When Is Oil-Free Air Really Free Of Oil?

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Standards of compressed air need to improve as the usage of air expands in industry and the quality of the air becomes increasingly critical to production processes. Should users attempt to meet the new demand for quality air using an oil-lubricated compressor or invest in an 'oil-free' installation?

Traditionally the rule has been that oil-free compressed air can only be produced by an 'oil-free'compressor. However, even a dry running compressor cannot deliver truly clean, dry and oil-free compressed air on its own and is still only as good as its associated compressed air treatment system. Indeed, the answer to oil-free air no longer lies in the choice of the compressor but in the compressed air treatment plant.

It is well known that oil-lubricated compressors are much more economical to run that 'oil-free' units. But is it possible to produce a system which can generate the highest quality compressed air from standard, oil-lubricated compressors?

To find the answer, a leading European compressor manufacturer recently co-operated with a well known purification company to run parallel tests on compressed air with 'oil-free' and oil-lubricated compressors.

THE TEST

The tests were undertaken at the works of compressor manufacturer Kaeser Kompressoren at Coburg, West Germany, where the quality control department houses a Wild Leitz three dimensional CNC measuring machine. This machine measures screw compressor housings to the tolerance of 0.1 micron necessary to meet exacting product quality requirements.

In order to achieve these exact measurements on every part manufactured, the measuring table is mounted on friction free air bearings into which air is blown through tiny holes at a pressure of 80 psi. Unlike conventional ball bearings, the air bearings never wear, ensuring that the accuracy of the measurement system is maintained at all times.

HIGH QUALITY AIR

The quality of compressed air is vital to the successful operation of the measurement system. Because the air must be obsolutely oil-free, dry and clean, Kaeser decided not to use the normal factory air but to install a decentralized 'oil-free' compressor dedicated specifically to the application. This standard solution meant installing a 4kW dry-running piston compressor with a refrigeration dryer.

Ultratrockner, manufacturers of the ultrafilter oilfreepac purification system, suggested, however, that an oil-lubricated screw compressor in combination with the oilfreepac would produce a better quality of compressed air than an 'oil-free' compressor.

In order to prove this claim, a type SX6 oil-lubricated screw compressor with an 'oilfreepac 0024' purification system was installed in parallel with the oil-free system and run in comparative tests for a period of twelve months.

At six weekly intervals measurements were made of working parameters such as volume, temperature, pressure and dewpoint, liquid oil aerosols and oil vapor. The equipment required to measure 'the last drop' of contamination in the compressed air system was supplied by the research and development department of Ultratrockner's sister company, ultrafilter gmbh.

LIQUID OIL MEASUREMENT

Separate measurements of the aerosols and of the amount of oil vapor are required in order to quantify the oil content of compressed air. Compressed air leaving the oilfreepac passes over a probe which draws off a sample into an absolute filter. This filter is made up of 15 layers of binder-free glass fiber which catches all aerosols, penetration through the filter according to the DOP method being less than 0.0001%. All particles in the sample stream between 0 and 100% larger than a size of 0.01 micron are held back.

The filter is washed in the laboratory with $C_2Cl_3F_3$ solution and the extractables analyzed in a two-channel infrared spectrometer by comparing the light absorption of a clean sample with that of a contaminated sample to reveal the hydrocarbon content.

Kaeser Kompressoren's expectation was, of course, that air from the oil-lubricated compressor would show a high remaining oil content and that from the 'oil-free' unit would should show no oil. The result was exactly the opposite.

The liquid oil content after the oilfreepac was 0.012 ppm while that after the 'oil-free' compressor was seven times higher at 0.09 ppm. Both values related only to liquid oil and were the result of averaging many measurements taken over a number of months.

The fact that the oil-lubricated compressor produced seven to eight times

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less oil carry over than the 'oil-free' unit not only highlights the extremely efficient oil removal achieved by the purification system but also shows, yet again, that 'oil-free' compressors do not produce oil free air, in spite of the fact that they do not themselves introduce any oil. This oil is drawn in from the ambient air along with other contamination and is then compressed and intensified and finds its way into the compressed air system.

OIL VAPOR ANALYSIS

Having measured the liquid oil content, a second system is required to check the hydrocarbons present in the compressed air in gaseous form. This was achieved with a Flame Ionisation Detector.

The probe for this equipment is placed after the absolute filter that measures the liquid oil particles, thus ensuring that no liquid oil penetrates to the probe which is therefore only testing for gaseous contamination.

A C^+ anion stream is measured in a reactor oven, the fuel gas being hydrocarbon-free synthetic air (pure oxygen, nitrogen and hydrogen) which ensures that the measured ions can only come from the test gas. This analysis shows an even greater discrepancy in performance between the two systems.

Compressed air from the oil-lubricated compressor fitted with the oilfreepac purification system exhibited an oil-vapor content of 1.33ppm (ca 0.7 vpm) which is very near to the limit of measurement of the machine. By contrast, tests on air from the 'oil-free' compressor revealed an oil vapor content of 17.75 ppm (approximately 10 vpm), confirming that a refrigeration dryer is incapable of removing oil vapor.

These values apply to hydrocarbons and particularly carbon deposits. Their value will depend on the amount of hydrocarbons present in the original compressor oil and, when this is known, the probe can be set to measure the oil content per cfm (Air at 14.7 psi and 70° F).

MEASUREMENT TECHNOLOGY

In the last few years the techniques for measuring the residual oil content in compressed air have made great strides. The levels found after the oilfreepac would not have been measurable just a few years ago. Now, however, it is possible to measure oil in quantities as small as a few tenths of parts per million.

With these new techniques standards have to be changed. Ultrafilter has recently been involved in updating the ISO/TC 118/SC4 Standard so that the results are reproducible and consistent.

A particularly important feature of the ISO Standard is the sampling method. The probe must take a continuous sample since a false, that is non-isokinetic, sample can give readings that are incorrect by a factor of 10 to 100.[1] Ultrafilter uses a sampling probe manufactured by Fernandez & Suter which takes an absolutely isokinetic sample of the gas or compressed air.

THE OIL-FREE PARADOX

Clearly the paradoxical conclusion to be drawn from the trial is that, against accepted practice, it is now possible to better the compressed air quality of an 'oil-free' compressor fitted with a refrigeration dryer by using an oil-lubricated compressor in conjunction with an oilfreepac.

The tests show that an 'oil-free' compressor delivers 14 times more oil than an oilfreepac purification system, in spite of the much higher challenge rate the latter faces. How does it do it?

A SAFE SOLUTION

The oilfreepac is a complete six-stage compressed air purification system enclosed in a single cabinet and designed to treat compressed air from a normal, economical oil-lubricated system to a clean, dry and oil-free state.

In the package, the first stage prefilter removes coarse particles such as pipe scale and water droplets before the second stage microfilter. This filters down to 0.01 micron and removes all solid particles and separates oil and water aerosols. The third stage, a sub-microfilter, then removes any remaining particles together with any oil aerosols.

After these three stages the compressed air is clean but is still saturated with water and oil vapor. The moisture is removed by a fourth stage heatless absorption dryer which drys the air, according to the customer's requirement, to between −40 and −100 F dew point. The oil vapor is then removed by the fifth stage oil vapor absorber. Finally, at the sixth stage, a dust filter picks up any dust generated by friction in the dryer or the activated carbon beds. The result is a package which can be guaranteed to generate the same standard of clean, dry and oil-free compressed air from either an 'oil-free' or oil-lubricated compressor.

ECONOMY WITH SECURITY

Two important questions remain. Is the system economical and is it 100% secure? For example, could an oil surge caused by the malfunction of an oil-lubricated compressor lead to incurring the very high cost of cleaning oil-contaminated pipework?

Built into the oilfreepac is a safety device which precludes an oil-related accident. The differential pressure across the microfilter is constantly monitored, allowing it to act as a 'police' filter. The unit is generously sized, limiting the clean differential pressure to only 5-7 psi.

If, for example, the separator in the compressor fails, the resultant oil surge will immediately be detected as a change in the differential pressure in the microfilter. This increase in differential pressure is instantly relayed to the central control which activates a valve to shut off the compressed air and can also be linked to the compressor itself. This arrangement ensures the security of the system even under extreme conditions.

In new installations, the capital cost of an oil-lubricated compressor with a purification system is considerably less than that of a dry-running 'oil-free' compressor producing the same quality of air. Moreover, as the tests at Kaeser Kompressoren demonstrate, the presence of contamination in the ambient air requires that, for the very highest quality compressed air, even an 'oil-free' compressor requires the addition of a purification system such as the oilfreepac.

As well as being more expensive initially, 'oil-free' compressors are also more expensive to run, first because they require more expensive maintenance and, second, because they use more energy to produce the same amount of compressed air.

Existing users of oil-lubricated compressors seeking to upgrade the quality of their compressed air need no longer consider the substantial investment in replacing their existing plant with 'oil-free' systems. Instead they can up-rate to the highest quality air by using their old compressors with an oilfreepac.

But in many applications, as is demonstrated by Kaeser Kompressoren's own installation, only a small percentage

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