IMI
Precision Engineering

Engineering GREAT Solutions

Compressed Air Treatment
A Guide to Filtration and Drying in Compressed Air Systems

IMI NORGREN

Contents

Engineering GREAT solutions through people, products, innovation and service

IMI Precision Engineering is a world-leader in fluid and motion control. Building close, collaborative relationships with our customers, we gain a deep understanding of their engineering needs and then mobilise our resources and expertise to deliver distinctive products and solutions.

Wherever precision, speed and engineering reliability are essential, our global footprint, problem-solving capability and portfolio of high performance products enables us to deliver GREAT solutions which help customers tackle the world's most demanding engineering challenges.

> **Reliability**
We deliver and support our high quality products through our global service network.

> **High performance products**
Calling on a world-class portfolio of fluid and motion control products including IMI Norgren, IMI Buschjost, IMI FAS, IMI Herion and IMI Maxseal. We can supply these singly, or combined in powerful customised solutions to improve performance and productivity.

> **Partnership & Problem Solving**
We get closer to our customers to understand their exact challenges.

Compressed air - the facts

Compressed air is used in almost every industry, including the food, dairy, beverage, brewing, semiconductor, pharmaceutical, biotechnology, chemical, petroleum, oil & gas, offshore and all process industries. Clean and dry compressed air is an essential requirement for efficient, reliable and profitable service, manufacturing and processing operations.

Compressed air starts its life as atmospheric air and by the process of compression though compressor equipment is converted into a source of potential energy which can then be stored, distributed in pipework and associated equipment then used as a source of motive power for pneumatic systems and processes. Applications includes: air tools, pneumatic machines, pneumatic valves & cylinders used in automation systems, shot blasting, spray painting, product transportation brewing, fermentation, aeration, breathing air and a host of other processes – in fact the list is limitless.

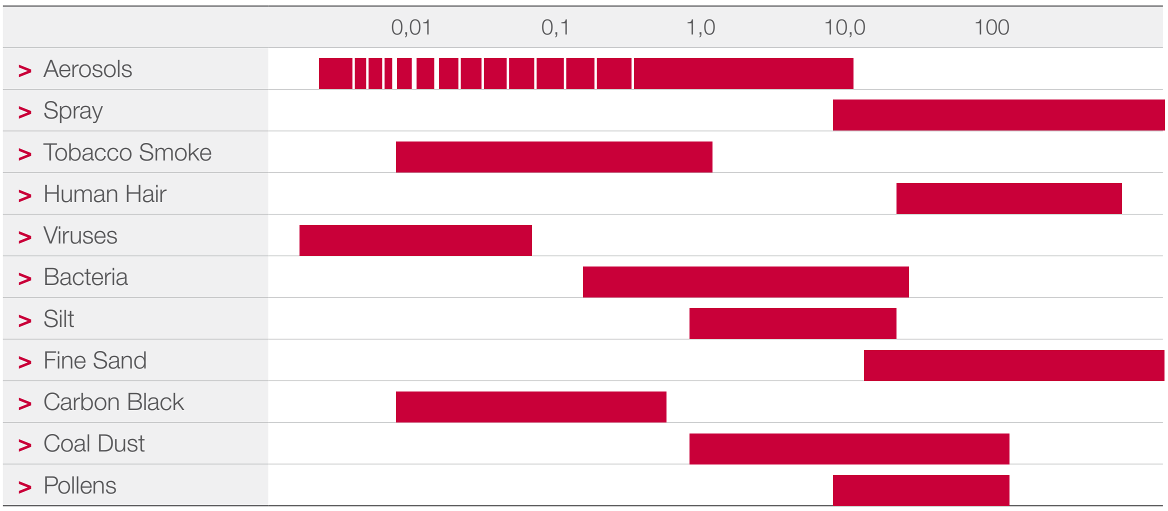
Atmospheric air is mainly composed of nitrogen, oxygen and a mixture of other gasses, water and hydrocarbon vapour. It also contains solid particulate in the form of contaminants in a variety of types, shapes and sizes which range from small sub-micron to large 100+ micron to heavy dirt particles of 1000 micron [1 mm] in size - a human hair is about 75 microns across. Intake filters on a compressor are designed to stop solids entering and potentially damaging the compressor but do not remove the smaller particulates which are passed into the air stream.

When air is compressed, heat is generated which increases its capability to hold water vapour which is present in the atmosphere in varying amounts depending on weather conditions, expressed as relative humidity.

Most compressors are lubricated with oil, and while the bulk of this is removed by an oil separator and recirculated; the hot and often acidic oil in the form of fine mists, aerosols and oil vapour can enter the compressed air stream along with any solid particulate from the atmosphere. Atmospheric hydrocarbon oil vapours entering an oil free compressor will be passed into the air distribution system.

As the compressed air leaves the compressor via a heat exchanger into the air storage receiver and distribution pipework system, it cools – this is beneficial as it allows the water and oil vapour to condense and turn into liquid, oil/water liquids and/or emulsions (called condensate) which can be removed by an efficient condensate management drainage system. However, entrained solid particulate and any remaining water and oil vapour is carried downstream into the distribution system where it can pick up more contaminates such a rust and debris from old receivers, treatment equipment and pipework.

Particle diameter, microns



Compressed air contaminants – the problem

Compressed air produced by a compressor is hot, wet and dirty. It contains water and hydrocarbon/oil vapour, liquid (aerosols) and solid particles. Professional Compressed Air Treatment is the best way to achieve Clean Compressed Air. The first step is to understand the sources of compressed air contamination and the types of contaminants which must be reduced or eliminated. This is a key factor in planning an efficient compressed air system.

Water liquid and vapour

Water in the compressed air system enters through the compressor intake as a gas - water vapour from the environment.

The ability of air to hold water vapour is dependent upon its pressure and temperature. The higher the temperature, the more water vapour that can be held by the air, the higher the pressure, a greater amount of water vapour is dropped out in liquid form (condensate).

The amount of water vapour per m^3 is a function of temperature and pressure. When ambient air is compressed, the gas volume is reduced which causes a reduction of water vapour by condensation. On the other hand, water vapour content per given volume is increasing with increasing temperature. This is the reason that hot compressed air in most cases contains more water vapour per volume than ambient air and is generally “saturated” with water vapour. Air at a constant temperature has a maximum capacity for water vapour for a given volume whether at atmospheric pressure or in a compressed state. Compressing air then cooling it back to ambient temperature will result in 100% RH in the compressed air with the excess water vapour condensing as bulk water.

As the compressed air cools down, water vapour gradually condenses to liquid water that has to be removed from the compressed air system. The temperature at which water vapour condenses is called “Pressure Dew Point” (PDP).

Once all liquid water is removed from compressed air by use of condensate management drains, then generally the air will be completely saturated with water vapour. The particular temperature and pressure at which the compressed air exists at that moment is known as the pressure Dew Point.

In the tropics humidly is very high and when compared to the typical daytime temperature it is described in terms of relative humidity (RH). So for example in South East Asia (SEA) daytime temperatures are typically 30-35°C with RH typically at 90%. Humidity builds up during the day so it is common for precipitation (rain) to occur in the evening as the temperature drops below its daytime highs. For as little as a 5°C temperature drop, RH will exceed 100% and precipitation occurs.

In the Sahara desert daytime temperatures range 40-50°C but with low humidly of 20-25%. When night falls the air loses its temperature rapidly due to its dryness. Air at just 40°C and 25% RH (contains 10-15mg/m^3 of water vapour) will lead to dew forming when the night time air reduces by 15°C or more.

Compressing air in either location leads to the formation of condensate as the pressure squeezes out excess water vapour.

96 litres per day on a 24
hour running cycle
That's about 2 kegs of beer!

Example in South East Asia - 1m^3 of atmospheric air at 30°C and 90% RH contains 27.3 g/m^3 of water vapour. When compressed to 7 barg (8 bara) this reduction in volume means the air can now only hold 30.4/8 = 3.8g of water vapour at 30°C. The balance of water vapour condenses producing 27.3-3.8 =2 3.5g/m^3 of condensate. An 18 KW compressor operating 4,000 hours produces up to 16,000 litres of condensate.

15.6 litres per day
in a 24 hour running cycle –
that's equivalent to over 20
bottles of wine!

Example Sahara - 1m^3 of atmospheric air at 40°C and 20% RH contains 10.2g/m^3 of water vapour. When compressed to 7 barg (8 bara) this reduction in volume means the air can now only hold 51.1/8 = 6.4g of water vapour at 40°C. The balance of water vapour condenses producing 10.2-6.4=3.8g/m^3 of condensate. An 18 KW compressor operating 4,000 hours produces up to 2,600 litres of condensate.

In both examples the compressed air is completely saturated with water vapour at 100% RH. The difference for these two examples is the amount of condensate produced.

Humid, water saturated compressed air is never desirable since further condensation may occur in the downstream pipework and application.

This leads to problems such as:

- Corrosion of metals in the system
- Washing out lubrication from pneumatic components
- Freezing of condensate when the temperature drops below the freezing point of water

Solid particles contaminants

Like water, solid particles exist in all compressed air systems regardless of the type of compressor. These can arise from four principle sources.

- Atmospheric dirt entering the compressor intake
- Corrosion products due to the action of water and weak acids formed by the interaction of water and gases such as sulphur dioxide inhaled by the compressor
- Carbon products formed by the action of the heat of compression on the lubricating oil or the normal wear of the carbon piston rings used in some types of oil free compressors
- Particles of debris originating from the mechanical fixing of the metal pipework and components into the air distribution system

The size of solid dirt particles covers a very wide range from below 1 micron to several hundred and the level of filtration required to remove them depends upon the degree of cleanliness required for the application.

Atmospheric air in industrial and urban environments will typically contain 140-150 million dirt particles in every cubic meter. As 85% of these particles are less than 2 micron in size, they are too small to be captured and removed from the air stream by the compressor intake filter and will travel unrestricted downstream into the distribution system.

Oil in the compressor

Oil in a compressed air system can exist in three forms, oil/water emulsions, aerosols/mists (small liquid particles suspended in the air) and oil vapours.

The principle source of oil contamination within a compressed air system is from the compressor lubricant.

An oil lubricated compressor of 160 Nm^3/h (100 scfm) capacity (a relatively small machine) may introduce as much as 8 litres per year of oil into the system.

Oil is used for lubrication of the compressor but when it emerges with the compressed air prior to entering the distribution system the oil is now in a totally unusable state. Having being subjected to high temperatures during compression it becomes oxidized and acidic and can be considered as an aggressive contaminant which must be removed.

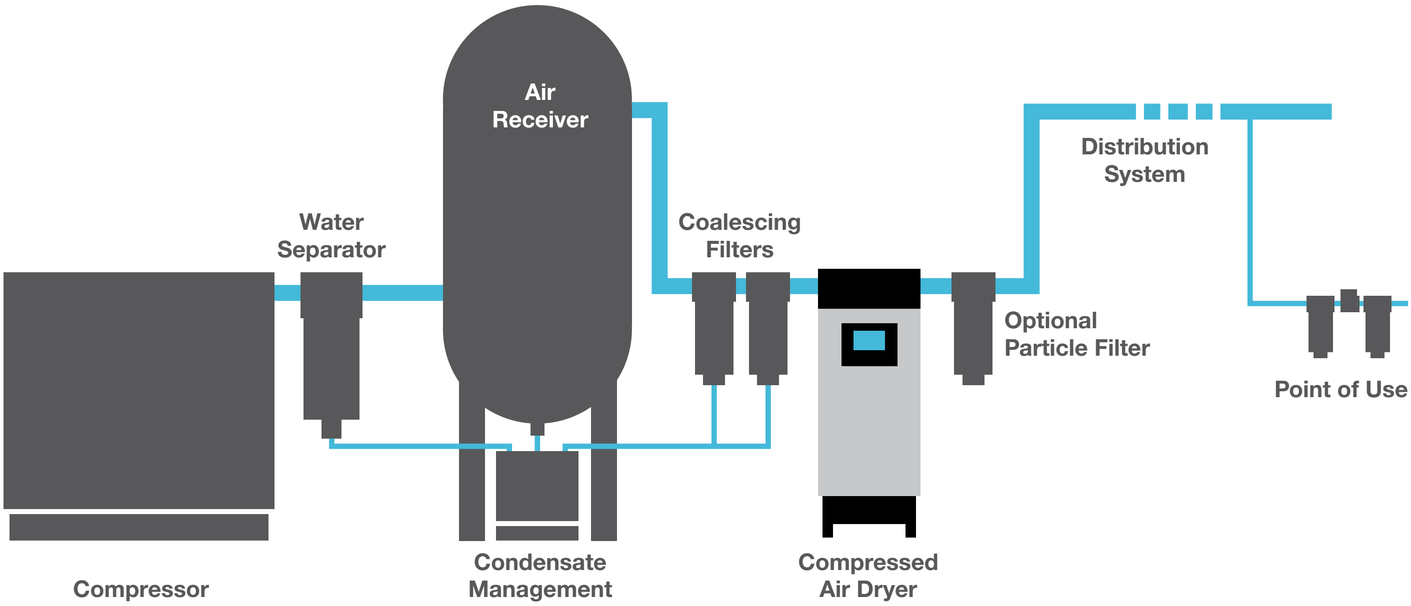
Oil contamination

Atmospheric air also contains oil in a gaseous form (hydrocarbon oil vapour) which can be drawn into the compressor intake. The location of the compressor intake may also have an effect and should be carefully positioned away from any sources of pollution such as vehicle and generator exhausts. When the oil vapour enters the distribution system it will cool and condense into a liquid and may combine with liquid water to form an oil emulsion. Oil vapour can taint manufactured products it comes into contact with and when exhausted from the application can make plant operators feel unwell. It is especially hazardous when it is found in compressed air used for breathing air.

Compressed air contaminants a solution for every contaminant

By taking all of these sources of compressed air contaminants into consideration, it is vital that proper and genuine compressed air treatment products/systems is are installed to ensure clean compressed air at a quality level as required by the application

Compressed air treatment is employed using the correct grades and sizes of particulate and coalescing filters, dryers and condensate management in the correct location in the distribution system. The volume of air flow at each stage must always be considered as basis for product selection. Undersized, inappropriate filters and compressed air treatment equipment that cause high pressure drops are a prime reason for high energy and maintenance costs as well as system downtimes.



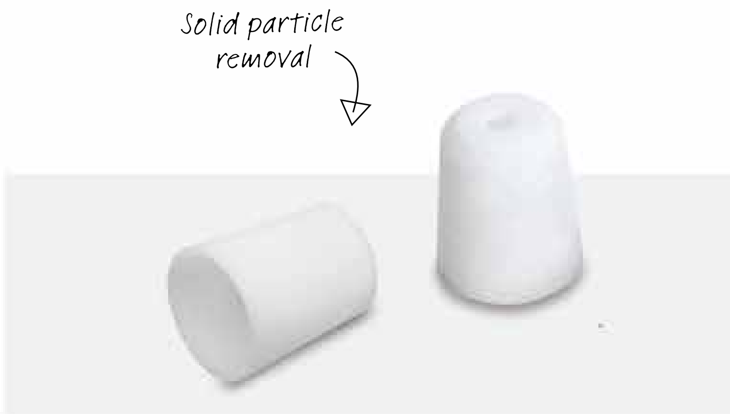
Liquid Oil & Water Removal

General purpose filters (also known as water separators) are used in a compressed air system to remove bulk condensate (water and liquid oil) contamination therefore protecting the downstream particulate and coalescing filters.

General purpose filters will only remove liquids and will not remove water or oil in either aerosol or vapour phase. The filters are designed to remove the water by centrifugal action which optimises the separation efficiency and reduces running costs.

Solid Particle Removal

General purpose filters also contain elements to remove solid particle contamination that originates from the atmosphere and possibly from compressor wear as well as the compressed air pipework and air receiver. They utilise a replacement filter element with a micron rating adequate to remove the solid particles and also act as a pre filter to the high efficiency coalescing filters downstream.



Oil Aerosol Removal

Coalescing filters are used in a compressed air system to remove small and submicron particles, water mists and oil mists aerosols. They are usually installed in pre filter and after filter combinations and each has its own automatic drain to discharge liquid emulsions to a condensate management system. The filter media efficiently employs the three main mechanisms of filtration, diffusion, inertial impaction and direct interception. IMI Norgren coalescing filters utilise a unique design and construction of filter housings with replacement filter elements that have high dirt holding capacity, low pressure drop and long life with a sub micron filter rating.

For systems with oil lubricated compressors or oil in the inlet air, pre and coalescing filters are needed

Water Vapour Removal

Clean and dry compressed air is easily achieved with the IMI Norgren HYDRA-D range of desiccant dryers.

Our desiccant air dryers are used for high purity applications where pressure dewpoints of -70,-40 and -20°C are required according to ISO8573.1 humidity classes 1, 2 and 3 respectively.

- High efficiency moisture removal
- Integral inlet and outlet filtration
- Reliable PLC control
- Energy saving option - dew point sensing for lowest possible purge air use
- Replacement desiccant cartridges for quick and easy servicing
- ISO 8573-1 (2010) class 2: -40°C PDP for water and class 1:1 micron particulate
- Alternative dew point settings

Designed for use in the compressor room, at the point of application or integrated into your original equipment, Hydra-D dryers are an effective solution to the problems caused by contaminated compressed air.

Oil Vapour Removal

IMI Norgren Activated Carbon Filters are used to remove hydrocarbons, oil vapours and odours from the compressed air, and are installed downstream of coalescing filters. The activated carbon granules in the filer media have a high surface area available for adsorption.

Carbon filter element

Energy saving in compressed air systems

Compressed air is often wrongly assumed to be a cheap or even ‘free’ source of power. It is not – that’s is why it’s vital to install the correct Compressed Air Treatment equipment.

A typical 1800m^3/hr (1,000 cfm) installation will consume £40,000 of electricity in a year. During its lifetime energy represents 75% of the total cost of buying and running a compressor. Numerous independent studies confirm that industry wastes around 30% of the compressed air it generates, equivalent to £12,000 [GBP] in our typical 1800m^3/hr installation by inefficient compressed air systems. The aim of this guide is to help the end user minimise wastage, by improving existing installed systems. It will highlight key areas for savings, and offer practical advice on an action plan.

Leakage

Leakage is the major source of energy loss in compressed air systems. A typical plant may lose 20% of its compressed air through poorly connected pipe joints, fittings, couplings etc. Fixing the leaks and introducing planned maintenance can produce substantial savings.

Misuse

The second major wastage of compressed air is to use it as a power source just because it is available. There may be better alternatives for moving, drying or cleaning products. Where compressed air is used, selecting correct equipment such as nozzles and use of control circuits can minimise wastage.

Over pressurisation

A considerable saving both in energy and equipment life can be made by using devices at the minimum pressure required for the application rather than full line pressure. Simple use of pressure regulators offers very fast payback.

Pressure drop

Loss in pressure, due to blocked filter elements and undersized pipework, can mean pressure starvation at the end of compressed air lines.

Energy and safety

Components fitted for safety reasons, such as preset regulators and shut off valves, can also help energy saving. This section reviews relevant parts of BS EN 983 and other standards linking them to energy issues.

Generation

The correct selection of control equipment to multiple compressor set ups, attention to inlet cooling and after treatment of the compressed air can realise good energy savings. Regular and correct maintenance of compressors, filters and dryers is also vital.

IMI Precision Engineering operates four global centres of technical excellence and a sales and service network in 75 countries, as well as manufacturing capability in the USA, Germany, China, UK, Switzerland, Czech Republic, Mexico and Brazil.

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