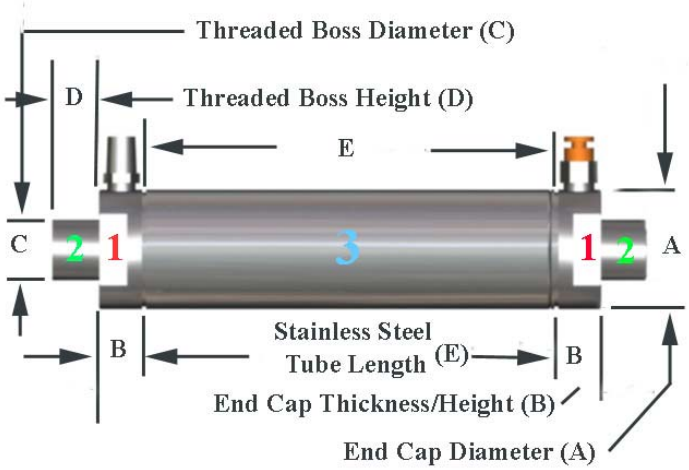
Pneumatic Reservoir Analysis Work Sheet



Getting Started

Use a pair of dial calipers to measure the length and diameter dimensions of the:

1. **End Cap**
2. **Threaded Boss**
3. **Stainless Steel Tube**

Record these dimensions on your sketch by substituting the letters A,B C etc. with the appropriate dimensions.

Measure and record the following dimensions in the chart above.

Component	Length	Diameter	Volume	Weight	
SS Tube			Extra Credit		
End Cap					**Aluminum Density**
Threaded Boss					
Pneumatic Reservoir	**DNA**	**DNA**	**DNA**	**W**	
Exterior Cylinder					**Stainless Steel Density**
Interior Cylinder					
Water Volume	**DNA**	**DNA**		Extra Credit	

Caution: Keep units consistent. Use either Imperial or SI units.

a. The length of the stainless steel cylinder body (Dimension E)
b. The diameter of the stainless steel cylinder body. (Dimension A)
c. The length of the aluminum cylinder (Dimension B)
d. The diameter of the aluminum cylinder (Dimension A)
e. The length of the threaded boss (Dimension D)
f. The diameter of the threaded (Dimension C)

Measure and Record the Weight of the Pneumatic Reservoir.

Record this value in the block marked "W" in the chart above.

Note: Be careful to keep your units consistent. Use, grams, ounces, kilograms or pounds, whichever you are most comfortable with, but keep all your units consistent. It is wise to locate and use a conversion calculator. The web has many to choose from. Search using keywords like "Conversion calculator", "Unit conversion" etc. Locate some useful on line calculators and save them to you favorites file.

1.) Calculate the Volume of the Reservoir Components

Using the measurements you made, find the volume of each of the reservoir Components and record this data in the chart above. Show evidence of your work in space below. Review the GEARS online geometry lesson for help if necessary.

Hint: The Volume of a cylinder formula; $Cylinder(Volume) = (\pi R^2) \cdot Length$

Exterior SS Cylinder

Show exterior volume calculation here

End Cap

Show volume calculation here

Threaded Boss

Show volume calculation here

Research the Weight Density of Aluminum and Stainless Steel

Research the weight density of aluminum and steel and record this information on the chart above. You can find the weight density of common materials in physics and chemistry textbooks, or on line. Use keywords like "Density of Common Metals".

Note: The weight densities of common metals are easily found on the web. Use a value for the density of steel in the event you cannot find a published value for stainless steel. Here is a relatively complete source of material densities
http://www.mcelwee.net/html/densities_of_various_materials.html

2.) Use the Weight Density Values to Calculate the Weights of the Components.

Hint: Use this formula to calculate the weight of each reservoir component.

$$Weight = Density \cdot Volume$$

1. Calculate the weight of the Aluminum end caps using the volume values you researched. Multiply the volume of each end cap by the weight density of the material. Record this answer on the chart above. Don't worry if everyone has somewhat different answers! That's pretty common. Remember, this is only a mathematical approximation of the interior volume. If you are careful, you will come very close to the "Measured" value.
2. Check that you have weighed the pneumatic reservoir and record that in the block marked with a "W" in the chart above. (Be certain to remove the mounting nuts from the threaded boss before weighing the unit)
3. Subtract the calculated weight of **both** the aluminum end caps from the actual weight of the reservoir. This will yield an approximation of the weight of the Stainless Steel Tube that forms the body of the reservoir.
4. Record the calculated weight of the stainless steel tube in the chart above

SS Tube Weight = Reservoir Weight – 2 (End Cap wgt.+ Threaded Boss wgt.)

Note: Be certain to use consistent units. If the published weight density is given in lbs. per cubic ft., then be certain to calculate the volumes for the pneumatic reservoir components in cubic ft., or recalculate the weight density in cubic inches. Remember to weigh the reservoir and to record this weight in the appropriate units.

Calculate the Interior Volume of the Reservoir

Using our understanding of volume and density it is possible to make a reasonably accurate determination of the interior volume of the pneumatic reservoir.

Develop the Algebraic Statement that Will Yield the Answer
Using the information we have it is possible to create a formula for the weight of a tube based on the tubes volume, known weight, the density of the material from which it is made.

Begin by assuming the Stainless Steel Tube is a solid Stainless Steel Cylinder

A = Weight of a Solid Stainless Steel Cylinder (Use the Outside Diameter and length of the Reservoir Tube)
B = Calculated Weight of Stainless Steel Tube (From the Chart Above)
C = A – B (C = the weight of the interior ss cylinder)
D = Density of stainless steel (approximately 8gram per cc or 0.289016 lbm/cubic inch)
$\mathbf{V_i}$ = Volume of the interior cylinder

Density Formula $\mathbf{D}$ (Density) = $\mathbf{W}$ (Weight) / $\mathbf{V}$ (volume)

Solving for V_i $\mathbf{V_i}$ = $\mathbf{C}$(Weight of interior SS Cylinder) /$\mathbf{D}$

Using the Values above $\mathbf{V_i = C/D}$

Remember: C is the weight of an imaginary solid stainless steel "Interior" cylinder. Using the weight of an imaginary interior stainless steel cylinder, we can apply the density formula to solve for the volume. We can substitute C, for the weight of the imaginary stainless steel cylinder and solve for the interior volume of the pneumatic cylinder.

Solving for $\mathbf{V_i}$ in the equation above will yield a reasonably accurate value for the interior volume of the pneumatic cylinder. It is a good exercise in building a mathematical model of an engineered system.

6.) Verifying the Interior Volume

There are several ways to verify your answer.

The easiest and most efficient way would be to refer to the manufacturers published drawings.

Another way would include a form of indirect measurement using water or vegetable oil and the process would look like this.

1. Unscrew and remove the Schrader valve.
2. Unscrew and remove the one touch tubing connector.
3. Holding the reservoir level, slowly fill it with water.
4. When the reservoir is full, empty the reservoir into a graduated cylinder.
5. Read the volume of water in the graduated cylinder.

After you have verified your answer, record the correct volume in the chart above. This answer will be necessary in order to complete other pneumatic exercises.

Extra Credit

Once you know the interior volume of the pneumatic reservoir it is an easy step to determine the wall thickness of the stainless steel reservoir tube. Can you develop a method to do this? Can you think of a way to substantiate your answer?

The answer to the two preceding questions lies in your understanding of how to use the calculated weight of the stainless steel reservoir tube and the formulas for the volume of a cylinder and a tube as well as the density formula to obtain the information you need.

Reservoir Tube Wall Thickness _____

Describe the method you used to determine this value.

Describe the method you used to substantiate this value.