Clean crankcase ventilation

All reciprocating engines need crankcase ventilation. This is because of the high gas pressure in the combustion chamber, which cannot be totally sealed off.

Because the combustion chamber cannot be completely sealed, a small amount of gas escapes as “blow-by”, via the piston/cylinder liner gap and the piston rings, into the crankcase. In turbo-charged engines, there is also blow-by gas entering through the shaft sealing in the turbocharger into the crankcase. Since the crankcase is not designed for high pressures, it requires a ventilation pipe to prevent pressure from building up inside.

Because the gas pressure is very high during piston blow-by, it violently tears the lube oil from the walls, breaking it into very small oil droplets to form a fine oil mist. These small oil droplets escape the crankcase via the ventilation pipe. This, in turn, leads to oil pollution in the close vicinity of the crankcase ventilation outlet and to increased lube oil consumption.

Crankcase emissions legislation
For Wärtsilä, environmental solutions are always the priority. The main source of emissions from a diesel or gas engine is still the exhaust gas. However, as engines become cleaner and more efficient, and equipped with emission abatement systems, the relative impact of the crankcase emissions increases.

Increasingly, new legislation such as clean air acts and environmental regulations, aim to limit or entirely prohibit crankcase emissions from reciprocating engines. This is already happening in certain segments of industry, and it will also affect stationary power generation and the shipping industry in the near future.

System requirements
Dealing with crankcase emissions might, at first, seem like an easy task. The first thing that usually comes to mind is to install some kind of filter to prevent the oil mist from escaping. As straightforward as this sounds, there are a couple of facts that make filtering difficult.

Maximum allowed crankcase pressure
The crankcase has a large volume and a lot of seals. Therefore, the maximum allowed gauge pressure (over pressure) in the crankcase is 3 mbar. Most conventional types of filter are not able to function properly with such a low pressure drop, especially for longer periods of time.

Oil droplets size
The oil droplets are extremely small, most of them being in the range of 0.2-2 μm. Their small size, in combination with the low crankcase gauge pressure, creates a challenge to filtering.

Long service interval
For any crankcase emission abatement device, Wärtsilä’s service interval requirement would be a minimum of 8000 hours and preferably 16,000 hours. During this time there should be no need to change any filter insert, or for any maintenance.

Efficiency
A droplet removal efficiency of more than 95% is required.

Little or no consumables
Wärtsilä’s environmental policy is to minimize all kinds of waste filter inserts.

Design
The device should not interfere with the operation of the engine, nor should it have any negative effect on its performance.

Evaluation of different solutions
Based on the listed requirements, Wärtsilä has tested and evaluated many different filter products. Most of them have failed to live up to their promises. However, one solution based on centrifugal separation, provided by Alfa Laval® showed very promising results, though it had to be adapted for the bigger Wärtsilä engines.

It was therefore decided to start a development project, and to scale-up this solution in co-operation with Alfa Laval. As a result of this development project, the PureVent™ oil mist separator was born.

The oil mist separator
The basic function of the oil mist separator is very simple (see Figure 2). oily gas enters at the bottom of the separator. Because of the centrifugal forces, the air is driven to the periphery of the disc stack separating the heavier oil droplets from the lighter gases by centrifugal separation. The cleaned gas, which is very clean since the process abates odour and smoke emissions as well, exits the separator from the upper pipe connection.

The separated oil is collected using a specially designed and tested draining
The main benefits with the oil mist separator are:

- **Very high and stable efficiency:**
  A stable separating efficiency of above 98% has been repeatedly measured on the Wärtsilä 20V34SG engine. Proven features, such as the separating disc design and the high rotational speed, originate from Alfa Laval’s mineral oil separator technology. The disc stack speed is boosted by a frequency converter to 7200 rpm for maximum centrifugal force and optimal efficiency.

- **No influence on the crankcase pressure:**
  There is no pressure drop over the separator. In fact, it slightly decreases the crankcase pressure, which is then neutralized by a restriction valve and a balancing pipe. This gives a stable crankcase pressure and reliable operation of the engine.

- **Long service intervals:**
  The electric motor and discs are specially designed for the high rotational speed, and have a service interval of 16,000 hours.

- **Low power consumption:**
  The electrical consumption of the oil mist separator is 0.3 to 1.5 kW, depending on engine size. For an engine with an output of 9000 kW, the electrical consumption is around 0.5 kW.

- **Robust, non-interference, design:**
  The system is of the add-on type and is, as such, suitable for most engine types. It is designed for a stable crankcase pressure and even in the rare event of a failed separator, the engine can be run normally, thanks to the balancing pipe used as an automatic by-pass line.

- **Lower lube oil consumption:**
  The captured oil is re-circulated back to the engine oil sump.

### Gas engines

For gas engines, the system can also be configured as a closed crankcase ventilation system. This will reduce all crankcase emissions to zero because they are re-circulated into the air inlet of the turbocharger.

### Installation

Installation is a straightforward procedure for all engine types. For engines up to 12 MW, one separator per engine is sufficient. For bigger engines, two separators in parallel mounted in a common module are used.

### References

Today all new engineering, procurement and construction (EPC) power plants include the oil mist separator as standard. Also, most equipment deliveries include oil mist separators. They have also been installed on a number of sea-going vessels, both as new and as retrofit installations. In the beginning of 2009 there were approx. 400 oil mist separators installed or on order worldwide.

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**Fig. 2 – Functional principle.**

**Fig. 3 – Separator models and their applications. Top to bottom:**
- Unit for marine applications.
- High capacity unit with dual separators.
- Unit mounted on the exhaust gas module for Wärtsilä 46/50DF engines.