Compressed Air Centrifugal Separator Applications

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

Dirt, water and oils within compressed air systems are a source of corrosion and contamination. Air contains water vapor which condenses into liquid droplets due to temperature and pressure changes in compressed air systems. Trace amounts of oil, pipe scale and other particulates from the local environment, air compressor, receiver tanks and distribution plumbing contribute to coating the pipeline and equipment in the system and it all coalesces to low points in the plumbing. While coalesced liquid at low sections of piping can be removed with float drain traps without any loss of compressed air, centrifugal separators will separate both entrained droplets and slugs of water that accumulate in those low areas of piping when drain traps are not installed.

Thus, centrifugal separators serve an important function within a compressed air system, to prevent entrained liquid and particles moving at high velocity through the system from clogging, wearing or fouling the other components of the air system. Centrifugal air/liquid separators achieve separation of entrained droplets and particles larger than 10 microns in diameter with 99% efficiency through impingement, change in velocity and centrifugal inertia.

Impingement and Velocity Reduction

The pathway for moist air within the separator is non-direct; it enters the separator and is deflected away from the outlet nozzle. Due to the difference in density of air and droplets/particles, the trajectory of the heavier droplets/particles causes impingement, especially at the separator entrance. This impingement coalesces the droplets and particles into a larger mass and via gravitational force, drain out of the bottom of the separator.

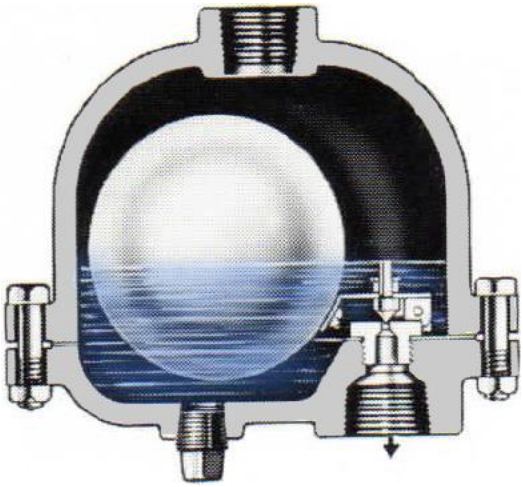
Simultaneously, since the separator body has a larger cross section than the inlet and outlet piping, the air velocity slows down as it passes through the separator. The gravitational force acting upon droplets and particles larger than 10 microns is strong enough to affect their trajectory downwards and away from the outlet nozzle. Thus, impingement and air velocity reduction combined is why separation efficiency is maintained at low flow conditions – the droplets are simply too heavy to exit the vessel. This is why we describe air/liquid separators as having an "infinite" turndown ratio, meaning that as long as the separator is sized for the high flow rate condition, it will maintain efficiency all the way down to a zero-flow condition because at lower flow rates the effects of gravity are more pronounced.

Centrifugal Vortex

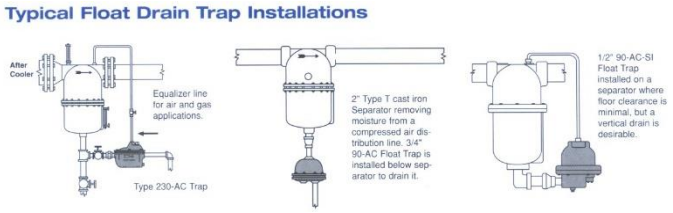
At higher flow rate conditions, a centrifugal vortex is formed in the center of the separator, creating an "air barrier" in which only the finest droplets (smaller than 10 microns in diameter) get carried though the outlet nozzle of the separator; all of the larger droplets and particles are propelled towards the inner circumference of the vessel where they coalesce into a liquid film and traverse to a common drain port.

Drainage

The separated liquid and particles collect in the lower section of the separator body, thus periodic drainage is required to prevent the liquid level from rising too high and exiting the separator. While actuated valves and pumps can be used to drain the separated liquid, for air compressor systems it is most common to use a mechanical valve referred to as a float drain trap.



The separated liquid and particles fill the trap body and an internal float rises, lifting a valve off its seat. The resulting differential pressure between the system and the drainage location results in purging the liquid from the trap at a rate dictated by both the differential pressure and the valve seat orifice diameter. Non-floating particles sink to the bottom of the trap which has a blow-down plug for periodic clean-out. It is also common to install a Y strainer between the separator drain and float drain trap to protect the trap from fouling.



We offer cast iron gas/liquid separators having an integral float drain trap which is easier to install. We also offer stand-alone cast iron, ductile iron, cast steel and stainless-steel float drain traps which can be installed at any air/liquid separator drain port. The most common

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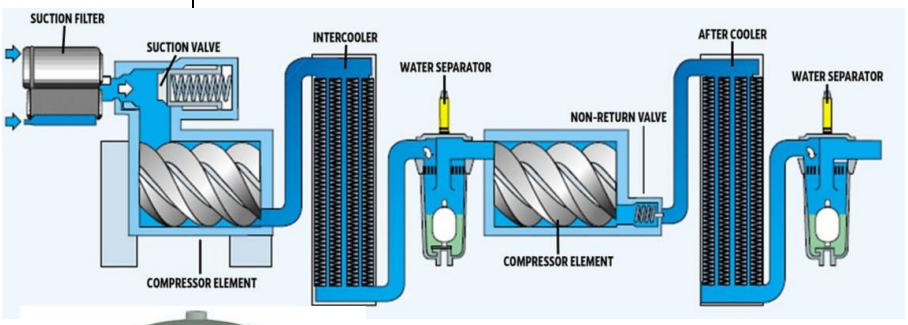
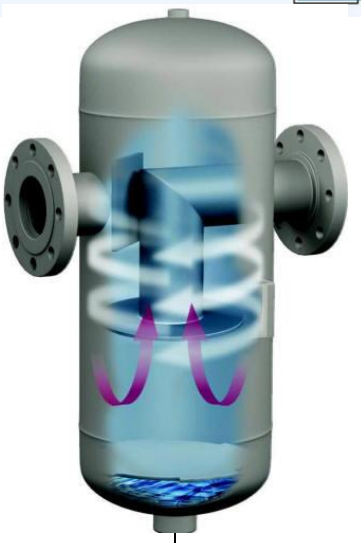
air/liquid separator materials are cast iron and carbon steel with 304L and 316L SS sometimes used for food/beverage/pharmaceutical type applications.

Air/Liquid Separators Locations
It depends upon the size of the air system, typically air/liquid separators are used at the outlet of the air compressor and often times prior to point of use or critical pipeline components in which entrained liquid and particles would either be detrimental to those components or the process itself. Large compressor systems may require several separators.

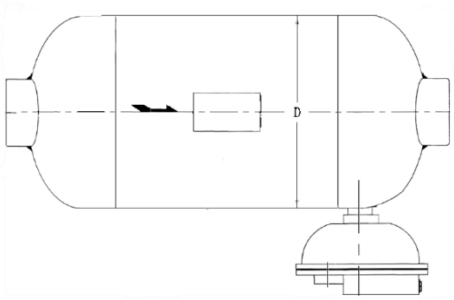


Aftercooler
Compressed air systems larger than 10HP often include an aftercooler, which is a section of water-cooled piping used to reduce the specific volume of air to increase the efficiency of the compressor. An aftercooler also condenses up to 2/3 of the liquid within the air, thus a separator installed after the aftercooler stage removes both condensate and oil carry-over from the compressor.

Intercooler
Similar to an Aftercooler except installed prior to the compressor or between compression stages to improve air compressor efficiency and protect the compressor. The removal of heat from the air results in the condensation of the water vapor suspended in the air.



Separator Styles
There are several different styles of separators; the most common versions used for compressed air applications are the type T and L series. The L series has a horizontal oriented cylindrical shaped body, making it very compact, however its liquid separation capacity is limited to the equivalent of 5% of its maximum flow rate capacity. Probably more importantly, the L series cannot handle liquid slugs, which is how we describe the phenomenon of liquid which builds up in low sections of piping and periodically swept downstream as a large liquid droplet whose diameter matches the pipeline ID.



The most common style of air liquid separator for compressed air applications is referred to as a type T because its profile looks like the letter "T", having an inlet and outlet 180° apart and in-line with each other. The T style has a liquid removal capacity up to 40% of its maximum flow capacity and separates liquid slugs.
We do offer additional separator designs to support a variety of flow pathways including vertical and combinations of vertical and horizontal.

Separator Sizing
There are four basic design criteria to properly size the separator body for a compressed air application:
1. Design temperature
2. Minimum operating pressure and design pressure
3. Maximum flow rate (volumetric or mass units)
4. Estimated flow of liquid to separate

If you have a reciprocating style air compressor, your maximum flow rate should be input at twice the rated value (whether you use sizing charts or our web-based sizing calculator).

It is often difficult to estimate the amount of entrained liquid to separate; our sizing calculator provides the maximum liquid removal rates in both volumetric and mass units in hours, minutes and seconds to assist with estimating the proper sized separator.

If the separator body size required is larger than the pipeline it is to be installed into, we can provide the separator with smaller connections to match your piping. If the separator size required is smaller than your existing piping, we typically recommend using a larger size separator to match your piping.

Our web based sizing calculator enables you to estimate your separator size very quickly and analyze "what if" scenarios using larger separators or performance with different design criteria; if you have many separators to size for a system, our calculator will simplify that aspect of system design immensely: https://fd-separators.com/sizing/FDPP-WA%20CALCULATOR-WEB/gas-separator-sizing-tool.html