ACG
Oil mist detection

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1. Oil mist detection

The presence of oil mist in compressed breathing air is a significant problem. Inhalation of either mineral and synthetic oil mist can cause respiratory irritation, dizziness, nausea and even unconsciousness. The presence of oil mist also results in the pipes of a compressed air system being coated with oil. This increases the risk of fire, particularly if used with enriched oxygen, and can be difficult and costly to clean up afterwards.

With the advent of synthetic oils the detection of oil mist has become more difficult. This is ironically due to some of the benefits of using synthetic oils in the first place. Their greater stability means that much higher temperatures are required to cause evaporation, meaning that oil vapour detectors are less effective at detecting the presence of oil mist. Their higher operating temperatures also mean that combustion is less likely and hence the presence of combustion products such as carbon monoxide is less likely too.

This paper outlines Analox's approach to the detection of oil mist and lubrication issues in the compressor.

2. What is mineral and synthetic oil?

Mineral oil is essentially a natural product derived from crude oil. Produced as part of the distillation of crude oil, it comprises a mixture of numerous light oil fractions (typically in the range C15 to C50, alkanes and cyclo-alkanes).

Synthetic oil is a synthesized product made from methane, carbon monoxide and carbon dioxide. By controlling the quality of the feedstocks and the synthesis process, the oil produced is much more uniform in composition (commonly poly-alpha-olefins or esters) and has fewer impurities than mineral oils. The key benefits are greater resistance to oxidisation and thermal breakdown, longer service life, and better chemical and shear stability.

3. How is oil mist generated?

The following diagram shows the typical elements that make up a breathing air compressor system and the flow of gas through it.

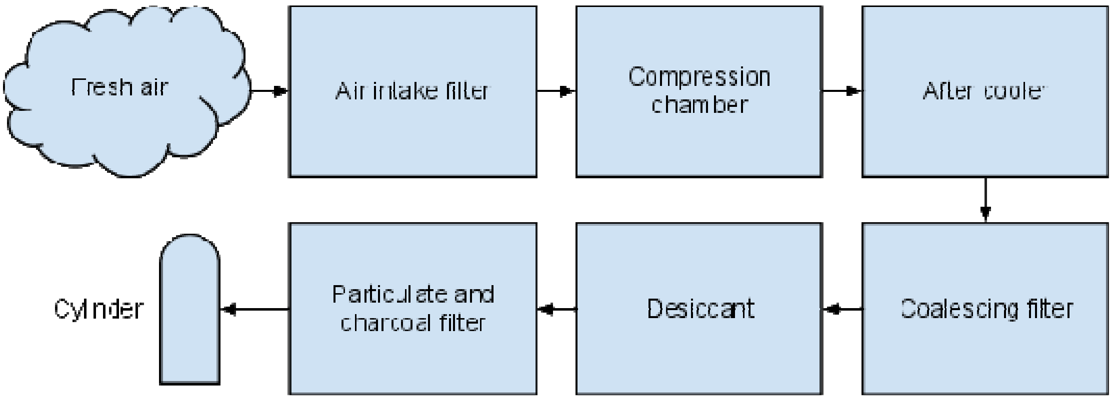

Figure 1 - A typical air compressor system.

All compressors require lubrication to minimise frictional heating and wear of their moving parts, the majority are oil lubricated. During normal operation, movement of a compressors internal parts leads to the deposition of a thin oil residue on all surfaces of the compression chamber. The high speed of motion and the great forces required to compress the air, result in some of the oil being atomised. As a result all compressed gas at the output of the compression chamber will contain some oil mist.

Under normal conditions this oil mist is then removed by the after cooler and filters on the output of the compressor, typically a mixture of coalescing and charcoal filters.

Other sources of oil mist can be as the result of filter carry over. Under certain fault conditions the oil collected by a filter is re-atomised back into the air flow.

In the respect of oil mist creation, both synthetic and mineral oils behave in much the same way.

4. Why does oil mist appear in the output of a compressor?

A properly maintained compressor should never generate oil mist above statutory levels in its filtered output.

There are however a number of mechanisms that can cause oil mist to appear in the output of a compressor:

4.1. Poor maintenance practices on the compressor filters.

If filters are not replaced or maintained in a timely manner, they can fail to remove the oil mist from the gas flow or even become a source of oil mist in their own right. In the case of coalescing filters they can re-entrain oil mist if the gas flow is prone to sudden high flow pulses or if they become flooded because the drain mechanism fails. Particulate or charcoal filters can fail by becoming exhausted and effectively saturated with oil or by being partially blocked, leading to higher than expected flows that can re-entrain oil from the filter media. These situations will result in oil mist being carried over into the compressor output.

If the filter media is not fitted correctly such that gas can bypass the media or the gas path is much less torturous than intended, oil mist carry over can also occur.

4.2. High compressor output temperatures.

The output of a compressor's compression chamber will always contain a quantity of oil mist. The quantity of this contamination is dictated by the temperature in the compression chamber and the volatility of the oil used. Under normal operating conditions the temperature of the gas leaving the compression chamber is well below the flash point of the oil so the quantity of contamination will be low. The filtration on the output will be designed to remove this level of contamination so the quantity of oil contamination is controlled.

If the discharge temperature of the compressor rises, more oil mist will be present at the compression chamber output. If the temperature rises significantly, the oil will break down and significant quantities of contaminants will be produced. Any increase of contamination will have the effect of consuming the filters at a higher rate than expected and result in their early failure. Oil mist can be carried over these exhausted filters.

There can be many causes of increased discharge temperature at the compression chamber:

- Lack of cooling, potentially cased by low air flow over cooling vanes, or failure of the cooling system.
- Overloading the compressor, by running the compressor outside its specified operating limits. For example by running the compressor for longer or at a higher output pressure than it was designed for.
- Running the compressor in an environment where the ambient temperature is higher than it was designed for.

- Insufficient oil delivered to the moving parts of the compressor will result in greater friction and higher operating temperatures.
- A build-up of carbon residues on valve seats, which results in a reduction in efficiency of the compressor and consequently an increase in the loading and operating temperature of the compressor. Carbon residues can also create hot spots in the compression chamber that can ignite oil vapour if the flash point is exceeded.

In extreme cases the temperature of the gas leaving the compressor can be so high that it will melt the casings of filter elements or even worse cause the oil that has been collected by the filters to burn. This produces large volumes of contaminants.

4.3. Failure of seals.

The seals on many of the working parts of a compressor are critical in separating both bulk quantities of lubricating fluids from the compressed gas and unfiltered and filtered flows of compressed gas.

If a seal fails in the compressor and bulk oil is introduced into the gas flow, the filters will quickly be overwhelmed and oil mist will be introduced into the compressor output.

If seals fail on filter elements, such that unfiltered gas can bypass the filter it will then be possible for any oil mist in the gas to pass straight to the compressor output.

One key factor to bear in mind with all three of the failure mechanisms listed above, is that other contaminants will also be generated or present at the output as a result of these failures.

5. How does the ACG sense oil mist?

The ACG has a sample support function for sampling the compressors output directly. This allows the use of industry standard colourmetric sampling tubes. These tubes operate by reacting chemically with the oil present in the sample and either display the concentration against a scale on the tube or change colour to indicate the presence of a specified quantity of contamination.

The same sample support function can also be used with a device such as the Draeger Impactor. This operates by a different principle to the tubes, in that the impactor collects a sample of the oil mist in the gas flow on a plate and by a novel optical method provides a quantitative display of the amount of oil mist present.

Use of the sample support function is a one shot detection method and does not give online protection at all times when the compressor is in use. In order to give an online warning of possible oil mist contamination, the ACG employs a number of other sensors that measure contaminants that are also typically found when oil mist is produced by a compressor. When one or more of these contaminants are detected and the source is not readily identified, it is recommended to also carry out an oil mist check with a tube or impactor. The sensors used to give a warning of oil mist are:

5.1. Volatile organic compounds (VOC) detection.

VOC's are a natural constituent of mineral oils and produce a greater concentration of VOCs at a given temperature than synthetic oils. The principle however remains; if oil mist is present, VOCs are present, any increase in oil mist concentration will have a corresponding increase in VOC concentration.

During fault conditions as described above, increased discharge temperatures from a compressor will result in increased oil mist generation. This will also result in an increased level of VOC's. The VOC sensor used in the ACG is high energy PID device

(10.6eV) and has been selected to detect as wide range of the VOCs as possible. When using Mineral oils the VOC sensor is a reliable method of detecting the presence of oil mist. When using synthetic oils, the VOC sensor can be an indicator that a failure has occurred in the compressor and oil mist may be present.

5.2. Carbon monoxide (CO) detection.

As described above, increased output temperatures from a compressor can result in increased oil mist generation. Increased compressor temperatures can also cause the partial combustion of the oil which will produce elevated levels of CO.

It should be noted that CO contamination can also result from other sources such as vehicle exhausts near to the air compressor inlet. As such the presence of CO should only be treated as a possible indicator of oil mist contamination.

5.3. Water detection.

As water vapour is usually a constituent of the inlet gases, it is generally the water content that causes the desiccant filters to become exhausted first. It is therefore a good indicator that filters are overdue replacement or service.

Elevated levels of water can also indicate that there is a potential problem with the operating temperatures of the compressor or that the seals are beginning to fail. Where discharge temperatures are increased the ability of the after cooler to remove the water content is compromised, this will result in the filters after it being consumed more quickly. In the case of seal failure, contaminated gas can bypass the filters. Once again these fault conditions can also result in greater oil mist contamination, so the increase in water content should be used as an indicator that an oil mist test should be carried out.

6. Q&A

So can I use the ACG as a monitor on my compressor which uses synthetic oil?
Yes, as many of the mechanisms that generate oil mist also generate other contaminants such as VOC's, CO and water vapour. The online sensors for these contaminants can give an indication that problems may be present with the compressor, that are resulting in the generation of oil mist. These indications can be used as a prompt to perform an oil mist test using the sample support feature.

It should be noted that the use of the ACG is not a substitute for regular preventative compressor and filter maintenance. The first line of defence against oil mist is ensuring that the compressor and filters are operating correctly!

How often would you suggest I take an oil mist sample at the ACG's sample support port?
The frequency of routine sample testing depends upon the level of usage of the compressor, how close to the design limits it is used and the scale of impact that contaminated gas would have on the compressed air system to which it is attached to. As a minimum we would recommend performing an oil mist sample test at least once every three months, to coincide with the calibration checks of the other sensors in the ACG.

Another good practice is to perform an oil mist sample test when the water, CO or VOC sensors alarm as they may be indicating a compressor problem, particularly if the source of the alarming contaminant is not obvious.

I have several compressors which use different types of mineral and synthetic oils – is the ACG suitable for use with all of them?
Yes, the ACG works with all types of breathing air compressor.

7. Acknowledgments

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