Exhaust Head Design

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

This article is the third in a series of articles describing gas/liquid separation via centrifugal force; it describes a specialized type of vortex separator referred to as an exhaust head and complements our articles Gas/Liquid Separator Designs and Coalescer Gas/Liquid Separator Designs.

Centrifugal Separation Explained

Vortex separators, commonly referred to as centrifugal separators, rely on centripetal force to overcome the inertia associated with droplets and particles larger than 10 microns such that their trajectory is curved away from the vortex and outlet nozzle and instead impinge upon the internal structure to coalesce to a common drain.

Advantages of centrifugal separation include:

1. high efficiency (99%) removal of entrained droplets >10 microns
2. reduced vessel size compared to mesh pad and vane styled separators; directly corresponds to reduced cost
3. simplicity of design has no serviceable or wearing components; there are no maintenance requirements.

Exhaust Heads Differ from In-Line Separators

Whereas an in-line separator has both an inlet and outlet pipeline connection, exhaust heads only have a pipeline connection to its inlet as the outlet is open to atmosphere.

This is a limiting factor relegating exhaust heads to certain types of applications involving venting of non-hazardous gasses and liquids.

Current exhaust head design is credited to Mr. Arthur J Filkins and his 1925 patent for "Exhaust head for exhaust steam pipes". The application he invented it for, removing entrained liquid (water droplets, trace lubricants and boiler treatment chemicals) from steam vent pipes remains the most common application for exhaust heads.

An exhaust head reduces the carry-out of liquids and associated contamination, which can be as innocuous as reducing rooftop icing in cold environments to reclamation of chemistry that otherwise would be contaminating the surrounding environment. The reduced exit velocity inherent with centrifugal separator design also corresponds with reduced projection into the surrounding environment.

Unintended Benefit

Due to the design of centrifugal or vortex style exhaust heads, the noise associated with high velocity venting is somewhat reduced. This sometimes leads to confusion between an **exhaust head** and **vent silencer**.

A vent silencer is designed to reduce the noise associated with venting a pipe to atmosphere due to the sudden expansion of the gas being vented. This is accomplished by using sound absorbing materials and creating a reactive section to reduce low frequency noise. Liquid separation due to the internal geometry of vent silencers may be considered an unintended benefit.

Thus, exhaust heads are designed to remove entrained liquid with any noise reduction a non-engineered "benefit" and vent silencers are designed to reduce noise; any liquid separation is a non-engineered "benefit".

To engineer or maximize both liquid removal and noise reduction would require installation of an in-line separator prior to a vent silencer.

Exhaust Head Design

Since all of the other vortex separator models are designed and manufactured in accordance to ASME Division I, Section VIII and stamped, exhaust heads are manufactured in-kind however since they are not pressure vessels, they cannot be code stamped.

Atmospheric pressure is the design pressure standard for exhaust heads and they are sized to have a $\leq \Delta$ 0.9 PSI pressure drop. This aspect often leads to confusion of piping design specifications associated with a given site, as the last piece of equipment cannot be code stamped and its "maximum pressure" is described as only 14.7 PSIG even though it has a fully welded design and often with 150 lb. class flanged connection. The internal welding of the separation impeller, vortex containment plate, inlet and drain connections are all in accordance to ASME code simply because that is the manufacturers standard.

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Exhaust Head Applications

Reduced opacity and projection of vented steam accomplished by removing droplets larger than 10 microns with 99% efficiency and reduced exit turbulence. A consequential benefit includes reduced noise attributed to the both reduced turbulence and an indirect path to atmosphere. The rooftop and surrounding environment are subject to less liquid carry-out and the removed condensate may be reclaimed to reduce chemical and water make-up.

Steam exhaust heads are often constructed of carbon steel and have a 304SS internal separation impeller. The inlet connection can be threaded, flanged or butt-weld to match the corresponding vent pipe. If the environment is corrosive, such as an off-shore natural gas or oil rig, they can be supplied in 304SS, 316SS or other alloys. For pipeline sizes ≤ 10" we offer cast iron designs for a significantly reduced cost and lead time compared to custom fabricated designs.

Air exhaust is another somewhat common application for exhaust heads. Sometimes there are processes involving mixing vessels or machining centers which are too numerous to vent through the rooftop and perhaps cost prohibitive to tie into a centralized exhaust system.

Whether it is lubricants, steam or wet air in some localized and contained process, an exhaust head provides a relatively inexpensive method for removing those entrained droplets and protecting the surrounding personnel/environment. Such applications are still typically accommodated by cast iron or fabricated steel designs, although some food, beverage and biopharmaceutical applications may require stainless steel construction.

Lifespan of an Exhaust Head

Since exhaust heads are fully welded or cast and have no moving or otherwise serviceable components, they have no maintenance requirements and an indeterminate lifespan. Usually exhaust heads are replaced when the process conditions change, relegating the existing exhaust head less efficient. If an exhaust head is unable to drain, the condensate will contribute to oxidation which can eventually compromise the integrity of the body.

They are designed such that water from the external environment flows directly to the exhaust head drain and does not bypass the exhaust head, so even when not in operation, standing liquid should not be a problem as long as the drain port remains open and unblocked. When an application is intermittent and there is concern of birds or other animals nesting within the exhaust head, we can attach a screen across the outlet to discourage that from happening.

Sizing an Exhaust Head

As with their inline versions, the physical body of an exhaust head required for an application (its internal diameter, surface area and volume) is dictated primarily by the volume of steam or air to separate and NOT the inlet pipe size. When we refer to a given "size" separator, we are referring to the maximum corresponding inlet nozzle size that can be used, but there is no "minimum" size. For example, an application having a 4" size vent pipe might require a 6" size separator, to which we can attach a 4" connection to match the intended vent pipe size. Likewise, a 4" vent pipe might only require a 3" size separator from a performance perspective, however it would require using a 4" size separator to match the intended pipeline size.

Our expertise lies with understanding the applicable design criteria for a given application and providing detailed proposals for the most cost-effective design.

Visit us at https://fd-separators.com and let us know how we can assist you with your separation application!

Chris Pasquali has provided sales and engineering support for Hayward/Eaton since 2001