Abstract
For every piston stroke in a combustion engine, there are exhaust gases, which flow between the piston rings and sleeves. These gases enter into the crankcase. In turbocharged engine applications, air can also make its way into the crankcase through the oil return pipe of the turbocharger. These gases are generally called blow-by gases. The pressure they create lead to an unacceptable pressure build-up and crankcase ventilation becomes necessary. In many countries, regulations governing car emissions stipulate that the crankcase ventilation must not enter the atmosphere. That is the reason why blow-by gases from car engines are redirected by so-called closed crankcase ventilation to the intake pipe assembly and burned. However up until now, there are no standard international regulations for commercial or industrial diesel engines. Both closed and open crankcase ventilation systems are available. The open systems (without a cleaning process) direct the oily blow-by gases through a pipe into the atmosphere exposing the environment to all the undesirable gases and their detrimental environmental effects.

Keywords: Crankcase ventilation, low load breather flow, Piston rings, blow-by gases

1. Introduction
Blow-by is the gas that enters an engine’s crankcase during a normal combustion event or compression stroke. It is composed of unburnt fuel, air, and combustion by-products. Note that at this Stage it does not contain any oil. Incidentally, the combustion by-products contained in blow-by gas are corrosive, which is why it is a bad idea to paint the underside of your car with old engine oil as a cheap under seal substitute. Blow-by happens because the seal around your cylinder is not perfect. It is composed of closely matched metal parts - the piston, rings and cylinder bore. The close sliding fit and tangential load pressing the rings into the bore wall create a good (and variable, as we will see later on) seal, but by necessity there are gaps, and gas will get through them. If left unchecked, this gas entering the crankcase will eventually pressurize it and can cause oil to be blown past the crankshaft a camshaft seals. I have seen articles on the internet that attribute crankcase pressurization to the motion of the pistons – a piston descending in the cylinder on the induction or power stroke will pressurize the gas behind it and a piston rising on the exhaust stroke will create a depression behind it. This is not true. In most common road car engine configurations there will be an equal number of pistons rising and descending at the same time. Even if slightly out of phase, the overall change in crankcase pressure should be negligible. However, this effect does cause gas to constantly move from one part of the crankcase to the other. The motion of this gas is called inter-bay breathing, and can have a knock-on effect to blow-by, which will be covered later.

2. Blow-by: What is it?
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at this stage it does not contain any oil. Incidentally, the combustion by-products contained in blow-by gas are corrosive, which is why it is a bad idea to paint the underside of your car with old engine oil as a cheap under seal substitute. Blow-by happens because the seal around your cylinder is not perfect. It is composed of closely matched metal parts - the piston, rings and cylinder bore. The close sliding fit and tangential load pressing the rings into the bore wall create a good (and variable, as we will see later on) seal, but by necessity there are gaps, and gas will get through them (see figure 1). If left unchecked, this gas entering the crankcase will eventually pressurize it and can cause oil to be blown past the crankshaft and camshaft seals. I have seen articles on the internet that attribute crankcase pressurization to the motion of the pistons - a piston descending in the cylinder on the induction or power stroke will pressurize the gas behind it and a piston rising on the exhaust stroke will create a depression behind it. This is not true. In most common road car engine configurations there will be an equal number of pistons rising and descending at the same time. Even if slightly out of phase, the overall change in crankcase pressure should be negligible. However, this effect does cause gas to constantly move from one part of the crankcase to the other. The motion of this gas is called inter-bay breathing, and can have a knock-on effect to blow-by, which will be covered later. There are other sources of blow-by: Air Leaking into the cam cover via the valve guides and seals in pressure-charged engines, for example. However, we will concentrate solely on piston blow-by for the remainder of this article. How much of it is there? The simple answer to this is “it varies”. The problem is that it varies depending on so many things that the accurate answer can be a complex one. Thankfully, for the purposes of this article there are some broad simplifications that can be made. Firstly, let us break down blow-by into two variables: The volume of air that your engine is ingesting and the blow-by rate. It is easy to make a simple calculation to roughly determine what volume of air your engine is breathing:

\[ V = \frac{N \times S}{2} \]

3. Parameters affecting Blow-By
Amount of Blow-by gases generated in an engine is dependent upon following different parameters. Engine load, engine speed, break mean effective pressure are the parameters which are measurable and have major effect on the amount of Blow-by. But there are few more small parameters which are important and affect amount of Blow-by gasses leaking through the piston sealing rings yet they are difficult to measure. For example wear of Components is extremely difficult to measure as we have to take reading for no. of days or no of hours like 1000 hrs, 2000 hrs of engine running condition to have rough idea about wear happening in different components. Amount of Blow-by directly depends on the wear of parameters i.e. as wear of piston or piston sealing rings increases the volume flue
gases leaking through which ultimately increases the Blow-by occurring in engine. Distributions of re-circulated gases between cylinders are slightly influenced by the injection Velocity and its Orientation. Injection location also affects re-circulating gases in intake manifold. Injection velocity of re-circulated gases determines the back pressure created at the non-return valve used as positive crankcase ventilation valve.

\[ Q = f(n, \epsilon, \pi, T, t, D, dz, z, i, li, s, k, \rho, \tau, bmep) \]

Where,
- \( n \) - rotational speed of engine crankshaft
- \( \epsilon \) - The compression ratio \( \pi \) - the mean indicated pressure
- \( T \) – Torque
- \( t \) – Temperature inside cylinder
- \( D \) - Cylinder diameter
- \( z \) - Wear within the PRC group
- \( i \) - Quantity of cylinder
- \( dz \) - shape and clearance of piston ring joint
- \( li \) - Quantity of piston sealing rings
- \( s \) - Stroke k - Type and shape of piston ring sealing’s
- \( \rho \) – Viscosity of lubricating oil
- \( \tau \) - Type of cycle (two strokes/ four strokes)
- \( bmep \) – break mean effective pressure

Analysis and evaluation of all the above mentioned parameters is not possible due to the complexity of problem. Hence to simplify the problem statement we decided to consider parameters majorly affecting the amount of Blowby. Therefore we have decided to consider following important parameters in our equation. And other small parameters are considered as some percent of power losses occurring due to blow-by gases.

1. **Engine Torque:**
The amount of Blow-by varies with torque. Blowby increases directly with increase in torque.

2. **Speed:**
With increase in speed there is decrease in amount of blow-by

3. **Break means effective pressure (bmep):**
With increase in bmep blow-by increases. Although at some instant of time due to variation in wear factor and other such small parameters the amount of blow-by decreases even with increase in bmep.

4. **Blow-By Prevention**
Blow-by is considered the phenomenon Where combustion gases flow from the combustion chamber past the ring pack to the crankcase. The combustion gases flow past the piston ring at various locations: (a) at the piston ring gap, (b) past the front side of the piston ring at starved lubrication conditions, (c) or past the backside of the piston ring when the ring is not in contact with either of the ring-groove walls. The hot blow-by combustion gases cause the piston and piston rings to overheat. The blow-by disturbs the piston and ring lubrication by affecting the oil film: combustion Gases contaminate the lubricant and cause the oil to entrain in them. When the combustion gas reaches the crankcase it pollutes the lubrication oil. Blow-by cannot be totally prevented as long as the rings have gaps and move in their grooves. This means that some blow-by will always have to be allowed. The blow-by affects directly or indirectly the engine power (fuel) efficiency: the blow-by consumes some of the combustion power and increases the friction as a result of less favorable lubrication conditions. The gap between the piston and liner wall is greater on the anti-thrust side of the piston than on the thrust side. This requires that the gap between the back-side of the ring and the ring groove is quite large and thus has a large gasflow area. Measurements have shown that the twist of the piston rings affects the amount of blow by past the ring pack. A negative twist on the second ring can cause instability of the ring, which results in an increase in the blow-by. A positive twist on the second ring can, in turn, cause high land pressure, which may result in radial
collapse or axial movement of the ring (Richardson, 1996).

4.1 Closed crankcase ventilation
In view of existing and pending regulations, the pollution aspect and environmental Protection, it is clear that allowing these blow-by gases into the environment is unacceptable. The closed crankcase ventilation system solves this problem (see Fig. 1). These pollutants can cause damaging, oily deposits that form on the intake pipe assembly components (turbocharger, charge cooler, etc.). This damage can negatively influence the engine performance, fuel consumption and the life of the engine. To avoid this, an oil separator (9) is used to remove the oil from the blow-by gases. Without loss, the engine oil taken out is then returned to the oil sump where it can reenter the engine oil circuit. After the blow-by gases are cleaned in the oil separator, they pass the pressure valve (4). This valve regulates the pressure inside the crankcase to within permissible limits. As the engine moves through its speed and load range, the way the breather System behaves varies. If blow-by volume is low and load is low, then the Part-throttle breather will tend to draw a higher vacuum than is required to draw off the pressure in the crankcases. Therefore the WOT breather will tend to suck in fresh air. Where blowby production is high but load is low, the parthrottle breather will draw off all the gases and there will be little or no flow through the WOT breather.

4.2 Open crankcase ventilation
In this case the pressure regulator of ProVent is not in operation. The output port is conducted in the atmosphere. In this configuration there is a slight excess pressure in the crankcase.

5. Conclusion
Breather systems equalize the crank case pressure created by blowby, and maintain the crankcase at slightly below atmospheric pressure to ensure that blow-by gases and oil cannot enter the atmosphere. Blow-by gases contain oil mist, which in excess, can get carried over into the intake system. Oil separation is required in the breather system to remove carry over oil and prevent it from re-entering the engine. Critical oil separator dimensions can be calculated if the blow-by volume is known. Separated oil can be either returned to the oil pan or held in catch can. The designs of oil separators and oil catch cans are necessarily different, principally in the location of the entry and exit pipes.
6. References:
2. Personal reference material – source unknown (Ford / Ricardo?).