Team Hydr8 Detail Review

Water Desalination
December 7, 2016

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Scope and Project Statement

Team Hydr8 shall design a mechanical water desalination device for use in natural disaster relief. Our device will allow users to convert seawater or other wastewater into drinkable water and allow survival for a family of four for an extended period of time.

Our product shall utilize the reverse osmosis (RO) architecture and will require the following components to be purchased or designed:

- Pump, membrane, inlet filter, check valves, tubing, and casing.

Components such as feedwater and permeate storage are out of scope, but considered for the design of the components which must interface with them.

The product lifespan is 100 hours of operation. At 3.8 hours of operation per day, the mean lifespan of the product is 26.8 days of regular operation.

Constraints considered include: cost, ease of operations, robustness, and ability to meet all customer requirements.

Project Requirements

Customer Requirements:

- Device must be entirely mechanical; no batteries, electric, or other power input.
- Device must remove at least 95% of the salt from standard sea water, resulting in potable water.
- Device must provide enough potable water in a 24 hour period to meet the survival needs of a family of 4.
- Device must be robust enough to drop from a 20 foot height and still be functional.
- Device must be easy to operate, clean and maintain.
- Device must be inexpensive.

Design Requirements

- A mechanical hand pump must provide the pressure necessary for the operation of the reverse osmosis membrane (380 psi minimum)
- All contaminants identified by the EPA Primary Drinking Water Regulations must be at or below acceptable levels (EPA-816-F-09-004) (2000 ppm salt, refer to document for other contaminant details)
- Must supply at least 0.8 gallons per person per 24-hour period to satisfy survival needs (3.17 gallons per day total)
- Components and protective casings must survive the forces associated with a 20 foot fall
- Hand pump must be operable within the average human strength capability (25 to 40 pounds of force)
- Total system must be cheaper than traditional methods of shipping water into disaster zones over the life of the product ($1.2 per gallon plus freight costs)
- Must be light enough to be easily carried by an average human (able to be lifted into the bed of a pickup truck, 45 pounds maximum)

Product Specifications

Our product:

The Hydr8 "Dos Aguas"

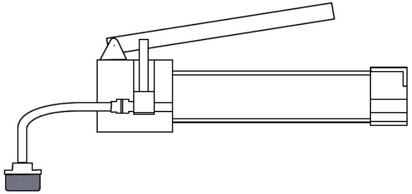
Parameter	Value
Flow Rate*	0.857 gal/h
Pumping Time*	 33% LOTR Extended (3.74 hours)
Max. Force	37.3 lbf
Handle Length	39 in
Working Pressure	450 psi
Weight with Case	23.9 lb
Envelope with Case	28" x 8" x 8"

Stay thirsty my friends….but only .8 gallons a day thirsty, the rest of your family has to drink too

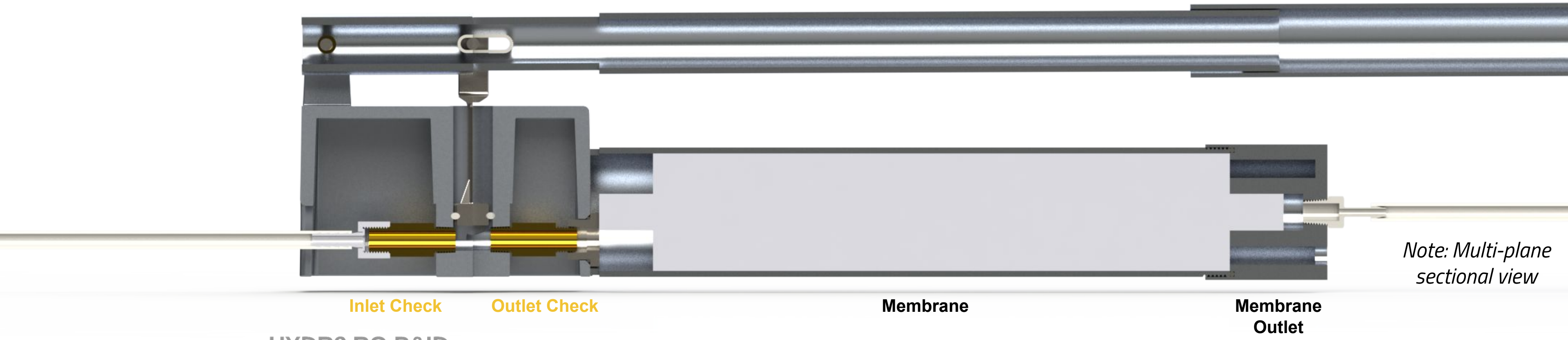
**30 strokes/min*
3.2 gallon target

Concept of Operation

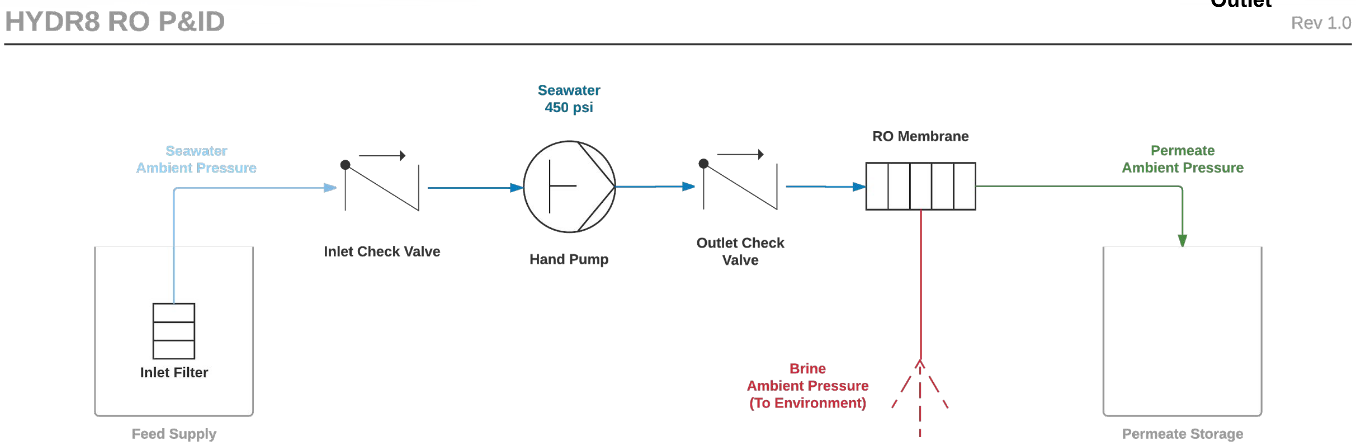
- The Hydr8 Product comes in a polycarbonate case with all components preassembled except for the handle extension
- The user removes the handle from the case, and attaches the handle extension to the handle
- The user then places the desalination device on a sturdy surface with the inlet tube placed into the source water and places her/his feet on the extended sides for support
- The user then raises the pump handle to draw water into the RO membrane and then forcefully pushes the handle down in order to drive the source water through the membrane
- Potable water will exit from the RO membrane through the outlet tubing and can be directed into an acceptable storage device
- If any part ceases proper functioning, the manufacturer will be contacted and the source of the failure will be Identified and corrected



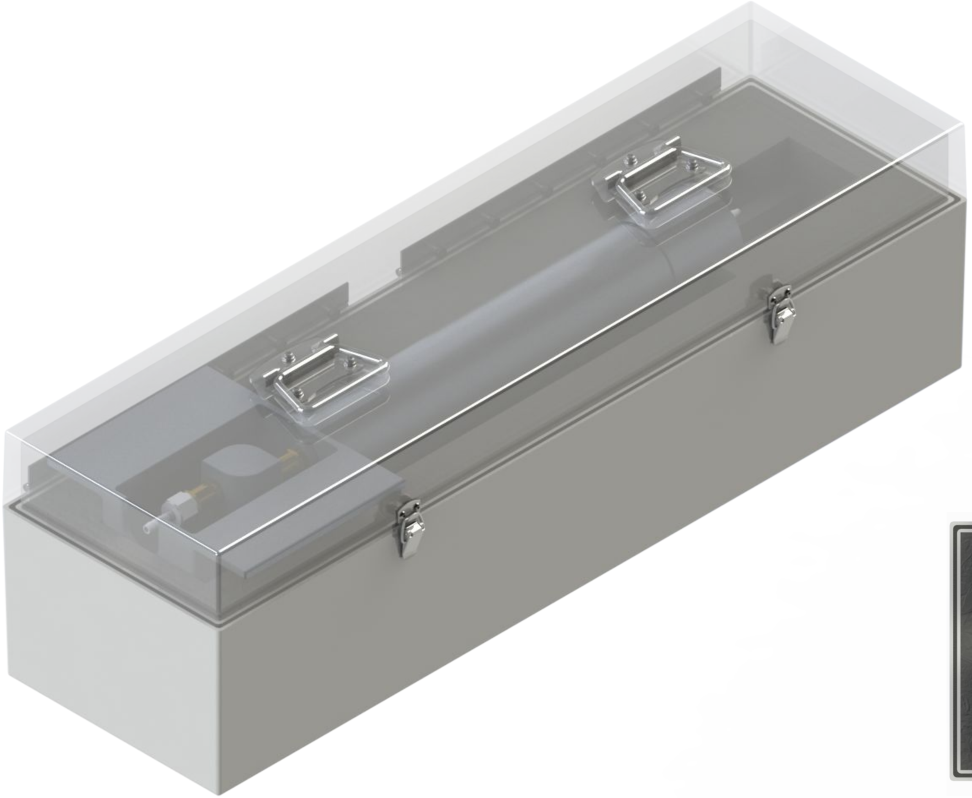
Fluid System Layout



Note: Multi-plane sectional view



Fall Protection



- Impact Resistance
  - Polycarbonate casing
- Energy Absorption
  - Closed-cell polyurethane foam of optimum density
- Environmental Resistance of Polycarbonate
  - Excellent resistance against seawater
  - Resistance satisfactory up to 120°F

Derived Requirement	Requirement Justification
Must use mechanical means to produce at least 380 psi for RO membrane (osmotic pressure of dissolved sodium)	Hand operated pump produces 450 psi
Must be portable and easy to transport by the average human (maximum 45 pounds)	The weight of the total system (the desalinator and the external case) is 23.9 pounds and the dimensions are 28”x8”x8”
Must produce at least 3.17 gallons of water per day	Produces 3.2 gallons over the recommended daily operating timeframe
Must produce the required amount of water in a 24 hour window	It takes the user approximately 32.76% the run time of the Lord of the Rings series extended edition to pump 3.2 gallons. (Roughly 3 hours 44 minutes in layman’s terms)
Must be operable within the average human strength capability (25-40 pounds)	Maximum force required on the handle is 37.3 pounds (at 45 degrees handle extension), and 27.8 pounds (at 0 degrees handle extension)
Must survive the forces associated with a 20-foot fall	External case is able to withstand 483.4 ft-lb (.648 kJ) of energy at impact
Total system must be cheaper than the cost of shipping water to a disaster area ($1.2 per gallon plus freight costs)	Final cost of the product is $450, which displaces water shipping costs at approximately 18 days of operation (lifespan of the product is roughly 27 days)

Bill of Materials

Part Number	Part	Material	Vendor Part Number	Vendor	Manufacturing Method	Quantity	Cost per Unit
HYD-100-001	Housing	K-Alloy/A304	N/A	Manufactured	Die Cast, Machine	1	$9.03
HYD-100-002	Seal Nut	316 SS	N/A	Manufactured	Machine	1	$6.06
HYD-100-003	Seal Nut O-Ring	Silicon	9396K66	McMaster-Carr	-	1	$0.18
HYD-100-004	Piston O-Ring	Silicon	9396K32	McMaster-Carr	-	1	$0.21
HYD-100-005	Membrane	Fiberglass	SWC-2514	WaterSurplus	-	1	$137.20
HYD-100-006	Barbed to Male Fitting	Nylon	5463K445	McMaster-Carr	-	1	$0.50
HYD-100-007	Membrane Housing	6061-T6 Aluminum	N/A	Manufactured	Extrude, Machine	1	$16.04
HYD-100-008	Inlet Tubing	Flexible PVC	5233K56	McMaster-Carr	-	1	$0.96
HYD-100-009	Check Valve	Brass	7775K22	McMaster-Carr	-	2	$12.98
HYD-100-011	Outlet Tubing	Food Grade Flexible PVC	5231K331	McMaster-Carr	-	1	$0.34
HYD-100-012	Silicon O-Ring	Silicon	9396K163	McMaster-Carr	-	1	$0.68

Make/Buy Justification

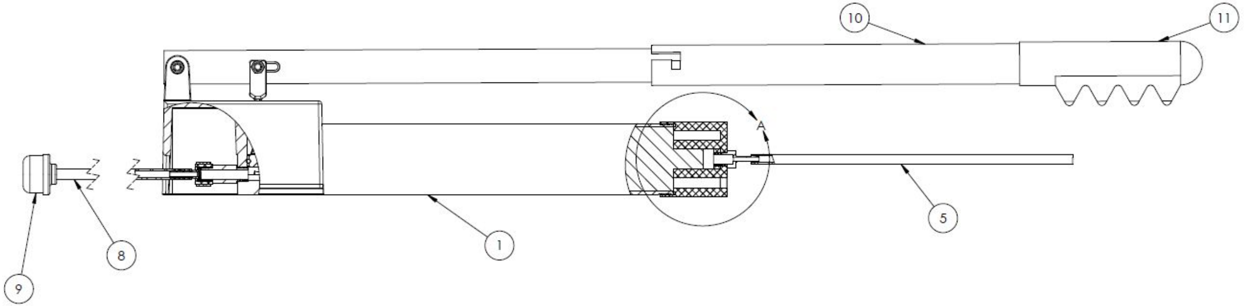
Purchased Parts:

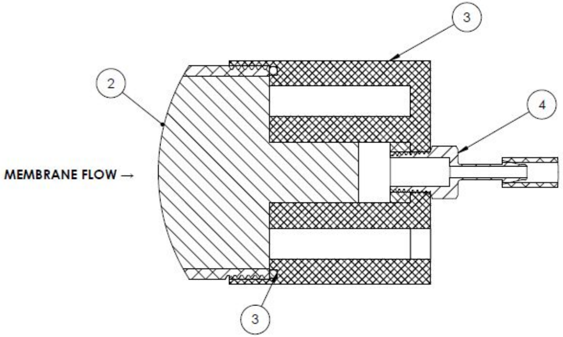
- Any components that could be purchased was purchased
  - This includes all fasteners, nuts, washers, hinges, latches, check valves, the RO membrane, and the handle rubber grip

Manufactured Parts:

- All other parts are required to be manufactured in order to fit the custom needs of the project
  - Most major components of the product must be manufactured, such as the pump housing, pump piston, external casing, and membrane casing.

Assembly Drawing





DETAIL A
SCALE 1 : 1

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	HYD-100-521	Pump, Fluid Assembly, Hydr8	1
2	HYD-100-005	Membrane, Fluid Assembly, Hydr8	1
3	HYD-100-015	Membrane Outlet End Cap, Fluid Assembly, Hydr8	1
4	HYD-100-006	Barbed to Male Fitting, Fluid Assembly, Hydr8	1
5	HYD-100-011	Outlet Tubing, Fluid Assembly, Hydr8	1
6	HYD-100-012	Silicon O-Ring, Fluid Assembly, Hydr8	1
7	HYD-100-026	Barbed to Female Fitting, Fluid Assemnly, Hydr8	1
8	HYD-100-008	Inlet Tubing, Fluid Assembly, Hydr8	1
9	HYD-100-014	Inlet Filter, Fluid Assembly, Hydr8	1
10	HYD-100-017	Handle Extension, Handle Extension, Fluid Assembly, Hydr8	1
11	HYD-100-019	Handle Grip, Pump, Fluid Assembly, Hydr8	1

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°

SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

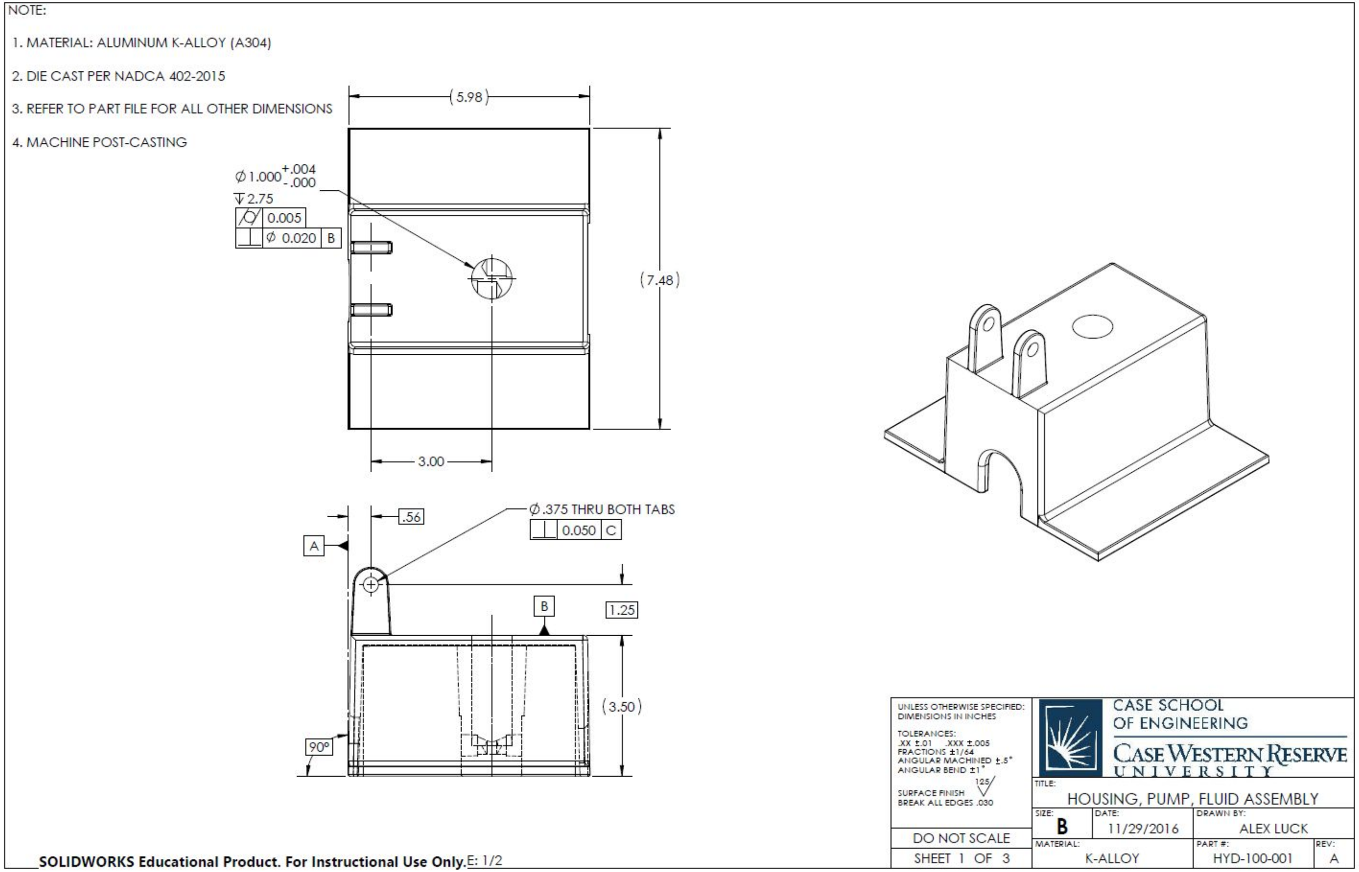
CASE SCHOOL OF ENGINEERING
CASE WESTERN RESERVE UNIVERSITY

TITLE: FLUID ASSEMBLY, HYDR8

SIZE: B | DATE: 12/4/2016 | DRAWN BY: ALEX LUCK

MATERIAL: N/A | PART #: HYD-100-501 | REV: A

Component Detail Drawing

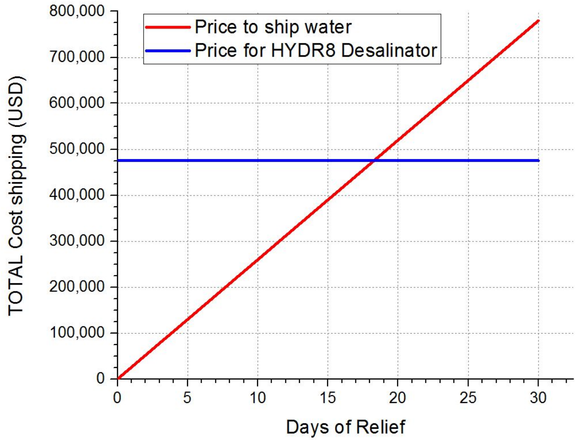


FMEA

Part Number	Part/Assy Description	Function	Failure Mode	Effects of Failure	Causes of Failure	Detection	S	O	D	RPN	Corrective Action	S	O	D	RPN
HYD-100-015	Membrane Outlet End Cap, Filter, Fluid Assembly, Hydr8	Seals membrane inside housing, directs permeate into outlet tubing	Manufacturing defects	Cap fails and membrane no longer able to be pressurized	Improper manufacturing, materials defects from casting process	User inspects end cap	8	4	4	128	Entire system should be pressurized above operating pressure	8	2	4	64
HYD-100-009	Check Valve, Pump, Fluid Assembly, Hydr8	Allows flow of water to pass in one direction only	High Cycle Fatigue	No way to pass water in required direction, failure of entire system	Part wears out over numerous cycles	User inspects part and ensures that check valves functioning as intended	7	4	4	112	Test check valves over high number of cycles before releasing to market	7	2	4	56
HYD-100-008	Inlet Tubing, Fluid Assembly, Hydr8	Provides pathway of water from source to pump piston	Blockage	Inability to draw water into pump	Insufficient filtering of source water by inlet filter	User observes operation of pump for consistent output	9	4	3	108	Increase tubing ID and improve inlet filtering	9	1	3	27
HYD-100-007	Membrane Housing, Filter, Fluid Assembly, Hydr8	Holds the membrane to allow for pressurization	Stress Rupture	Bursting of membrane housing, complete failure of system	Insufficient wall thickness, cyclic loading	User checks for visible damage	9	3	4	108	Increase wall thickness, factor of safety of 4 regarding yield stress	9	1	4	36
HYD-100-004	O-Ring, Piston, Fluid Assembly, Hydr8	Creates a seal between the piston cylinder and the pump bore so there is no loss of pressure	Seal breaks, allowing pressure to escape	Pump loses efficiency and may cease to be usable entirely	Corrosion, wear, or fatigue of the silicon o-ring	Inspection post-production	7	3	5	105	Use a factor of safety of at least 3 in terms of O-ring thickness, material selection	7	2	5	70

Cost Estimate

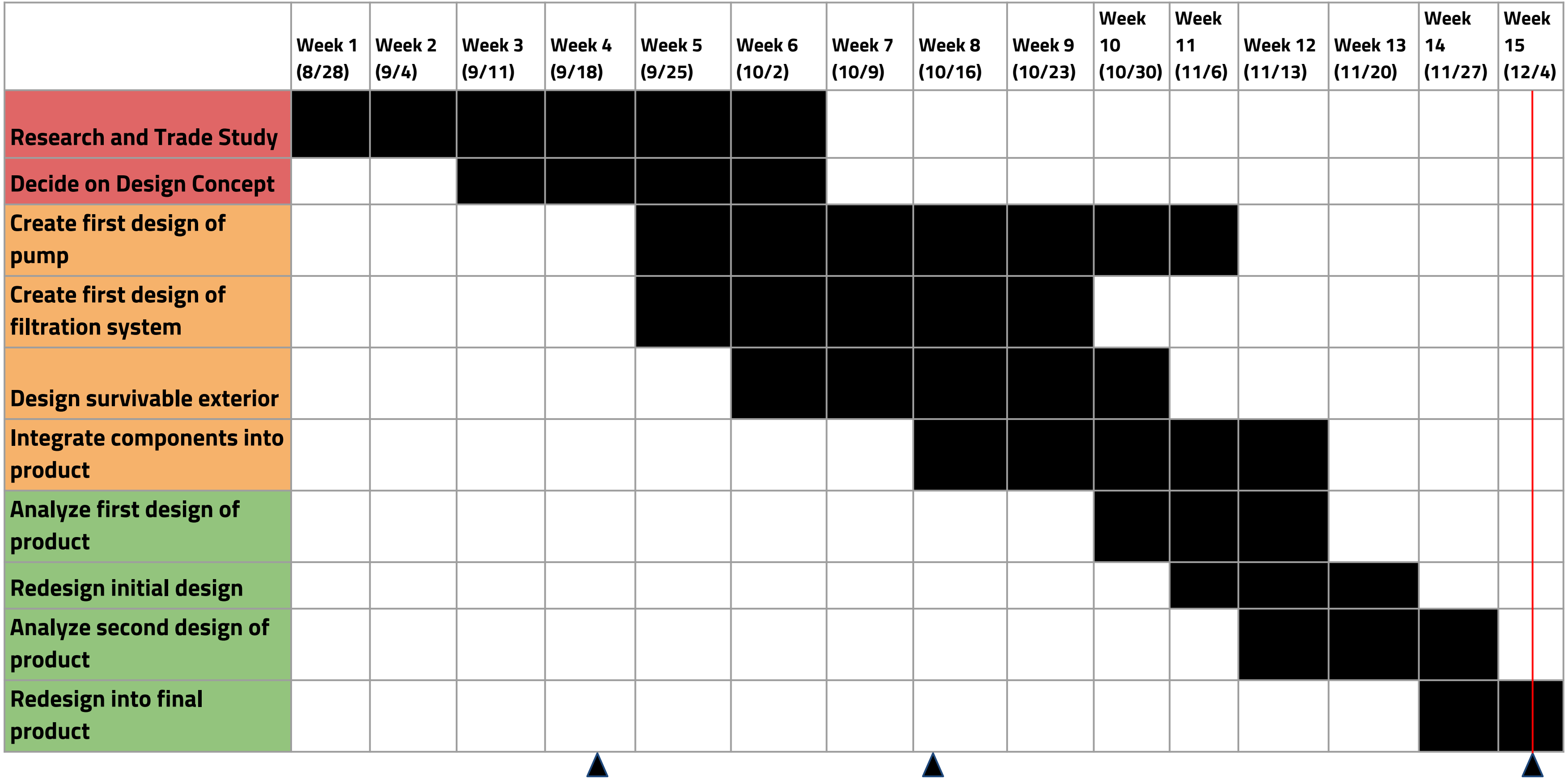
- Our cost
  - Original goal: $400 to make, retail at $500/unit (25% markup)
  - Current: $324.38 to make, retail at $450/unit (39% markup)
- Methodology for our Cost
  - Manufactured Parts: Solidworks costing
  - Purchased Parts: Provided by vendor
- Against our competitors
  - Katadyn Survivor 35: $2,395.00 per unit
  - Shipping water: Save $304,680 vs. shipping 30 days of water for 1000 families, breaks even at 18 days



Materials and Manufacturing

- Materials used in non purchased parts: 6061 and K-Alloy/A304 Aluminum, 316 Stainless Steel, Polycarbonate, and Acetal(POM)
  - Primary considerations were strength, corrosion resistance, and weight reduction
- Manufacturing processes used: Die Casting, Sand Casting, Injection Molding, Extrusion, and Machining
  - Methods to reduce cost for large productions runs used when possible

Gantt Chart


Week 1 (8/28)
Week 2 (9/4)
Week 3 (9/11)
Week 4 (9/18)
Week 5 (9/25)
Week 6 (10/2)
Week 7 (10/9)
Week 8 (10/16)
Week 9 (10/23)
Week 10 (10/30)
Week 11 (11/6)
Week 12 (11/13)
Week 13 (11/20)
Week 14 (11/27)
Week 15 (12/4)
Research and Trade Study
Decide on Design Concept
Create first design of pump
Create first design of filtration system
Design survivable exterior
Integrate components into product
Analyze first design of product
Redesign initial design
Analyze second design of product
Redesign into final product

Hydr8 Backup

Sources

- **WHO Technical Notes on Drinking-Water, Sanitation, and Hygiene in Emergencies**
  - Water intake needs of a single person per day (3L, 3.17 gallons for four people)
- **EPA Drinking Water Advisory (EPA 822-R-03-006)**
  - Salinity of acceptable drinking water (Seawater is 30,000 ppm, drinking water is 2,000 ppm)
- **EPA National Primary Drinking Water Regulations Contaminant Table (EPA-816-F-09-004)**
  - Acceptable levels of non-sodium contaminants (heavy metals, bacteria, etc)
- **Contaminants Removed by Reverse Osmosis** (https://www.h2odistributors.com/pages/contaminants/contaminants-reverse-osmosis.asp)
- **Human Strength Capability and Low Back Pain** by Dr. Don Chaffin and **Maximum isoinertial lifting capabilities for different lifting ranges and container dimensions** by Tzu-Hsien Lee
  - Maximum average human lifting capabilities
- **Human Performance Capabilities** (https://msis.jsc.nasa.gov/sections/section04.htm#_4.9_STRENGTH)
  - Human performance capabilities (force output of average human)
- **McMaster-Carr**
  - Purchased parts cost estimates
- **Valmatic Design and Selection Criteria of Check Valves** (http://www.valmatic.com/pdfs/DesignSelectCriteriaCV.pdf)
  - Check valve selection requirements

Sources (continued)

- **NADCA Product Specification Standards for Die Casting**
  - Die Casting specifications and requirements
- **Parker O-Ring Friction Estimation Guide** (https://www.parker.com/literature/O-Ring%20Division%20Literature/Static%20Files/frictionestimation.pdf)
  - Estimation of friction forces acting on the piston
- **Cost of Bottled Water** (http://www.bottledwater.org/economics/real-cost-of-bottled-water)
  - Shipping freight costs of bottled water
- **"Mechanical Properties and Energy Absorption Characteristics of a Polyurethane Foam"**
  - PU energy absorbed, http://www.osti.gov/scitech/servlets/purl/485941/, pg. 24
- **Cole-Palmer**
  - Chemical compatibility of polycarbonate with seawater
- **Impact Properties and Uses of PC**
  - https://www.ecnmag.com/article/2013/11/polycarbonate-vs-fiberglass-and-stainless-steel
  - http://aviation.stackexchange.com/questions/21802/what-kind-of-materials-is-being-used-for-fighter-jets-glass-shields

BOM Continued

Part Number	Part	Material	Vendor Part Number	Vendor	Manufacturing Method	Quantity	Cost per Unit
HYD-100-013	Handle	6061-T6 Aluminum	N/A	Manufactured	Extrude, Weld	1	$7.60
HYD-100-014	Inlet Filter	PVC	98755K11	McMaster-Carr	-	1	$2.57
HYD-100-015	Membrane Outlet End Cap	6061-T6 Aluminum	N/A	Manufactured	Machine	1	$22.34
HYD-100-016	Piston Fulcrum Pin	316 Stainless Steel	N/A	Manufactured	Machine	1	$5.07
HYD-100-017	Handle Extension	6061-T6 Aluminum	N/A	Manufactured	Extrude, Machine	1	$8.26
HYD-100-018	Bushing	Brass	1677K3	McMaster-Carr	-	2	$1.11
HYD-100-019	Handle Grip	Rubber	97045K36	McMaster-Carr	-	1	$2.14
HYD-100-021	Piston	316 Stainless Steel	N/A	Manufactured	-	1	$3.52
HYD-100-022	Lock Nut	Stainless Steel, Nylon Insert	90715A125	McMaster-Carr	-	4	$0.15
HYD-100-023	Handle Fulcrum Pin	316 Stainless Steel	N/A	Manufactured	Machine	1	$5.08
HYD-100-024	Polymer Insert	POM (Acetal)	N/A	Manufactured	Injection Mold	1	$5.42
HYD-100-026	Barbed to Female Fitting	Nylon	5372K212	McMaster-Carr	Market Research	1	$0.98

BOM Continued

Part Number	Part	Material	Vendor Part Number	Vendor	Manufacturing Method	Quantity	Cost per Unit
HYD-200-001	Upper Shell	Polycarbonate	N/A	Manufactured	Injection Mold	1	$9.84
HYD-200-002	Lower Shell	Polycarbonate	N/A	Manufactured	Injection Mold	1	$10.51
HYD-200-003	Upper Foam	Polyurethane (closed cell)	N/A	Manufactured	Hand Cut	1	$2.98
HYD-200-004	Lower Foam	Polyurethane (closed cell)	N/A	Manufactured	Hand Cut	1	$0.81
HYD-200-005	Hinge	Aluminum (Clear Anodized)	1575A74	McMaster-Carr	-	2	$4.46
HYD-200-006	Latch	304 Stainless Steel	6082A12	McMaster-Carr	-	2	$6.77
HYD-200-007	Hinge Mounting Hardware	Zinc-Plated Steel	91263A507	McMaster-Carr	-	24	$0.11
HYD-200-008	Hinge Sealing Washer	EPDM	90130A007	McMaster-Carr	-	24	$0.06
HYD-200-009	Hinge Hex Nut	Zinc-Plated Steel	90480A007	McMaster-Carr	-	24	$0.01
HYD-200-010	Latch Mounting Hardware	Passivated 316 stainless steel	98164A438	McMaster-Carr	-	8	$0.14
HYD-200-011	Latch Sealing Washer	Neoprene Rubber	90133A005	McMaster-Carr	-	8	$0.07
HYD-200-012	Latch Hex Nut	8-18 Stainless Steel	91841A006	McMaster-Carr	-	8	$0.06
HYD-200-013	Gasket	Buna N (Nitrile)	8635K364	McMaster-Carr	-	1	$0.48
HYD-200-014	Handle	Zinc-Plated Steel	1647A31	McMaster-Carr	-	2	$3.77
HYD-200-015	Handle Mounting Hardware	410 Stainless Steel	94629A670	McMaster-Carr	-	6	$0.05

Pump Backup

Diameter (in)	Stroke (in)	Pressure Req (psia)	Target Gallons	Strokes/Min	Memb Efficiency	Length B (in)	Length A (in)	Handle Length (in)		Seal Friction (lb)
1	2	450	3.2	30	0.07	36	3	39		8

Piston Area (in^2)	Volume (in^3)	Vol Per Stroke (gal)	Permeate (gal)	Strokes Req	Feed Rate (gpm)	Theta (max)	Relative B	Relative A
0.785	1.571	0.007	0.000	6722.705	0.204	41.810	26.833	2.236

Fp (lb)	Minutes Req
361.429	224.090

Hours Required	Fmin (lb)	Fmax (lb)	gal/h
3.735	27.802	37.301	0.857

Survivability Backup

Material Properties

- Tensile Strength: 900psi (6.205MPa)

Other Uses of Polycarbonate

- Used in making bulletproof windows
- F22 Canopy to protect it from bird strikes

Survivability Backup

Survivability Backup

Polyurethane Foam Energy Absorption

- Energy Absorption is about $1.5 J/cm^3$ at a density of $0.36 g/cm^3$
- Upper case foam: $3,376 cm^3$
- Lower case foam: $12,405 cm^3$
- $1.5 J/cm^3(3,376 cm^3+12,405 cm^3) =$ 23,671.5J absorbed

Energy to be absorbed:

- Basic Concept: KE = PE
- Basic Equation: $\frac{1}{2}mv^2 = mgh$
- [Calculation Spreadsheet]

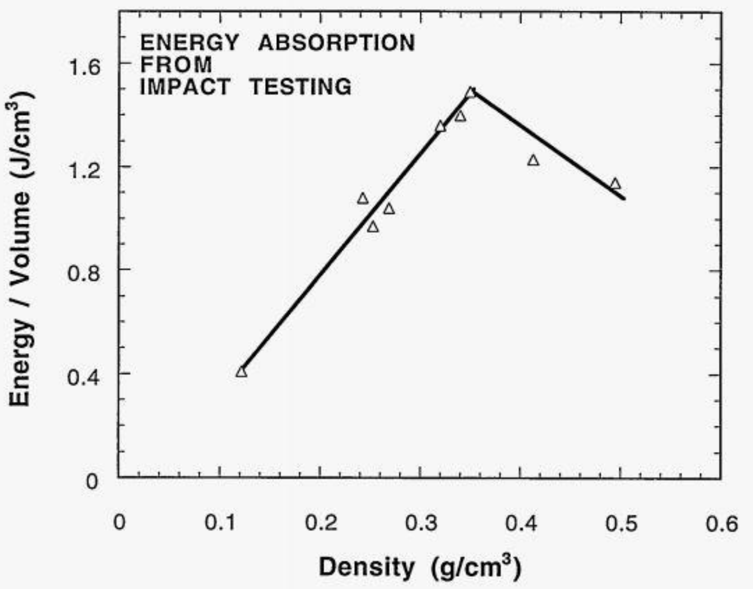


Figure 15. Energy absorption of CRETE vs. density for impact testing. Unlike quasi-static testing, energy absorption peaks at an intermediate value of density.

Flotation Calculation

$F_b = \rho_w Vg$ (Bouyant force)

- ρ_w is the density of water, V is volume of object submerged

$F_g = mg = W$ (Force of gravity)

Setting $F_b = F_g$ we get: $\rho_w Vg = W$

Rearranging, the minimum required submerged volume to float is: $V_{min} = W/(\rho_w g)$

$V_{min} = 23.9\text{lb} / (1.940 \text{ slugs/ft}^3 * 32.2\text{ft/s}^2) = 0.383 \text{ ft}^3$

Our volume: 28”x 8”x 8” = 1792 in^3 = 1.037 ft^3

*Note: the ρ_w used is for fresh water, which is less dense than seawater

Pressure Drop Calculations

Check Valves		
GPM (based on pump)	Specific Gravity (water)	Acceptable Pressure Drop (psi)
0.204	1	1
Cv = GPM * (SG/dp)^1/2		
Minimum Cv	0.102	
Actual Cv	1.1	
Actual Pressure Loss (psI)	**0.034**	
http://www.engineeringtoolbox.com/flow-coefficients-d_277.html		

Inlet Tubing				Outlet Tubing		
Absolute rougheness (in)	0.00000192			Absolute rougheness (in)	0.00000192	
Diameter (in)	0.25			Diameter (in)	0.25	
Relative roughness	0.00000767			Relative roughness	0.00000767	
Density (slugs/ft^3)	1.937888199			Density (slugs/ft^3)	1.937888199	
Flow rate (GPM)	0.204			Flow rate (GPM)	0.204	
Flow rate (lb/s)	0.02856			Flow rate (lb/s)	0.02856	
Area (ft^2)	0.004090615			Area (ft^2)	0.004090615	
Velocity (ft/s)	0.111888374			Velocity (ft/s)	0.111888374	
Kinematic Viscosity (ft^2 /s)	0.0000105			Kinematic Viscosity (ft^2 /s)	0.0000105	
Reynolds number	222			Reynolds number	222	
Friction Factor	0.289	f = 64/Re		Friction Factor	0.289	
Length (in)	48			Length (in)	12	
Pressure Drop	0.673	(lb/ft^2)		Pressure Drop	0.168	
Pressure Drop	**0.00467**	**psi**		**Pressure Drop**	**0.00117**	**psi**

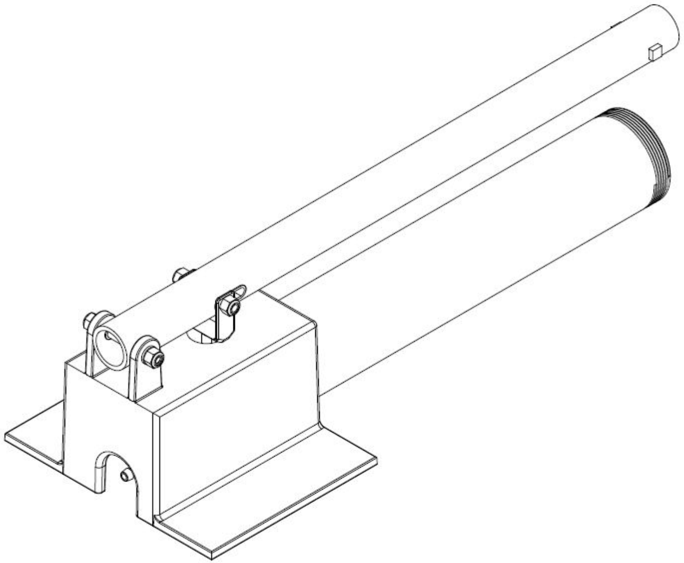
Membrane Housing Calculation

Controlling stress in a cylindrical pressure vessel is circumferential (hoop) stress		
circumferential stress = Pressure * radius / thickness		
Radius (in)	1.2	
Pressure (psi)	1000	
Yield Strength (psi)	40000	6061 T6 aluminum
Thickness required (in)	0.03	
Thickness of 1/8" (0.125") provides a factor of safety of greater than 4.		

Pump Drawing

NOTES:

1. USE TEFLON TAPE ON ALL NPT THREADS
2. WELD USING ER4043



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	HYD-100-001	Housing, Pump, Fluid Assembly, Hydr8	1
2	HYD-100-009	Check ValveCheck Valve, Pump, Fluid Assembly, Hydr8	2
3	HYD-100-007	Membrane Housing, Pump, Fluid Assembly, Hydr8	1
4	HYD-100-002	Seal Nut, Pump, Fluid Assembly, Hydr8	1
5	HYD-100-018	Bushing, Pump, Fluid Assembly, Hydr8	2
6	HYD-100-023	Handle Fulcrum PinHandle Fulcrum Pin, Pump, Fluid Assembly, Hydr8	1
7	HYD-100-022	Lock Nut, Pump, Fluid Assembly, Hydr8	4
8	HYD-100-003	Seal Nut O-Ring, Pump, Fluid Assembly, Hydr8	1
9	HYD-100-026	Barbed to Female Fitting, Fluid Assemnly, Hydr8	1
10	HYD-100-013	Handle, Handle, Fluid Assembly, Hydr8	1
11	HYD-100-024	Polymer Insert, Pump, Fluid Assembly, Hydr8	1
12	HYD-100-021	Piston, Pump, Fluid Assembly, Hydr8	1
13	HYD-100-012	Silicon O-Ring, Fluid Assembly, Hydr8	1
14	HYD-100-016	Piston Fulcrum Pin, Pump, Fluid Assembly, Hydr8	1

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°

SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 4

CASE SCHOOL OF ENGINEERING
CASE WESTERN RESERVE UNIVERSITY

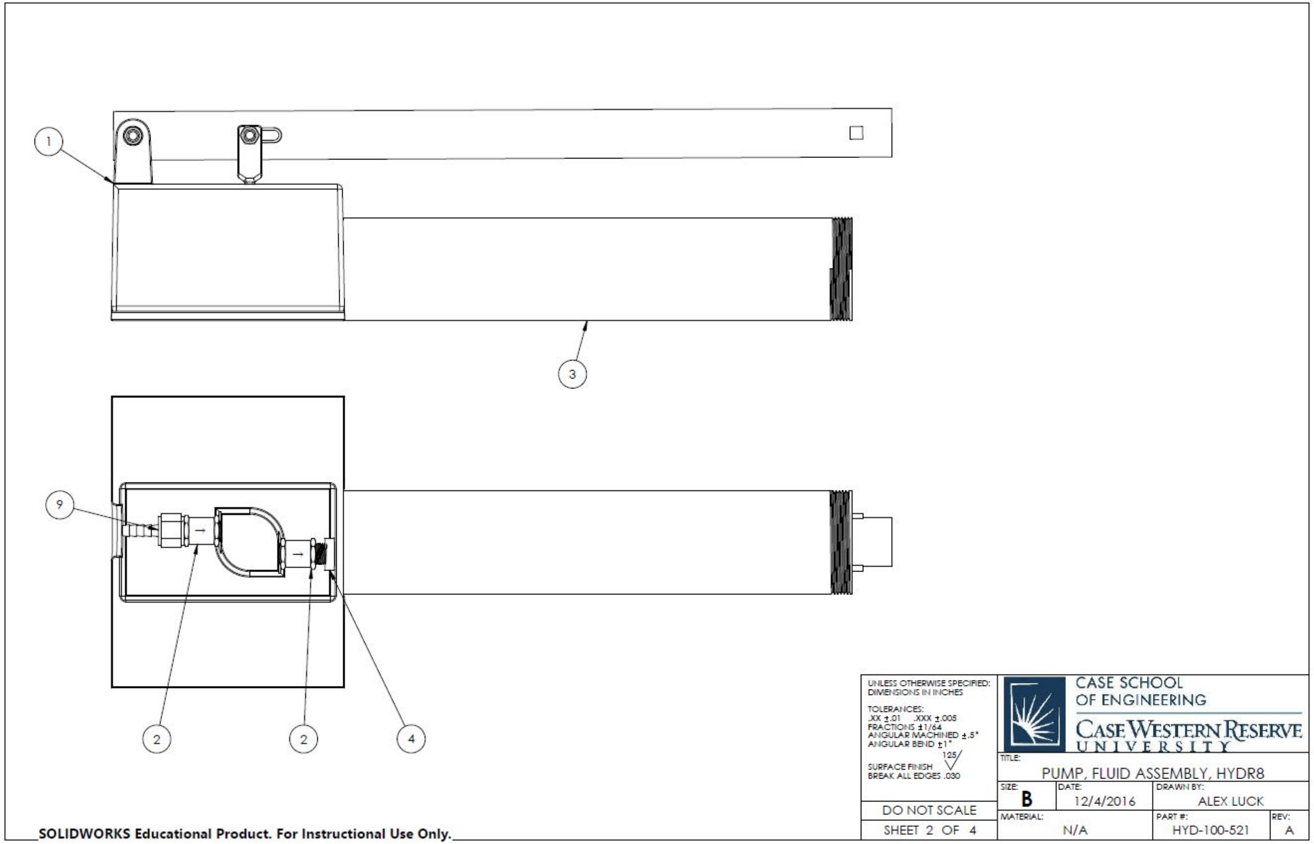
TITLE: PUMP, FLUID ASSEMBLY, HYDR8

SIZE: B | DATE: 12/4/2016 | DRAWN BY: ALEX LUCK

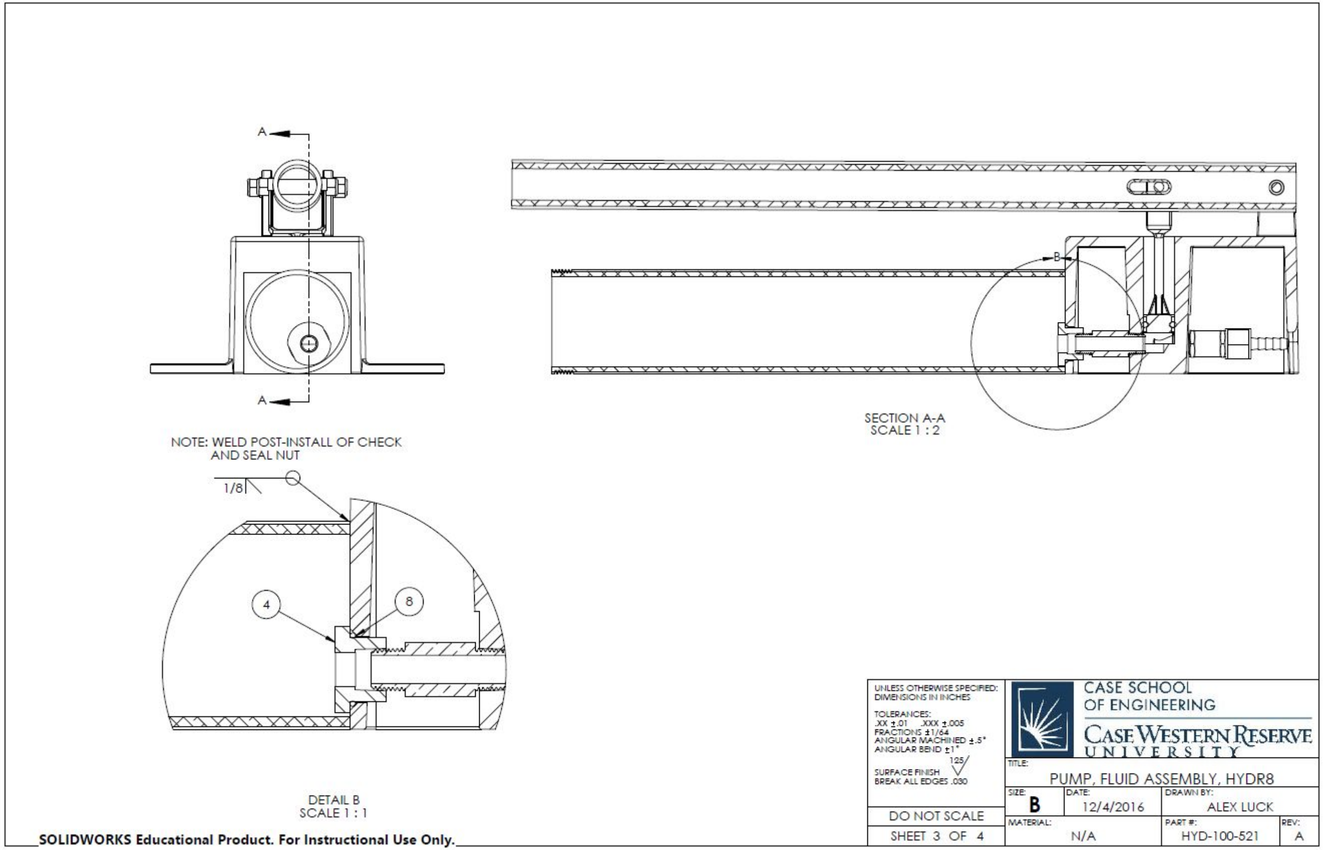
MATERIAL: N/A | PART #: HYD-100-521 | REV: A

SOLIDWORKS Educational Product. For Instructional Use Only.

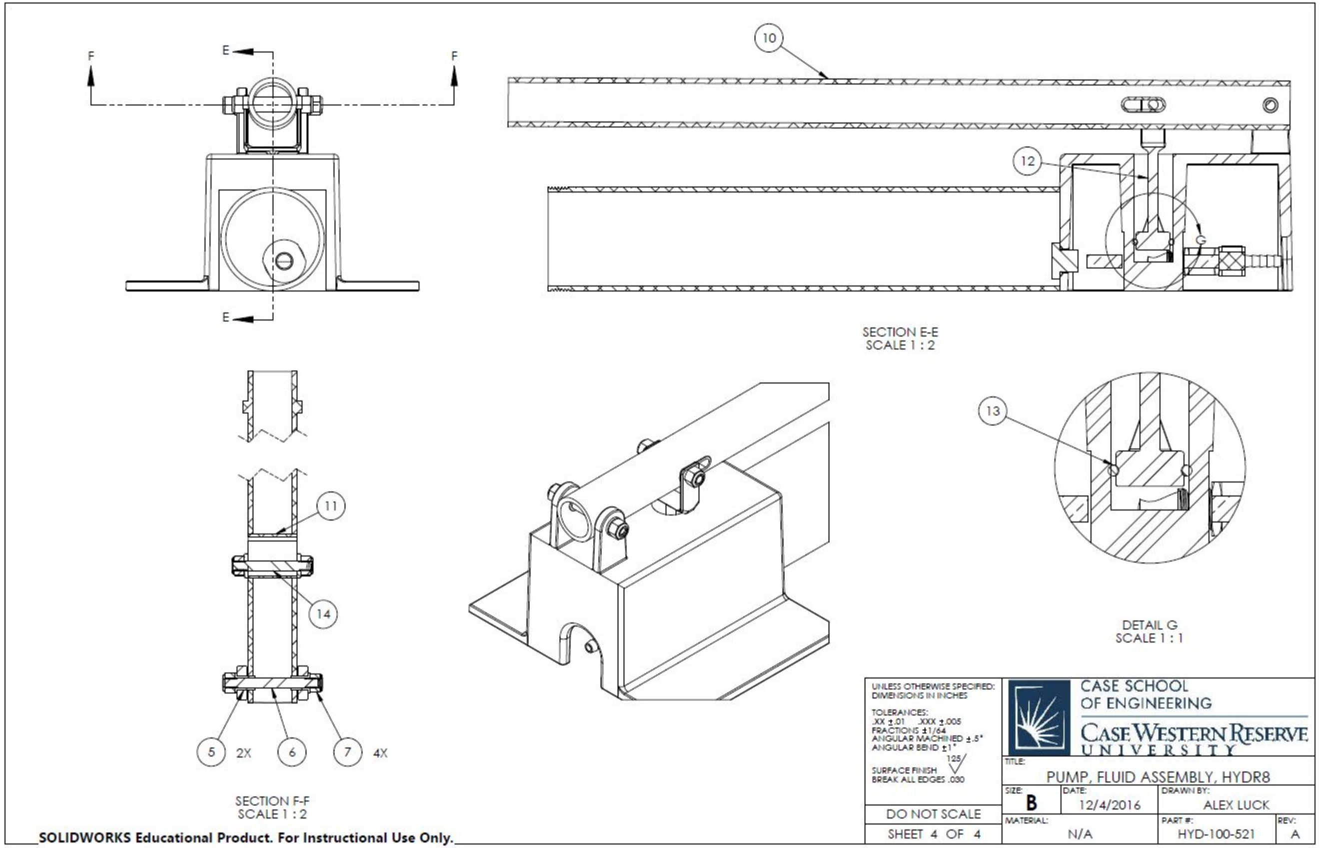
Pump Drawing



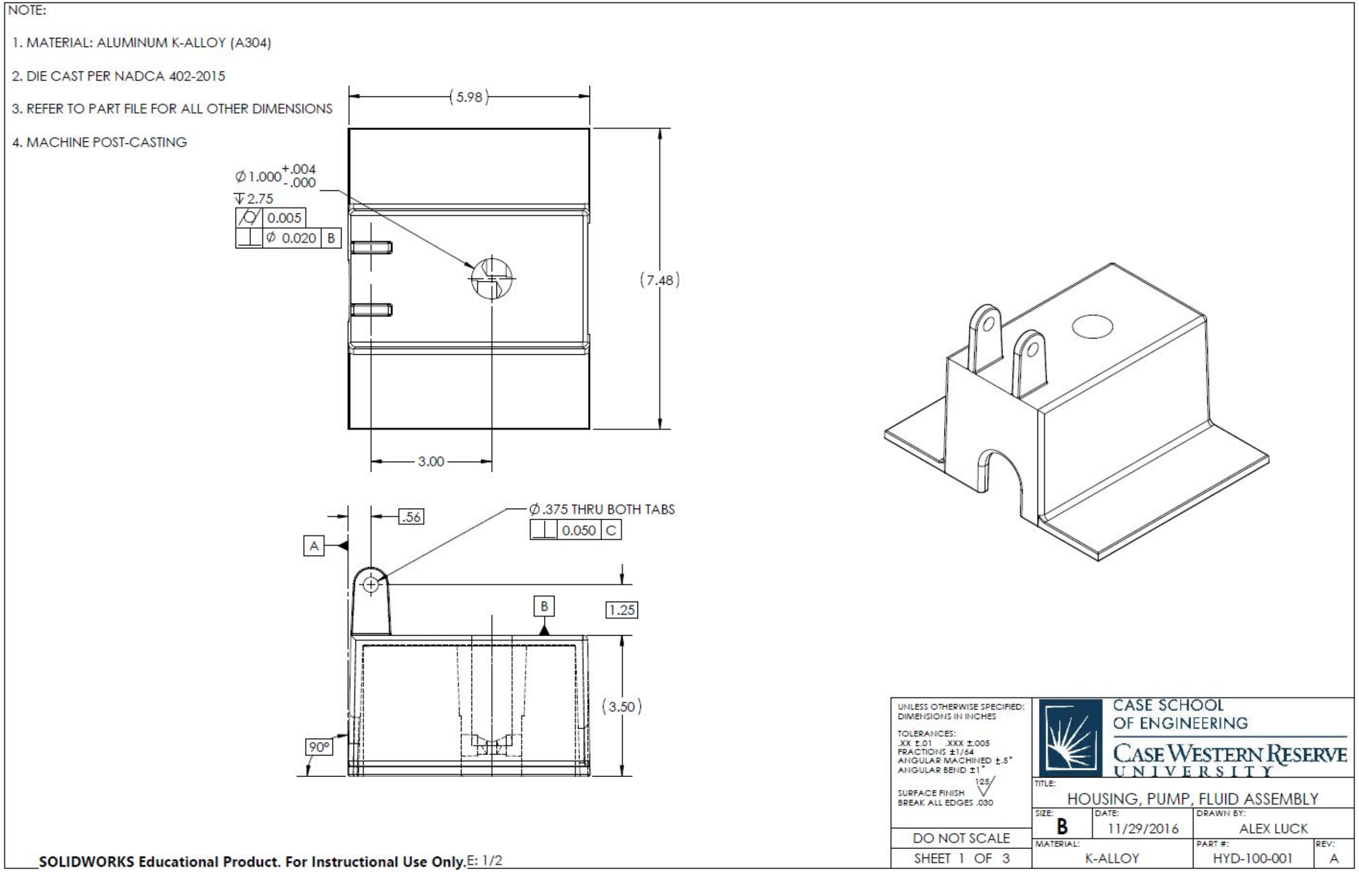
Pump Drawing



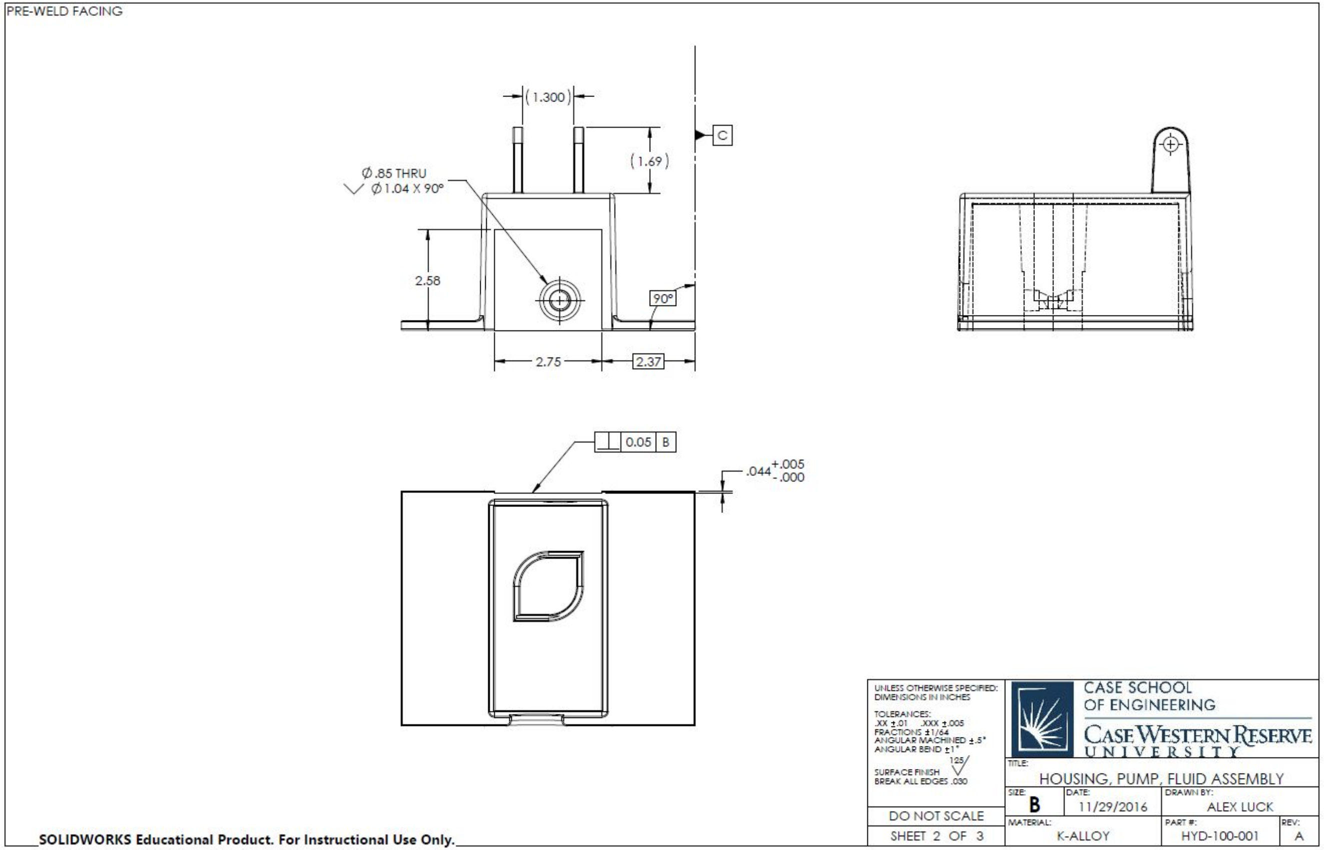
Pump Drawing



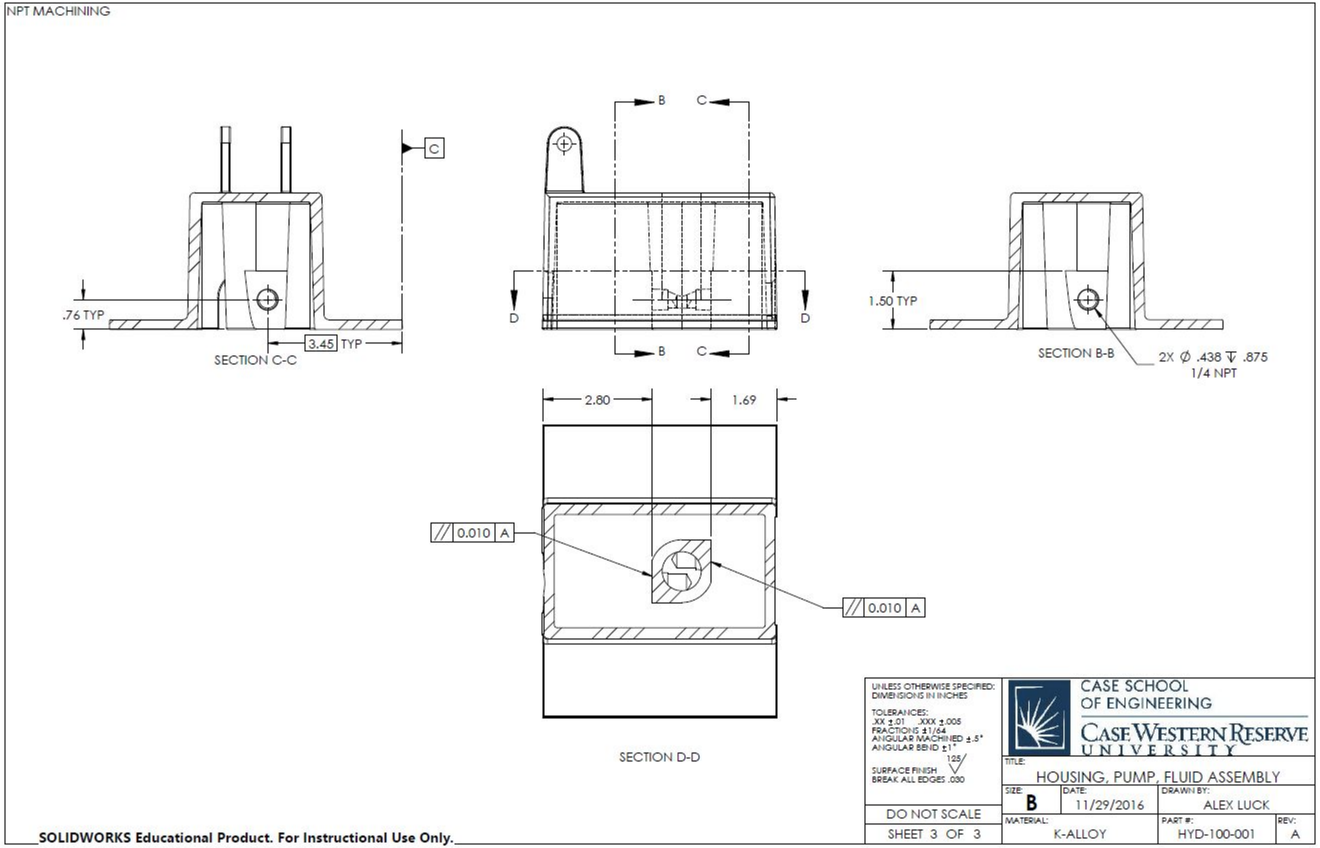
Housing Drawing



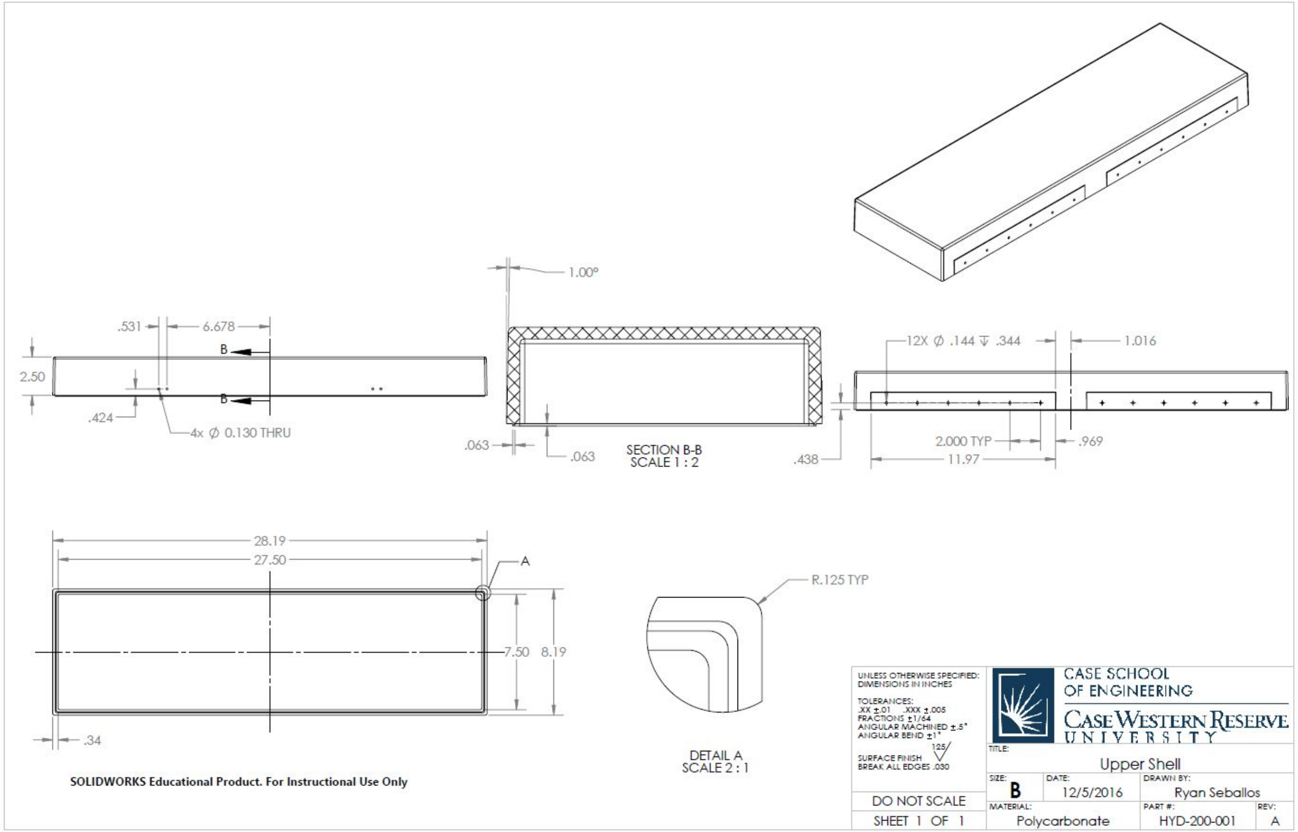
Housing Drawing



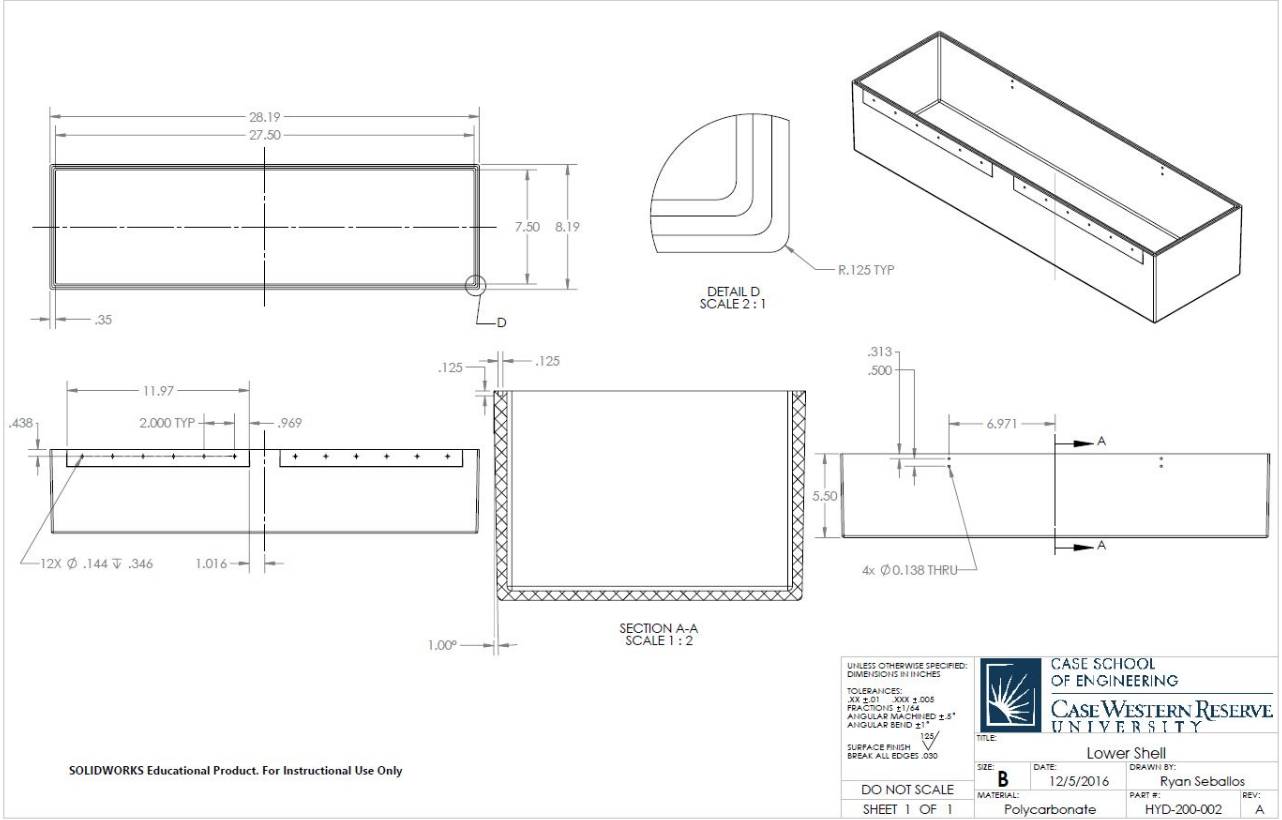
Housing Drawing



Upper Casing Drawing



Lower Casing Drawing



Membrane Specifications

Nitto

HYDRANAUTICS Nitto Group Company

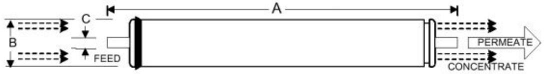
	Membrane Element	SWC - 2514
Performance	Permeate Flow:	110 gpd (0.4 m^3/d)
	Salt Rejection:	99.4 % (99.0 % minimum)
Type	Configuration:	Spiral Wound
	Membrane Polymer:	Composite Polyamide
	Membrane Active Area:	5.0 ft^2
Application Data*	Maximum Applied Pressure:	1,000 psig (6.9 MPa)
	Maximum Chlorine Concentration:	< 0.1 PPM
	Maximum Operating Temperature:	113° F (45°C)
	pH Range; Continuous (Cleaning):	2-11 (1-13)*
	Maximum Feedwater Turbidity:	1.0 NTU
	Maximum Feedwater SDI (15 mins):	4.0
	Maximum Feed Flow:	6 GPM (23 l/m)
	Minimum Ratio of Concentrate to Permeate Flow for any element:	5:1
	Maximum Pressure Drop for Each Element:	10 psi

* The limitations shown here are for general use. For specific projects, operating at more conservative values may ensure the best performance and longest life of the membrane. See Hydranautics Technical Bulletins for more detail on operation limits, cleaning pH, and cleaning temperatures.

Test Conditions

Elements are wet tested for quality assurance using the following conditions:

32000 PPM NaCl solution
800 psi (5.5 MPa) Applied Pressure
77 °F (25 °C) Operating Temperature
10% Permeate Recovery
6.5 – 7.0 pH Range
(Data taken after 30 minutes of operation)



A, inches (mm)	B, inches (mm)	C, inches (mm)	Weight, lbs. (kg)
14.0 (355.6)	2.4 (61)	0.75 (19.1)	1 (0.45)

Core tube extension = 1.10" (27.9 mm)

Notice: Minimum permeate flow for individual elements is 15 percent below listed flow. All membrane elements are supplied with a brine seal and o-rings. Most elements are packaged dry, sealed in polyethylene bags, and shipped in a cardboard box. Some elements are sealed in polyethylene bags containing less than 1.0% sodium meta-bisulfite solution and shipped in a cardboard box.

2/25/15

Hydranautics Corporate: 401 Jones Road, Oceanside, CA 92058
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