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Knowing the true sources of contamination in compressed air systems and what to do about them can lead to improved operating efficiencies for the equipment and far fewer maintenance headaches for you.

Ask many maintenance engineers what the major contaminant in their compressed air system is, and their answer would be oil. Oil is perceived to be the greatest cause of contamination in these systems because it can be seen emanating from open drain points and exhaust valves. Most of the time, however, what may look like oil actually *is oil condensate* (oil mixed with water).

In reality, nearly 99.9% of the total liquid contamination found in a compressed air system is water, with oil being only a very small part of the overall problem. A small 100 cfm compressor and refrigeration dryer combination, operating for 4,000 hours in typical northeastern U.S. climate conditions, can produce approximately 2,200 gallons of liquid condensate per year- a staggering amount. Filter systems can remove oil and dust, but well maintained air dryers are required to remove water and adjust humidity levels.

Sources of contamination

Contaminants in the compressed air system generally can be attributed to:

- **The quality of the air drawn into the compressor**
- **The operation of the air compressor**
- **Compressed air storage devices and distribution systems**

Air quality...

Air compressors draw in large amounts of air from the surrounding atmosphere that contains a large number of airborne contaminants, including atmospheric dirt, micro-organisms, oil vapor and water.

In an industrial environment, there are 140 to 150 million particles of dirt in every cubic yard of air. Eighty percent of these particles are too small to be captured by compressor intake filters. Consequently, they pass directly into the compressed air system.

Bacteria and viruses also are brought into the compressed air system. The warm, moist

air provides an ideal environment for the growth of micro-organisms. Ambient air typically contains up to 3,850 micro-organisms per cubic yard. If only a few of these bacteria or viruses enter a sterile process or clean production system, enormous damage could result, diminishing product quality or even rendering a product unfit for use and subject to recall.

Air also contains oil in the form of unburned hydrocarbons that are drawn into the compressor intake, as well as vaporized oil from the compression stage of a lubricated compressor. When these vapors cool and condense, they cause the same contamination issues as liquid oil.

Water vapor, condensed water and water aerosols from the atmosphere can wreak havoc on a compressed air system. The air's ability to hold water vapor is dependent upon its temperature. As the temperature increases, the level of water vapor that is held by the air increases. It takes 7.8 cubic feet of free air to generate 1 cubic foot of compressed air @ 100 PGSI. During compression, air temperature is increased significantly, which allows the air to easily retain incoming moisture. Significant amounts of water, as well as the other previously mentioned contaminants, enter the compressed air system without proper protection.

Air compressor operation…
The air compressor itself can add contamination, from wear and tear particles to coolants and lubricants. Rust and pipe scale can be found in air systems without adequate air dryer systems. Over time, this contamination breaks away and causes damage or blockage in production equipment and may also contaminate final products and processes.

> Maintenance programs should be tailored to the type of compressed air system, size of connecting lines, water capacity, flow capacity, filtration capability, construction material of air dryers and safe working pressures.

Almost all air compressors use oil in the compression stage for sealing, lubrication and cooling. Some oil, in liquid or aerosol form, enters the compressed air system and mixes with water vapor, which can cause damage within the system. The amount of oil in the

oil/water mixture accounts for less than 0.01% of the overall volume. But it is this resemblance to oil that leads to the mistaken belief that oil is the major contaminant in compressed air systems.

Storage and distribution…

After the compression stage in a system, air is typically cooled to a usable temperature, reducing the air's ability to retain water vapor. A proportion of the water vapor condenses into liquid water and is removed by a drain fitted to the compressor after-cooler.

Additional condensation, however, occurs in the compressed air system because the air continues to be cooled by the air receiver, piping and the expansion of air in valves, cylinders, tools and machinery.

Fig. 1. Refrigiration dryers provide pure, dry compressed air at a guaranteed dew point of 35 F.

Condensed water and water aerosols can cause corrosion to the storage and distribution system, as well as damage to production machinery and an application's end products. Liquid water also can wash away prelubricants on cylinders and valves, decreasing their operational life. Furthermore, water in a compressed air system reduces production

efficiency and increases maintenance costs. Removing liquid water and water vapor from such a system helps ensure that it runs properly and efficiently.

Purification technology overview

Coalescing filters are probably the most important purification equipment in a compressed air system. They are designed to remove aerosols (droplets) of water and oil using mechanical filtration techniques. Coalescing filters have the additional benefit of removing solid particulate to very low levels (as small as 0.01 micron in size). To be effective, they should be installed in pairs. Both filters perform the same function, with the first-*a general-purpose filter*-used to protect the second-*a high-efficiency filter*-from bulk contamination. This dual filter installation ensures a continuous supply of high-quality compressed air with low operational costs and minimal maintenance requirements.

Fig. 2. Desiccant dryers pass over a regenerative adsorbent material that strips moisture from the air and can provide a pressure dew point as low as -100 F.

The next component in the compressed air system is the air dryer. Properly maintained air dryers remove moisture from the compressed air system, eliminating condensation in the system's piping, pneumatic tools and instruments. There are two basic types of air

dryers: refrigeration and adsorption (*desiccant*). A dryer's efficiency is measured as the dew point, which is the level of dryness in a compressed air system.

***Refrigeration dryers* (such as the one shown in Fig. 1) cool air to a pressure dew point of 35 F, which is the effective limit on this type of dryer because water freezes at 32 F. This style of dryer is ideal for general industrial applications in light assembly, including those that use air motors, air tools, valves, cylinders and rotary actuators, painting and welding equipment, to name a few. Refrigeration dryers are not suitable for installations where piping is installed in ambient temperatures below the dryer dew point (i.e., systems with outside piping).**

Adsorption (*desiccant*) dryers (like those shown in Fig. 2) pass the air over a regenerative adsorbent material that strips the moisture from the air. These types of dryers are extremely efficient and can provide a pressure dew point as low as -100 F, with a typical range of -40 F. Desiccant dryers remove liquid from the compressed air system through the use of chemical beds. They often are used in cold-weather pneumatic applications, such as mining, agriculture, utilities, pulp and paper and transportation.

It should be noted that refrigeration and adsorption dryers are designed for the removal of water vapor, NOT water in liquid form. To work efficiently, air dryers require the use of coalescing filters installed in front of them in the compressed air system.

Other types of filters include:

- ***Adsorption filters*-Oil vapor passes through a coalescing filter just as easily as compressed air. These filters, which provide a bed of activated carbon adsorbent, remove oil vapors and provide protection against oil contamination.**

- ***Dust removal filters*-These are used to remove particulates when no liquid is present. They perform to the same level as the system's coalescing filters.**

- ***Microbiological (sterile) filters*-A sieve retention or membrane filter removes solid particulates and micro-organisms. These filters are often referred to as sterile air filters because they provide sterilized compressed air.**

Maintaining compressed air systems To achieve the stringent air quality levels required for today's production facilities, a compressed air maintenance system must be employed. Air-treatment maintenance should address the complete compressed air system. It is highly recommended that compressed air be treated to a quality level suitable for protecting air receivers and distribution piping prior to entering the distribution system. Maintenance programs should be tailored to the type of compressed air system, size of connecting lines, water capacity, flow capacity (system size), filtration capability, construction material of air dryers (i.e., steel or copper) and safe working pressures. Evaluation of each factor helps ensure proper and economical compressed air system operation. Low-pressure dew points derived from proper maintenance of air dryers and other purification technologies help to prevent corrosion and inhibit the growth of micro-organisms within the compressed air system. Well-maintained air dryers and purification components also help minimize pressure loss in the air system, a major contributor to operational costs, thus reducing energy consumption. Finally, air dryers that are maintained properly have a longer life cycle, reducing production downtime, while contributing to increased output and profitability.

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