D-Weld Sub-Assembly Leak Test Fixture

Final Report

Mechanical Engineering Technology

IPFW

Tenneco Inc.

Department of Manufacturing & Engineering Technology

Ariana Jarvis

Uriel Contreras

Sam Weisser

Cody Turner

About the Company Sponsoring This Project

Tenneco, Inc. is a designer, manufacturer, and distributer of ride performance and clean air systems. They make products and systems for multiple markets and after-markets such as: automotive, commercial truck and off-highway. Being a global leader, Tenneco, Inc. has over 90 manufacturing facilities spanning across six continents [3]. The fixture design for this project is specific to Tenneco's Ligonier plant in department 12. This is where the Y-pipe sub-assemblies are designated.

Disclaimer

The following information contains some information that is proprietary to Tenneco, Inc. This information should not be used unless prior consent from Tenneco, Inc. is obtained.

Issue with Current Fixture

The portion of the manufacturing process that this project focuses on consists on welding two exhaust pipes together. These pipes are previously pressed to form two "D" shape ends which are welded together. Then on a different operation a cap pipe slides over the D-weld and is welded 360˚around the pipe.

Figure 1: D-weld on the left, Cap pipe over D-weld on the right of exhaust y-pipe assembly.

The purpose of this project is to reduce the amount of scrap of complete exhaust Y-pipe assemblies due to linear leaks on the outlet D-weld. Once the cap pipe is welded over the D-weld (see Figure 1) the assembly is tested for leaks; the assembly fails the leak test if it leaks more than 4.5 square liters per minute. If the D-weld has a leak there is no way to repair it, because the cap pipe is already covering the welds, and the full assembly has to be scrapped.

What the Future Fixture Will Achieve

Our design allows for sub-assembly to be mounted and tested without the cap welded over the D-weld. If the test determines the part has a leak then it can be easily fixed and tested again for a leak. So, because the leaks can be fixed the company would no longer need to scrap the parts that have this D-weld issue. This will save the company thousands, they were previously losing, yearly.

Initial performance

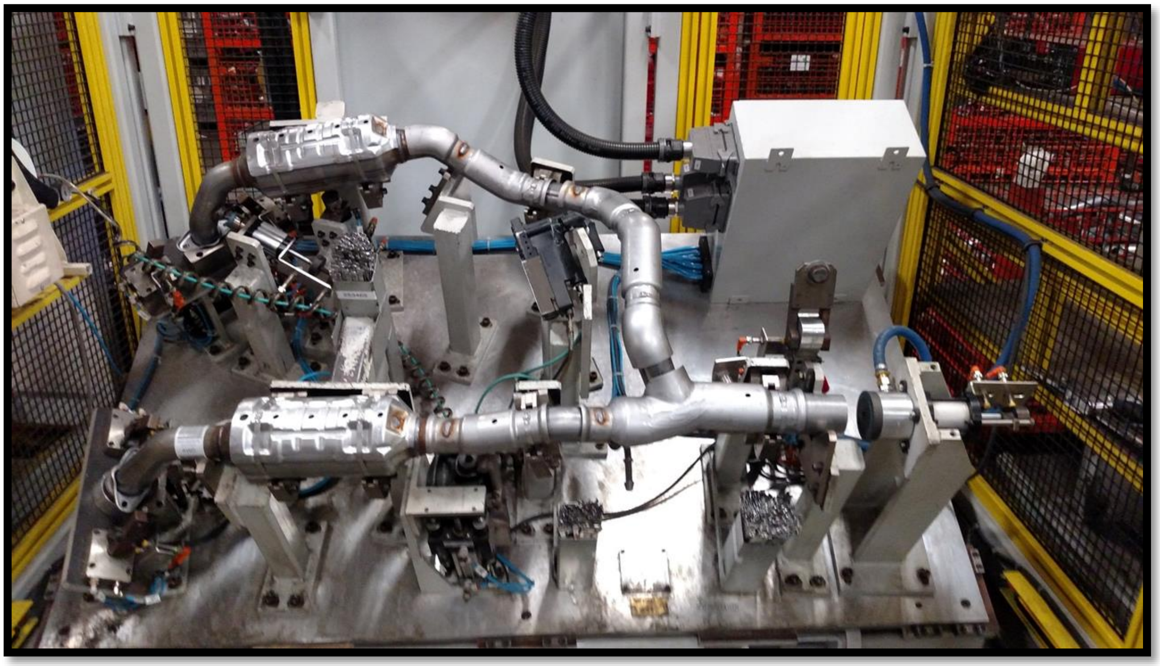

Figure 2: Current leak tester with full finalized assembly

Figure 2 shows a completed Y-pipe sub-assembly being leak tested. An initial performance baseline has been established after analyzing six month worth of the overall scrap data of this assembly. It has been concluded that linear and component burn through are the primary reasons for complete y-pipe assemblies.

No.	of	Reason	for	movement	13	ValStckIssValue				
	Reason	for	movemen	Val.stk	iss	qty	ValStck	Val.stk	rec	qty
	Total	112.00	EA	37,556.91	USD	0	EA	0	USD	
	7103	7,103	34	EA	11,411.14	USD	0	EA	0	USD
	3105	3,105.00	17	EA	5,709.36	USD	0	EA	0	USD
	1101	1,101.00	13	EA	4,355.18	USD	0	EA	0	USD
	7104	7,104.00	8	EA	2,686.20	USD	0.00	EA	0	USD
	4202	4202	8	EA	2,685.92	USD	0	EA	0	USD
	3104	3104	8	EA	2,678.90	USD	0	EA	0	USD
	5401	5401	6	EA	2,004.11	USD	0	EA	0	USD
	5403	5403	4	EA	1,343.10	USD	0	EA	0	USD
	7106	7106	4	EA	1,339.58	USD	0	EA	0	USD
	7101	7101	4	EA	1,336.07	USD	0	EA	0	USD
	6205	6,205.00	3	EA	1,002.06	USD	0	EA	0	USD
	7111	7111	2	EA	668.04	USD	0	EA	0	USD
	6105	6105	1	EA	337.25	USD	0	EA	0	USD

CHART 1

Leak Test Scrap Pareto	Scrap Reason	Code	Scrap Dollars
7103 Component Burn Thru	Component Burn Thru	7103	11,411.14
3105 Seam Splits	Seam Splits	3105	5,709.36
1101 Orientation,Rotation	Orientation,Rotation	1101	4,355.18
7104 Linear: Burn Thru	Linear: Burn Thru	7104	2,686.20
4202 Destruct Test	Destruct Test	4202	2,685.92

Figure 3: Six month worth of scrap data collection of full y-pipe assemblies

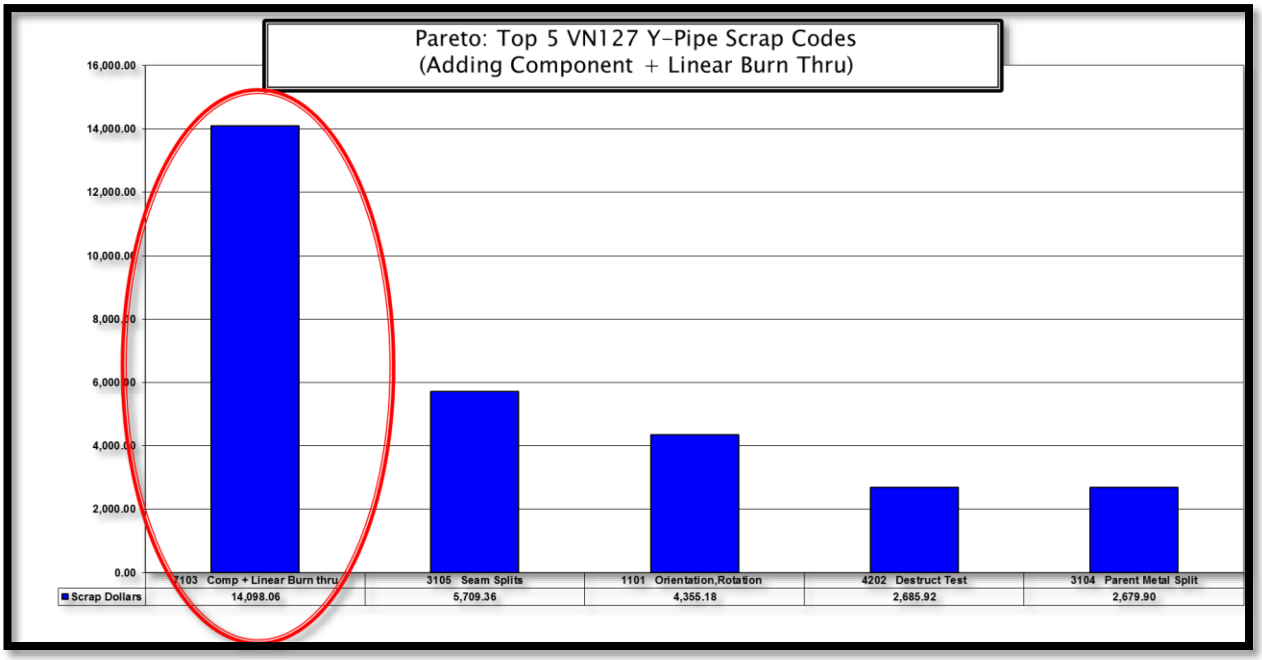

Figure 4: Pareto of top 5 producers of y-pipe scrap

Figure 3 and 4 show the data collected and the Pareto chart ranking the top five reasons of scrap of full y-pipe assemblies.

Design Calculations

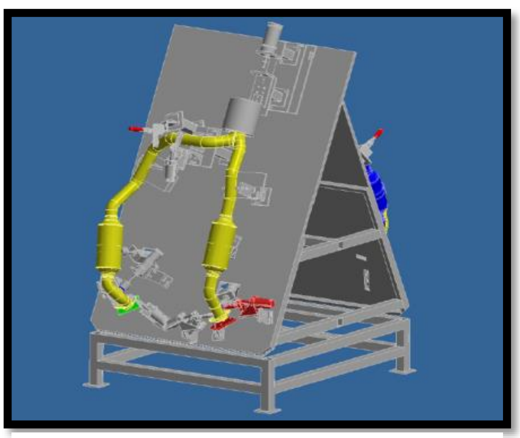

Figure 5: CAD model of Y-pipe before cap pipe being leak tested

The part will be loaded as depicted on the CAD model in Figure 5 to the left. The load can be treated as a non-uniform distributed load. The part weighs approximately 39 lbs. The material of the base plate is Aluminum which has a yield strength of 35 ksi.

Then, by using the stress formula:

Stress $\sigma = F/A = W/A$

The stress caused by the weight of the part on the aluminum plate can be calculated as follows:

σ = (39 lbs.) / ((45 in x 72 in)) = 0.012 psi

0.012 psi < σ_{ys} 35 ksi

The stress caused by the weight of part on the on the aluminum plate is significantly less than the yield strength of the aluminum plate.

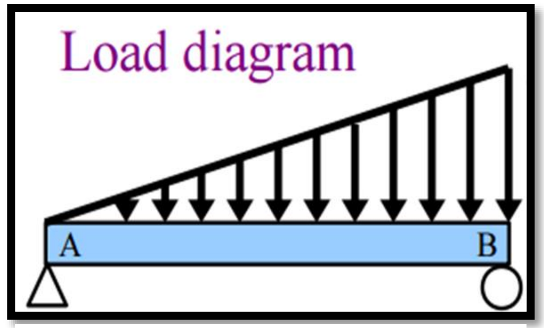

Figure 6: Non-uniform distributed load model.

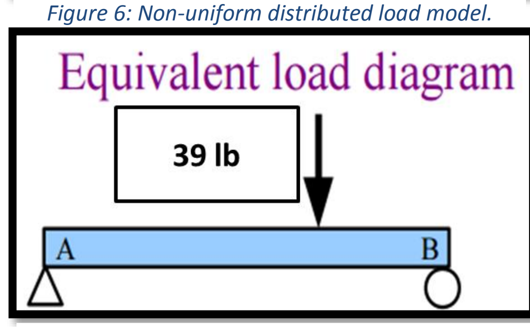

Figure 7: Equivalent load diagram of a non-uniform distributed load.

Figures 6 and 7 show the load diagrams for a non-uniform distributed load and its equivalent single point load.

Even after the weight of the part is added to the load stress calculation the result does not come close to the maximum allowable stress.

Adding the weight of the 45” x 72” x 0.5”Aluminum plate, and knowing the density of aluminum (0.098 lb/in^3):

Weight of base plate = 45 in x 72 in x 0.5 in x 0.098 lb/in^3 = 158.76 lb

Calculating the Stress σ = F/A = W/A

σ = (39 lb+158.76)/((45 in x 72 in)) = 0.061 psi

0.061 psi < σ_{ys} 35 ksi

The stress caused by the weight of part and the weight of the aluminum plate is again less than the yield strength of the aluminum plate.

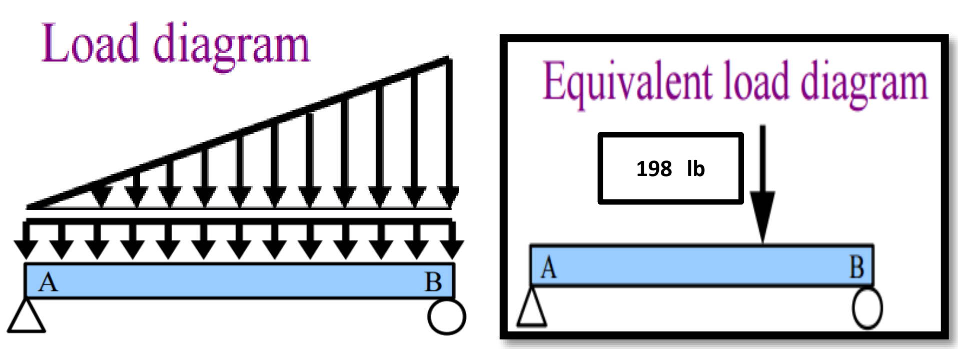

Figure 8: Load diagrams after adding the weight of the aluminum base plate.

The material of the parts are 409 Stainless Steel as well as the flanges and threaded bosses. To avoid crushing and bending of the parts and flanges all the cylinders will be set up at 60 to 80 psi. Since the yield strength of 409 SS is 30 ksi it is well above the current pressure of 60 to 80 psi.

Fabrication Procedure

The fabrication process is currently at a halt. The Engineering Manager, Jason Carnahan, is in the process of approving the fabrication of the fixture. All sketches and drawings have been sent to the fabricator, B & B Machine and Repair Shop, to be reviewed and readied for when the approval is submitted. At this point in time the submission of approval for the fixture is estimated to be within the week of July 30th, 2016. From the initial approval it is projected by B & B Machine and Repair Shop that the fixture will take three to four weeks to be completed. At the completion of the fixture it will be tested to make sure all seals and clamps work properly.

Design Analysis

Due to the limited space available in this department and the current flow of the part (VN127) it was decided to use a current leak tester for a different part number (4058) that runs through the same flow. In Figure 10 the black arrow represents the flow for all parts, the red arrow represents the flow for the VN127 (which is the main focus of this project), and the green line represents the flow for the 4058 Y-pipes. The blue circle signifies the leak test station that is going to be repurposed for this project.

There are two sides to this leak test fixture; one side is the main focus of the project (VN127 pipes) and the other side is editing the current leak test station of the 4058 pipes by adding a manual clamp. Since the leak test station will have two sides the base will be able to rotate 360 degrees for easy change overs. Each side will be at a 65 degree angle for easy loading and unloading.

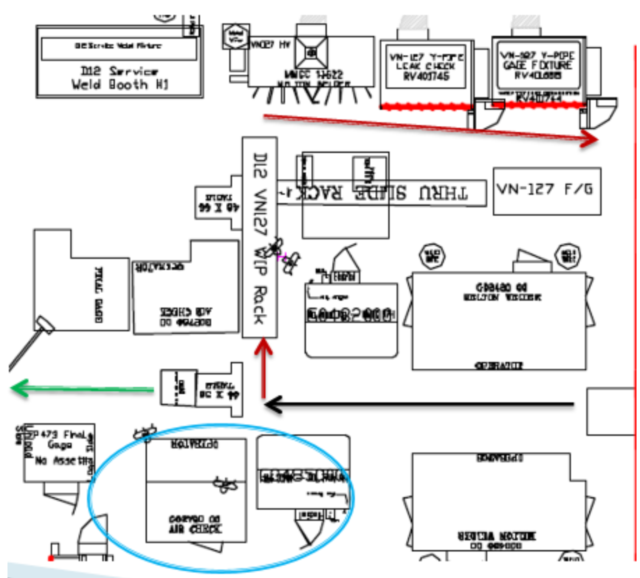

Figure 9

Since each fixture will be at a steep angle they will have manual clamps that will be used once the part is placed inside the fixture, on the saddles, to secure the part and prevent it from falling on the operator.

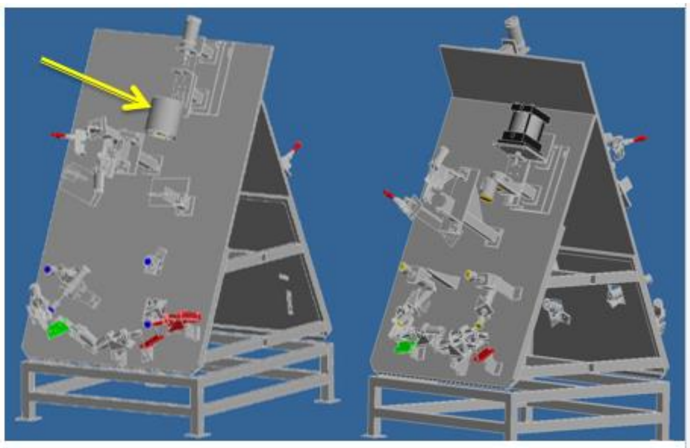

*Figure 10 *Right fixture is for the 4058 *Left Fixture is for the VN127 (main focus)*

The main focus is finding the leak on the D-weld on the VN127. To be able to securely seal this abnormal shape it has a 360 rubber seal that will go over the D-weld and shrink, this will create a tight seal over the D-weld portion. In Figure 11 the yellow arrow shows the location of this feature.

Table 1 Detailed description of fixture components

Item	Description
Aluminum base plate	45” x 72”
Hego Sensor Boss Cylinder mounts x 4	Adjustable cylinder mounts. Standard ½ inch hardened tooling steel. The location is determined by the position of Datum A, B, C. with the help of the CAD files. Standard 1.5 inch seals and bases bolt on to cylinder shafts.
Inlet flare clamps and cylinders	Both inlet flare seals are datum A, and B. They consist in 2 clamps actuated by cylinders securing the flanges on the flares and pulling the part to the seals.
Upper Saddle & Manual Clamp	Saddle located at bend point from part print. Standard ½ inch thick saddle. Adjustable saddle base mount. With mount for manual Desta clamp.
Side saddle	Saddle located at bend point from part print. Standard ½ inch thick saddle. Adjustable saddle base mount.
D-weld outlet cup	Outlet cup with 1 inch tolerance (½ inch all the way around). When cylinder extends the D-weld will be sealed. D-weld diameter is approximately 3.25 inch. The cup ID will equal 1 inch. Cup will mount to a cylinder, and adjustable cylinder mount.

Plan for Testing Procedure

Plans for testing the D-Weld Sub-Assembly Leak Test Fixture start with running the fixture in a normal cycle. The test consist of loading the Y-pipe onto the fixture. Once the exhaust is in place the clamps are then locked down securing it from moving. When the exhaust is in place the operator checks to ensure that the part fits within all the components. Then the operator must initiate the leak test with two-palm buttons and ensure that all the features are sealed. The machine then puts 15 psi of air in the exhaust and determines how much air is lost over the course of an undetermined amount of time. The monitor will determine if the Y-pipe leaks more than 4.5 squared liters per minute. Once the test is finished, the fixture will then be checked for signs of stress or cracking in the areas where the clamps are located. If there are no noticeable stress related defects on the fixture the test will be repeated for the approval requirement of 30 times.

Prints & Drawings

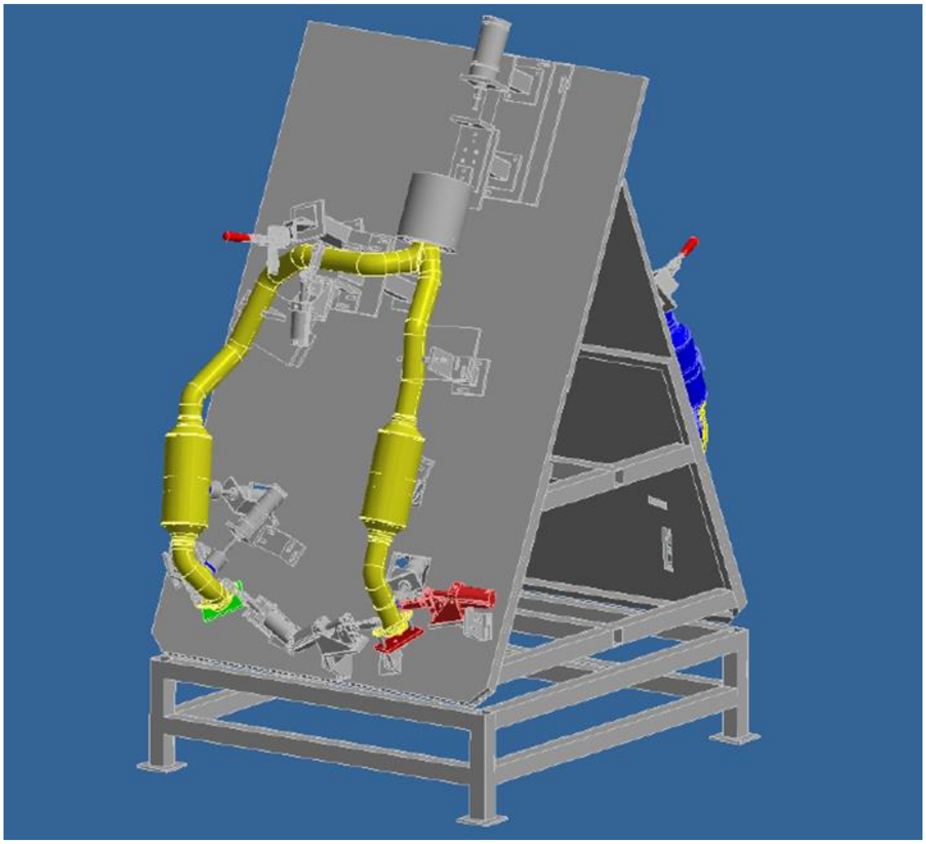

Figure 11 ISO view of leak tester with larger sub-assemble attached

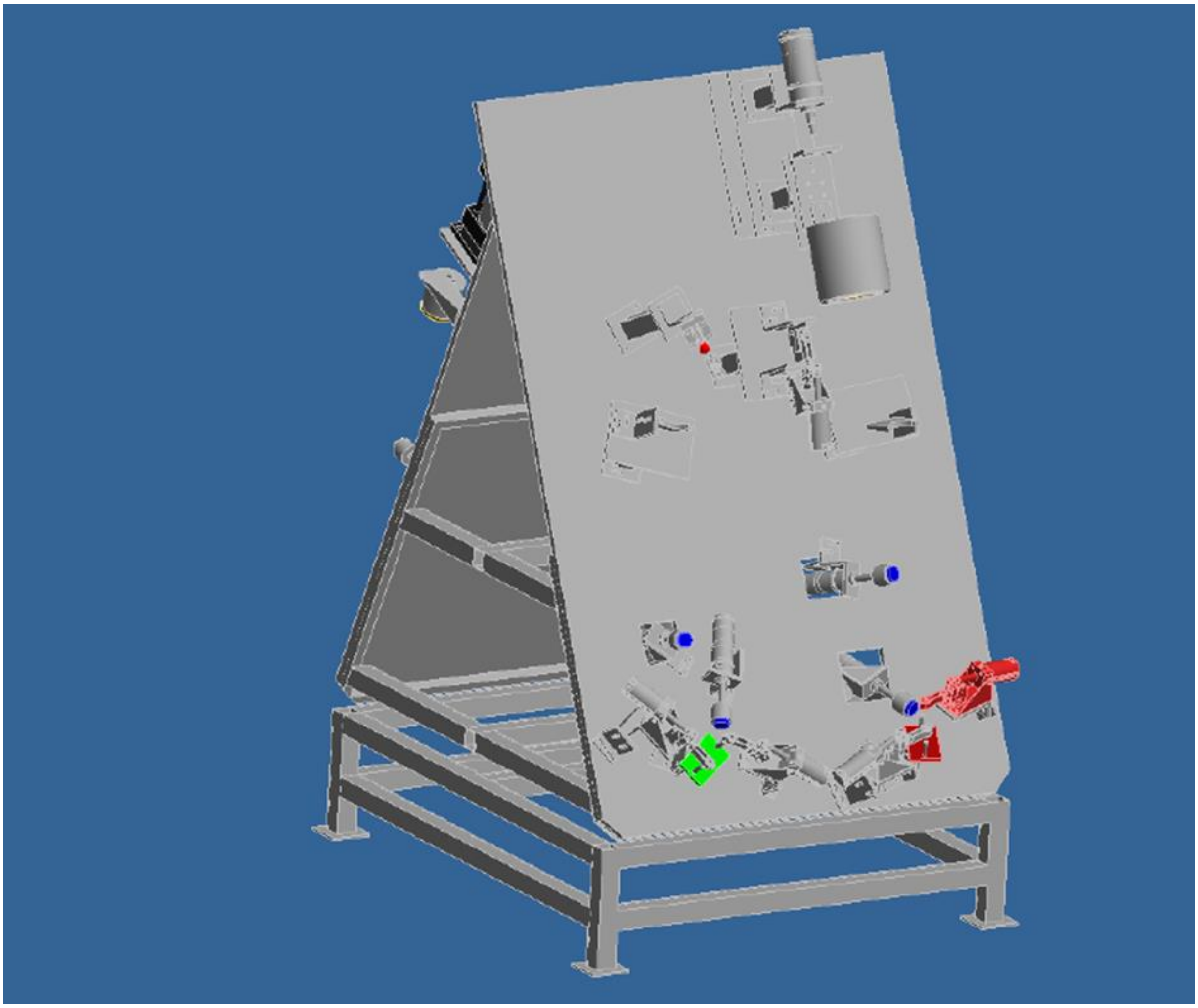

Figure 12 ISO view of same side as in Figure 1, without sub-assembly

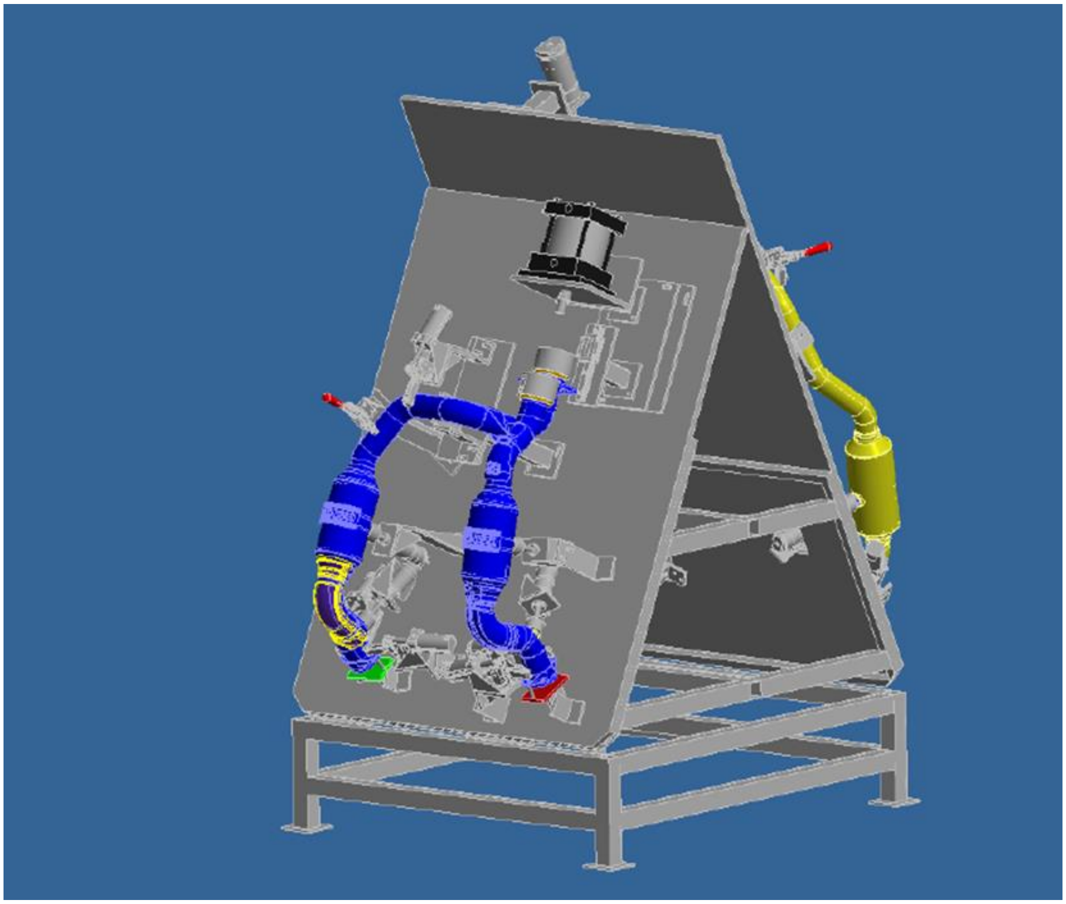

Figure 13 ISO view of back of leak test fixture, with smaller sub-assembly

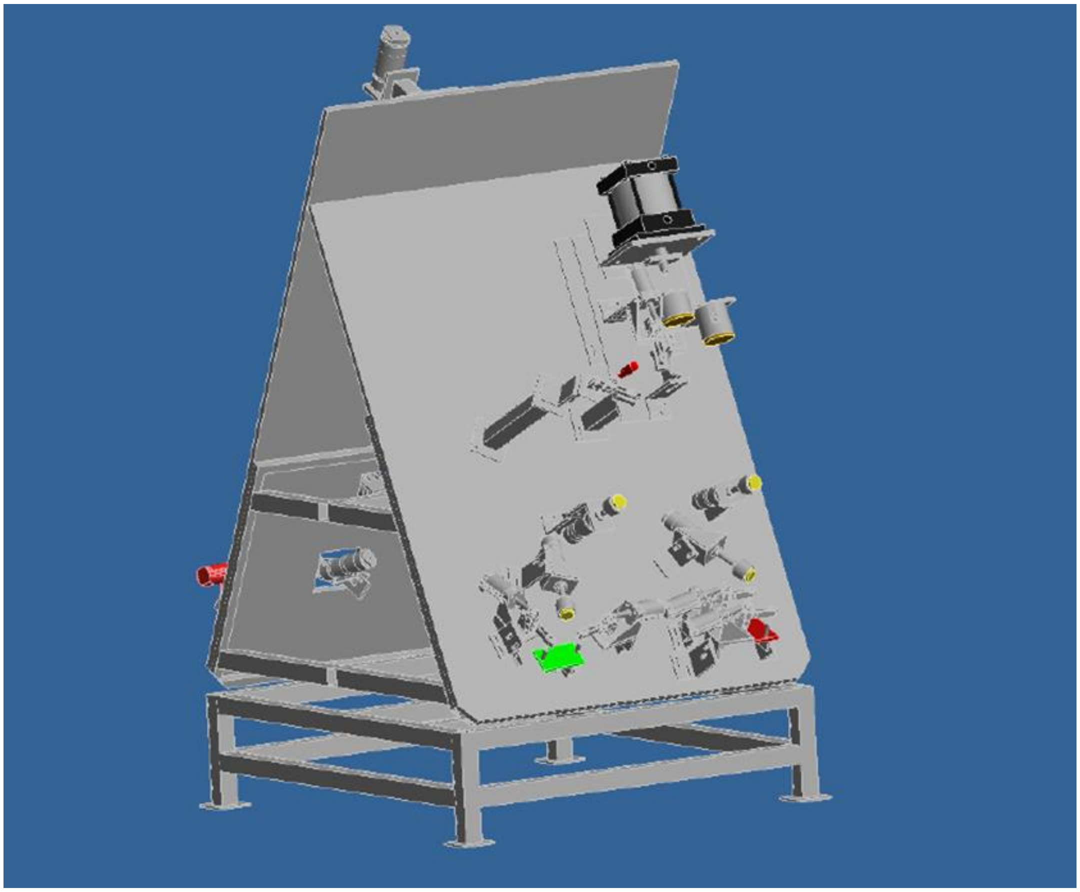

Figure 14 ISO view of same side as Figure 3, without sub-assembly

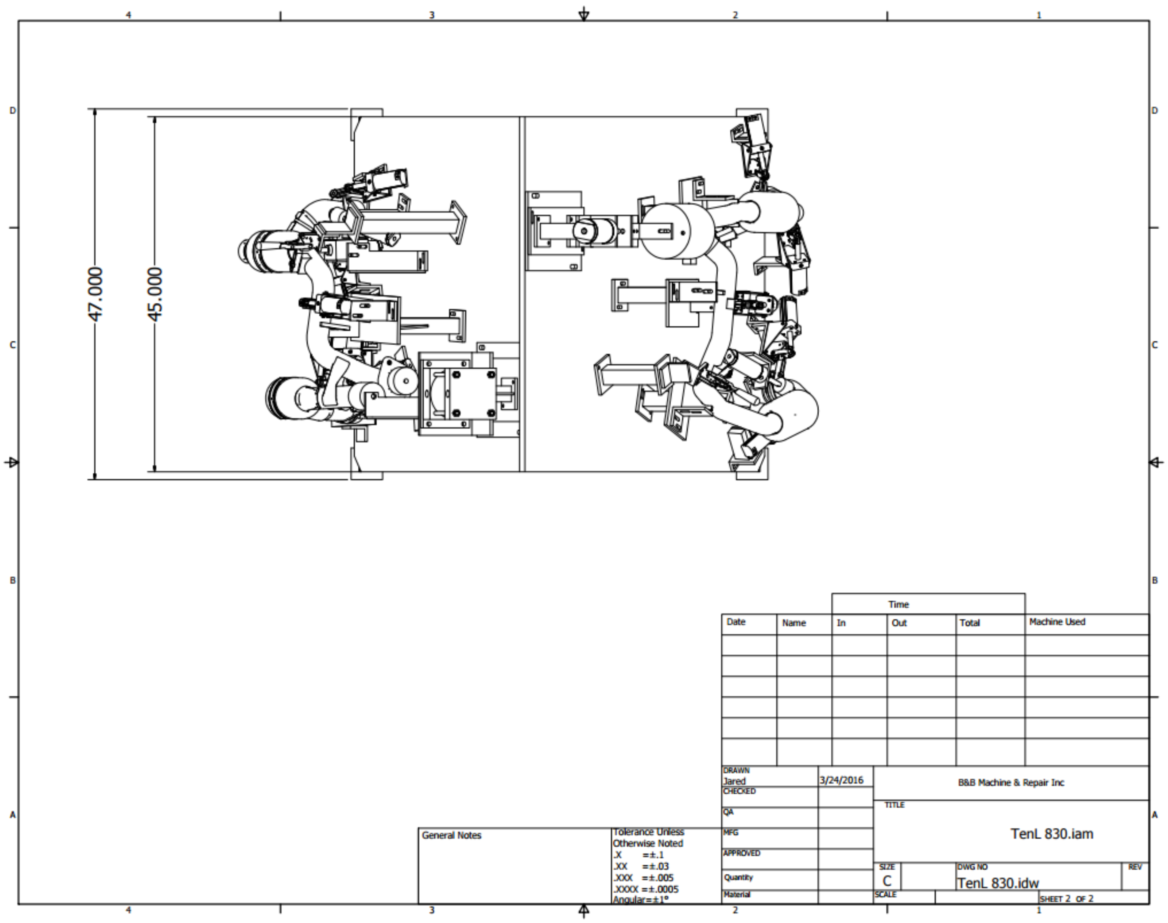

Figure 15 Overall width dimensions for the leak test fixture

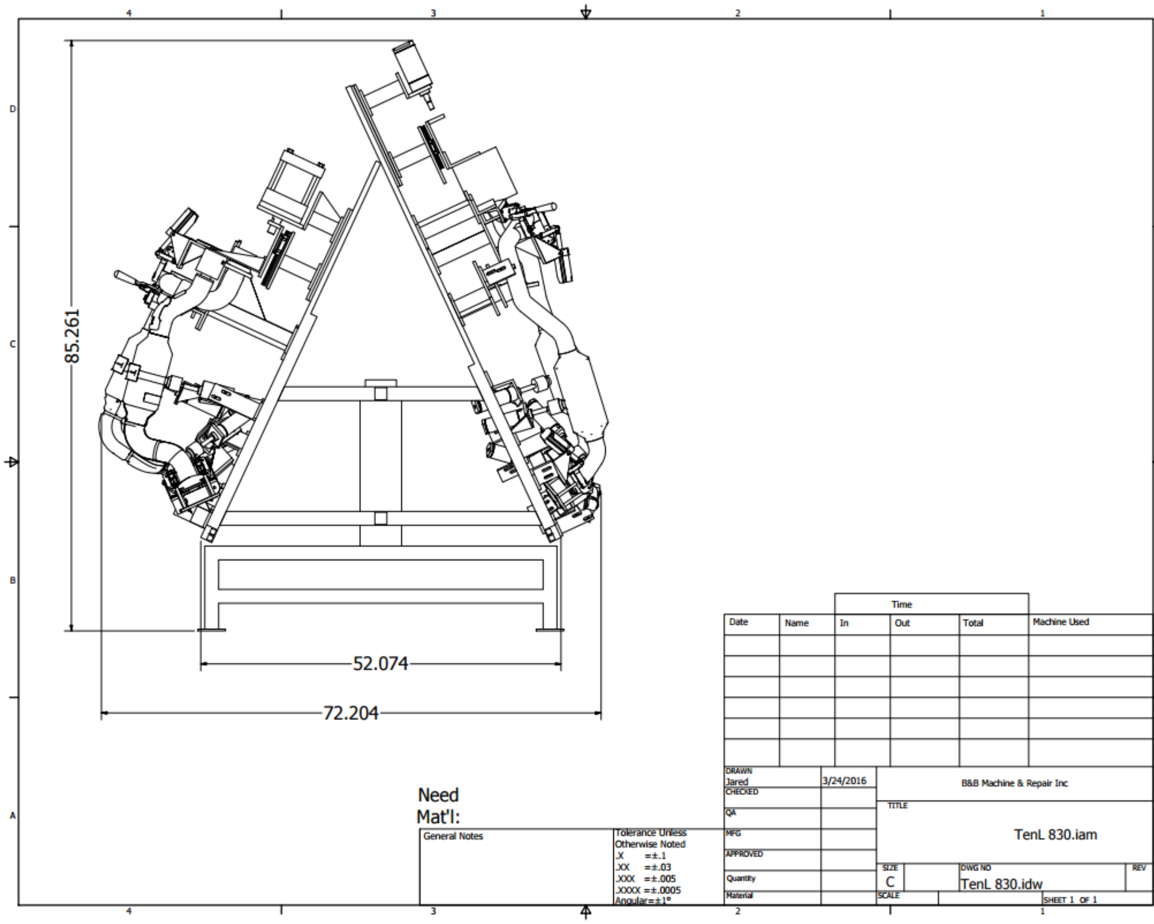

Figure 16 Overall height and depth dimensions of the leak test fixture

Gantt Chart

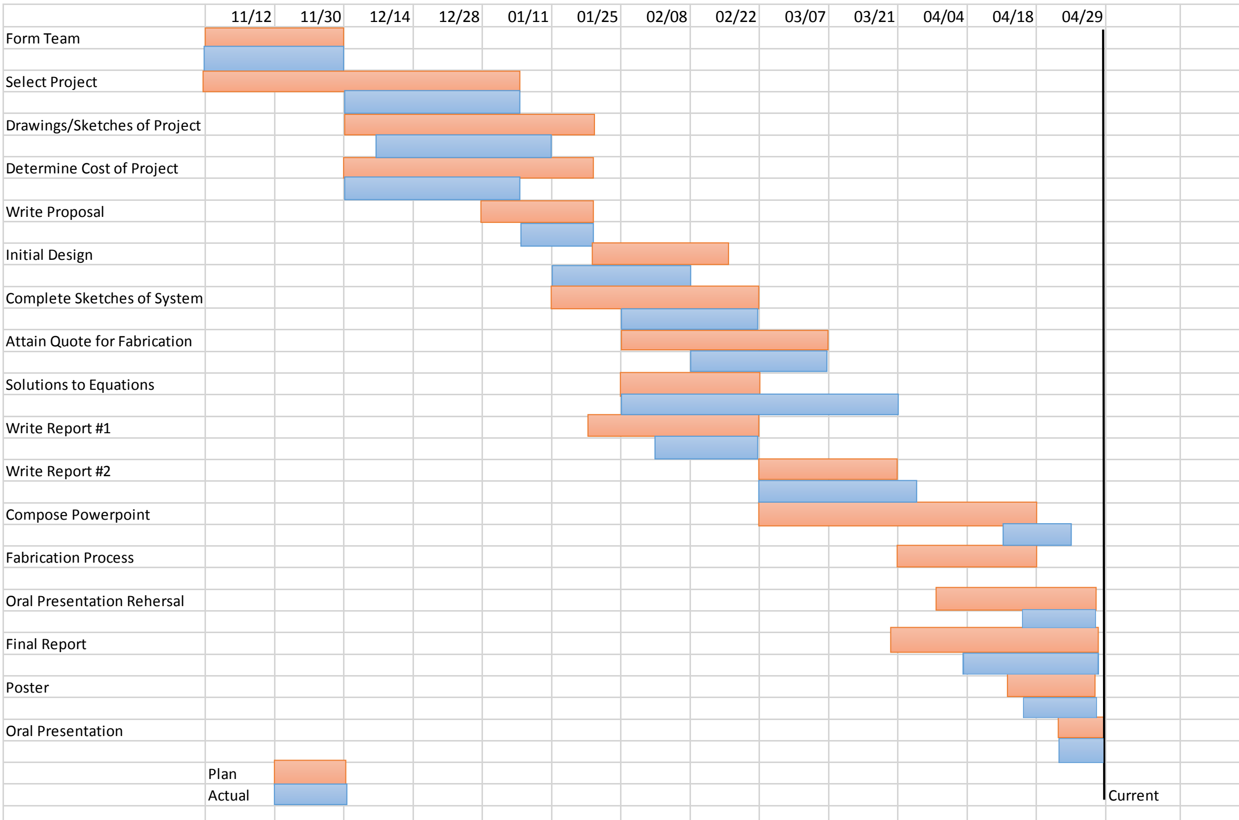

Figure 17 The Gantt Chart of the planned and actual progress during this project

Cost Analysis

The quote for the cost of the fixture, provided by B & B Machine and Repair Shop, is estimated to be $15,000. A baseline of scrap produced by this issue has been established by collecting scrap data from September 2015 through February 2016 and it equated to $14,098. The annual savings target after introducing the D-weld leak tester is 50% of the 6 month baseline which equates to $14,098 by one year after it is introduced.

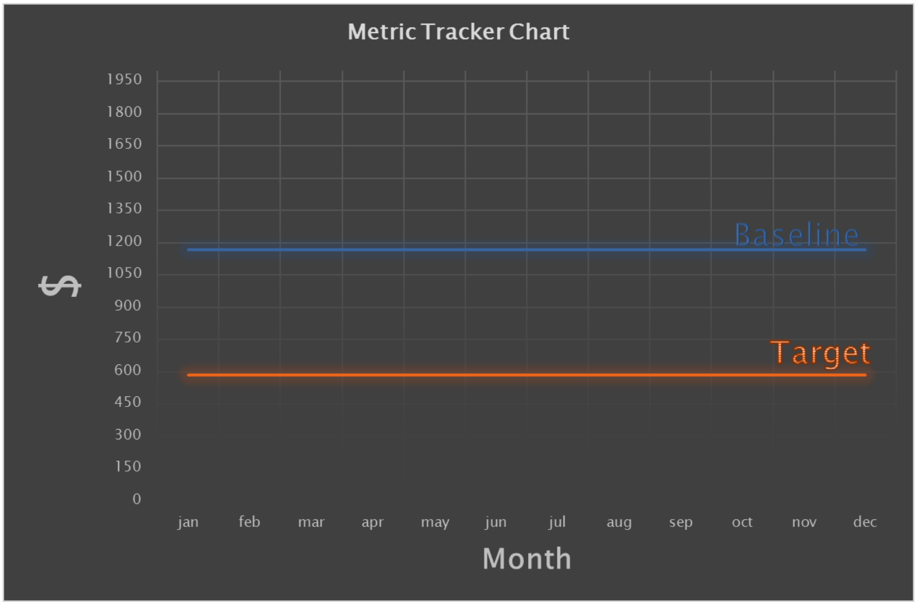

Figure 18 Baseline vs. target scrap dollars tracking chart

Summary of Objectives and Conclusion

The new fixture design will allow for the sub-assemblies to be tested without the cap pipes. This improvement provides the company with an opportunity to repair leaks in the D-weld. The large majority of the scrap that comes from these sub-assemblies is due to the D-weld leaks; with the reparation of the welds the sub-assemblies will no longer become scrap metal that cannot be used.

The measures taken to prevent the D-weld from leaking will allow the company to save $14,098 a year. This total is the baseline established for the amount of money lost due to D-weld leaks from a period of six months. The value is also the target amount for the company to save over the course of one year. The company will acquire the total value of the fixture, which is $15,000, in a little over one year's time. Starting from that point forward the company will profit from the leak test fixture.

Bibliography

[1] B & B Machine and Repair Shop, Cromwell, Indiana.

[2] Dupen, Barry, "Finite Elements Applied to Strength of Materials.”, 2016. [Online]. Available: http://www.etcs.ipfw.edu/~dupenb/ET_200/Applied%20Str%20of%20Mat%20for%20ET%20v9%20Jan%202016.pdf. [Accessed: 21- Mar- 2016].

[3] Tenneco.com, "Tenneco Inc. | Tenneco Inc.", 2016. [Online]. Available: http://www.tenneco.com/. [Accessed: 22- Feb- 2016].