ME 360 – Project

Your team will design a first stage regulator used for SCUBA. This regulator connects to the valve on the tank and reduces the pressure from the tank pressure to 140 psi gauge. The requirements for the design are listed below.

1. The regulator should be designed for tanks with pressures as high as 3,500 psi and it should have a structural safety factor of 1.5. The yoke assembly should have a safety factor of 2.0.
2. The regulator should attach to the tank valve with a standard yoke connection.
3. The regulator should have 4 low pressure ports and 2 high pressure ports.
4. The low pressure ports will have a 7/16-20 thread size.
5. The high pressure ports will have a 3/8-24 thread size.
6. The cylindrical shape that connects to the tank valve is .700 inches in diameter.
7. The low pressure setting should be adjustable so that a technician can accurately adjust the pressure.
8. The regulator will compensate for the depth so that the downstream pressure of 140 psi gauge is reasonably accurate for all depths above 200 feet of seawater. One of the measures of the quality of a regulator is how well it maintains this downstream pressure under differing operating conditions. The regulator should maintain a relatively constant downstream pressure when used at different depths and with different flow rates.
9. The regulator must be constructed from materials that are very corrosion resistant in both fresh and seawater. The body of the regulator will be brass. It may be chrome plated to resist corrosion. The internal parts and the yoke assembly may be made of other materials.
10. The regulator will be diaphragm operated.

**DELIVERABLES**

1. A discussion of your design approach.
2. A discussion of your design.
3. A presentation of your design to members of the class, other faculty, and students.
4. Dimensioned drawings of the regulator. The drawings should specify the material used in each part.
5. If springs are used in your design, list the following data for each spring.
   a. The spring constant
   b. The wire diameter
   c. The free length of the spring
   d. The length of the spring in the regulator under both no flow and maximum flow conditions
   e. The minimum spacing between the wires under all operating conditions.
6. Structural analysis of all regulator parts. The analysis should show a fringe plot and list the maximum von Mises stress for the analysis. This maximum von Mises stress should be compared to the yield stress of the material. The structural analysis should include:
   a. An analysis of the regulator using pressure induced stresses.
   b. 3 other analyses using loading conditions that may occur in the field under expected use and abuse. All loading conditions should be well defined in your report.

7. A graph of the calculated downstream pressure at different flow rates and at different depths. The depth should range from zero to 200 feet of seawater. The following flow rates should be used:
   a. An aggressive breathing rate for recreational diving is 37.5 liters per minute to a depth of 200 feet of sea water.
   b. A rate of 62.5 liters per minute (RMV) at 130 feet of sea water is used by both the European Conformance Standard EN250 and US Navy Class A requirements. This equates to two divers breathing from the same regulator.

These volumetric flow rates are measured at the depth of the diver, not at the pressure produced by the regulator. Tank pressures of 3000 psi and 500 psi should be graphed. Discuss the method you used to make the computations and your findings. Also discuss any changes you made to your design to reduce this pressure drop.

**BONUS**

Assuming that a diver will spend about as much time breathing in as out, the actual amount of air used will be about half that listed above. Using this criterion, if a diver is consuming 18.75 liters of air per minute, the flow rate of air is 37.5 liters per minute because they are inhaling half the time.

As air expands, it may cool (Joule-Thompson cooling and/or cooling induced by the high velocity in the orifice). If the surrounding water is near freezing, this cooling of the air could cause the water in the regulator to freeze. Do a thermal study of your regulator to see if the water in the regulator will freeze when the ambient fresh water temperature is 33 degrees Fahrenheit. Use fresh water for these calculations. Discuss your methods, your findings, and what changes you made to the regulator to prevent the freezing. Do not assume that all water subject to freezing is on the outside of the regulator.

Note:

- Fresh water weighs 62.4 lbs / ft$^3$
- Seawater weighs 64 lbs / ft$^3$