

SUMMARY: DETAIL DESIGN REVIEW

Biodiesel Reactor Improvements
 University of Idaho
 Team Liquid Gold

Meeting: BAE Conference Room, 3:30, 02/26/2015

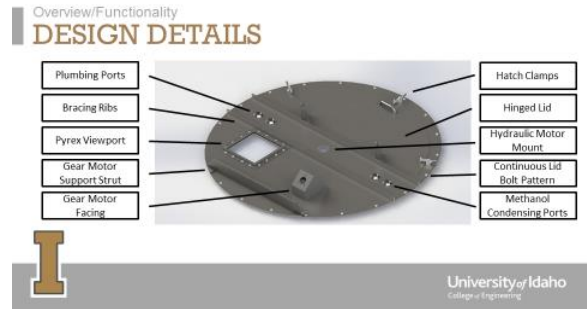
Present:

- Jon Van Gerpen, Ph.D., BAE Chair, Client
- Dev Shrestha, Ph.D., BAE Faculty, Client
- Keegan Duff, BAE Staff, Client
- Steve Beyerlein, Ph.D., ME Faculty, Adviser
- Andrew Engel, Team Member
- Brian Hanson, Team Member
- Connor Saxe, Team Member
- Gene Staggs, Team Member

Summary: *On February 26, 2015, members of Team Liquid Gold met with members of the BAE faculty to present a design proposal for improving the biodiesel reactor located in BAE experimental facilities. Approval to go ahead with the design was obtained, with suggestions for additional validation of design choices.*

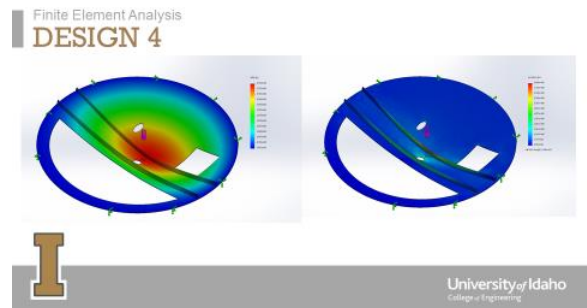
On February 26, 2015 the above-listed met to review the detail design proposed by Team Liquid Gold for enclosing the biodiesel reactor operated by the BAE department. During previous meetings, the scope of the project, originally a full redesign and automation of mixing, heating, and reacting of biodiesel, had been reduced to designing a lid to enclose the existing reactor. Additional modifications were not approved based on cost limitations.

Because of this refined scope, the problem statement, goals, and design specifications were revised to focus on this narrower design. These revisions were accepted by the clients.



During previous meetings, the clients expressed concerns that the tank lid could develop harmonics from resonant frequencies similar to those of a drum surface. The team presented that experts consider FEA frequency modal analysis of mixers mounted on vessels only essential for mixers over 100 HP. As the system motors are much less than 100 HP, the team elected to consider such an analysis as not necessary. The clients accepted the team’s analysis, but requested that the team treat the lid as a drum surface and find a resonant frequency to avoid during operation.

The team presented a finite analysis of four iterations of lid structural design, representing possible combinations of lid sheet thickness and the presence or absence of reinforcing webs. The design as proposed offered minimal stress loading and deflection with 100 pounds force applied at the center of the lid. The client requested that we increase the central loading to 200 pounds force or more in order to reflect upper limit design considerations.



The team presented the proposed lid layout and fabrication methods. The clients approved the

general design, but requested further engineering proof of analysis on the quantity and type of bolt specified to fasten the lid to the existing tank, citing concerns about edge of tank sealing. The clients noted incompatibilities between the proposed sealant (Buna-N) and recommended use of Viton sealants instead.

The team is following up on the questions of bolt specification, drum head resonance, and improved FEA analysis. Viton sealant will be researched, and if appropriate, specified for tank sealing. Further research is being done into design of a system to condense methanol vapors venting from the reaction.

The team is currently working to analyze concerns about the regularity of the tank diameter. Observations have indicated that the current tank is out of round when filled with biodiesel and with equipment braces mounted on it. It will be necessary to measure the tank in a completely relaxed state to define the effect of filling and bracing the tank on the roundness of the tank. If effects are noted that will impair mounting of the current design to the tank flange, these will be accounted for by revisions to the design. The delay until these measurements can be taken is not yet known, and will impact the date for parts ordering.

Budget needs are well within available constraints, allowing some stretching of expenses in case revisions add cost to the project. The clients reviewed the budget plan and approved the scope of the team's expenses.

The schedule proposed by the team estimates that assembly can begin on or around April 1, with the caveats of necessary redesign or parts unavailability notwithstanding. The clients approved the proposed schedule.

For further questions, please contact the team at enr-liquidgold@uidaho.edu or review the powerpoint attached in this document.

TEAM LIQUID GOLD 2014-15 BIODIESEL REACTOR



SUMMARY

The BAE Department at the University of Idaho operates a reactor for the production of biodiesel. The system has several needs:

- Reduce methanol exposure levels
- Enclose transesterification process
- Provide explosion safety with enclosure



SUMMARY

The goals of the project are:

- Provide a stainless lid for the reactor
- Incorporate a hinged access hatch
- Provide viewports, mixer mounts, and fixtures for plumbing
- Include enclosure venting and methanol condensing
- Control potential explosion paths



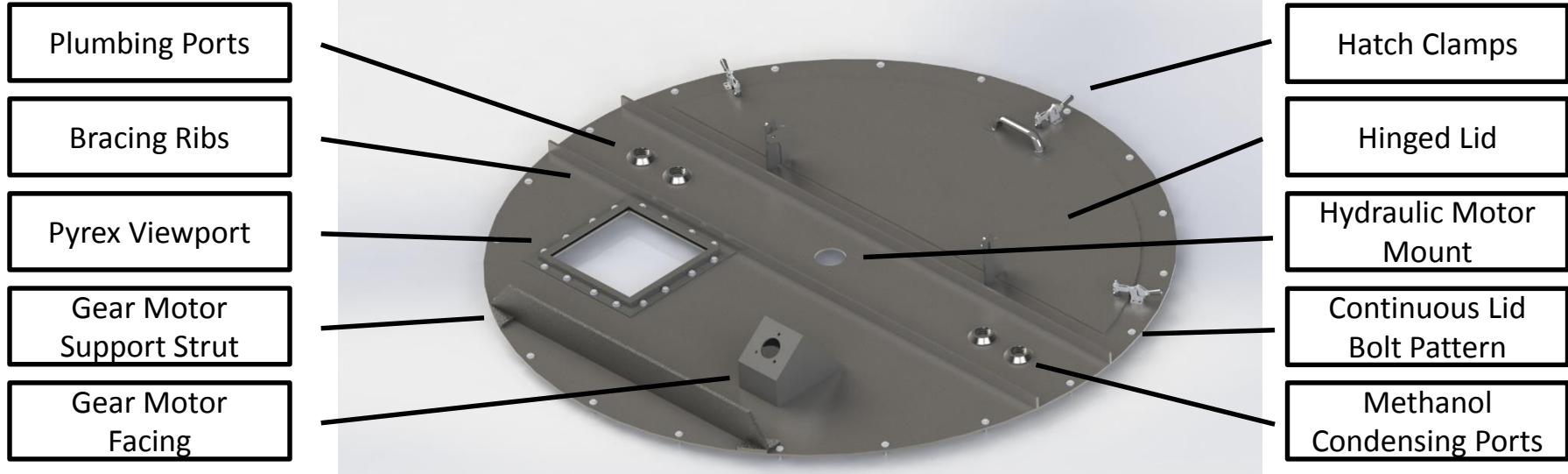
Design specifications

SUMMARY

- No materials used will react with the chemical process
- The design shall be cleanable without disassembly
- The design shall prevent methanol escape from the enclosure
- The design shall channel explosion hazards away from areas of use
- The design shall provide an illumination source to the tank interior



DESIGN DETAILS



DESIGN DETAILS

"The possibility of any coincident frequencies between the operating speed and its harmonics and the tank structure needs to be addressed. While this is not normally a problem for smaller mixers and tanks a finite element modal analysis of the mixer-vessel-mounting structure is recommended for mixers over 100 hp."

Mixer Mechanical Design – Fluid Forces
Weetman & Gigas
2002



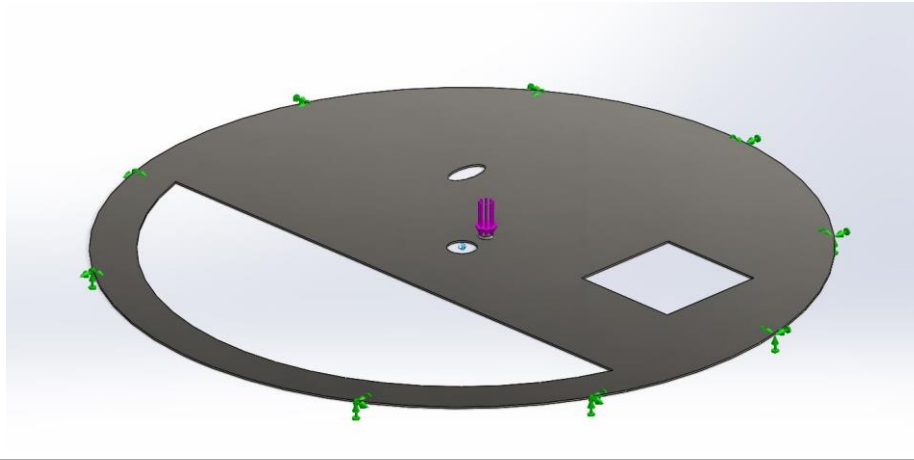
DESIGN DETAILS

- Four designs tested using FEA
 - Design 1: 0.1875" Stainless Steel Plate
 - Design 2: 0.135" Stainless Steel Plate
 - Design 3: 0.1875" Stainless Steel Plate with ¼"-1" Double Stainless Steel Flat Bar Bracing
 - Design 4: 0.135" Stainless Steel Plate with ¼"-1" Double Stainless Steel Flat Bar Bracing



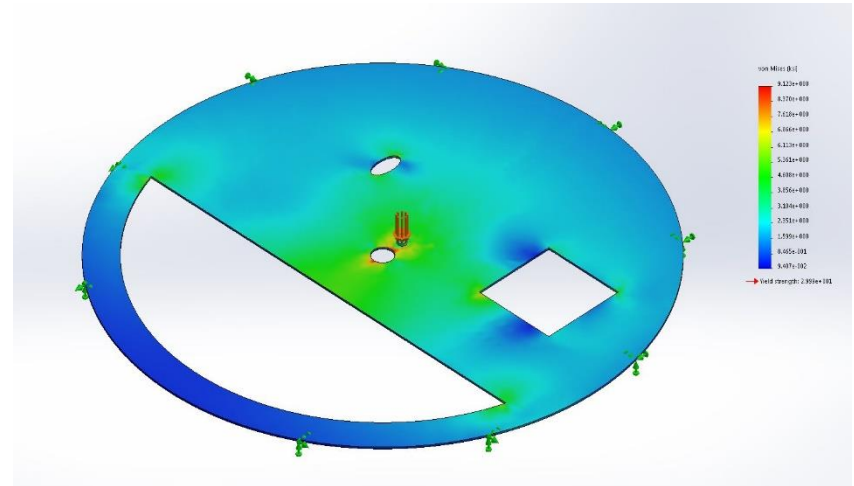
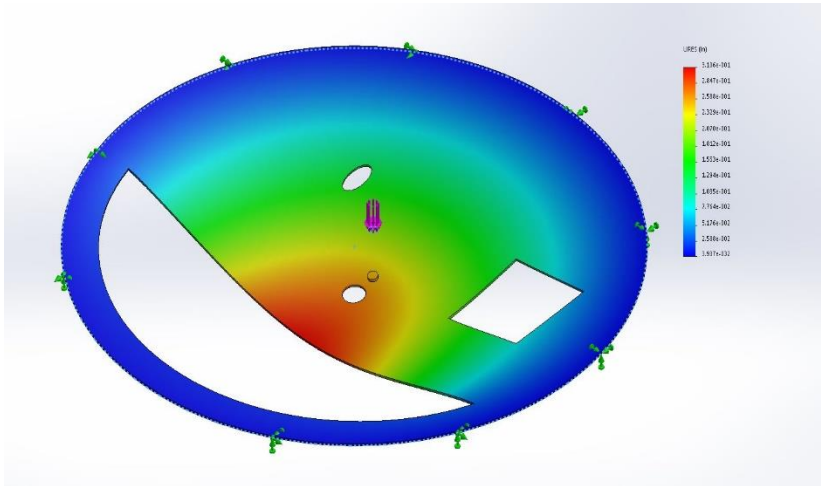
DESIGN DETAILS

- FEA Experiment Design
 - Force Applied: 100 lbf concentrated load applied to center of tank enclosure
 - Boundary Condition: Fixed static geometry along perimeter of the tank lid



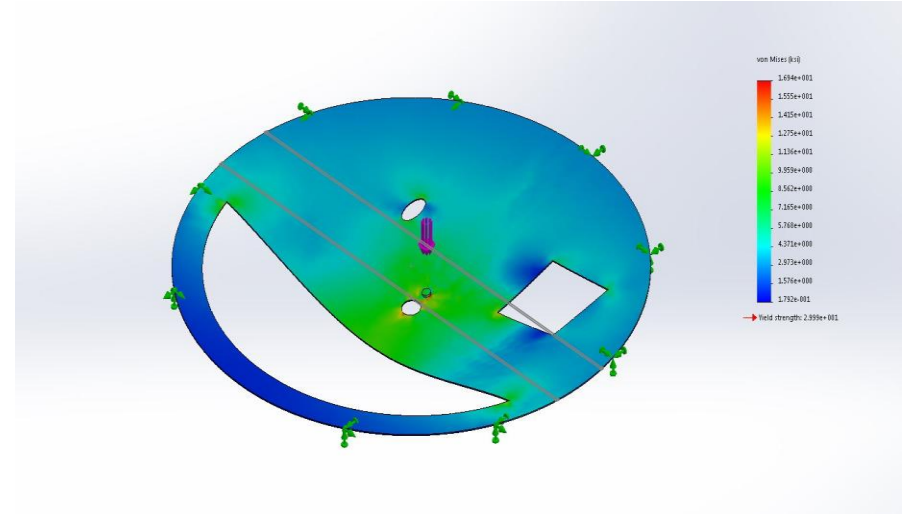
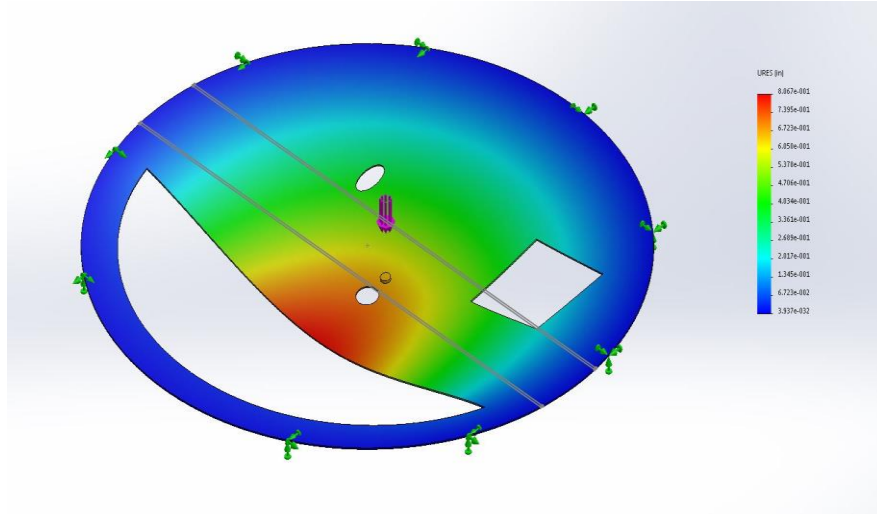
Finite Element Analysis

DESIGN 1



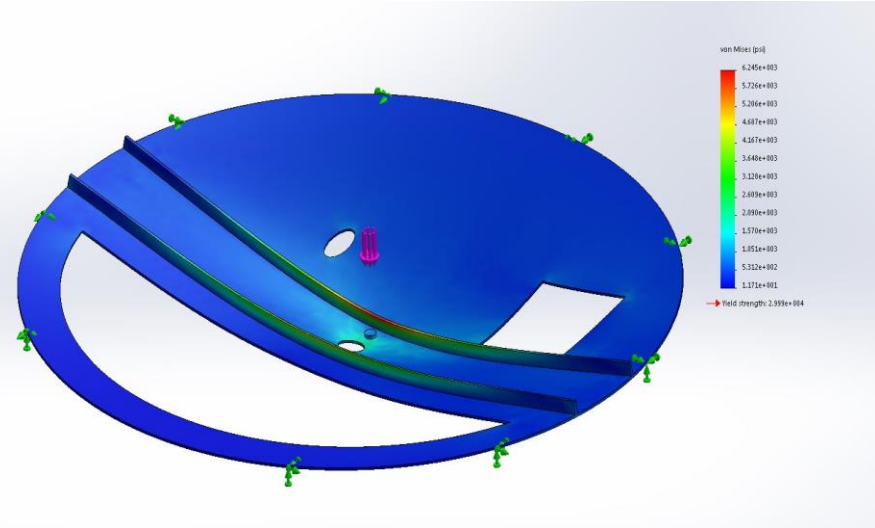
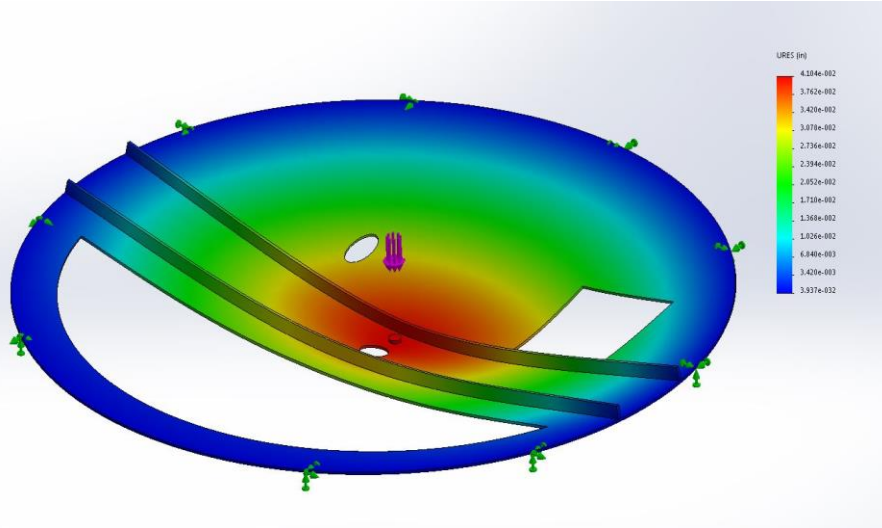
Finite Element Analysis

DESIGN 2



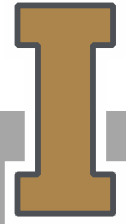
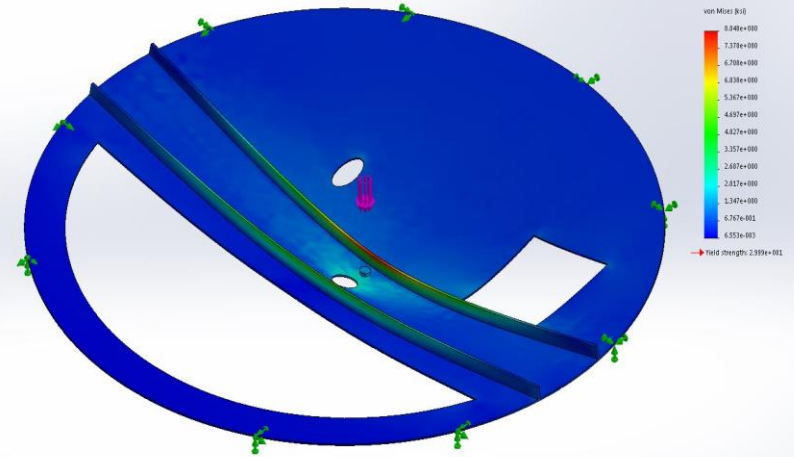
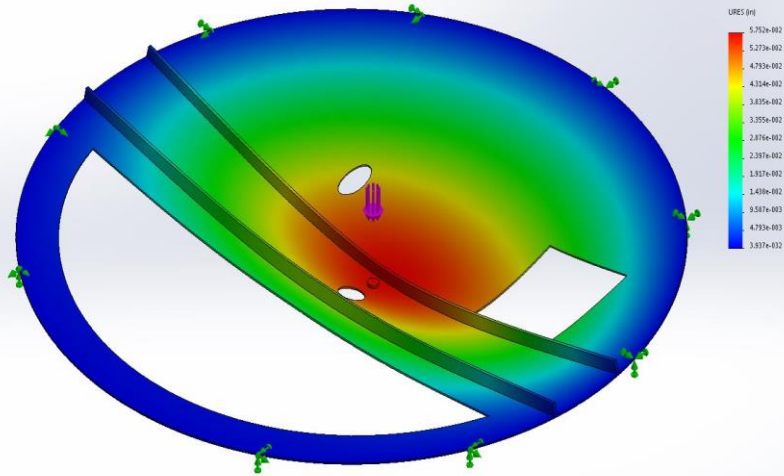
Finite Element Analysis

DESIGN 3



Finite Element Analysis

DESIGN 4



FEA SUMMARY

- Design 1:

- Displacement: 0.3106”
- Stress: 9.123 (ksi)

- Design 2:

- Displacement: 0.8067”
- Stress: 16.94 (ksi)

- Design 3:

- Displacement: 0.04104”
- Stress: 6.245 (ksi)

- Design 4:

- Displacement: 0.0572”
- Stress: 8.048 (ksi)



Key features

DESIGN DETAILS

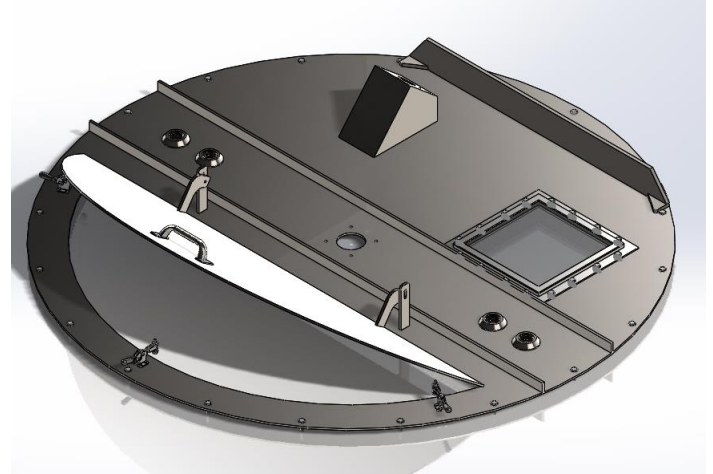
- Stainless construction
- Combined vent and condenser
- In-lid viewports and connections
- Sealed, fastened access hatch



Manufacturing process

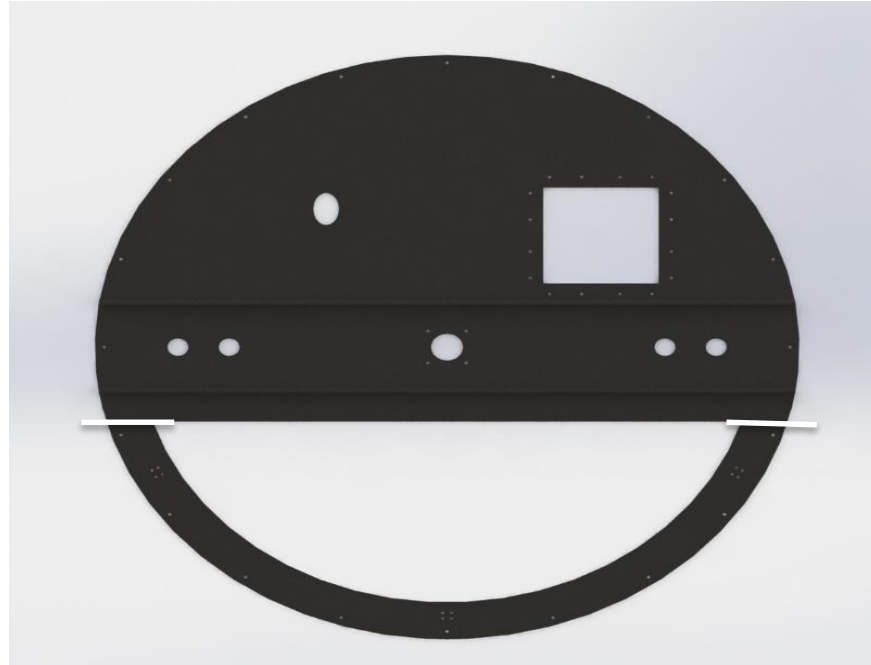
MANUFACTURING

1. Water jet stainless components (Bay Shore Systems)
 - Cost: Free
2. UI Facilities Welding
 - Cost: \$129.00
3. Tank Flange Drilling
 - Cost: Unknown
4. Assembly w/ purchased parts



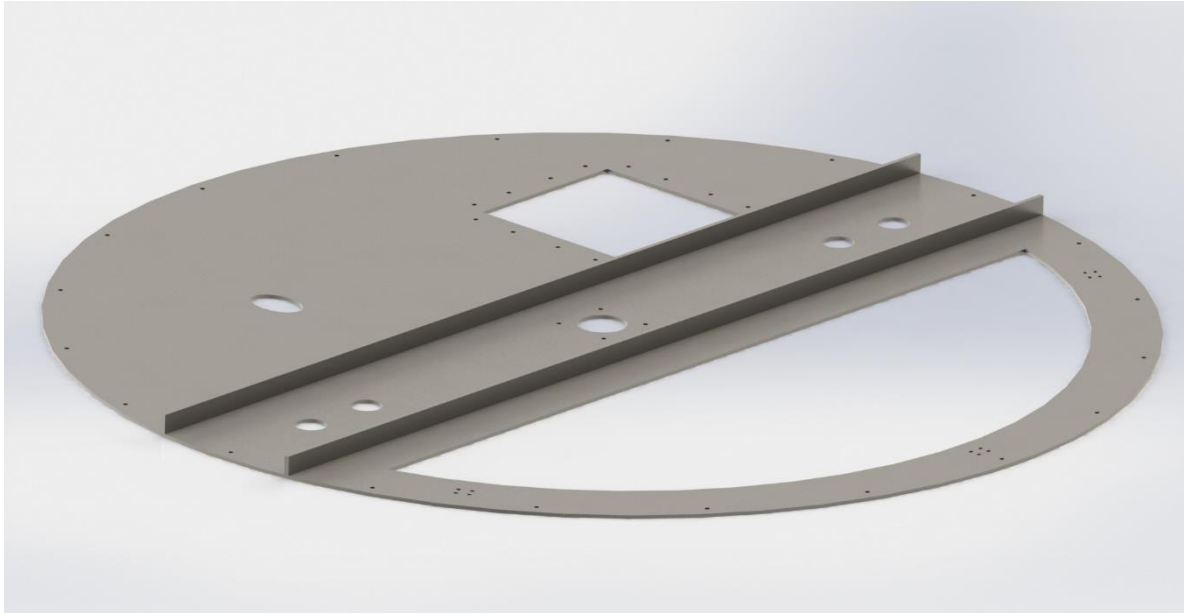
Manufacturing Process

TANK ENCLOSURE



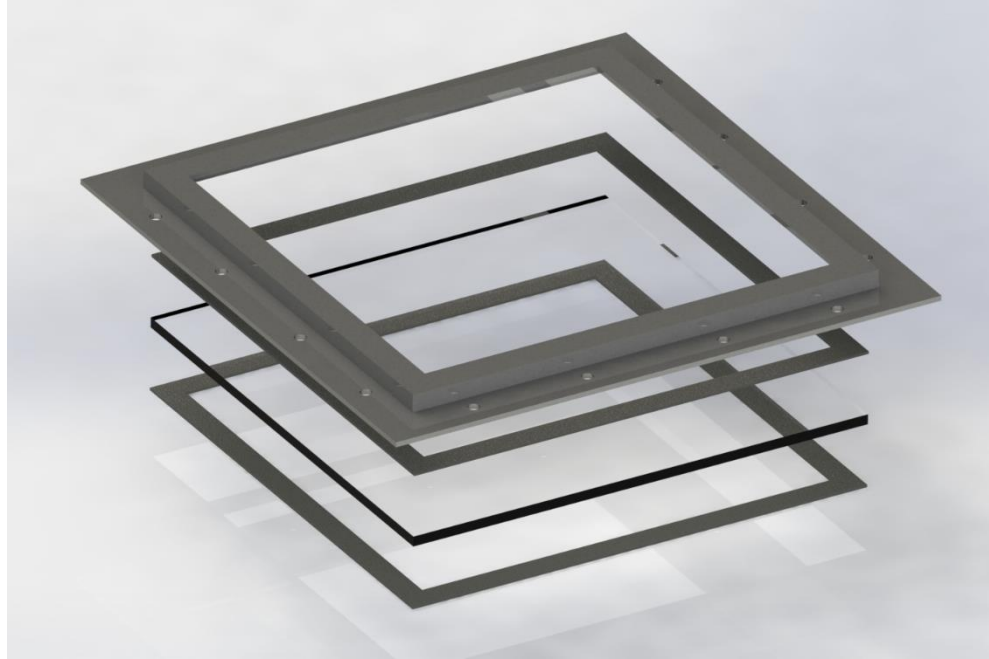
Manufacturing Process

TANK ENCLOSURE



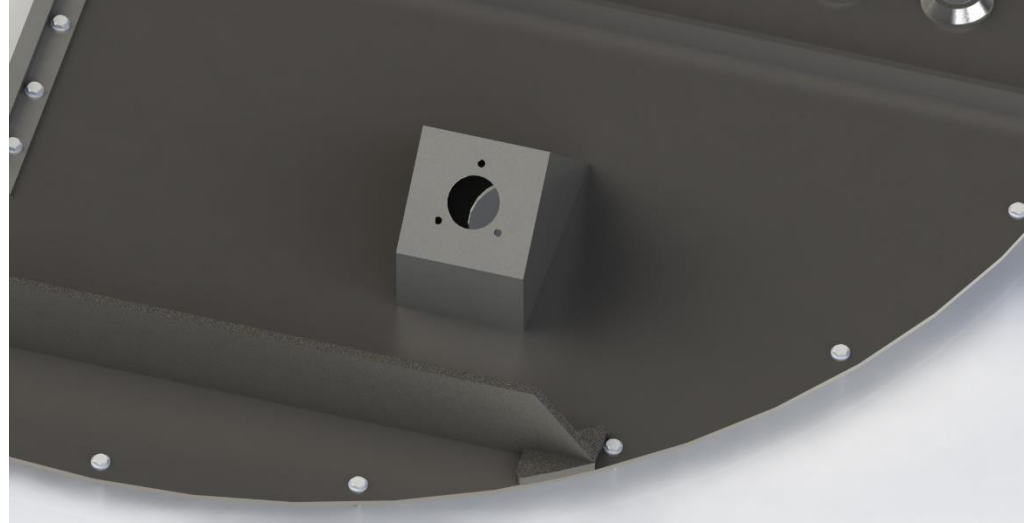
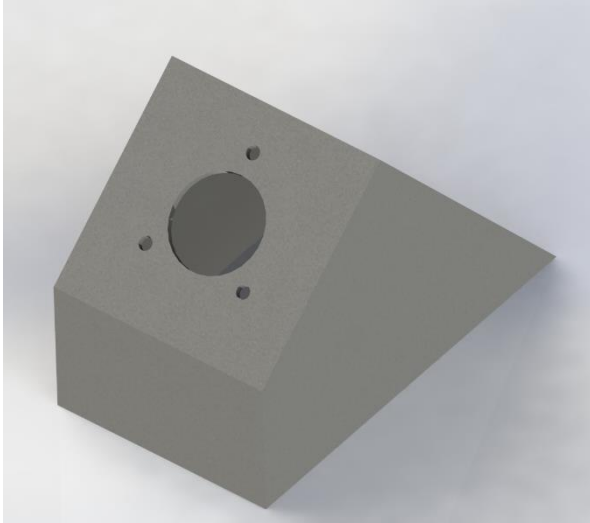
Manufacturing Process

TANK VIEWPORT



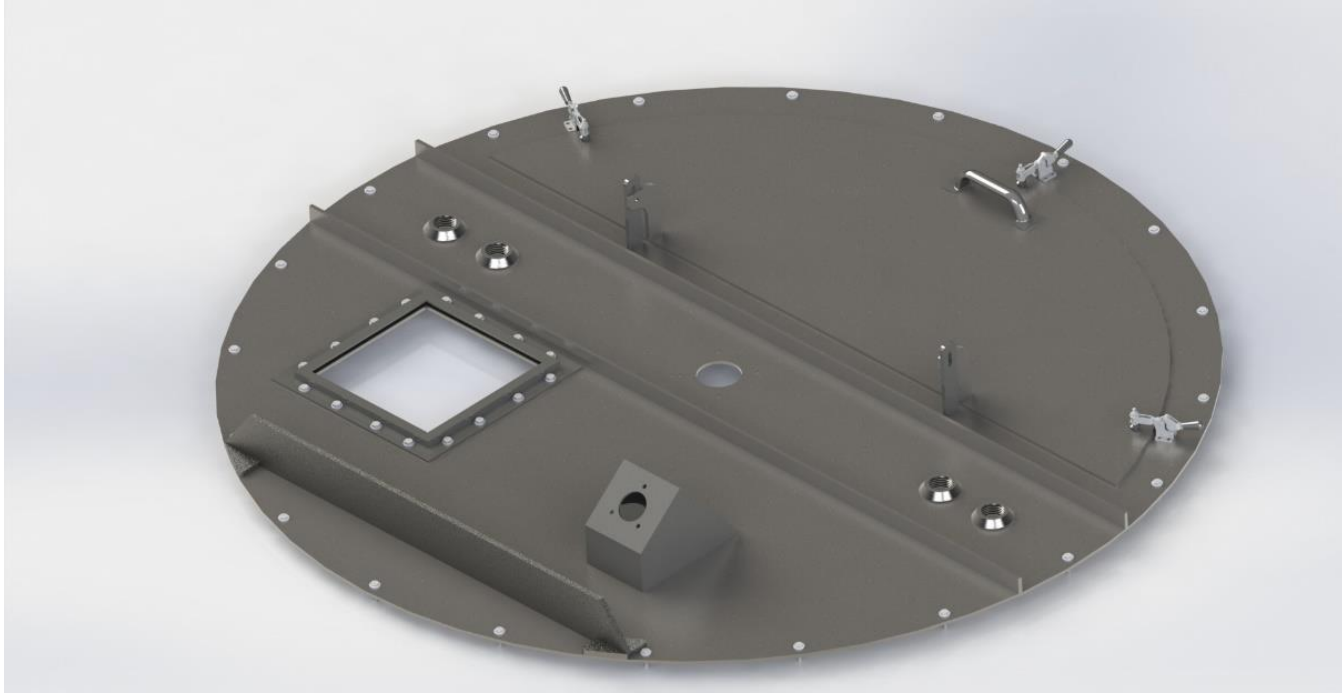
Manufacturing Process

AGITATOR BRACE



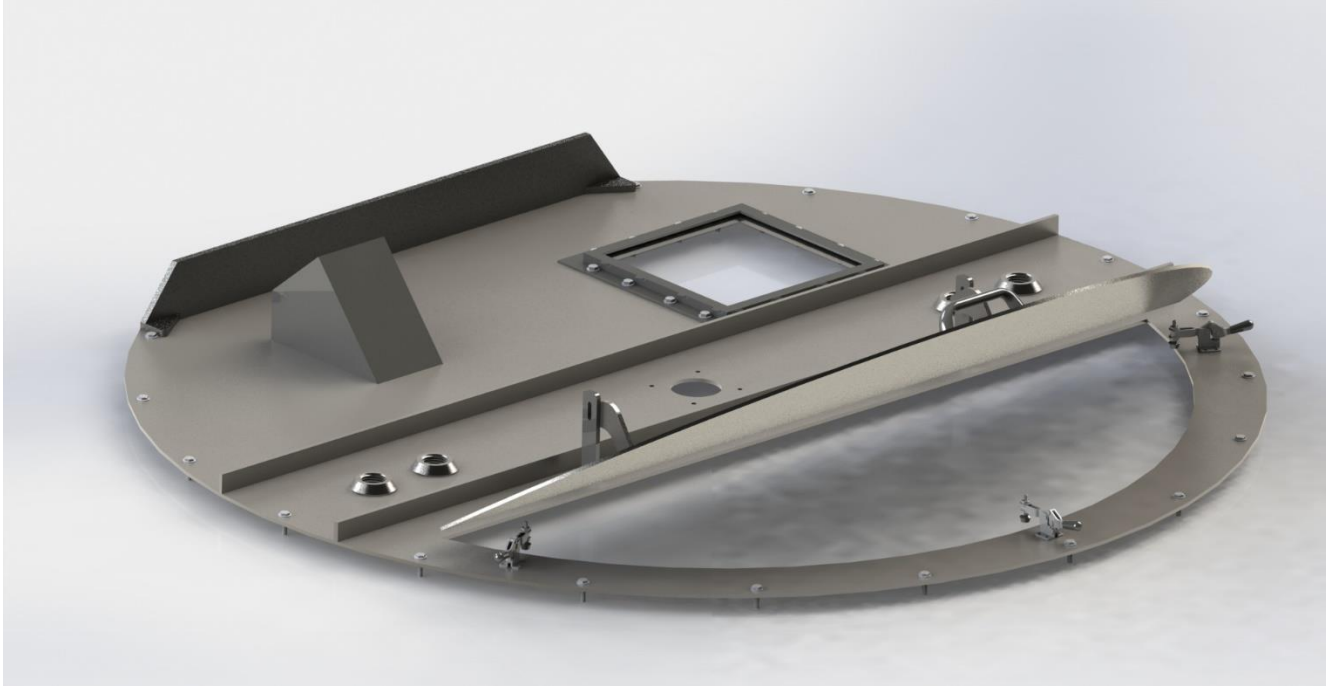
Manufacturing Process

ENCLOSURE ASSEMBLY



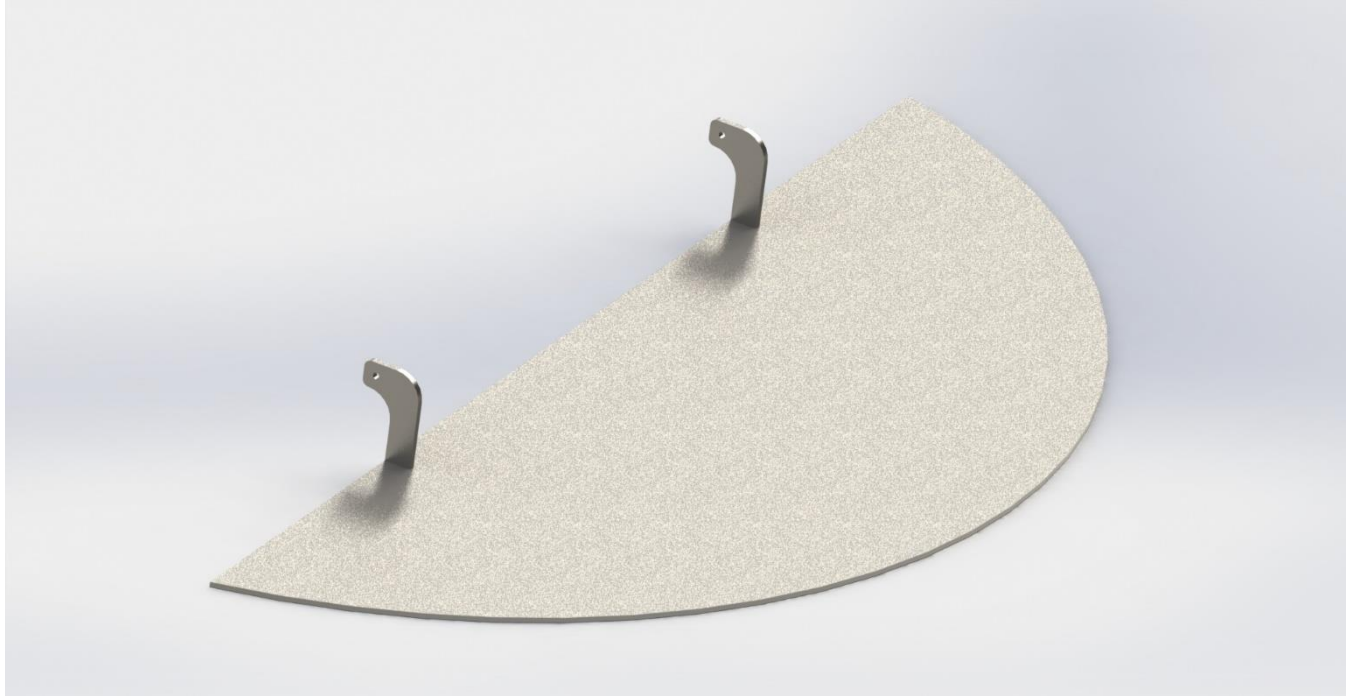
Manufacturing Process

ENCLOSURE ASSEMBLY



Manufacturing Process

DYNAMIC ENCLOSURE



Bill of Materials

MANUFACTURING

Part Name	Quantity	Manufacturer	Part Number	Description	# of Units	Unit Cost	Cost
Clamp	1	McMaster Carr	5126A64	Hold-Down Toggle Clamp, Steel, Standard, 200 lb. Maximum Hold Capacity, 1-3/8" Long Arm	6	\$ 11.15	\$ 66.90
Tank Fitting	1	McMaster Carr	1145K55	Weld-on Fitting for Flat Tanks, Easy-Weld Steel, 1 Pipe Size, 2-3/8" OD	4	\$ 36.82	\$ 147.28
Stainless Steel Plate	1	Metals Depot	S410	10 GA. (.135+/-) thick T304 Stainless Steel Sheet - Dull Mill Finish	1	\$751.04	\$ 751.04
Stainless Steel Flat Bar	1	Metals Depot	F5141	1/4 X 1 304 Stainless Steel Flat	2	\$ 22.80	\$ 45.60
1/4-1" Bolts	2	McMaster Carr	93190A542	Type 316 Stainless Steel Hex Head Cap Screw, 1/4"-20 Thread, 1" Long, Fully Threaded	2	\$ 6.40	\$ 12.80
1/4" Nuts	1	McMaster Carr	94804A029	Type 316 Stainless Steel Hex Nut, 1/4"-20 Thread Size, 7/16" Wide, 7/32" High	1	\$ 9.05	\$ 9.05
1/4" Washer	1	McMaster Carr	90107A013	Type 316 Stainless Steel Flat Washer, Oversized, Number 12 Screw Size, 0.250" ID, 0.562" OD	1	\$ 7.72	\$ 7.72
1/4" Seal Washer	5	McMaster Carr	93781A029	Pressure-Sealing Washer for Nuts and Washers, Zinc-Plated Steel, 1/4" Screw Size, 0.255" ID, 0.562" OD	5	\$ 8.16	\$ 40.80
1/16" Buna-N Rubber Sheet	1	McMaster Carr	8969K73	Ultra-Strength Oil-Resistant Buna-N Rubber, Plain Back, 1/16" Thick, 12" x 24"	2	\$ 17.85	\$ 35.70
Silicon Sealant	1	McMaster Carr	7587A3	Dow Corning Silicone Sealant, Number 732, 10.1-Ounce Cartridge	2	\$ 6.47	\$ 12.94
Gasket Tape	1	McMaster Carr	95705K121	Expanded-PTFE Value Seal Gasket Tape, 0.020" Thick, 1/2" Wide, 50 Feet Long Roll	1	\$ 41.00	\$ 41.00
Pyrex Glass	1	McMaster Carr	8476K21	Heat-Resistant Borosilicate Glass, Square, 10" x 10"-1/4"	1	\$ 33.63	\$ 33.63
Steel Sheet	1	Metals Depot	S110	10 GA. (.135 thick) Steel Sheet Hot Rolled Steel Sheet	1	\$ 38.76	\$ 38.76
Handle	1	McMaster Carr	5187A2	Weld-on Stamped 304 Stainless Steel Oval-Grip Pull Handle, Dull Finish, 6-5/16" Overall Length, 1-1/2" Projection	1	\$ 8.97	\$ 8.97
Grand Total							\$1,252.19



Milestones and Tasks

SCHEDULE

- March 1: Quoting Completed
- March 15: Orders to Suppliers
- April 1: All Parts Procured

