Finite Element Analysis of WaterFence- Water Load and Wind Load

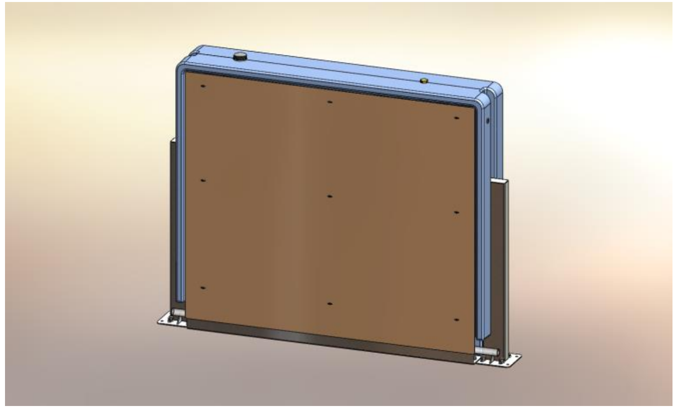

Fig. 1: WaterFence Assembly

The following is a brief report on the findings of wind loaded and water loaded finite element analyses performed on the WaterFence assembly. The model file used for both tests was 19681-02 B_R B6. The resin properties used were based on the Surpass RMs-539-U. The wall thickness of the fence/tank for all tests was .3125". Below in Fig. 2, is a plot of the mesh applied to the tank/fence part and post. Yield Strength = 2900 psi, Poisson's Ratio = 0.394. The analyses were both non-linear.

Fig. 2: Mesh

Wind Loaded FEA:

The wind loaded FEA was run several times, starting at 92 mph on up to 150 mph loads. The flexural modulus was de-rated from 113,000 psi to 100,000 psi to simulate a conservative test as the properties of the resin can vary due to variances in manufacturing . At that 150 mph load, the fence and posts were still engaged and would stay intact. If higher wind loads are desired, they can be run until they no longer converge which would indicate a failure. The fence posts were not touching the plastic fence/tank as a 1/2" gap is used for thermal expansion when higher temperatures occur. The part is in contact with a sheet metal tray on the bottom and is held at two points to prevent the part from spinning during the test. The side recesses are free to move up to the fence posts. The stresses from the 150 mph wind load are shown in figures 3 and 4 below. The highest stresses are approx. 1313 psi which is well below the resin's properties.

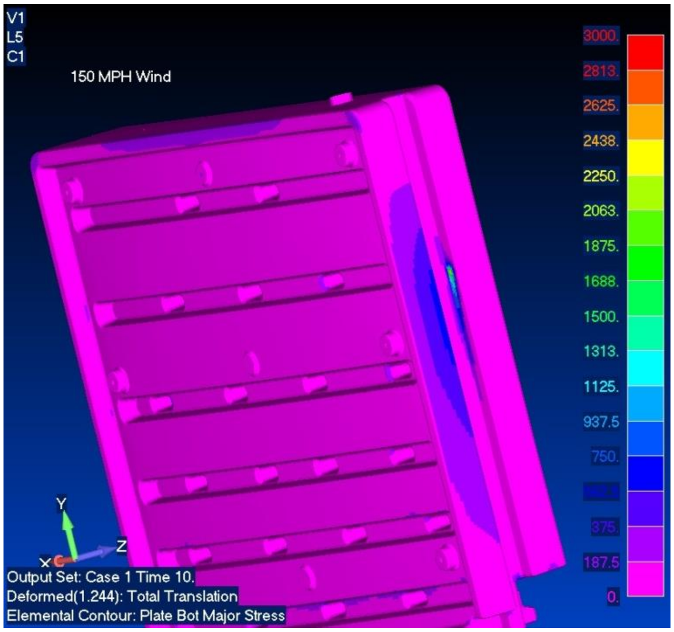

Fig. 3: Front Side Stresses

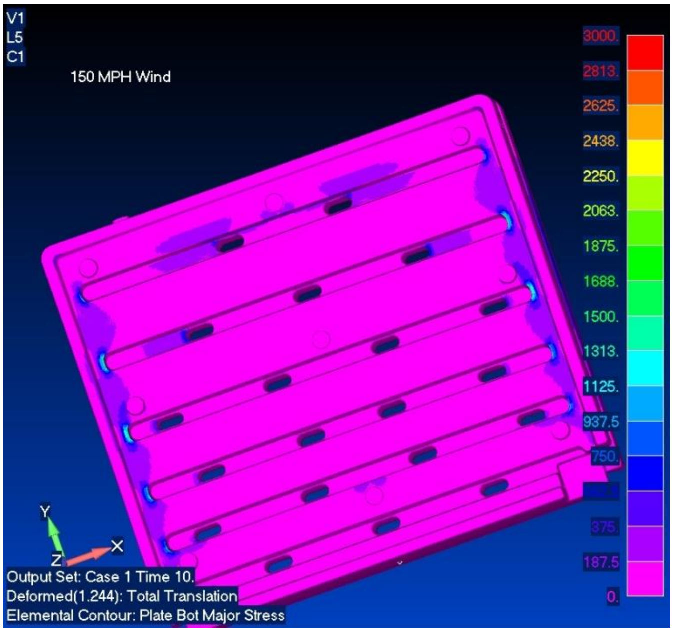

Fig. 4: Back Side Stresses

In fig. 5, the stresses are shown for the HSS fence posts. The wall thickness of the hollow rectangular tubes was .125". The posts were constrained from movement in all directions at the bottom.

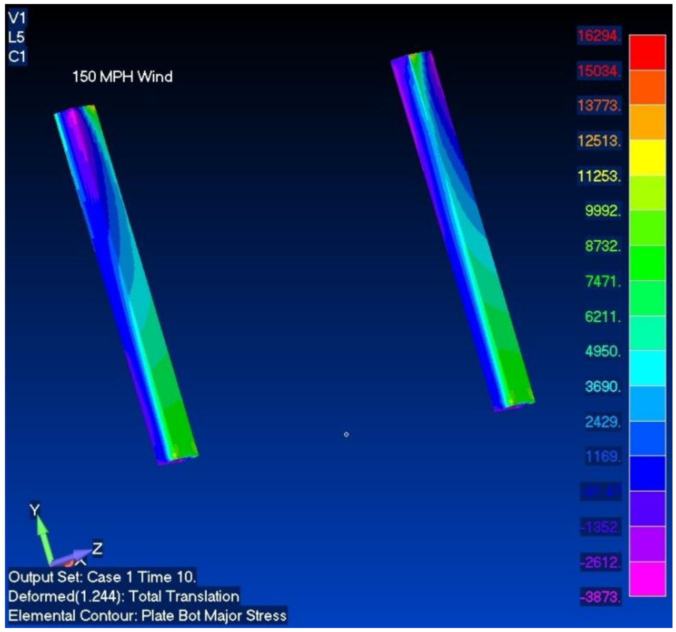

Fig. 5: Fence Post Stresses at 150 mph.

In fig. 6 below, the expected deflections of the empty tank at a 150 mph wind load are shown. The maximum deflection on the face of the fence/tank is 1.244" and the fence posts are still engaged within the recesses of the fence.

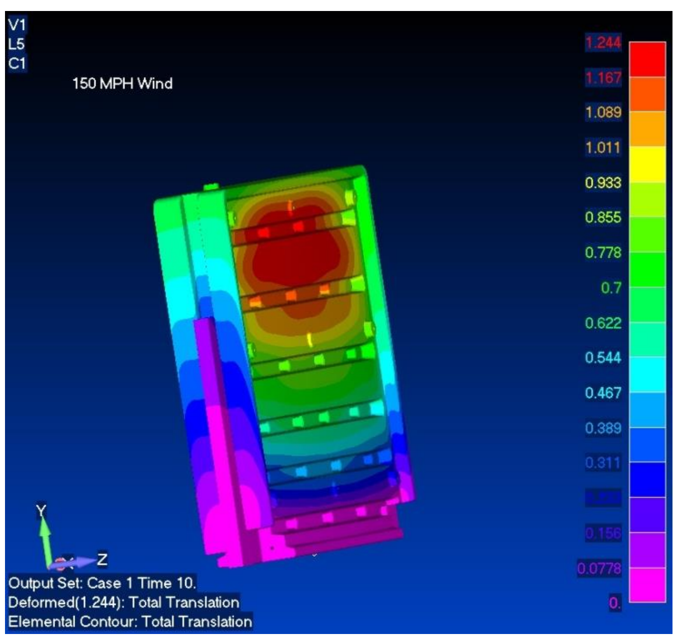

Fig. 6: Deflections of the Empty Tank.

Conclusions:

The empty tank assembled between the fence posts simulated by the de-rated conservative flexural modulus of 100,000 psi can withstand wind loading of 150 mph and still stay assembled to the fence posts as a unit. It may be possible it can withstand higher winds, but further testing would be required.

Water Loaded FEA:

The water loaded FEA used a de-rated flexural modulus of 70,000 psi as the plastic is likely to see elevated temperatures of 120° and to simulate creep. The simulation assumed the tank/fence was filled to the top with water. The load of the water was applied as a gradient of 0 psi at the very top down to 2.6 psi at the bottom. Fig. 7 shows the expected deformations under load. The maximum deflections are shown in red as .551". The sides will bulge that much up to the fence post to fill the gap and then stop. The sides of the post recesses in the plastic tank will expand to fill the clearance gap and stop.

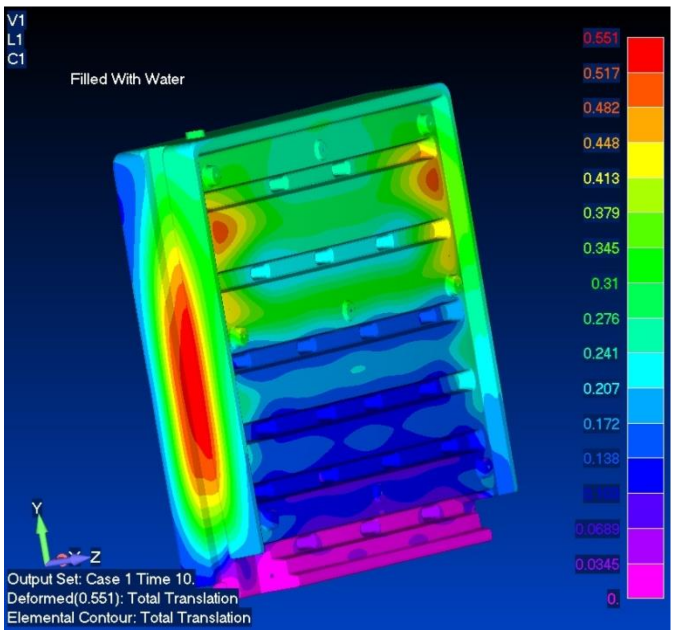

Fig. 7: Deflections Under Water Load.

The next plot, fig. 8, shows the deflections in strictly the Z axis which is front to back on the part. When looking at these deflections, it is important to keep in mind relative distance also. For example, the red areas show .473" of movement, but are surrounded by green which is .241". This means that the distance from the red area to the green area is .232".

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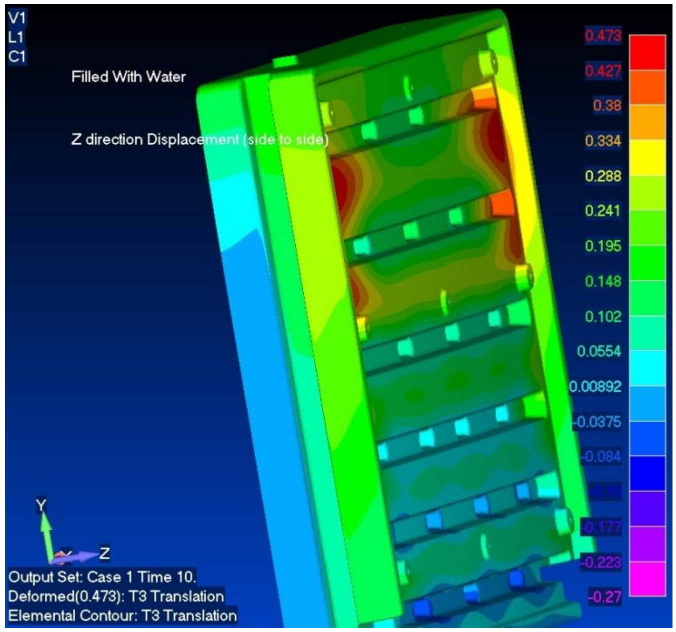

Fig. 8: Z Direction Displacements Only

To see the stresses expected for the completely filled tank/fence, see fig. 9 below. The expected max. stresses of 750 psi of the filled tank are well below the resin's specs. and show no failure.

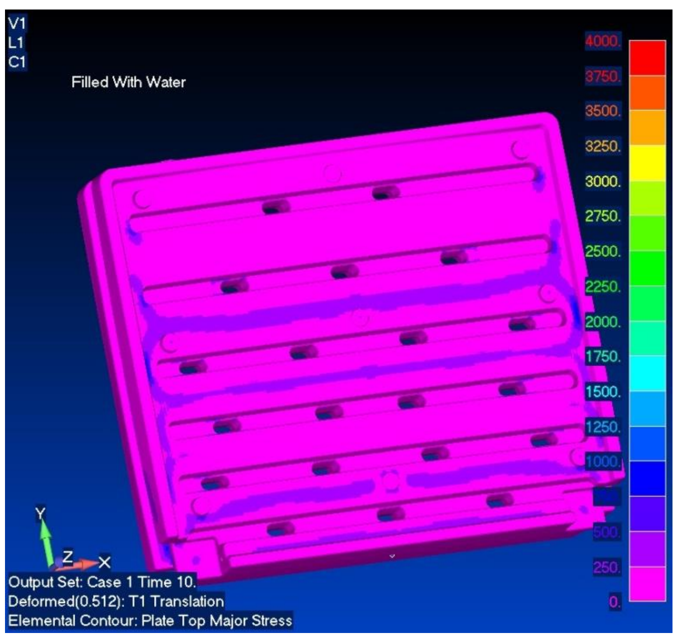

Fig. 9: Filled Tank Stresses

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Conclusions:

The completely filled tank/fence will support the load of the water with little stress, but with some deformation. The deformation that will occur in the post recesses shouldn't be a problem as the flexural modulus is de-rated signifying reduced properties from high temperature. If the fence is at a high temperature, the gap is filled and the plastic is reinforced at that specific area by the post.

Addendum:

Since the FEA's were completed before a last minute change to the fence/tank part, I wanted to be sure there wouldn't be a possibility that the water loaded FEA wasn't applicable any more. The change was to remove the bottom "framing" boss that protruded from the curved front and back surfaces of the fence outward so that the tray could be narrowed to make the 3" vertical lip be hidden behind the decorative fascia. The model file 19681-02 B_R B7 was used for this quick test. The part was subjected to a 4 psi internal pressure on all surfaces and constraining it minimally to see if the bottom stresses would be too high. This does not give any support to the model beyond what is needed to prevent rigid model motion and the internal load is higher than that seen when filled with water. Note that the water loaded FEA test was run at a high of 2.6 psi at the bottom. The plot of fig. 10 shows deformations of 1" at the bottom where the revision was made.

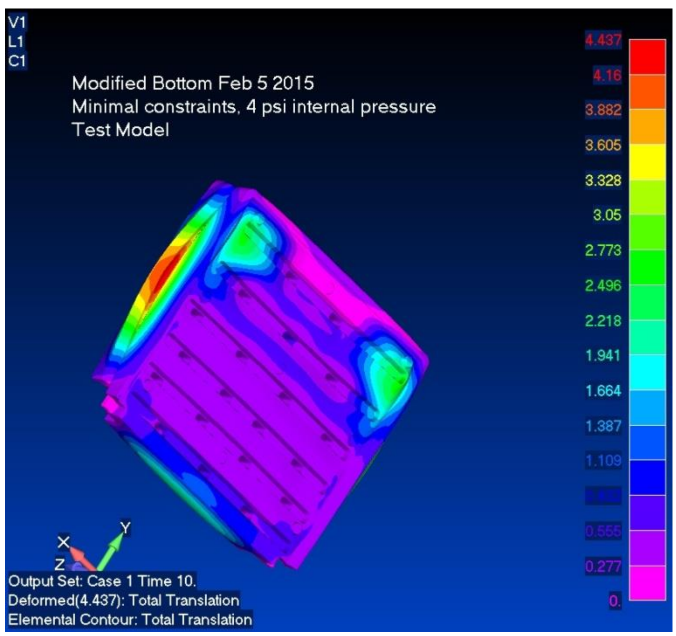

Fig. 10: Deformations at 4 psi.

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The plot of fig. 11 shows the stresses associated with the 4 psi load. The area at the bottom where the change was made show very low stresses of approx. 250 psi.

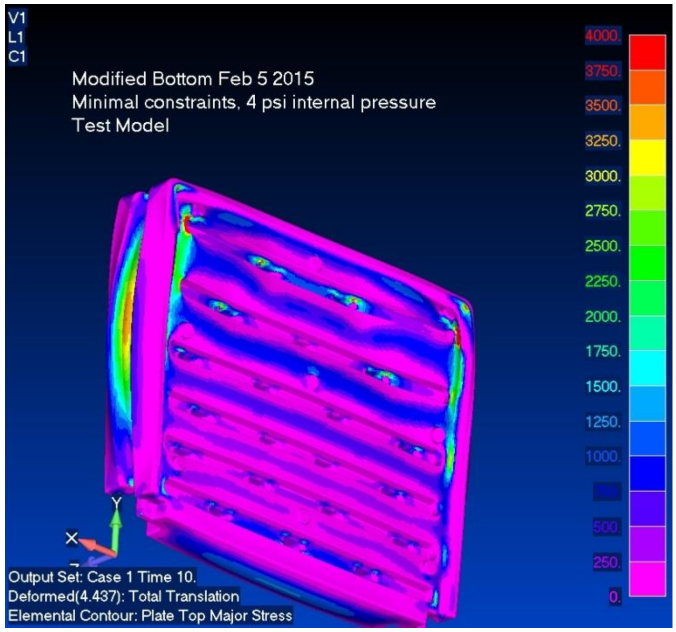

Fig. 11: Stresses at 4 psi.

Conclusions:

Since the stresses are so low and the deflections are reasonable at that area, there is no reason to rerun the water loaded FEA.