Shuttle Valve Design

Team #17

Date
November 21th, 2013

Group Members
Ryan Laney – Team Leader
Billy Ernst – Team Webmaster
Samantha Zeidel – Team Treasurer

Instructor
Dr. Kamal Amin

Sponsor
Verdicorp Inc.
Robert Parsons

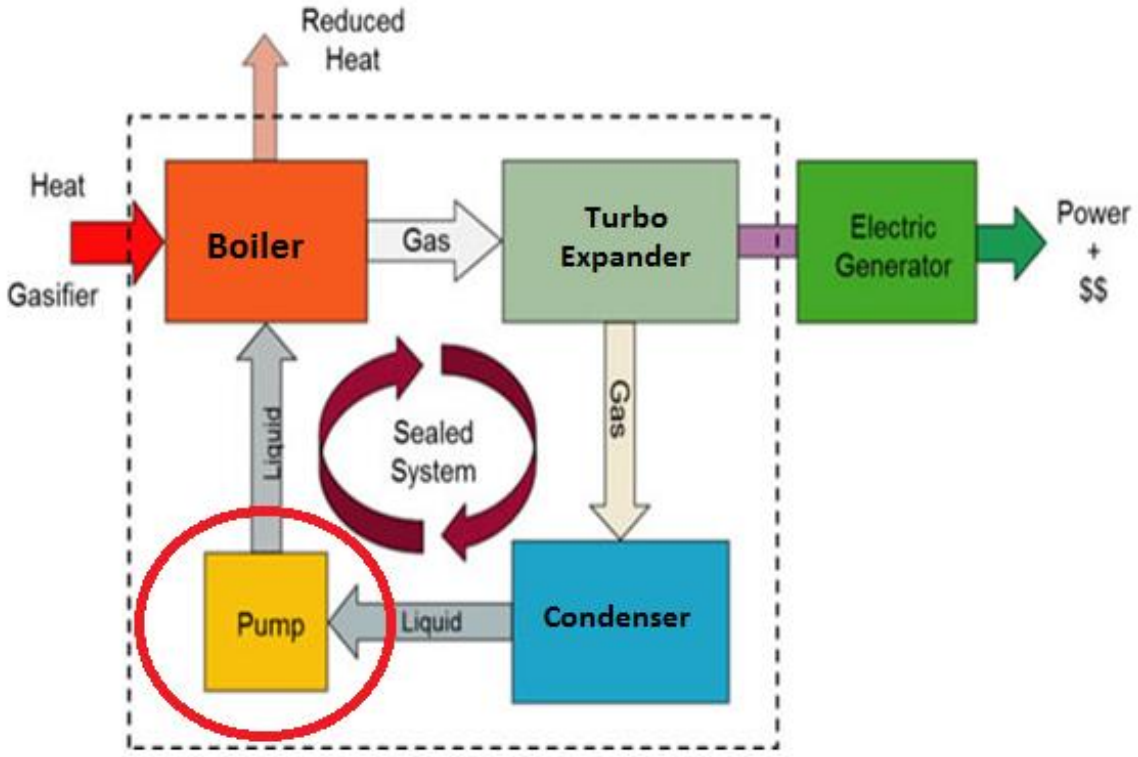
Faculty Advisor
Dr. A. Krothapalli

Project Overview

- Verdicorp Environmental Technologies has developed a revolutionary Organic Rankine Cycle (ORC)
- ORC uses waste heat from a low grade source and converts it to useful power
- The ORC systems have somewhat low efficiency (~10-14%); Special concern within the company to maximize this efficiency in any way possible
- ORC is cable of producing ~125 kW
- Parasitic losses consume ~20 kW

  (Pump ~10 kW)
- Senior Design Team 17 has been tasked with increasing the efficiency of the system

  (Removal and replacement of the pump)



Presented by: Ryan Laney

Project Objectives

- Design a shuttle valve system to replace the pump within the ORC
- Maintain the continuous flow of liquid within the ORC (~ 3 gpm)
- Use solenoid valves with the aid of gravity to adjust the pressure inside the vessels
- Transfer the liquid in the system from the low pressure side to the high pressure side
- Minimize the parasitic losses in the system (electrical consumption)
- Confirm on a final design concept by late-October 2013
- Construct a prototype of the final design during Spring 2014

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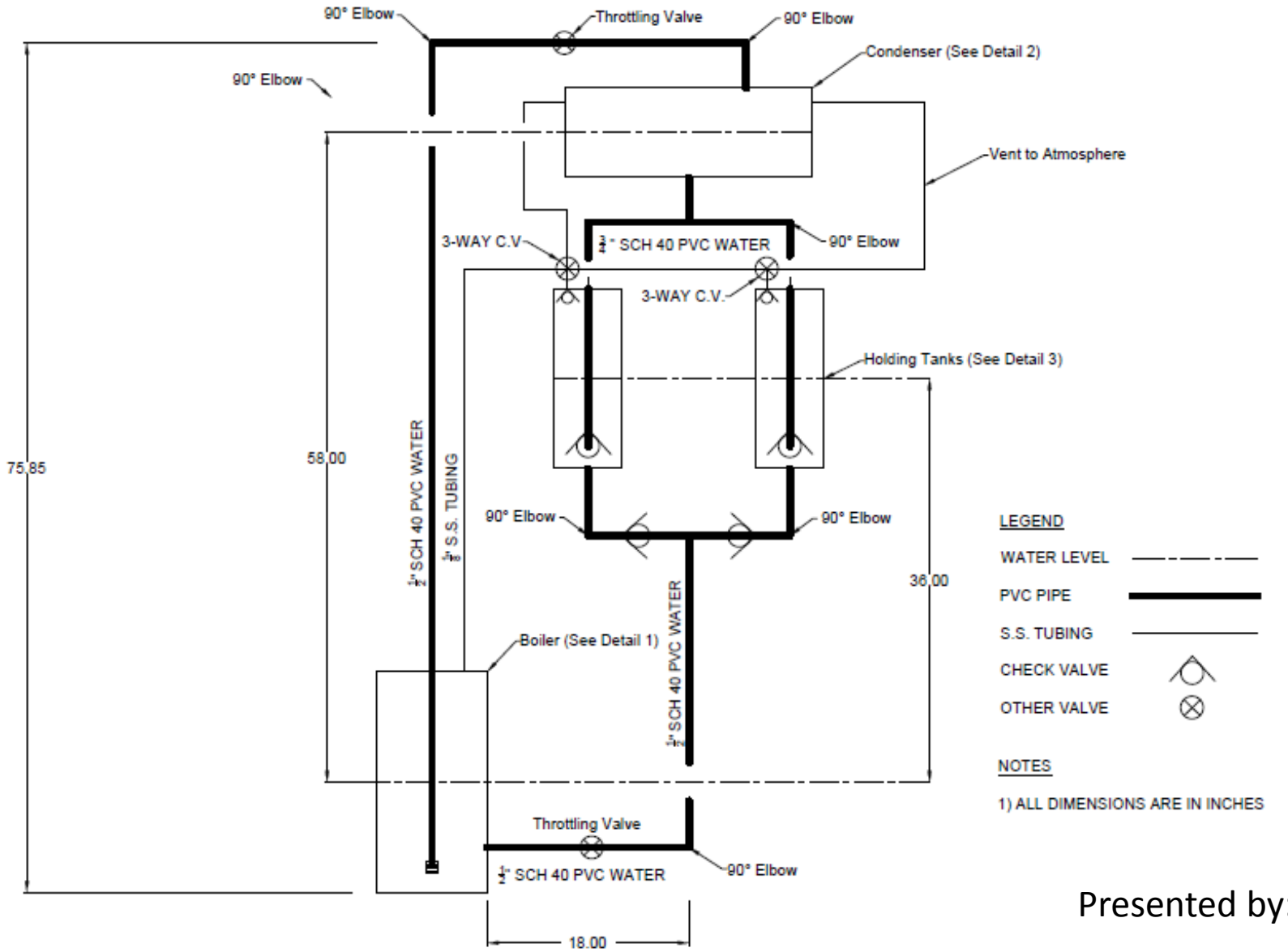
Final Design Concept



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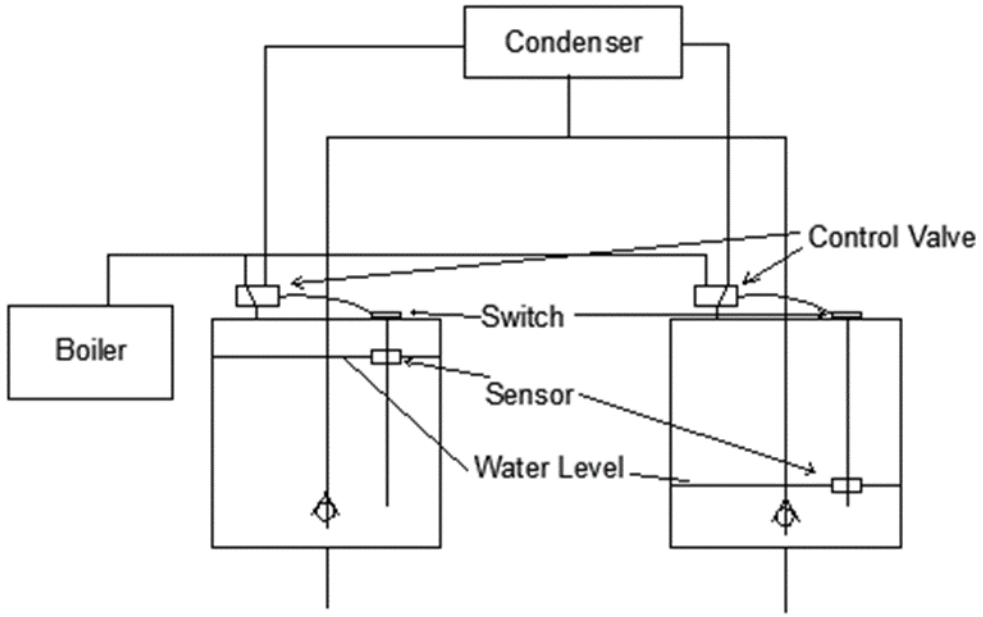
Final Design Concept

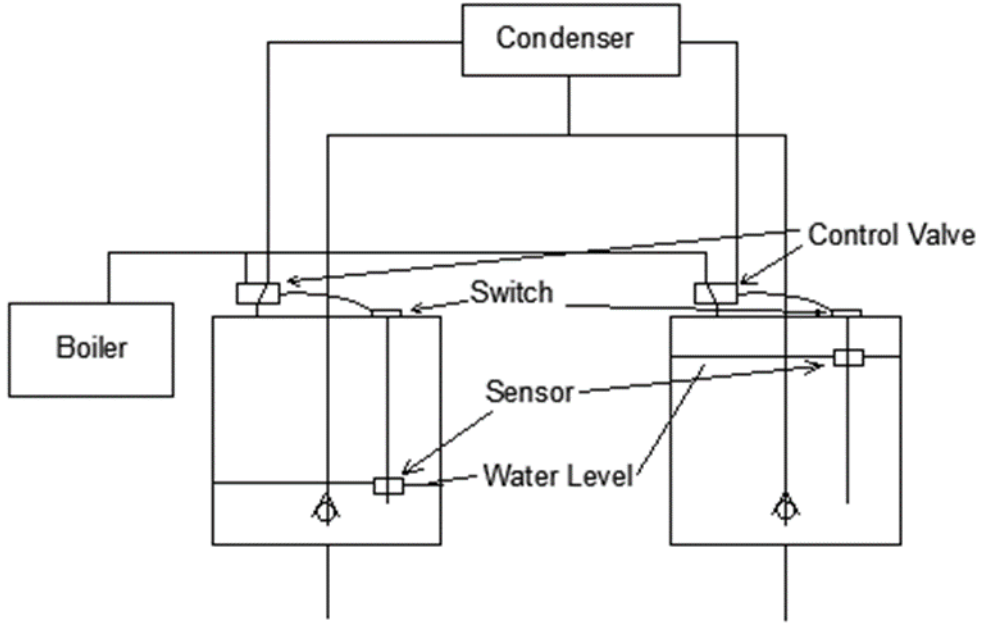
- Execution of Holding Tank 1

Phase 1



- Execution of Holding Tank 2

Phase 2



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Relevant Equations for Pipe Flows

- *Modified Bernoulli Equation*
- $\frac{p_1}{\rho g} + \frac{V_1^2}{2g} + z_1 = \frac{p_2}{\rho g} + \frac{V_2^2}{2g} + z_2 + \frac{fLV^2}{D2g} + \sum K \frac{V^2}{2g}$
- $\Delta P_L = \frac{\left(\frac{fL}{D} + K_t\right)V^2}{2g}$
- $\frac{fL}{D}$ term applies to friction in piping
- K term applies to minor losses in fittings

Presented by: Billy Ernst

PIPE-FLO Software Calculations

- **Boiler to Condenser**
  - dZ = 58 in. (Hydrostatic Head)
  - Minor Losses (Two 90° Elbows) – Major losses (L = 8.562 ft.)
  - With an internal pressure in the boiler of 50 psi and using ½” PVC, the flow rate will be 39.04 GPM
  - A throttling valve will be used to model the turbo expander and provide the pressure drop and decrease the flow rate to the required 3 GPM

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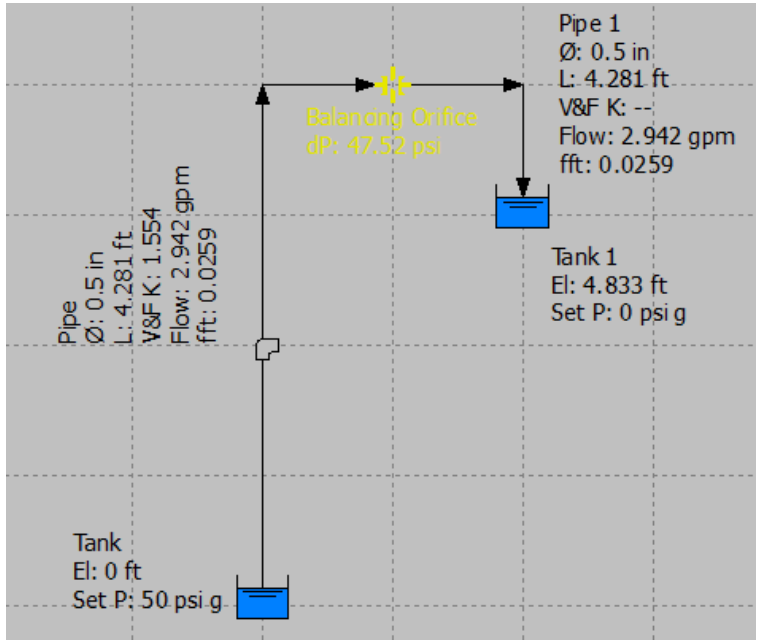


Presented by: Billy Ernst

PIPE-FLO Software Calculations

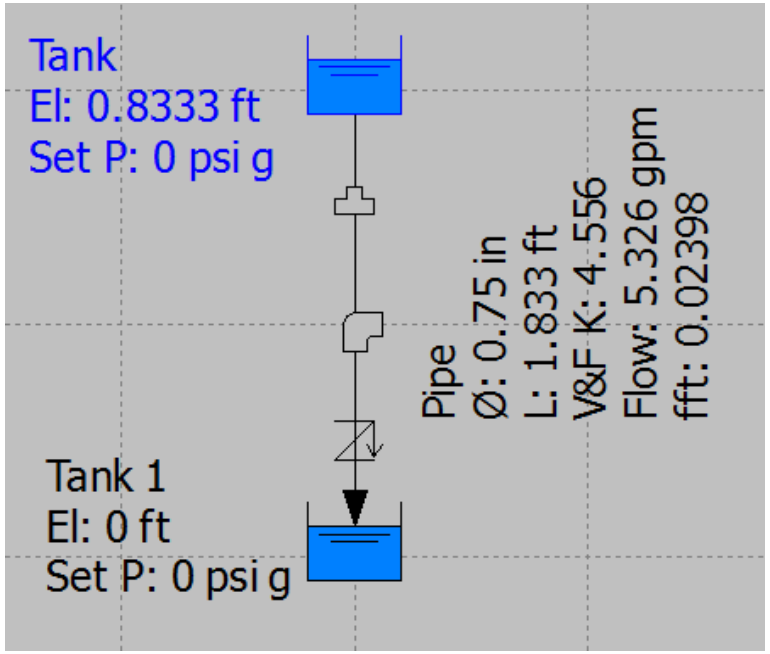
- **Condenser to Holding Tanks**
  - Flow rate will be gravity driven
  - dZ = 22 in. (Hydrostatic Head)
  - Minor Losses (One 90° Elbow, 1 Tee, One Check-Valve) (To each tank)

  - Using ½” PVC, GPM (max) = 2.86 GPM

  (Not sufficient for design flow rate of 3 GPM)

  - Using ¾” PVC, GPM (max) = 5.33 GPM

  Therefore ¾” PVC must be used



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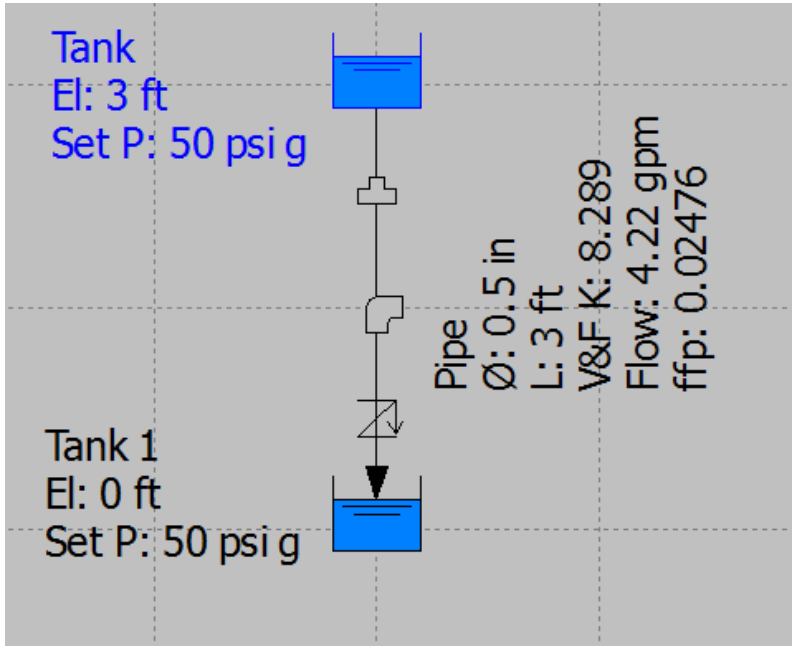
PIPE-FLO Software Calculations

- **Holding Tanks to Boiler**
  - Flow rate will be gravity driven
  - dZ = 36 in. (Hydrostatic Head)
  - Minor Losses (Two 90° Elbows, 1 Tee, One Check Valve)(To each tank)
  - Using ½” PVC, GPM (max) = 4.22 GPM

  Therefore ½” PVC must be used along with a throttling valve to restrict the flow down to 3 GPM



Presented by: Billy Ernst

Components of Design

- **Boiler**
  - Pittsburgh Automotive 6.25 Gallon Oil Extractor
  - Pressurized vessel in our system (50 psi)

- **Condenser**
  - Ace/DenHartog 5 Gallon Flat Bottom Utility Tank
  - Thickness: 1/4 in. (Allowing for modifications)
  - Non-pressurized vessel in our system

- **Holding Tanks**
  - 6 in. Acrylic Tubes (Walls)
  - 2 – 3 in. Acrylic Sheet (End Caps)
  - Needs to be constructed by the team
  - Pressurized vessel in our system (50 psi)

Presented by: Samantha Zeidel

Manufacturing/Machining Approaches

- **Boiler**
  - All modifications will be done at Verdicorp machine shop
  - Top of oil extractor must be modified
  - Components must be removed to insert ½ in. PVC and two 1/8 in. Stainless Steel tubing
  - Bottom of tank must be modified to insert ½ in. PVC from holding tanks

- **Condenser**
  - All modifications will be done at Verdicorp machine shop
  - Holes must be cut into top and bottom of condenser for pipe inlets/outlets

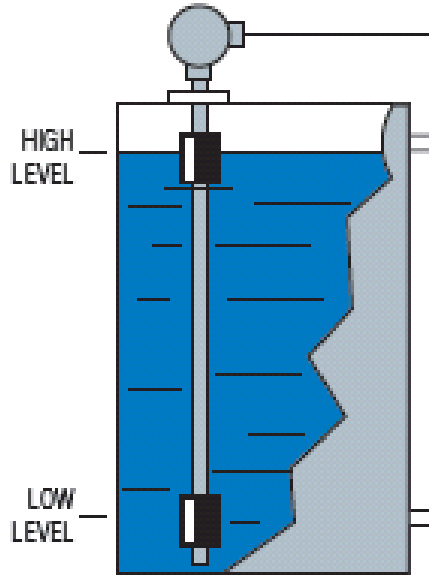
- **Holding tanks**
  - Will be made from 6 in. Acrylic tubes (Walls) and 2-3 in. Acrylic sheet (End Caps)
  - Top and Bottom end caps will be threaded and attached to the ends of the tubes
  - All holes for valves and switches will be drilled and threaded by machinist at Verdicorp

Presented by: Samantha Zeidel

Components of Design

- **Control Valves**
  - Parker Pneumatic Single Solenoid, 3-way, 2-position, NC
  - Air Control Valve; Port Size: 1/8 in. NPT
  - Voltage: 24 VDC

- **Sensor**
  - Gems LS-300 Series Multi-Point Level Switch
  - Simple and efficient way of monitoring water levels

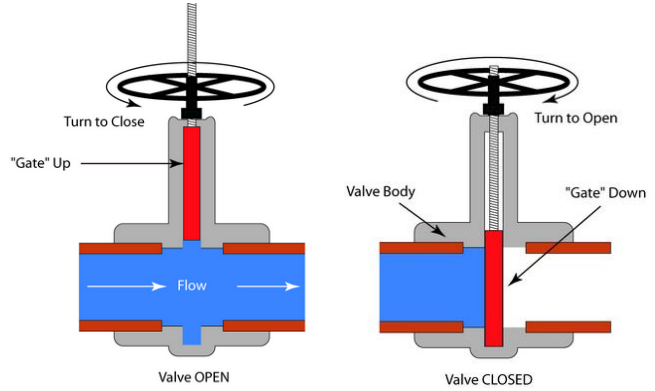


- **Relay**
  - Provided by Verdicorp
  - Voltage: 24 VDC (Control valve voltage)

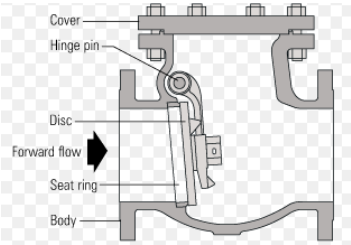
Presented by: Samantha Zeidel

Components of Design

- **Piping**
  - **Water Pipes:** ½ in. and ¾ in. PVC Schedule 40
  - **Pressure Pipes:** 1/8 in. Stainless Steel Tubing



- **Throttle Valves**
  - Homewerks Worldwide ½ in. and ¾ in. Brass FPTxFPT Gate Valve
  - Threaded connection, Max Pressure = 125 psi



- **Check Valves**
  - Homewerks Worldwide ½ in. and ¾ in. Lead Free Brass FPTxFPT Swing Check Valve
  - Threaded connection, Max Pressure = 200 psi

- **Pipe Fittings**
  - Mueller Streamline ½ in. and ¾ in. PVC SCH 40 SxS 90° Elbow
  - Mueller Streamline ½ in. and ¾ in. PVC SCH 40 SxSxS Tee

Presented by: Samantha Zeidel

Project Procurement

Part #	Component	Product Description	Quantity	List Price	Status
1	Boiler	6.25 Gallon Oil Extractor	1	$134.99	Ordered
2	Condenser	5 Gallon Flat Bottom Utility Tank	1	$37.99	Ordered
3	Holding Tanks	NEEDS TO BE MANUFACTURED Clear Acrylic Tubes/Sheet	2	N/A	Not Purchased
4	Throttle Valve 1	1/2” Brass FBTxFBT Gate Valve	2	$6.35	Not Purchased
5	Throttle Valve 2	3/4" Brass FBTxFBT Gate Valve	1	$7.73	Not Purchased
6	Check Valve 1	1/2" Lead Free Brass FPTxFPT Swing Check Valve	2	$7.02	Not Purchased
7	Check Valve 2	3/4" Lead Free Brass FPTxFPT Swing Check Valve	2	$9.41	Not Purchased
8	Control Valve	Parker Air Control Valve Single Solenoid, 3-way, 2-pos, 1/8” NPT	2	$51.95	Not Purchased
9	Sensor	LS-300 Series Multi-Point Level Switch (QUESTIONABLE)	2	$163.60	Not Purchased
10	Relay	PENDING DECISION	2	N/A	Not Purchased
11	Pressure Line	1/8” x 6’ Stainless Steel Tubing	~11 ft.	$23.70	Not Purchased
12	Water Pipe 1	1/2" x 10’ PVC Schedule 40 Plain-End Pipe	~16 ft.	$1.81	Not Purchased
13	Water Pipe 2	3/4" x 10’ PVC Schedule 40 Plain-End Pipe	~6 ft.	$2.28	Not Purchased
14	Water Pipe Elbow 1	1/2” PVC Pipe 90° Elbow	5	$0.46	Not Purchased
15	Water Pipe Elbow 2	3/4” PVC Pipe 90° Elbow	2	$0.46	Not Purchased
16	Water Pipe Tee 1	1/2" PVC Pipe Tee	1	$0.47	Not Purchased
17	Water Pipe Tee 2	3/4” PVC Pipe Tee	1	$0.47	Not Purchased
18	Air Compressor	Porter-Cable 3.5 Gallon 135 psi Pancake Compressor	1	$99.88	Not Purchased

Presented by: Ryan Laney

Project Summary

- Final Design
  - Final design concept has been finalized
  - Modifications may need to be made after prototyping and testing has been completed
- Project Components
  - All components have been selected and will be used pending that the prototype works sufficiently during testing
- Next Steps:
  - We will begin purchasing of components and material immediately
  - Continue to analyze project and write final report
  - Start building and testing individual portions of the system before building entire system starting in January, 2013

- **Any Questions??**

Presented by: Ryan Laney