Rail Stress Analysis

Applicable DPT lead resource organization:	Integrated Consultants & Engineers, Inc. (ICE)

JOB NO. **DPT Project 06055**	Location	CALCULATION DESCRIPTION **Stress Analysis**	DISCIPLINE **FEA**
JOB TITLE: **JPod system**			

CALCULATIONS APPLY TO DRAWINGS AND REVISION SHOWN

DRAWING	REV.	DRAWING	REV.	DRAWING	REV.	DRAWING	REV

CALCULATIONS ORIGINATOR

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SIGNATURE DATE SIGNATURE DATE

CALCULATIONS REVIEWED BY

Komarek Martin
SIGNATURE DATE SIGNATURE DATE

APPROVED BY

SIGNATURE DATE SIGNATURE DATE

REMARKS:
ALL CALCULATIONS AGREE WITH DESIGN CRITERIA.

DATE	REV.		Originator	Reviewer
12/08/2006	**1**	**Change Ref. to Legal Name of "JPods, LLC"**	**LRL**	**NA**

STATUS: PRELIMINARY ☐ FINAL **X** CHECK ☐ VOID ☐ HOLD ☐ OTHER

REASON FOR VOID OR HOLD:

TABLE OF CONTENTS

1 Purpose

This report presents calculations, which demonstrate that the design of the JPod system rail is structurally adequate for all applicable load conditions. These loadings include: dead weight, wind and ice. Applicable load combinations are also addressed.

2 Methodology

The structural analysis was performed using ANSYS program. This is finite element method program widely used for engineering calculations. The general methodology of the model development and structural analysis consists of:

1. Developing a three-dimensional model of the JPod system. The model incorporates geometry, appropriate materials and boundary conditions.
2. Applying loads due to dead weight, side wind and ice.
3. Performing structural analysis using ANSYS program.
4. Evaluating the results of the structural analysis. The major focus was on the stresses and displacements of the rail.
5. Documenting the results.

3 Assumptions

The connection between the rail and the frame above the rail is modeled in ANSYS as rigid for conservatism. Future analyses (Phase 2) will consider actual fixity of the joint once the design is complete.

Outside proportions of the JPod cabin are A = 7 ft (high), B = 10 ft (length), C = 5 ft (width)

4 References

1.) Dynamic Power Technologies, LLC, Project-Specific Quality Plan, DPT Project No. 06055. Document: DPT – PQP – BI1, Dated; September 2005.
2.) JPods, LLC, Drawing: 0001A0003-R00 6 inch Drive wheel
3.) JPods, LLC, Drawing: 0001A0005-R01 Aluminum Rail Rev.1
4.) JPods, LLC, Drawing: 0001A0005-R01 Rail Chevron Transitions Rev.1
5.) JPods, LLC, Drawing: 0001A0011-R01 Rail Curve Sections Rev.1
6.) JPods, LLC, Drawing: 0001A0026-R00 Rail Alignment Plate Rev.0
7.) JPods, LLC, Drawing: 0001A0025-R00 Rail Alignment Plate Installation Rev.0
8.) JPods, LLC, Drawing: 0001D0006-R00 JPod Chassis Envelope Rev.0
9.) JPods, LLC, Drawing: 0001D0007-R01 JPod Drive Boggie Rev.1
10.) JPods, LLC, Drawing: 0001D0008-R00 JPod Rail Suspension Concept Rev.1
11.) JPods, LLC, Civil / Structural Engineering Tasks
12.) JPods, LLC, JPod Suspension Tower Calculation
13.) JPods, LLC, JPod System Structural and Civil Design Scope of Work
14.) Material list from www.matweb.com, 6061-T6
15.) Material list from www.matweb.com, Polyether
16.) Dynamic Power Technologies, Rail Loading Diagram
17.) Dynamic Power Technologies, Suspension Truss
18.) Dynamic Power Technologies, Wind Calculations

5 Input Data

Materials

Material used for the rail is Aluminum 6061-T6 (Ref.3)
Material used for the JPod wheels is Polyether (Ref.2)

Table 5-1: Material properties used in analysis

Component	Young's modulus E [ksi]	Poisson's ratio μ [1]	Density ρ [lb/in^3]	Tensile Yield strength Sy [psi]	Reference
Rail 6061-T6	10000	0.33	0.0975	40000	14
Polyether	72.5	0.4	0.0397	5800	15

Ice parameters

$\rho_i = 0.03613\,\mathrm{lb/in^3}$ *- density of ice*

$t_{i1} = 1\,\mathrm{in}$ *- thickness of the ice on the top of the rail*

$t_{i2} = 0.25\,\mathrm{in}$ *- thickness of the ice on the sides of the rail*

Dimensions

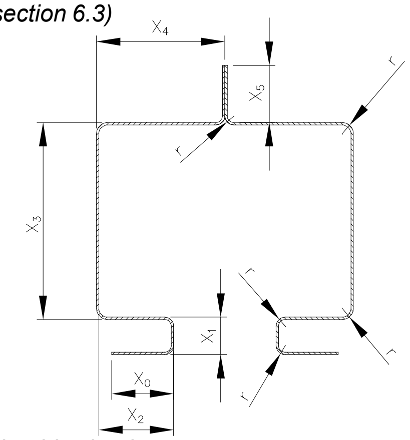
$L = 144\,\mathrm{in}$ *- total length of one rail segment*

$t_1 = 0.162\,\mathrm{in}$ *- rail wall thickness*

$t_2 = 0.2\,\mathrm{in}$ *- rail wall thickness (for thickness effect calculation, see section 6.3)*

$t_3 = 0.25\,\mathrm{in}$ *- rail wall thickness (for thickness effect calculation, see section 6.3)*

$l_O = x_0 + x_1 + x_2 + x_3 + x_4 + x_5$ *- circumferencial length*



$x_0 = 2.6\,\mathrm{in}$

$x_1 = 1.57\,\mathrm{in}$

$x_2 = 3.14\,\mathrm{in}$

$x_3 = 8.07\,\mathrm{in}$

$x_4 = 5.29\,\mathrm{in}$

$x_5 = 2.5\,\mathrm{in}$

$r = 0.38\,\mathrm{in}$ *- radius*

$A = 7\,\mathrm{ft}$ *- high of the JPod cabin*

$B = 10\,\mathrm{ft}$ *- length of the JPod cabin*

$C = 5\,\mathrm{ft}$ *- width of the JPod cabin*

$S = 33.5\,\mathrm{in}$ *- distance from the center of the JPod to the center of the drive bogie*

$R = 4.5\,\mathrm{in}$ *- distance between upper and lower side wheels of the drive bogie*

Loads

$W_1 = 7\,\mathrm{psf@30mph}$ *- side wind pressure*

$W_2 = 20.7\,\mathrm{psf@90mph}$ *- side wind pressure*

$F_A = 1750\,\mathrm{lb}$ *- total weight of the loaded JPod cabin and drive bogie*

6 Loading and Configuration Description

6.1 Load Cases

NOTE: The initial investigation and corresponding results (Tables 9-1 to 9-6 and Figures 9-1 & 9-2) assumed that the rail was rigidly attached to the support structure above (which is overly conservative). However, the actual "proposed" rail connection permits the rail to pivot. See Section 9.3, which documents the final qualification and excludes Load Case 1.

Load cases were defined by customer. There are three different possible load combinations which should be applied on the JPod system and analyzed.

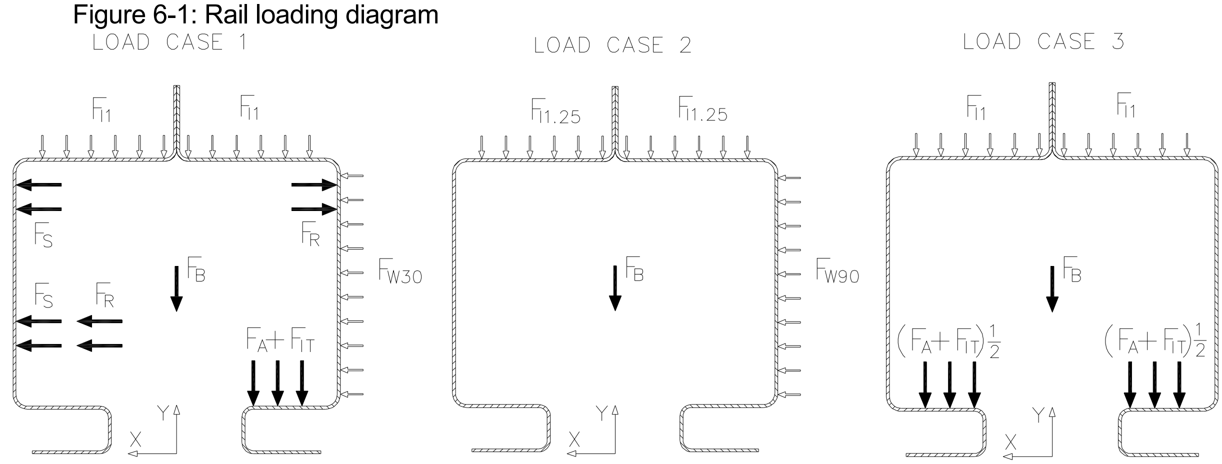
LOAD CASE 1
This load case is combination of the following loads:
- Front drive bogie wheels carry 2/3 of F_A load (see section 5.).
- Rear drive bogie wheels carry 1/3 of F_A load (see section 5.).
- Dead weight of the rail
- Load from steady wind blowing on the JPod cabin and rail, 30mph = 7psf
- Load from 1in thick ice on the top of the rail and JPod cabin

Dead weight loads of the JPod cabin and ice on the cabin are applied only on one side of the rail due to side wind.

LOAD CASE 2
This load case is combination of the following loads:
- Dead weight of the rail
- Load from steady wind blowing on the rail, 90mph = 20.7psf
- Load from 1in thick ice on the top of the rail and 1/4in on the sides of the rail

LOAD CASE 3
This load case is combination of the following loads:
- Front drive bogie wheels carry 2/3 of F_A load (see section 5.).
- Rear drive bogie wheels carry 1/3 of F_A load (see section 5.).
- Dead weight of the rail
- Load from 1in thick ice on the top of the rail and JPod cabin

Figure 6-1: Rail loading diagram



X – Lateral, Y – Vertical, Z – Along the rail axis

F_A = *Maximum load from the full JPod cabin*

F_B = *Weight of the rail by gravity*

F_{I1} = *Weight of 1" of ice on the top of the rail*

$F_{I1.25}$ = *Weight of 1" of ice on the top and 1/4" of ice on the sides of the rail*

F_{IT} = *Weight of 1" of ice on the top of the JPod cabin*

F_S = *Force from side wind on the JPod cabin apply as a single force @30mph*

F_{W90} = *Force from side wind on the side of the rail @90mph*

F_{W30} = *Force from side wind on the side of the rail @30mph*

F_R = *Rocking force due to side wind @30mph on the JPod cabin.*
Rocking force comes from the wind blowing on the JPod cabin from one side. Moment generated by the wind on the side of the JPod was transferred to the rail by equivalent force couple.

6.2 Configurations

Two different positions of the JPod cabin were considered in this analysis. It is expected that these cases are controlling and will generate the highest stresses. Three configurations were defined as follows:

Configuration A – Cross-Section at Center of the Rail

The JPod cabin is approximately in the middle of the rail segment so that the wheel carrying 2/3 of the dead weight load is right between the rail supports. Rail segments are connected together by alignment plate at the bottom of the rail. All three load cases are applied.

Configuration B – At End of the Rail with No Alignment Plates

JPod cabin is at the end of the rail segment. Front wheels are located at the end of the rail. It is expected that this configuration will generate the highest stresses for this region and may be the critical case. Rail segments are NOT connected together by alignment plate at the bottom of the rail. All three load cases are applied.

Configuration C – At End of the Rail with Alignment Plates

JPod cabin is at the end of the rail segment. Front wheels are located at the end of the rail. It is expected that this configuration will generate the highest stresses for this region and may be the critical case. Rail segments are connected together by alignment plate at the bottom of the rail. All three load cases are applied.

6.3 Thickness effect calculation

To investigate effect of the different rail wall thickness, load case 1 is analyzed for all three configurations using thickness of 0.2in and 0.25in. There are possibilities that the different wall thickness has significant effect on the stresses and deflections of the rail.

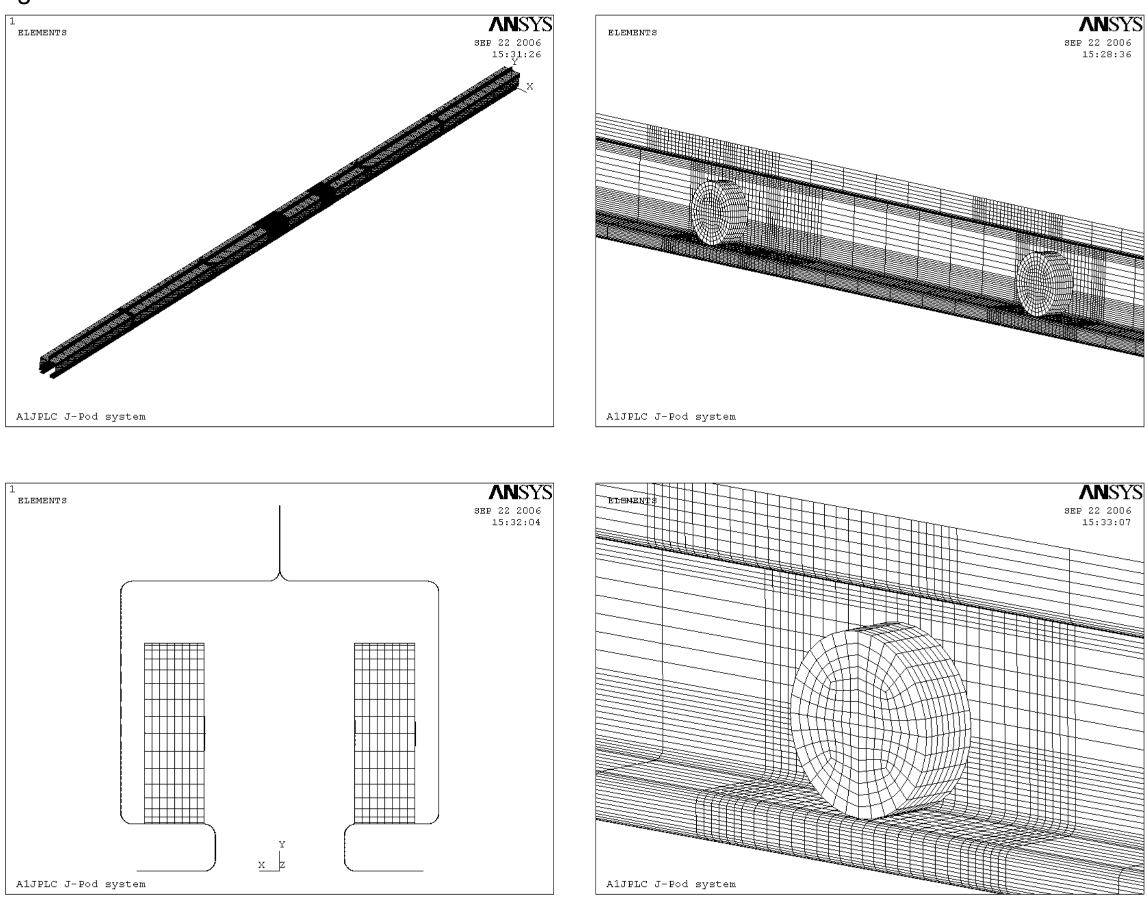
7 Model Description

7.1 Model design description

The model is created and analyzed using the ANSYS, Version 8.1 finite element analysis code.
Model is composed from 3 straight rail segments and four wheels. The rail segment model consists of SHELL63 elastic shell elements. This type of element has all six degrees of freedom at each node. The shell element thickness was defined to be 0.162 inches (for thickness effect calculation values of 0.2 and 0.25 inches were used, section 6.3). Wheels were modeled using SOLID45 brick elements with 8 nodes. Contact between the rail and the wheels are realized by contact pairs and CONTAC173. 3-D 4 node surface to surface contact elements are applied on the wheels and 3-D target surface element TARGE170 are applied on the rail inner surface where wheel - rail contact occurs. Default real constants were used for these contact elements. The length of the rail segment is constructed to be 144in. Side wheels were not modeled this time and reactions from these wheels were applied as forces in Load Case 1.

The rail is analyzed for two different positions of the JPod cabin. For details see Section 6.2 configurations.

Figure 7-1: Model with mesh



7.2 Boundary conditions

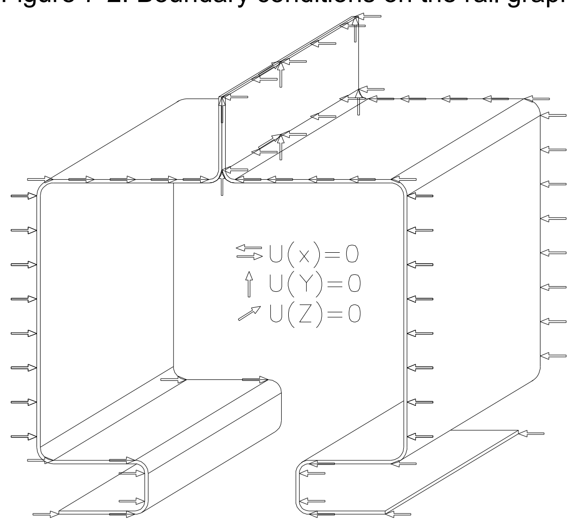
The model in all load cases includes following boundary conditions:

Ux = 0 is applied along the top of three segments of the rail, in the middle of every wheel and on both ends of the rail. The rail consists of three rail segments. The ends of the middle segment are not restrained. The rail ends are restrained at the beginning of the first segment and the end of the last segment only.

Uy = 0 is applied in the middle and at the end of every segment.
Uz = 0 is applied in several nodes in the middle of every segment.

The rail is restrained in “z” direction in the middle of each rail segment.

Figure 7-2: Boundary conditions on the rail graphically



8 Calculations

Calculation of forces and moments applied on the rail.

Load Case 1:

$$F_A = 1750\,\text{lb}$$
$$F_B = 2\times L\times t_1\times \rho\times l_0 = 2\times 144\times 0.162\times 0.0975\times(2.6+1.57+3.14+8.07+5.29+2.5) =$$
$$= 105.4\,\text{lb}$$
$$F_{I1} = 2\times\rho_i\times t_{i1}\times L\times(x_4 - r) = 2\times 0.03613\times 1\times 144\times(5.29-0.38) = 51.1\,\text{lb}$$
$$F_{IT} = 144\times B\times C\times\rho_i\times t_{i1} = 144\times 10\times 5\times 0.03613\times 1 = 260\,\text{lb}$$
$$F_S = W_1\times A\times B = 7\times 7\times 10 = 490\,\text{lb}$$
$$F_{W30} = W_1\times\frac{(x_3 - 2\times r)\times L}{144} = 7\times\frac{(8.07-2\times 0.38)\times 144}{144} = 51.2\,\text{lb}$$
$$F_R = \frac{F_S\times S}{R} = \frac{490\times 33.5}{4.5} = 3648\,\text{lb}$$

Total force in two directions

$$F_Y = F_A + F_B + F_{I1} + F_{IT} = 1750 + 105.4 + 51.1 + 260 = 2166.5\,\text{lb}$$
$$F_X = F_S + F_{W30} = 490 + 51.2 = 541.2\,\text{lb}$$

Rocking force is applied separately as a force couple in X direction as it is shown in Figure 6-1.

Load Case 2:

$$F_B = 2\times L\times t_1\times \rho\times l_0 = 2\times 144\times 0.162\times 0.0975\times(2.6+1.57+3.14+8.07+5.29+2.5) =$$
$$= 105.4\,\text{lb}$$
$$F_{I1.25} = 2\times\rho_i\times t_{i1}\times L\times(x_4 - r) + 2\times\rho_i\times t_{i2}\times L\times(x_3 - r) =$$
$$= 2\times 0.03613\times 1\times 144\times(5.29-0.38) + 2\times 0.03613\times 0.25\times 144\times(8.07-0.38) =$$
$$= 71.1\,\text{lb}$$
$$F_{W90} = W_2\times\frac{(x_3 - 2\times r)\times L}{144} = 20.7\times\frac{(8.07-2\times 0.38)\times 144}{144} = 151.3\,\text{lb}$$

Total force in two directions

$$F_Y = F_B + F_{I1.25} = 105.4 + 71.1 = 176.5\,\text{lb}$$
$$F_X = F_{W90} = 151.3 = 151.3\,\text{lb}$$

Load Case 3:

$$F_A = 1750\text{ lb}$$
$$F_B = 2 \times L \times t_1 \times \rho \times l_0 = 2 \times 144 \times 0.162 \times 0.0975 \times (2.6 + 1.57 + 3.14 + 8.07 + 5.29 + 2.5) =$$
$$= 105.4\text{ lb}$$
$$F_{I1} = 2 \times \rho_i \times t_{i1} \times L \times (x_4 - r) = 2 \times 0.03613 \times 1 \times 144 \times (5.29 - 0.38) = 51.1\text{ lb}$$
$$F_{IT} = 144 \times B \times C \times \rho_i \times t_{i1} = 144 \times 10 \times 5 \times 0.03613 \times 1 = 260\text{ lb}$$

Total force in two directions

$$F_Y = F_A + F_B + F_{I1} + F_{IT} = 1750 + 105.4 + 51.1 + 260 = 2166.5\text{ lb}$$
$$F_X = 0$$

9 Results

The structural analysis for all configurations and load combinations was performed using ANSYS program. This section documents calculated displacements and stresses. As discussed before, all nine combinations are evaluated for nominal rail wall thickness of 0.162in. In addition, the Load Case 1 and Load Case 3 is evaluated for another two rail wall thicknesses of 0.2in and 0.25in.

9.1 Results for the rail wall thickness of 0.162in

Both stresses and displacements are considered to demonstrate that the design of the JPod system rail is structurally adequate for all applicable load conditions.

Stress results:
Several different stresses are evaluated and compared to its allowable values.

- Stress Intensity (S_{INT}) – maximum stress intensity is directly taken from the model and compared to allowable stress of Sy.
- Normal stress (S_N) – normal stress is taken from the model as maximum absolute value of principal stresses (S1 and S3). The allowable stress value is taken as Sy.
- Shear stress (S_{Shear}) - Shear stress is not calculated directly in the model. It is conservatively taken as 1/2 of the stress intensity since this is the maximum value which can eventually occur. The allowable stress value is taken as 0.4*Sy.
- Bearing stress ($S_{Bearing}$) – bearing stress is taken from the model as maximum contact pressure between the wheels and the rail. The allowable stress value is taken as 0.9*Sy.

Note that allowable stress values used for comparison are typical ASME Code stress allowables. Table 9-1 documents calculated stresses and its allowables as discussed above.

Displacements:
In addition to the stress results, the maximum displacements in X (lateral) and Y (vertical) directions are evaluated and documented. These displacements include both effects: global deflection of the rail as a beam segment and local deformation of the rail profile. These results are listed in Table 9-2. Negative displacement in X direction means that the rail profile is opening up. Negative displacement in Y direction means that the rail is deformed downward due to vertical load. Positive displacement in Y direction means that rail is deformed upward, that is caused mostly by the local effect of the profile deformation.

Table 9-1: List of stresses for all load cases and configurations (* Assumes Rigid Attachment)

Configuration / Load Case	S_{INT} [psi]	S_N [psi]	S_{Shear} [psi]	$S_{Bearing}$ [psi]
A / 1*	64502	65860	32251	3559
A / 2	4252	4272	2126	33
A / 3	29074	29074	14537	2131
B / 1*	138741	140204	69370	15941
B / 2	5481	5600	2740	5
B / 3	73880	74673	36940	10571
C / 1*	106184	107344	53092	9208
C / 2	4225	4316	2113	9
C / 3	63593	64283	31796	2237
Allowable stress	**40000**	**40000**	**16000**	**36000**

* Load Case 1 is considered overly conservative – see Section 9.3

Table 9-2: List of displacements for all load cases and configurations (* Assumes Rigid Attachment)

Configuration / Load Case	X [inch]	Y [inch]
A / 1*	-2.761	0.520
A / 2	0.149	-0.038
A / 3	0.049	-0.117
B / 1*	-5.676	1.273
B / 2	0.187	-0.050
B / 3	0.106	-0.257
C / 1*	-2.852	-0.670
C / 2	0.150	-0.038
C / 3	0.086	-0.159

* Load Case 1 is considered overly conservative – see Section 9.3

9.2 Comparison of results for rail wall thickness of 0.2in and 0.25in

To investigate effect of the different rail wall thickness, load case 1 and load case 3 was analyzed for all three configurations using thickness of 0.2in and 0.25in. Table 9-3 shows stress results and Table 9-4 shows displacements for the wall thickness of 0.2in. Table 9-5 shows stress results and Table 9-6 shows displacements for the wall thickness of 0.25in.
Charts in Figure 9-1 to 9-6 show comparison of stresses and displacements for all three thicknesses (0.162in, 0.2in and 0.25in).

Table 9-3: List of Stresses for thickness of 0.2 [in] (* Assumes Rigid Attachment)

Configuration / Load Case	S_{INT} [psi]	S_N [psi]	S_{Shear} [psi]	$S_{Bearing}$ [psi]
A / 1*	42981	43725	21490	2927
B / 1*	99473	101246	49737	16287
C / 1*	74652	75365	37326	4494
A / 3	20538	20538	10269	1596
B / 3	55574	56566	27787	9015
C / 3	43697	44122	21849	1724
Allowable stress	**40000**	**40000**	**16000**	**36000**

* Load Case 1 is considered overly conservative – see Section 9.3

Table 9-4: List of Displacements for thickness of 0.2 [in] (* Assumes Rigid Attachment)

Configuration / Load Case	X [inch]	Y [inch]
A / 1*	-1.46	-0.265
B / 1*	-3.016	0.679
C / 1*	-1.397	-0.364
A / 3	-0.030	-0.071
B / 3	-0.071	-0.174
C / 3	-0.048	-0.104

* Load Case 1 is considered overly conservative – see Section 9.3

Table 9-5: List of Stresses for thickness of 0.25 [in] (* Assumes Rigid Attachment)

Configuration / Load Case	S_{INT} [psi]	S_N [psi]	S_{Shear} [psi]	$S_{Bearing}$ [psi]
A / 1*	30863	31145	15432	2616
B / 1*	73547	74855	36774	9959
C / 1*	50832	51729	25416	2794
A / 3	9128	9128	4564	1395
B / 3	45081	45081	22541	3688
C / 3	27493	27894	13747	1321
Allowable stress	**40000**	**40000**	**16000**	**36000**

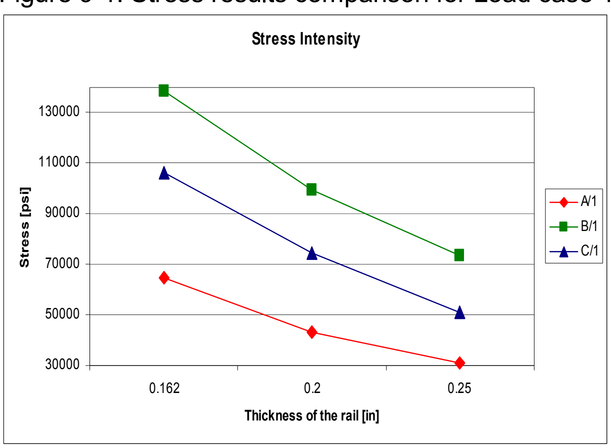
* Load Case 1 is considered overly conservative – see Section 9.3

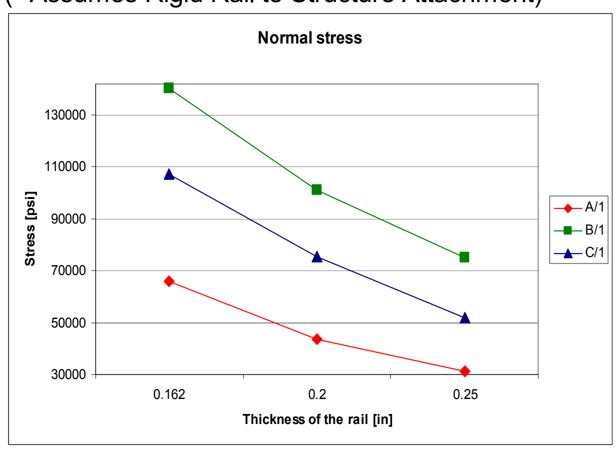
Table 9-6: List of Displacements for thickness of 0.25 [in] (* Assumes Rigid Attachment)

Configuration / Load Case	X [inch]	Y [inch]
A / 1*	-0.849	-0.156
B / 1*	-1.545	0.349
C / 1*	-0.881	-0.189
A / 3	-0.016	-0.047
B / 3	-0.039	-0.138
C / 3	-0.017	-0.057

* Load Case 1 is considered overly conservative – see Section 9.3

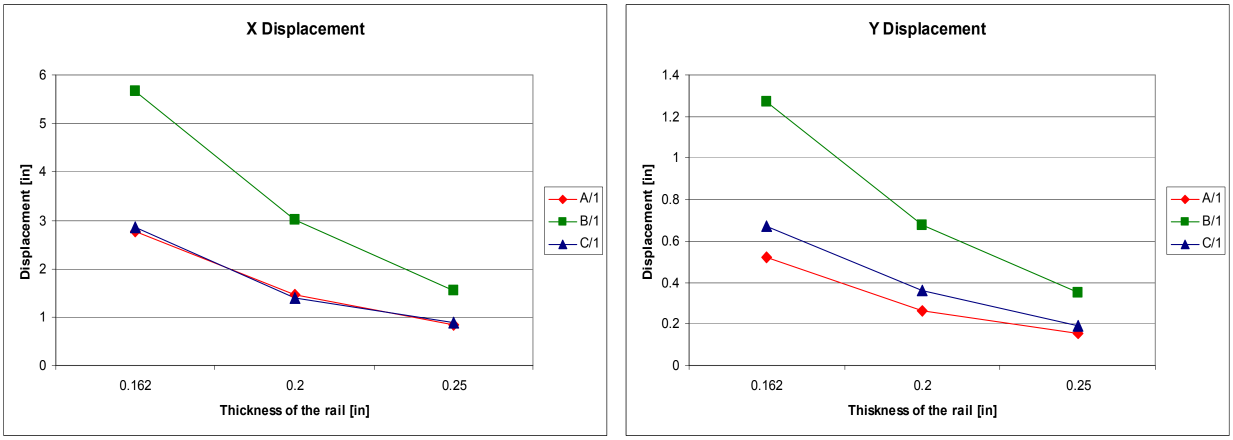
Figure 9-1: Stress results comparison for Load case 1 (* Assumes Rigid Rail to Structure Attachment)





* Load Case 1 is considered overly conservative – see Section 9.3

Figure 9-2: Displacement results comparison for Load case 1 (* Assumes Rigid Rail Attachment)



* Load Case 1 is considered overly conservative – see Section 9.3

Figure 9-3: Stress results comparison for Load case 3

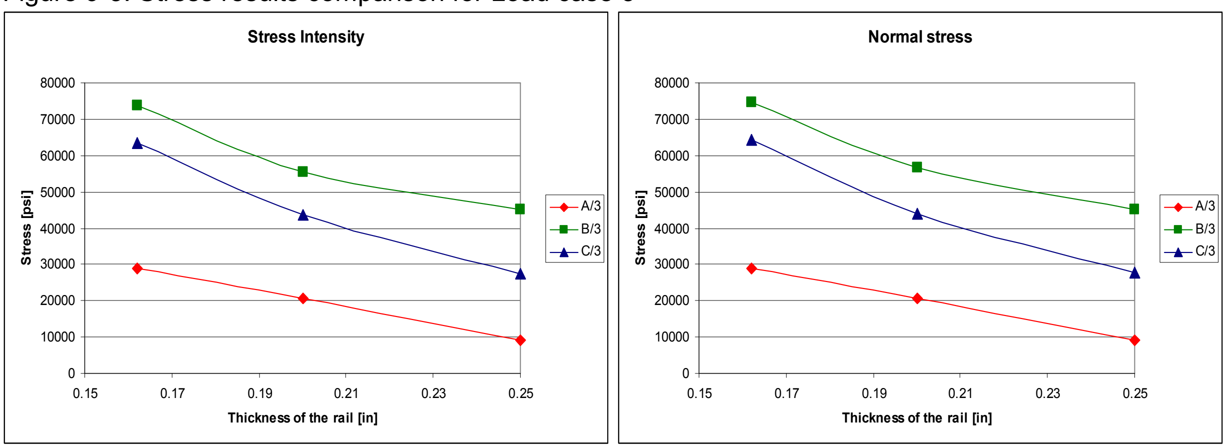


Figure 9-4: Displacement results comparison for Load case 3

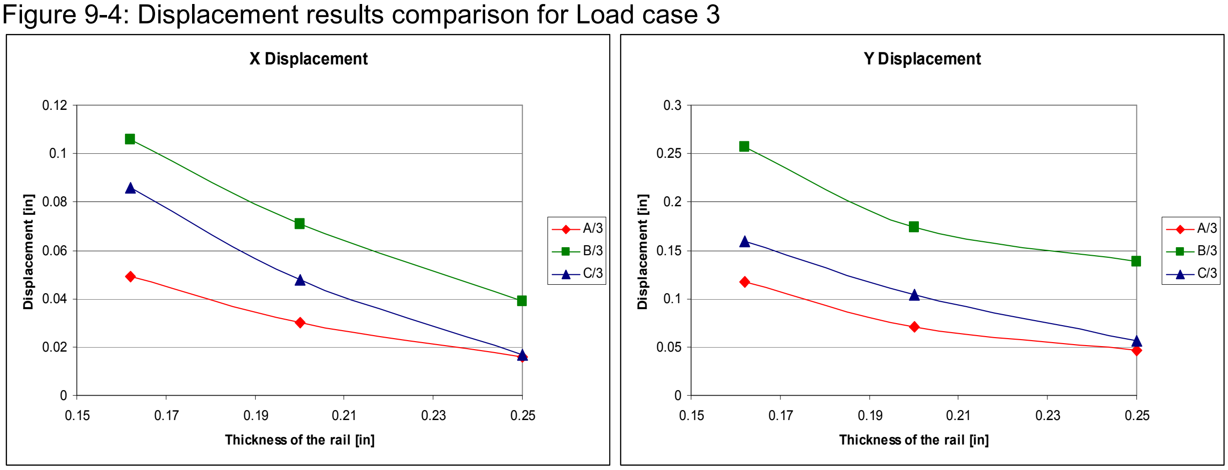
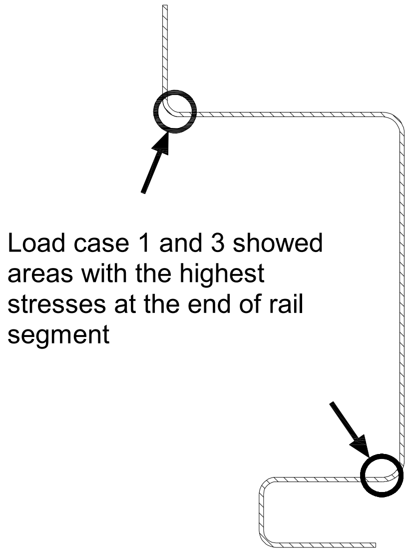


Figure 9-5: Areas with critical stresses



9.3 Design Qualification

This section provides the qualification of the rail design. It was analyzed for three different load cases, three different configurations and three different thicknesses of the rail wall.

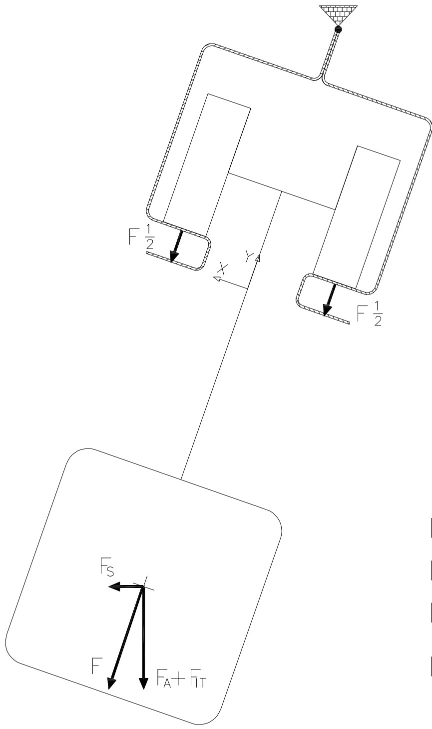
However, Configuration B (without alignment plates) has been dismissed during the course of this investigation and no longer is valid. Load Case 1 is deemed to be overly conservative since it assumes that the rail is rigidly attached to the support structure above. With the rail rigidly attached, winds load on the side to JPod carriage is restrained by a force-couple pushing on the inside of the rail (as depicted in Figure 6-1). Where as, the actual design detail (using horizontal bolts or pins) for connecting the rail to the structure permits rotation. In addition, Load Case 3 provides for higher stresses and displacements than Load Case 2. As such, Load Case 2 will not be addressed in the final qualification.

Therefore a new case, Load Case 3EX will be used for final qualification, which includes the Load Case 3 effects (worse case working conditions) and accounts for wind effects on the JPod carriage. JPod Carriage Wind Forces are actually transferred into an added downward force as indicated in Figure 9-6 (below). The increase in downward force is approximately +3%, but for conservatism, the stresses for Configuration C, Load Case 3 found in Tables 9-1, 9-3 and 9-5 have been increased by 5% as shown in Table 9-7.

Table 9-7: List of Stresses for 3 Wall Thickness (Configuration C and Load Case 3EX)

Rail Wall Thickness	S_{INT} [psi]	S_N [psi]	S_{Shear} [psi]	$S_{Bearing}$ [psi]
0.162 inch	66773	67497	33386	2349
0.20 inch	45882	46328	22942	1810
0.25 inch	28868	29289	14434	1387
Allowable stress	**40000**	**40000**	**16000**	**36000**

Figure 9-6: The rail profile pinned to the frame



$$F_S = W_1 \times A \times B = 490\text{lb}$$
$$F_A = 1750\text{lb}$$
$$F_{IT} = 144 \times B \times C \times \rho_i \times t_{i1} = 144 \times 10 \times 5 \times 0.03613 \times 1 = 260\text{ lb}$$
$$F = \sqrt{(F_A + F_{IT})^2 + F_S^2} = \sqrt{2010^2 + 490^2} = 2070\text{lb}$$

The new downward force calculated in Figure 9-6 is 3% higher than downward force F_A+F_{IT}.

10 Conclusions & Recommendations:

The rail cross-section meets the stress criteria presented for all load cases provided that:

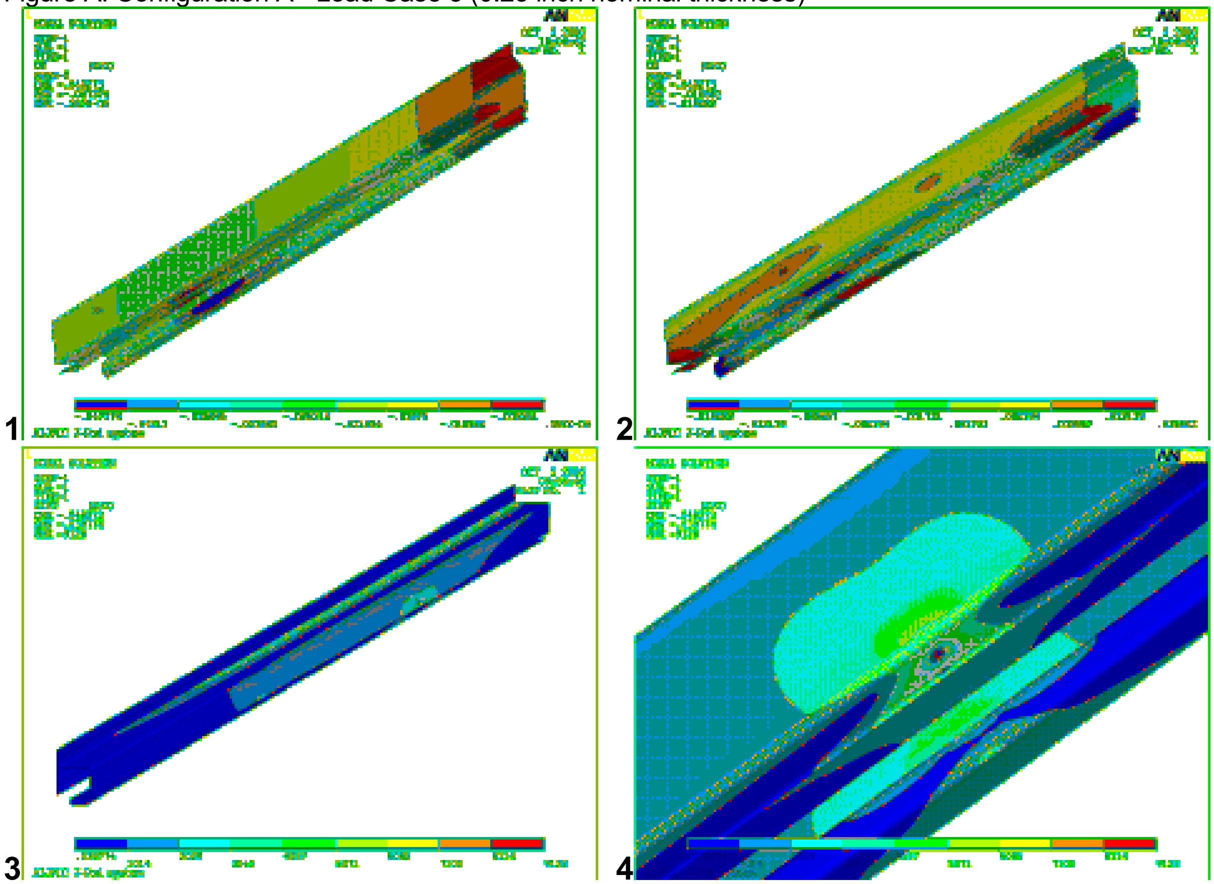
1. The rail is pinned to the support frame above and the rail is permitted to pivot
2. The rail segments are connected together by alignment plates
3. The wall thickness of the rail is not less than 0.25 inch.
4. Rail halves are bolted together at intervals of 6.0 inches or less

The lateral (x direction) deflection of the rail is not more than 0.03 inch (Configuration 3, Load Case 3) and the vertical (y direction) deflection is not more than 0.10 inch (Configuration 3, Load Case 3); which both seem reasonable.

Additional analysis / confirmation may be required, once a specific project / code requirements are identified and in particular to make an assessment of fatigue effects. At that time, the rail model can be refined in order to change the fixity of the rail to support structure (i.e., to a pinned joint).

APPENDIX A

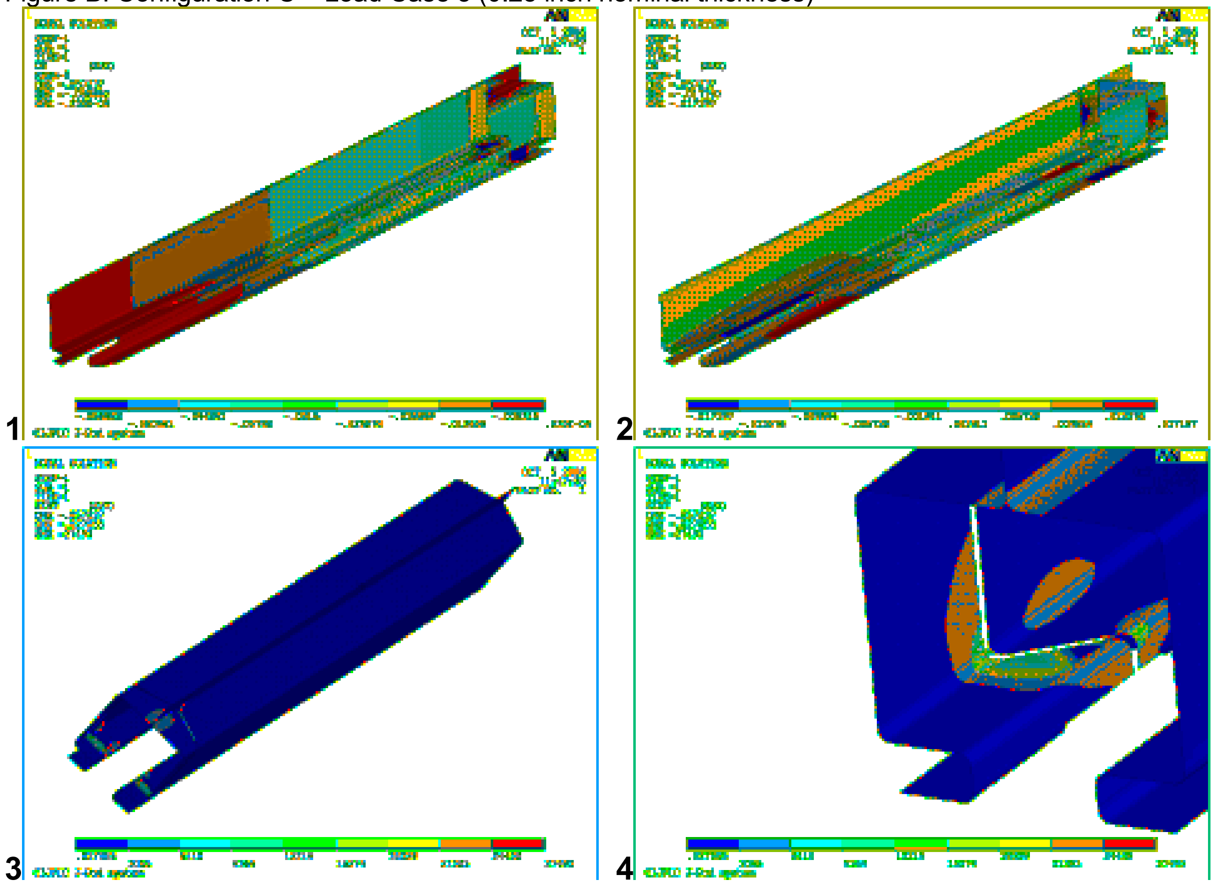
Figure A: Configuration A - Load Case 3 (0.25 inch nominal thickness)



1 – DY displacement [inch] axonometric view, deflection of the rail in vertical (Y) direction.
2 – DX displacement [inch] axonometric view, deflection of the rail in lateral (X) direction.
3 – Stress Intensity [psi]
4 – Maximum Stress Intensity [psi] is on the bottom part of the rail.

APPENDIX B

Figure B: Configuration C – Load Case 3 (0.25 inch nominal thickness)



1 – DY displacement [inch] axonometric view, deflection of the rail in vertical (Y) direction.
2 – DX displacement [inch] axonometric view, deflection of the rail in lateral (X) direction. The largest deflection of the rail is at the end of the rail.
3 – Stress Intensity [psi]
4 – Maximum Stress Intensity [psi] is on the bottom part of the rail at the corner.