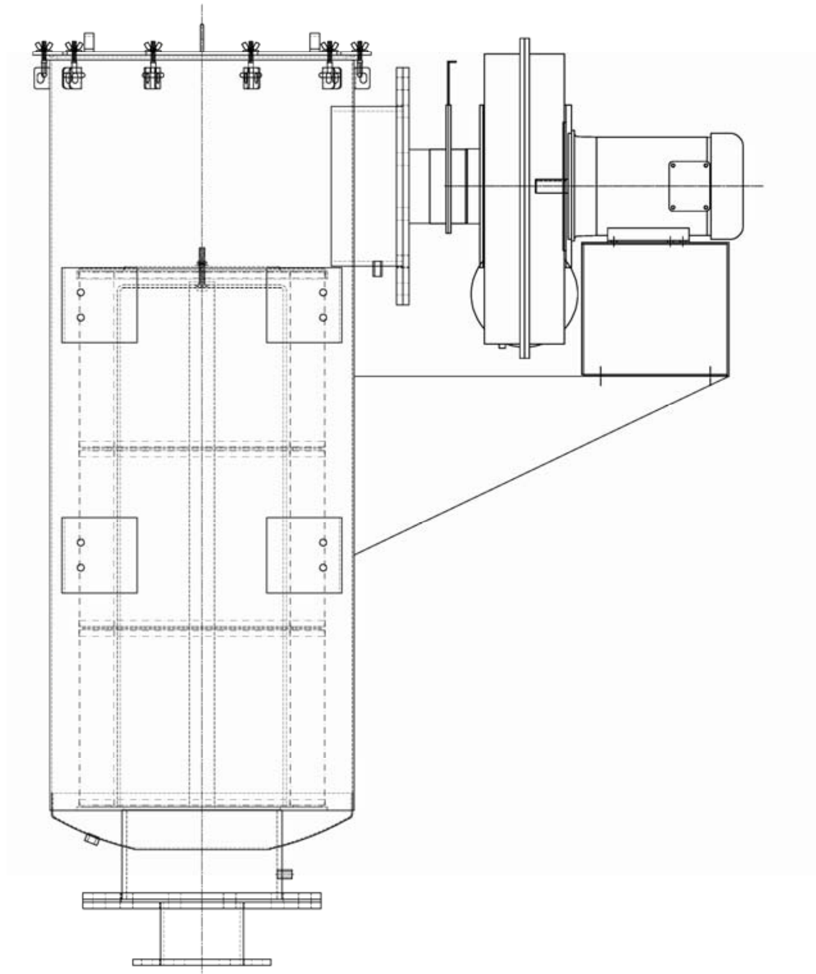
White Paper

Operational Aspects of Oil Mist Eliminators



VAE Series

SOLBERG **Oil Mist Solutions**

Operational Aspects of Vacuum Assisted Oil Mist Eliminators:

What are the issues facing turbo-machinery users?

The internal working parts (bearings, gears and pistons) of turbines, turbo-compressors and reciprocating engines, need constant oil lubrication. As the equipment operates, these parts become hot, and lube oil vaporizes into mist on contact. Excess pressure naturally builds in the lube oil systems and crankcases and need to be vented to protect bearing and shaft seals from leaking. When relieving this pressure, the entrained oil mist needs to be properly captured to prevent a host of environmental and safety issues. Stricter environmental regulations and opacity inspections are being implemented by federal and state organizations, and fines are levied on plants with excessive visible emissions. The most effective method to correct these issues is to use a high efficiency Oil Mist Eliminator. This document focuses on the Vacuum Assisted Oil Mist Eliminator.

What is the function of a VAE (Vacuum Assisted Oil Mist Eliminator)?

A Vacuum Assisted Oil Mist Eliminator (VAE) creates and maintains a continuous vacuum level inside a lube oil reservoir or crankcase to prevent excess positive pressure. When set correctly, the vacuum prevents seal damage and resulting oil leakage. The vacuum level is typically maintained by using a regenerative blower or centrifugal fan as the vacuum source.

The VAE extracts oil mist laden air from the lube oil reservoir/crankcase, and this air passes through a filter element to separate and capture the oil. The resulting clean air is released safely to the atmosphere, and any collected oil is recycled to the lube oil system. This is a continuous process that takes place while the unit is operating.

Design Parameters of a Solberg VAE

Typical Components:

- **Carbon or Stainless Steel Vacuum Rated Vessel**
- **High Efficiency Pleated Fiberglass Internal Separator Element (99.97% efficient for .3 micron particles)**
- **Vacuum Sources**
  - **Regenerative Blower, Centrifugal Fan or High Pressure Fan**
  - **Vacuum Regulator (Manual Valve or Variable Frequency Drive)**
- **Oil Return Drain Line**
- **Vacuum Regulator**

Pressure Differential & Efficiency:

Pressure differential is a significant factor to consider when designing a (VAE). The differential varies throughout the life of the unit as the internal separator element progresses from a dry to an oil saturated state and as it becomes contaminated with particulate. These variations can significantly impact the vacuum levels inside the lube oil system.

Solberg's premium VAE's are 99.97% efficient for 0.3 micron particulate and are designed to reduce emissions to 5PPM or less. Optimal performance and reduced maintenance are ensured when VAE components are properly sized around an application's requirements. For example:
If an application calls for minimal system maintenance, the separator element can be oversized to minimize pressure differential fluctuations during start-up, saturation and continuous operation.

Vacuum Regulation:

As a general rule, the greater pressure differential created by the separator element, the larger capacity blower/fan is required for a VAE. If the specified vacuum source is unable to overcome this differential, the results are excess positive pressure in the lube oil system and consequential seal damage and leakage. When operating a VAE, users prefer to make minimal adjustments to the vacuum level. These adjustments are typically made manually, and can be cumbersome if there are large fluctuations throughout the element's life cycle.

For example, in most turbine applications, the lube oil reservoir requires a constant vacuum level of less than 10" of Water Column (typically between 1"-8" Water Column). This calibration is critical, because it results in a specific vacuum level at the bearing houses along the output shaft. The vacuum source must overcome the pressure differential produced by the separator element to maintain these levels.

The initial pressure differential produced by the separator element increases as it is saturated with oil. The pressure differential normally stabilizes over a saturation period of 24-48 hours. The blower/fan typically has the capacity to create deeper vacuum than required in the system, so each system needs a mechanism to regulate this. Some problems that can arise from poor vacuum regulation include: oil contamination through the shaft seals, inadequate bearing lubrication, costly seal damage and oil migration up the drain line. There are a few common ways to control the system and avoid these issues.

1. **Flow Control Valve (Most Common):** This mechanism is typically used in **centrifugal fan** applications and can be located in one of two locations. It is typically a butterfly valve or slide gate style valve.

    1. Between the oil reservoir and VAE vessel
    2. Between the VAE vessel and the blower/fan

Operators use the valve to manually regulate vacuum by controlling the flow of **system air** to the blower/fan. Operators must be aware that too much restriction of flow to the blower/fan can damage the electric motor

2. **Bleed-In Filter:** This method is commonly used in **regenerative blower** applications. Operators control the vacuum level by manually regulating the introduction of **ambient air** into the system via a valve and intake air filter set-up. This allows for a more precise adjustment than a simple flow control valve. This mechanism is typically located in one of two locations

    1. **Between the Lube Oil Reservoir and VAE Vessel:** At start up, the valve is wide open to atmosphere so system flow is maximized and vacuum is minimized. As the element saturates, differential pressure increases across the separator element and more vacuum is needed to overcome it, and maintain a required vacuum level in the lube oil system. This is accomplished by closing the valve and is a preferred method when the lube oil system can handle a range of vacuum (eg. 2"-6" H20). If set correctly and the separator element is properly oversized, the vacuum level in the lube oil system will stabilize at the required (2" H20) after element saturation. At this point, the VAE will be relatively maintenance free during the separator element's lifespan.

        The filter feature is necessary to clean in incoming ambient air, so particulate does not clog the separator element and contaminate the recycled oil. However, in this location, the operator runs a risk of

introducing water vapor to the separator element from the ambient air. Excessive water can negatively affect separator performance and result in excess differential during operation.

2. **Between the Vacuum Source & the VAE Vessel:** At start-up, the valve is wide open to atmosphere, so system flow is maximized and vacuum is minimized. As the element saturates, differential pressure increases across the separator element and deeper vacuum is needed to overcome it and maintain a required vacuum level in the lube oil system. This is accomplished by closing the valve and is a preferred method when the lube oil system can only tolerate a specific vacuum level (eg. 4" H20). Therefore during the 24-48 hour saturation period, the valve will be incrementally closed multiple times to increase vacuum, and maintain the required level in the system. Once the element is saturated, the differential pressure will stabilize and the valve will be locked into place for the remainder of the element's life span.

   The filter feature is necessary to clean the ambient air and protect the blower/fan from harmful particulate. In this location, the separator element runs a minimal risk of becoming contaminated with particulate or water from the ambient air.

3. **A Variable Frequency Drive (VFD)**: This method is the most reliable and maintenance free. The VFD is used to vary the motor speed of the blower/fan to regulate the vacuum level in the lube oil system. This is accomplished using pressure transducers and a control unit to automatically adjust the speed of the blower/fan's motor. The convenience of automated regulation also makes it more costly in comparison to manually regulated alternatives.

Note: In all cases, proper vacuum gauges are required, so levels can be constantly monitored.

4. **Vacuum Breaker:** This valve is used to protect the lube oil system from excessive vacuum levels. It is typically located on the VAE vessel or between the blower/fan and the separator element, and can be used in conjunction with any of the three vacuum control mechanisms mentioned above. When the vacuum level in the VAE vessel reaches a particular point, the valve opens and allows ambient air to enter and flow into the system. This increased flow results in a decrease in vacuum level. Without this safety feature, vacuum can be excessive and result in oil migration up the drain line, ambient contamination through the oil seals and inadequate lubrication for the bearings.

Note: In all cases, proper vacuum gauges are required, so levels can be constantly monitored.

Drain Line and Stand Pipe Design:

All VAE units are equipped with a drain port and line, so captured oil is recycled to the lube oil reservoir. The units are installed vertically; thus, the oil in the drain line uses gravity to return to the reservoir. There are a few rules to follow when sizing these components.

1. The drain line must be submerged below the low oil level, so any oil mist suspended at the top of the reservoir does not migrate up through the drain line. A loop seal can also be used to accomplish this.
2. The stand pipe length is calculated to an exact distance above the high oil level inside the lube oil reservoir or loop seal. The height is application dependent and is influenced by the vacuum source, and the required amount of vacuum in the lube oil system. The proper stand pipe height allows for the drain to be sized to the correct length. Improper sizing can result in oil migration up the drain line and inadequate bearing lubrication.

Developing a Solution

Step 1: Obtain Customer Specifications

Solberg's team of Outside Salespeople and Technical Experts work directly with turbine or engine Operators, Packagers, and OEM's to determine their exact needs. The most critical parameters are listed below. With this information, the Solberg team will appropriately size a unit for each application.

Main Parameters:	**Sample Specifications**
a) Flow	120 CFM
b) Operating Temperature	125 degrees F
c) Desired Vacuum Level in Reservoir	4" H20 Vacuum
d) Filter efficiency	99.97% @ 0.3 microns
e) ATEX Certified	Yes

Connections:

a) Vent Port	2" NPT

Additional Equipment:

a) Vacuum gauge – reservoir:	Please include
b) Vacuum gauge – filter housing:	Please include
c) Vacuum control – manual or automatic	Please include manual system ball valve

Electric Motor Specifications:

a) Voltage:	230/400 VAC
b) Frequency:	60 Hz
c) # of phases:	3
d) Thermal protection:	F, class B
e) Motor protection:	IP 54/55
f) Horsepower	2HP
g) Heater Required	Yes

Step 2: Select the Vacuum Source

Once the electrical parameters for the blower/fan and motor are specified, the proper equipment is selected based on the desired vacuum levels in the lube oil reservoir/crankcase. Solberg also accommodates special blower/motor requirements such as ATEX Certifications.

Step 3: Select the Separator Element

After confirming the operating temperature and required filtration efficiency, Solberg uses the flow rate and desired vacuum level to determine what separator element size will work best. During this process, estimated pressure drop curves are calculated and are shared with users upon request.

Step 4: Wealth of Knowledge

Solberg's 20+ years of oil mist elimination experience give us a very good handle on how much differential pressure is contributed by a separator element during its operational life and at various flow rates. Our knowledge allows us to accurately determine the optimal separator element size and the ideal vacuum source to create the required vacuum level at the specified flow.

Case Studies:

Click on http://www.oilmistsolutions.com/oil_mist_eliminators_case_studies.htm to view real world applications for the Solberg VAE.