specific Health Physics Control procedure. See also Section 7.3.4.2.

Objective: Ensure particulate release is within allowable values. Particulate release rates are a site specific requirement. Other variables such as releases from other site operations, location of the site boundary, and state and federal clean air permit requirements are taken into consideration when setting an allowable particulate release rate.

Action: The exhaust stack will be equipped with a continuous air monitor, which collects and monitors airborne particulate, iodine and noble gases.

Surveillance: Continuous monitoring.

Basis: Off Site Dose rates.

10.2.2.2 Cask Handling

10.2.2.2.1 Health Physics Surveys on the Receiving Cask

This will be addressed in the sit e specific health physics control procedure.

A. Security of Casks on Cask Trolleys

Title: Security of Casks on Cask Trolleys

Specification: Casks must be secured on the casks.

Applicability: Source Cask and Receiving Cask and their trolleys.

Objective: Prevention of cask tipover due to seismic event.

Action: Loaded trolleys will not be moved until casks are securely fastened.

Surveillance: Bolt torques shall be verified prior to moving trolley.

Basis: The cask holddown devices are designed against the design basis earthquake loadings assuming that they are securely fastened.

B. Interlocks

Title: Interlocks

Specification: Interlocks prevent operators from incorrectly performing operations which would affect the safety of the DTS, such as lifting a load without proper engagement, or opening the sliding door during fuel transfer.

Applicability: Control System

Objective: Prevention of inadvertent incorrect operations.

Action: Interlocks are provided per Table 5.4-1 which prevent the operator from performing operations which would result in an unsafe condition.

Surveillance: Interlocks cannot be bypasses without supervisory password or key.

Basis: DTS is designed so that operators cannot render the system unsafe by incorrect commands.

10.2.3 Surveillance Requirements

This section addresses the routine checking or continuous monitoring carried out to ensure that no undetected radiation or gas leak may occur tend to ensure no degradation of air flow through the DTS.

Tests and inspections of equipment necessary to maintain limits are addressed in Section 10.2.1 and 10.2.2.

10.2.3.1 Area Gamma Radiation Monitoring

Title: Area Gamma Radiation Monitoring

Specification: Alarm if in excess of limits specified in Chapter 7.

Applicability: Monitors specified in 7.3.4.1.

Objective: To warn operators of high radiation fields where they might otherwise be working.

Action: If alarm triggered, evacuate/do not enter affected area. Supervisor will arrange to find source of radiation and correct fault under health physics control.

Surveillance: Permanent monitoring with alarms locally, in the Control Center and repeated as a general alarm in the on-site Reactor Control Room.

Basis: See Chapter 7.

10.2.3.2 Portable Radiation Detection

Title: Portable Radiation Detection

Specification
Applicability
Objective
Action
Surveillance

These will be addressed in the site specific Health Physics Procedure

10.2.3.3 Ventilation Systems Radioactivity Monitoring

Title: Ventilation Systems Radioactivity Monitoring

Specification: Alarm if radioactivity exceeds instrument set points

Applicability: Ventilation systems radioactivity monitor at exhaust stack

Objective: To measure, record and alarm radioactivity which may be discharged to atmosphere

Action: If radioactivity is detected, return fuel to casks,and install source cask lid and receiving cask shield plug. Supervisor will arrange to find source of radiation and correct fault under health physics control.

Surveillance: Permanent Monitoring

Periodically check that sampling method is accurate.

Basis: To ensure that discharges are maintained at ALARA levels in accordance with 10CFR20.

10.2.3.4 Shut down during Tornado Watch or Warning

Title: Tornado Watch or Warning Shutdown

Specification:	If a tornado watch or warning is issued for the vicinity of the DTS, the DTS will be shut down.
Applicability:	Any tornado watch or warning within a specified radius of the DTS.
Objective:	To ensure recovery of the fuel assemblies after a tornado.
Action:	Fuel assembly being transferred will be installed in nearest cask. Source cask lid and receiving cask shield plug will be installed on the casks. TC port covers and upper shield port covers will be closed. Control center may be moved to a sheltered area. Casks which are not fully closed (partially welded or bolted) will be moved into the Lower Access Area and the sliding door will be closed.
Surveillance:	Weather shall be monitored on site or from a weather tower within 10 miles of the DTS.
Basis:	Ensure that the fuel assemblies can be removed from the DTS safely after the DTS is struck by a tornado missile.

10.2.4 Design Features

Any minor changes in the design of essential equipment to suit specific site requirements will be covered in site-specific license applications. Control of further changes will be addressed then, and therefore no design controls are provided in this Topical Report.

10.2.5 Administrative Controls

Site specific license applications will contain a full description and discussion of organization and administrative systems and procedures, record keeping, review, audit and reporting necessary to ensure that the operation of the DTS is performed in a safe manner. Therefore, no administrative controls are provided in this report.

CHAPTER 11

11.1 QUALITY ASSURANCE PROGRAM

This chapter describes the quality assurance controls which apply to activities that affect the components and systems important to safety. "Quality Assurance" includes quality control, which comprises those quality assurance actions related to control of the physical characteristics and quality of the material or components to predetermined requirements.

All quality-related activities will be controlled under an NRC-approved quality assurance program, meeting the requirements of 10CFR72 (Ref 11-1), Subpart G. The licensee's QA program will be used to control activities performed by the licensee.

TN is responsible for the DTS as discussed in Section 1.4 of this SAR. TN implements its Quality Assurance Program for nuclear quality-related activities. The TN Quality Assurance Program is being invoked by TN to provide uniformity in the 10CFR72, Subpart G, quality program. The TN Quality Assurance Procedures are used to implement the provisions of the TN Quality Assurance Program for the nuclear quality-related activities associated with the DTS.

The TN Quality Assurance Program will be applied to the Important to Safety (10CFR72) components of the DTS and to the associated nuclear quality-related activities. In addition to compliance with 10CFR72, Subpart G, guidance for the TN Quality Assurance Procedures have been taken from Regulatory Guide 7.10 (Ref. 11-2) and from NUREG/CR-6407 (Ref. 11-3). These quality procedures are used to establish the quality category of components, subassemblies, and piece parts according to each item's importance to nuclear safety.

The matrix in Table 11-1 shows the 10CFR72, Subpart G, criteria and the respective sections of the TN Quality Program that address the criteria.

11-2 Reference

11-1 Title 10, U.S. Code of Federal Regulations, Part 72, (10CFR72), Licensing Requirements for the independent Storage of Spent Nuclear Fuel and High-Level Radioactive Waste, 1995.

11-2 Regulatory Guide 7.10, Establishing Quality Assurance Programs for Packaging Used in the Transport of Radioactive Material, U.S. Nuclear Regulatory Commission, June 1974.

11-3 NUREG/CR-6407, Classification of Transportation Packaging and Dry Spent Fuel Storage System Components According to Importance to Safety, U.S. Nuclear Regulatory Commission, February 1996.

Table 11-1 – Quality Assurance Criteria Matrix

10CFR72, Subpart G		TN Quality Assurance Manual
Section	**Criteria**	**Section**
72.142	Organization	1
72.144	Quality Assurance Program	2
72.146	Design Control	3
72.148	Procurement Document Control	4
72.150	Instructions, Procedures, and Drawings	5
72.152	Document Control	6
72.154	Control of Purchased Material, Equipment, and Services	7
72.156	Identification and Control of Material, Parts, and Components	8
72.158	Control of Special Processes	9
72.160	Licensee Inspection	10
72.162	Test Control	11
72.164	Control of Measuring and Test Equipment	12
72.166	Handling, Storage, and Shipping Control	13
72.168	Inspection, Test, and Operating Status	14
72.170	Nonconforming Materials, Parts, or Components	15
72.172	Corrective Action	16
72.174	Quality Assurance Records	17
72.176	Audits	18