Size Matters

Understanding Sizing Factors for Centrifugal Separators

By: Chris Pasquali, CEO Factory Direct Pipeline Products, Inc.

Properly sizing centrifugal separators is often daunting for non-air applications because all of the test data used to calculate performance was based upon actual tests with air at atmospheric pressure and temperature of 60°F. Sizing separators for other gasses requires several calculations to essentially "convert" these gasses, temperatures and pressures to the equivalent of air at atmospheric pressure and 60°F. To make this easier we have designed a web-based calculator that enables sizing to be completed within just a few seconds. This article clarifies what is meant by separator size and explains features of the calculator.

What is a Centrifugal Separator?

Centrifugal "vortex" separators remove particulate and entrained droplets from air, steam and other gaseous applications.

Gas flows into the separator body and due to both internal geometry and ratio of critical distances within the separator, entrained droplets traverse across the circumference of the vessel at an angle to the inlet nozzle, forming a vortex. Entrained droplets either directly impinge onto internal structures or are propelled to the circumference; only droplets finer than 10 microns navigate both the low velocity center of the vortex and exit baffle due to angular momentum. Thus, entrained droplets and particles larger than 10 microns accumulate and coalesce at the bottom of the centrifugal separator with 99% efficiency. Our article Design Capabilities of Gas/Liquid Separators delves into the underlying design in more detail.

Sizing Centrifugal Separators for Your Application

We have created an Internet based centrifugal separator sizing tool that is easy to use and enables you to quickly compare your options based upon key design criteria.

The sizing process begins with inputting (4) design criteria related to internal velocities:

1. Average molecular weight of the gas
2. Design (maximum) temperature
3. Design (minimum) pressure
4. Volumetric flow (the calculator will convert mass flow to volumetric flow)

"Sizing" for two types of separators are automatically calculated, referred to as the "standard separator size" and the "receiver separator size". Receiver separators have a complex design and are used to remove a higher volume of droplets for a given size vessel body. Refer to "standard separator size" for all other designs. It is important to note that "standard" in this case is a reference to centrifugal separators that are not the receiver style.

Refer to our article Types of Centrifugal Separators for an overview of various separator designs to determine which is most applicable to your process.

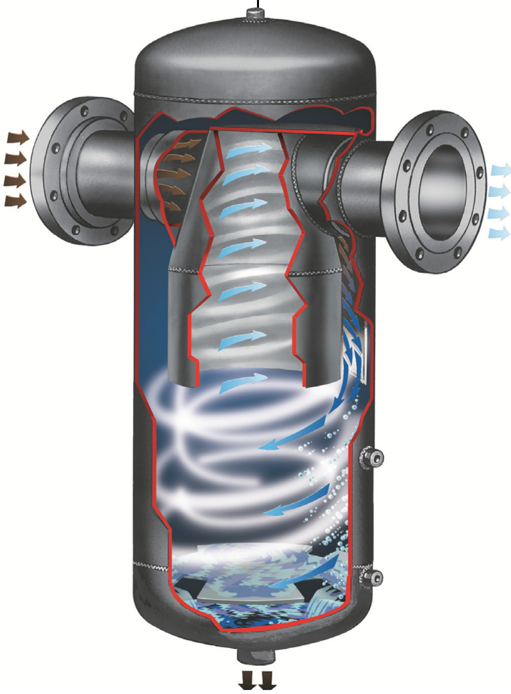
"Size" and "Standard" Have Multiple Meanings

Ultimately "separator size" is an indirect reference used to define the vessel length and diameter, representing the largest size nozzle which CAN be attached to a particular separator body, NOT the actual nozzle size used to connect to your process.

All centrifugal separators have a cylindrical body shape with dished heads and their diameter and length (along with positioning of internal geometry) are determined by the maximum velocity allowable to ensure entrained droplets larger than 10 microns are removed with 99% efficiency.

The sizing formula for centrifugal separators calculates the minimum nozzle ID required as corresponds to its relationship with length and diameter of the separator for optimal performance. Thus the resulting "calculated size" is usually not a "standard" nozzle ID size; it is the theoretical "minimum size" as relates to the minimum corresponding vessel dimensions to maintain performance.

If the inlet nozzle ID along with diameter and length of each separator were custom fabricated, there would not be any confusion, however for manufacturing efficiencies, "standard size" separators have been established according to the "standard size" nozzles available. Thus centrifugal separator designs are based upon the required diameter and length associated with standard nozzle sizes.



Another way of stating this is that drawings refer to "size" as the maximum nozzle size which can be accommodated based upon the diameter and length of the vessel whereas the calculation of the minimum nozzle size required is based upon creation of a proper vortex within the separator body.

"Chosen Size": Beyond the Initial Calculations

The chosen size is a feature enabling you to quickly compare key performance characteristics applicable to standard separator designs. In the following example a 2.29" size is "required", thus in actuality it corresponds to *at least* a 2.50 inch size, but we can use this tool to select larger sizes also; in our example the performance information for the 3.00 inch size is shown.

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DESIGN CRITERIA				
Mole Weight:	29.0	MW	F_g	1.00081528
Temperature (F):	60.0	T	F_t	0.99997400
Pressure:	150.0	PSI	PSIA	164.70
Volumetric Flow (SCFM):	1,000.00	Q_{sg}		
Weight Flow, lbs/hr:		0.00	W	
SCFM of equivalent air:	1,000.79	Q_c		

CALCULATED SEPARATOR SIZE REQUIRED		
Standard Separator Size:	**2.29**	
Receiver Separator Size:	2.85	
CHOSEN SIZE:	3.00	
Maximum Capacity (SCFM):	1,735	(Qc)
Maximum Capacity:	7,988	lbs/hr
% of Maximum Capacity:	0.58	
Chart Pressure Drop:	1.44	PSI
Calculated Pressure Drop:	0.48	PSI

Calculated Sizes

Input a standard nozzle size ≥ the calculated size

CONDENSATE REMOVAL RATE BY SEPARATOR DESIGN				
Percentage of Weight Flow	lbs/hr:	GPH:	GPM:	GPS:
5%	399.4	47.9	0.80	0.01
10%	798.8	95.8	1.60	0.03
20%	1,597.5	191.6	3.19	0.05
40%	3,195.1	383.1	6.39	0.11
60%	4,792.6	574.7	9.58	0.16
90%	7,188.9	862.0	14.37	0.24

Reasons for "Oversizing" a Centrifugal Separator

Continuing with the earlier example, you could use the separator design based upon a 2.50 inch inlet nozzle and thus minimize the physical size of the separator. However, if your inlet piping was to be larger than 2.50 inches, for example 3.00 inches, then the inlet pipe ID determines the separator nozzle size and therefore you would use the separator body associated with 3.00 inch size nozzles. It is not recommended to install a separator having an inlet size smaller than the pipeline it will be attached to, even if the design criteria indicates a smaller size separator would be sufficient. The thought behind this is that there is likely an engineering reason for the existing pipeline size and it is usually not a good idea to unnecessarily restrict it.

Conversely, if the pipeline size is less than the minimum separator inlet nozzle size, then it is perfectly acceptable to install smaller nozzles onto the separator to eliminate plumbing transitions..

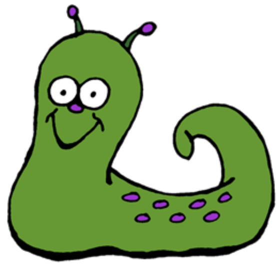
Liquid Load and Differential Pressure

If the calculated differential pressure based upon the chosen size is too high for your application, increase it until it satisfies your requirement.

Likewise use the liquid removal capacity chart to determine if the desired *separator design* satisfies your requirements; if not, increase the chosen size until it does.

Understanding "Maximum Capacity"

The calculated maximum capacity of the separator is based upon the standardized volumetric flow (Qc) which is also converted to weight flow because entrained droplet removal capacity is expressed as a percentage of its maximum weight flow capacity. The percentage of maximum capacity provides another way to evaluate tolerance for surges in flow. The maximum capacity calculation is accurate to within 2% for 6" to 32" sizes and 4% for other sizes.



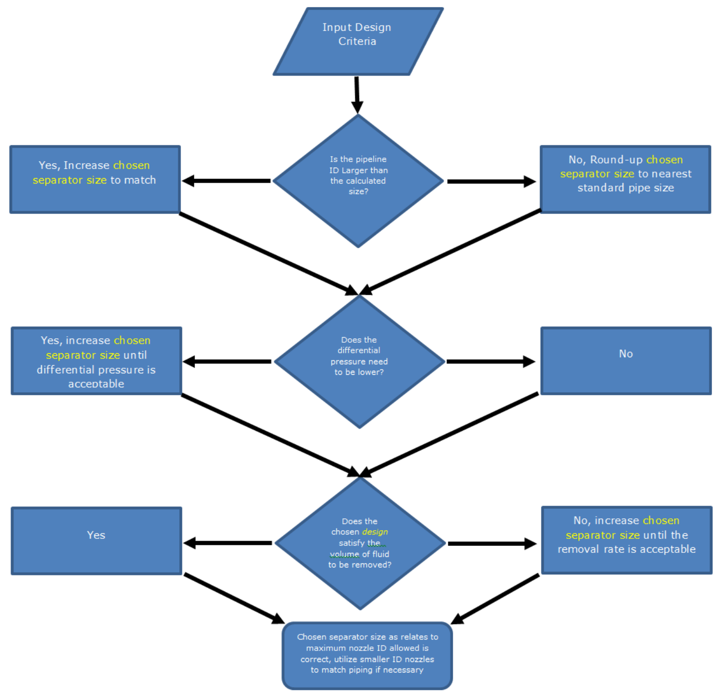
Got "Slugs"?

Separators designed for condensate removal equivalent to ≥ 20% of the separators maximum capacity will handle most "liquid slugs" associated with upset conditions or low sections of piping.

Condensate Removal Capacity

Float drain traps are often used to automatically remove separated liquid and these devices are available with a variety of body sizes and valve orifices. The condensate removal rate provides both mass and volumetric flow rates for easy comparison to float drain trap capacity charts to help ensure your separator and trap are sized properly in relation to their respective capacities.

Centrifugal Separator Sizing Flow Chart



Our sizing tool is available to assist you with a better understanding of your options. Such options include the different styles of centrifugal separators offered but you can also use the calculations to compare centrifugal separators to vane and mesh pad style separators. Typically vane and mesh style separators need to be physically larger (more expensive) and have a higher pressure drop, not to mention loss of efficiency at low flow rate conditions (such as start-up and shut down of a system).

Visit us at http://www.fdpp.com and let us know how we can assist you with your gas/liquid separation application!

Chris Pasquali has provided sales and engineering support for the Wright-Austin product line since 2001, trained by both Hayward and Eaton.