Quality Counts

A Guide to Clean Compressed Air

The topic of Quality in Compressed
Air raises a lot of questions.
Being in the field of Compressed Air Systems,
this book is our endeavour to answer the
most complicated questions in the
simplest of ways.

Quality Counts

(A Guide to Clean Compressed Air)

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Why Quality Counts?

Compressed air is considered an important utility in any industry after electricity. Every industry segment has compressed air application and it is important to note that compressed air can rarely be used without some form of treatment…which is generally ignored.

For every application, in addition to understanding compressor types, efficient methods to reduce contaminants need to be investigated.

The purpose of this book is to answer all questions related to quality air because Quality is our right and the need of our process as well.

A wide range of filtration and drying equipment is available to improve air quality. However, it needs to be remembered that careful selection, installation and maintenance of treatment equipment is required to reduce the energy costs of treating air. These costs can be quite high and include direct energy costs for running equipment, the extra generation cost needed to overcome additional pressure drops, or the cost of purging air.

This book shall answer all your questions from the simplest to the most complicated in quality compressed air. Contaminants like moisture, oil, particles kill your profits and costs you money. Simple steps of caution for your compressed air system can save money, equipment down time and end products.

Quality is important because it ensures the viability of a business. The lack of quality is costly through waste (redundancies, errors, scrap, time, etc.). Those costs are taken from the bottom line. Whether it be quality of products or quality of services. Whether we talk about quality in processes, practices or compressed Air systems….**Quality Counts** in every aspect of the business**.**

Frequently Asked Questions

- What is a compressor?
- What are compressed air applications?
- What are contaminants?
- What are different kinds of Contaminants?
- What is quality air and why is it important?
- What quality of air does your application need?
- What are quality air standards?
- What are air treatment equipments?
- What is an after cooler and why is it important?
- What are air dryers?
- What are frequently used terminologies in dryers?
- What are different types of dryers?
- Are you choosing the right dryer for you?
- What are Compressed Air Filters?
- How is Filtration achieved?
- What are different types of Filters?
- How do you select the right Filters for you?
- What is an air receiver and how is it selected?
- How do you install an air receiver?
- What is condensate management?
- What is Compressed air distribution?
- How is distribution essential for Quality of air?
- What is Compressed Air Package?
- What is Compressed Air Audit?
- Why is audit important for quality of compressed air?
- What is life cycle cost of Compressed Air System?
- Points to Remember
- A name you can count on

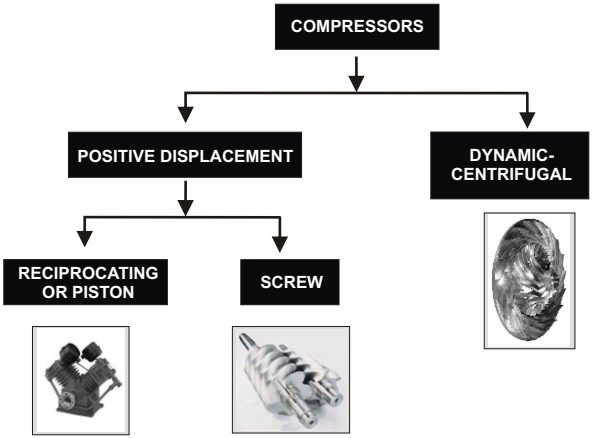
What is a compressor?

An air compressor is a machine that increases the amount of air in a particular space. By packing in the air, the air pressure is increased which creates a force that is useful for a variety of purposes, from industrial and manufacturing to commercial and personal purposes.

Compressors generally fall into one of two types, positive displacement or dynamic, defined by its mode of operation. A positive displacement air compressor works by filling and then emptying an air chamber. Three common types of positive displacement air compressors are: reciprocating, rotary screw and rotary sliding vane.

A dynamic air compressor, on the other hand, uses a rotating device to accelerate and then decelerate air. This process uses the speed or velocity of the air to increase the air's pressure. Centrifugal air compressors are dynamic air compressors.

CLASSIFICATION OF COMPRESSORS



Positive Displacement Compressors can further be classified as oil injected compressor and oil less compressor. The highest quality of air is delivered by an oil-less compressor

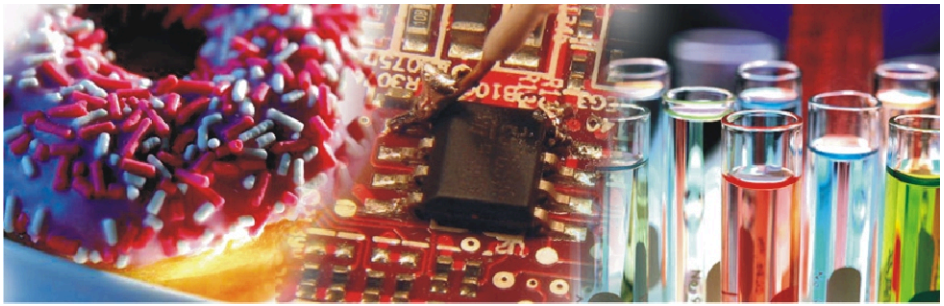
What are compressed air applications?

Compressed air has numerous applications in industries, agriculture and domestic. The major types of compressed air application can be summarized as Power applications, Process applications and Control applications

1) In Power applications, Compressed air is used as a source of energy to produce a motion or exert a motion or in some cases both. For instance pneumatic tools, clamping devices, Air lifts, Pneumatic conveyors etc.

2) In process applications the compressed air enters the process itself for doing the work. In other words it is like a raw material for a process. For Examples Aeration, Dehydration of food, Combustion, Oxidation, Liquefaction

3) In control applications compressed air triggers, modulates and controls machine and processes. For Examples Instrument Air, Operation of pneumatically controlled valves and cylinders automated assembly stations, automated machineries



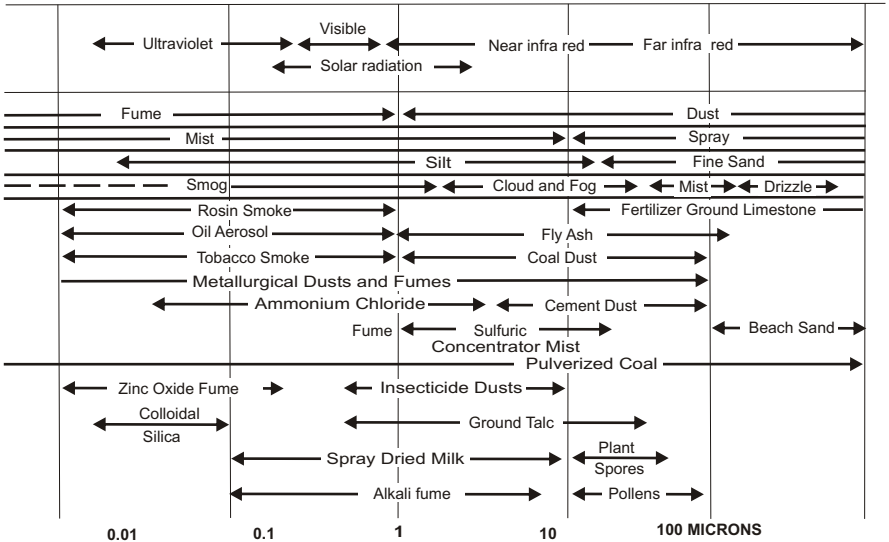
Your application determines what level of quality compressed air you need. It is always advisable to treat the air coming out of a compressor before usage.

What are contaminants?

Contaminants can be present in the compressed air from three sources

- Atmosphere
- Compressor
- Distribution system

Taking the atmosphere first, in a typical metropolitan environment there are something like 140 X 10 dirt particles per cubic meter. Approx. 80% of them are less than 2 microns and are not removed by the compressor intake filter. In addition to this there are hydrocarbon vapours (from unburnt fuels and industrial processes) and water vapour. All these are drawn into the compressor and their concentration increased by compression process. Inside the compressor, wear particles and lubricating oil are added to the air. Also, degraded and oxidized oil from an oil injected compressor travels in the distribution system.



What are different kinds of Contaminants?

Different contaminants can also be classified as under:

Water Vapour, Condensed Water and Water Aerosols

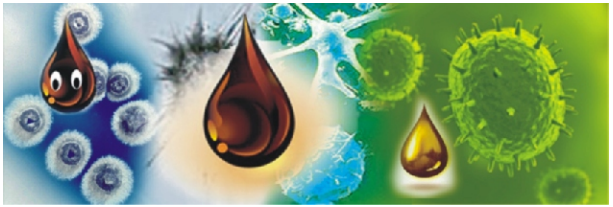
Atmospheric air contains water vapour (water in a gaseous form). The higher the temperature, the more water vapour that can be held by the air. During compression, the air temperature is increased significantly, which allows it to easily retain the incoming moisture.

Liquid Oil and Oil Aerosols

Most air compressors use oil in the compression stage for sealing, lubrication and cooling. During operation, lubricating oil is carried over into the compressed air system as liquid oil and aerosols.

Rust and Pipescale

Rust and pipescale can be found in air receivers and the piping systems. Over time, this breaks away to cause damage or blockage in production equipment. Moreover, this can also contaminate final product and processes.



What is quality air and why is it important?

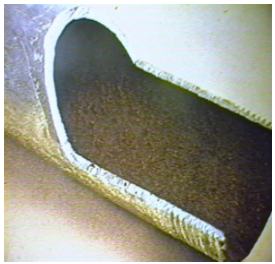
Quality air is obtained by cleaning and drying compressed air to levels in accordance with some standards. The difference between high quality and low quality air are the levels of moisture and contaminants.

Clean and dry compressed air is important to power up your busy production environment. Untreated compressed air, containing moisture, aerosols and dirt particles, poses a substantial risk as it can damage your air system and end products.

Infact, your operations depend on three crucial elements – your compressed air system, production process and end product. While good quality air is an essential ingredient for the success of your plant, untreated air may cause extensive damage and lead to serious performance deterioration to your operations and end products.

When air is compressed, the concentration of dust particles, oil carryover and moisture increases. This creates an abrasive mixture that when left as such may bring about severe instrument failures and even

contaminate your end product costing a manufacturer in terms of both money and reputation. It is important to use efficient filters and dryers to efficiently reduce all types of contamination.



By improving air quality, lowering energy consumption, and minimizing maintenance, air dryers from leading providers can reduce the total cost of ownership and improve a manufacturer's bottom line through improved production efficiencies. They also last longer than lower priced models, reducing downtime and maintenance costs while contributing to increased output.

What quality of air does your application need?

The quality of the compressed air produced by a system can be used for a range of applications from plant air to high quality breathing air. Different applications require different levels of air quality. The higher the quality of air required, higher is the need to design the system properly. Improper compressed air system design not only increases initial capital investment but also makes the overall system more expensive to operate in terms of energy consumption and maintenance costs. It is, therefore, important when designing the system to assess the level of air quality required.

For e.g.. Paint spraying that requires the removal of water from the air to eliminate blemishes in the painted surface or while folding, taping or gluing cardboard boxes water could affect adhesives and/or damage the boxes. Similarly semiconductor processes that populate circuit boards would be compromised if moisture reaches component contacts. Similar is the case in chemical, pharmaceutical or food industry.

Broadly, Quality Air is classified under four types as below:

Types of Air Quality

Breathing Air	Hospital air systems, refill diving tanks, Respirators for cleaning and/or grit blasting
Instrument Air	To operate control instruments & electronics
Process Air	Food and pharmaceutical Process air, Laboratories, Paint spraying, Powder Coating, Climate control
Plant Air	Air tools, General plant Air, Cleaning

For ease of understanding quality air can also be classified as below:

1. Dry compressed air and gases are required in each stage of separation process. They prevent corrosion, wear and other defects and are used in particular in compressors, sub coolers, compressed air lines etc.
2. Particle free – compressed air gases and fluids that is particle free are used in chemical industry, plastic industry, air conditioning technology and general machine construction.
3. Oil free – Oil free air and gases are indispensable in the following areas – dairies, breweries, packaging industry, electronics industry.
4. Odour and aroma free – odour and aroma free compressed air and gases are needed in the following sector – food industry, aromatic industry, cosmetic industry, filing cylinders for diving.
5. Vapour free – Compressed air and gases which are dry, i.e. free of oil vapour are required in following areas – filter processing, warehouse ventilation, textile machines, food technology.
6. Sterile – Sterile compressed air, gases and fluids are used in the pharmaceutical industry, bio technology, gene technology, hospitals, and beverage industry.

Mostly, refrigeration dryers are selected with a thumb rule of PDP (Pressure Dew Point) of 3°C and desiccant dryers with a PDP of -20°C. whereas dryers need to be selected based on the application and the ambient temperatures. For most Indian ambient conditions and applications a pressure dew point of 5-7°C is sufficient to design the compressed air system.

What are quality air standards?

Internationally, guidelines are available that allow the quality of air to be specified, such as ISO Standard 8573.ISO 8573.1: 2001 is the primary document used from the ISO 8573 series as it is this document which specifies the amount of contamination allowed in each cubic metre of compressed air. ISO 8573.1: 2001 lists the main contaminants as solid particulate, water and oil.

How do I read the chart given below?

If your application needs air purity as per class 1.2.1. This means following air quality is required for your application.

Class 1 Particulate

- No more than 100 particles in the 0.1 - 0.5 micron size range allowed in each cubic metre of compressed air.
- No more than 1 particle in the 0.5 - 1 micron size range allowed in each cubic metre of compressed air.
- No particles in the 1 - 5 micron size range allowed in each cubic metre of compressed air.

Purity Class	Solid Particulate					Water		Oil
	Maximum number of particles per m^3			Particle Size	Concentration	Vapour	Liquid	Total oil (aerosol, Liquid and vapour)
	0.1-0.5micron	0.5-1micron	1-5micron	micron	mg/m^3	Pressure Dewpoint	g/m^3	mg/m^3
0	As specified by the equipment user or supplier					As specified by the equipment user or supplier		As specified by the equipment user or supplier
1	100	1	0	-	-	-70°C	-	0.01
2	100,000	1,000	10	-	-	-40°C	-	0.1
3	-	10,000	500	-	-	-20°C	-	1
4	-	-	1,000	-	-	+3°C	-	5
5	-	-	20,000	-	-	+7°C	-	-
6	-	-	-	5	5	+10°C	-	-
7	-	-	-	40	10	-	0.5	-
8	-	-	-	-	-	-	5	-
9	-	-	-	-	-	-	10	-

Class 2 Water

- No liquid water allowed. Pressure dewpoint of -40°C or better.

Class 1 Oil

- Not more than 0.01mg of oil allowed in each cubic metre of compressed air. This is a combined level for both oil aerosol and oil vapour.

ISO 8573 is the group of international standards relating to the quality of compressed air and consists of nine separate parts. Part 1 specifies the quality requirements of the compressed air and parts 2 – 9 specify the methods of testing for a range of contaminants. On-site testing is often difficult due to the complexity of the test method and the expense of test equipment required and for this reason, all air treatment products from leading manufacturers are already tested in accordance with the relevant international standards and this must be verified by end users

What are air treatment equipment? What all equipment do I need?

A compressed air treatment system consists of several treatment equipment which work together to achieve optimum purity levels. These are the air compressor, water separators, drain traps, dryers, filters and condensate management systems.

Compressed Air treatment is done by equipment primarily in three different steps

- Drying
- Filtration
- Condensate management

To decide the equipment that you shall need to follow following simple steps:

- Determine the quality class of air you need for your application.
- Determine as to which type of dryers, filters or condensate management device you would need to achieve that class of air
- Size the components as per the inlet flow and pressure of your application and your desired air quality.

ISO committee has a few leading manufacturers hence they design filtration and drying solutions to provide compressed air purity that meets or exceeds the levels shown in quality air standards and according to your requirements.

Generally air treatment equipments are recommended as per the following tables.

Type of air	Examples	Recommended equipment (with oil injected compressor)
Dry & Pure Air	General use, blow guns, simple robotics, air gauging, fine pneumatic tools, Good factory air, air gauging, conveying, shot blasting, fluidics	Dryer, Prefilter and Afterfilter
Dry, Pure and Odor free Air	Blow moulding, Air bearings, fluidic sensors, paint spraying, critical control air, instrumentation, cosmetics, food packaging, dairy production	Dryer, Prefilter, Afterfilter, and activated carbon filter
Dry, Pure and Sterile Air	Process contact air, pharmaceutical, food/beverage, dairy, hospitals	Dryer, Prefilter, Afterfilter, and activated carbon filter and sterile filter

Type of air	Recommended equipments
Plant Air	Dryer, Prefilter and Afterfilter
Instrument Air	Dryer, Prefilter, Afterfilter, and activated carbon filter

Type of air	Recommended equipments
Process Air	Dryer, Prefilter, Afterfilter, and activated carbon filter and sterile filter
Breathing Air	Recommended use of Oil Free compressor

What is an Aftercooler and why is it important?

Aftercoolers are heat exchangers that help reduce compressed air temperatures to levels acceptable for further air treatment.

The aftercooler today may be a permanent component of the compressor, however, as is outlet temperature approximates to the inlet temperature of the air treatment equipments, its function must be taken into account when selecting the air treatment equipments.

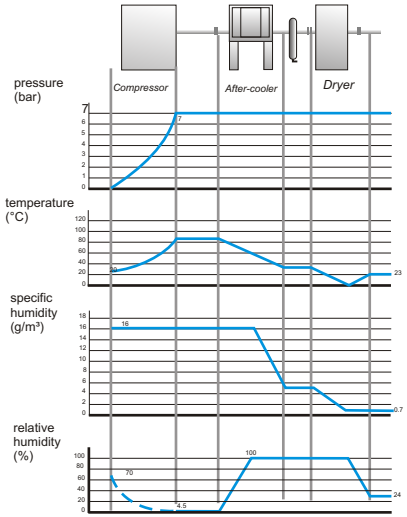
An aftercooler operates with either air or water cooling. Air cooled aftercoolers provide economical cooling by using ambient air to cool the hot compressed air from an air compressor. Discharge air from an air compressor is generally 80˚C to 180˚C, depending on the type of compressor.

As the compressed air cools, about 80% of the water vapor present condenses into liquid water which should be immediately removed from the system with a separator. Air-Cooled afteroolers can be sized to cool the hot compressed air just above ambient air temperature. Sometimes, aftercoolers can be installed so normal wasted heat can be reclaimed and recirculated.

On water cooled aftercoolers a temperature difference around 10ºC can be expected. The achievable outlet temperature in this case depends on the temperature of the water, which can differentiate considerably.

If the aftercooler is not a part of your compressor it needs to be designed by an expert else either the desired cooling is not achieved or the aftercooler becomes too big. The compressor expert can tell you exactly what design temperature is achieved at the outlet of the compressor and taking into account this inlet temperature, desired outlet temperature is the aftercooler designed.

Change of parameters across different equipment:



What are Dryers?

The moisture in the compressed air has to be removed. This can be achieved by passing the compressed air through the air dryers.

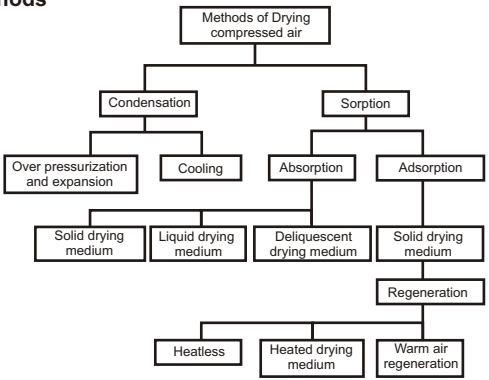
Air Dryers remove moisture through following different ways:

1. Over-compression: Over-compression is perhaps the easiest method to dry compressed air. Air is first compressed to a higher pressure than the intended working pressure, which means the concentration of water vapour increases. Thereafter the air is cooled, whereby the water is separated. Finally the air is allowed to expand to the working pressure, whereby a lower PDP is attained.

2. Absorption: Absorption drying is a chemical process, where water vapour is bound to the absorption material. The absorption material can be either a solid or liquid.

3. Adsorption: Adsorption drying is a physical process in which compressed air is passed through a bed of desiccant material where the moisture adheres to the surface and hence gets separated.

Drying Methods



What are frequently used terminologies in Dryers?

Atmospheric air

This is the air we breathe which contains nitrogen, oxygen, carbon dioxide, water vapour, other gases, and miscellaneous contaminants such as dust, pollen and smoke.

Dry air

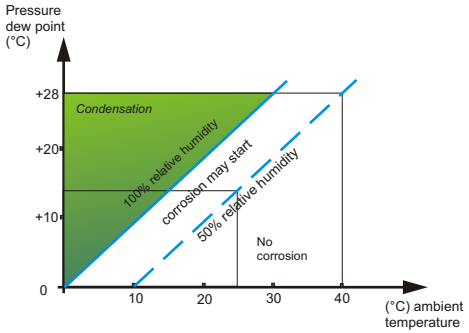
Dry air exists when all of the contaminants and water vapour have been removed from atmospheric air. By volume, dry air contains about 78% nitrogen, 21% oxygen and 1% other gases. Dry air is used as the reference in psychrometrics.

Moist air

Moist air is a mixture of dry air and water vapour. Due to the variability of atmospheric air, the terms dry air and moist air are used in psychrometrics. For practical purposes, moist air and atmospheric air can be considered equal under the range of conditions normally encountered.

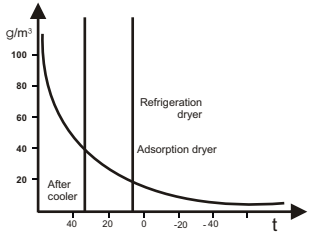
Air Temperature

Air temperature is a measure of the heat content of air.

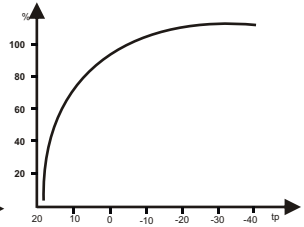


Dew point

If the air is gradually cooled while maintaining the moisture content constant, the relative humidity will rise until it reaches 100%. This temperature, at which the moisture content in the air will saturate the air, is called the dew point. If the air is cooled further some of the moisture will condense.



1. Drying ranges of the different systems



2. Reduction of water content (compared with +20°C) independent of the pressure dew point (at 7 bar)

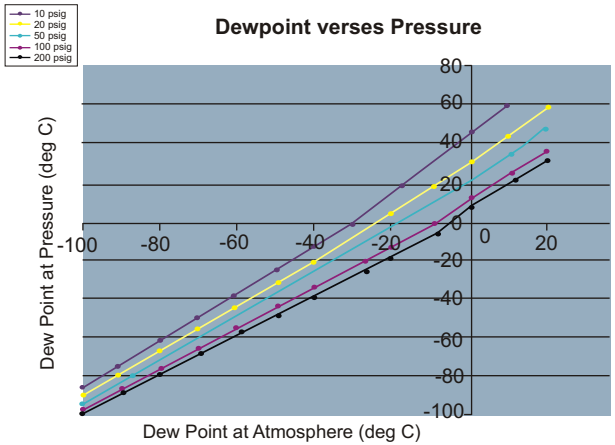
Relative Humidity

As the name implies, relative humidity is a measure of how much moisture is present compared to how much moisture the air could hold at that temperature. Relative humidity, which is expressed as a percent, is given in weather reports.

Psychrometic Chart

The psychrometic chart is a versatile chart that graphically represents interrelation of air temperature & moisture content.

Dew point for pressurized air is called PDP which is related to Atmospheric Dew Point as shown in graph



What are different types of dryers available?

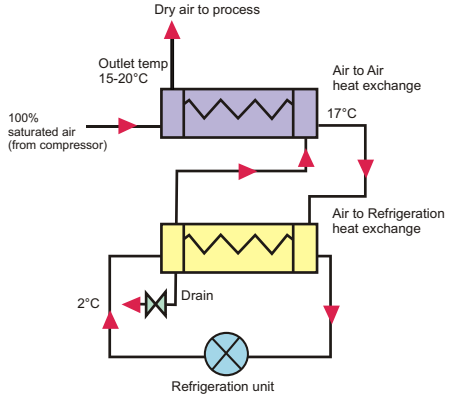
Refrigeration dryers:

Refrigeration drying is based on the principle that when the temperature of the compressed air is lowered, the moisture holding capacity is reduced. By lowering the temperature the water vapour in the compressed air is condensed and removed.

Basic Working Principle:

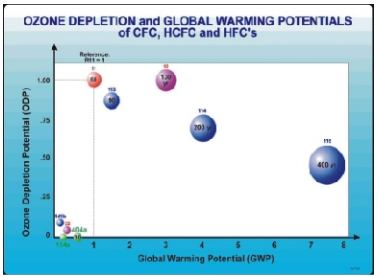
It is a simple mechanical refrigeration system, wherein the dew point is reduced by chilling. Additionally there is a second heat exchanger, where in the outgoing cool air pre cools the incoming compressed air. The lowest achievable pressure dew point in this kind of refrigeration system is +2°C . Normally PDP is +2°Cto +10°C.

The schematic diagram of the refrigeration type air dryer is shown in the fig.



Refrigeration type dryer

Few manufacturers offer refrigerant dryers with Variable speed drive which saves power.



Refrigeration dryers should be selected with environment friendly refrigerants like R134a and R404a because they have extremely low Ozone Depletion potential

Adsorption Dryers

In adsorption drying compressed air is passed through a bed of desiccant material where the moisture adheres to the surface. These desiccants have a very large internal surface. These desiccants once saturated with moisture can be regenerated and reused. These adsorption dryers can be classified into the following:

a. Desiccant heated, blower reactivated type

b. Desiccant heat less purge type

c. Desiccant Heat of compression type.

The operating principle of the above mentioned dryer is explained in detail below.

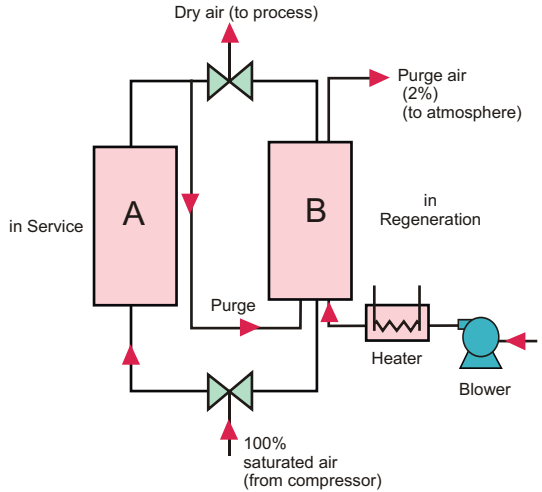
a. Desiccant heated blower reactivated type

This dryer consists of two pressure vessels filled with desiccants, which has the property to adsorb water. While one vessel is in service, the other vessel will be in regeneration mode. Regeneration involves heating and cooling of the desiccant, before put into use.

A blower and external heater is used to achieve the regenerating temperature.

The operating cost is higher because of the heater (electrical or steam) and also because there is a purge loss of about 1-2% of compressed air. The

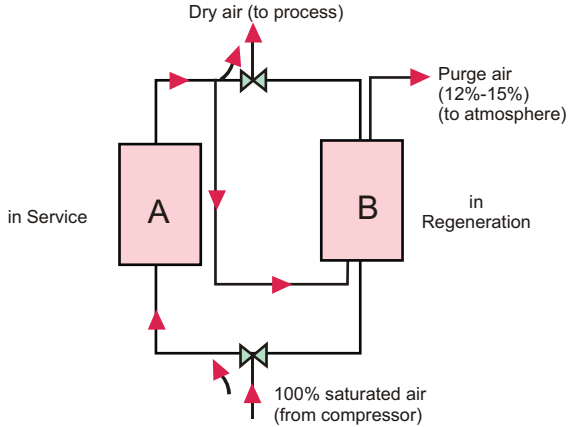
vessel, which is regenerated, is purged with dry air before it is taken into service. These dryers are normally used for capacities higher than 250cfm.The schematic of the dryer is shown.



Desiccant heated blower reactivated type dryer

If dew point is not critical refrigeration dryers should be considered because of low power consumption

Desiccant heat less purge type



Desiccant heatless purge type dryer

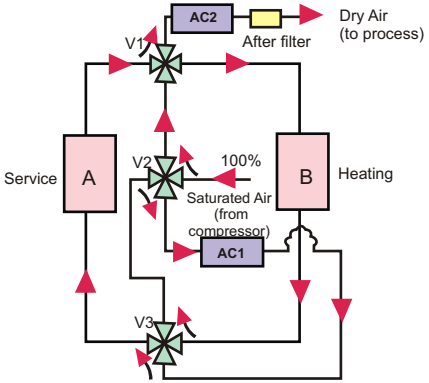
The operation is very similar to the blower-reactivated type, only difference being that no heating of the desiccant is done. Pure dry air is used for purging through the saturated desiccant. The operating cost is very high due to purge losses of about 10-12%. The schematic of the dryer is shown above. Intial cost of these dryers is generally low compared to the other dryers.

Desiccant Heat of Compression (HOC) type dryer

This is a break through in drying technology where the operating cost is zero or very minimal. HOC dryers are suitable from 400 cfm to 15000 cfm capacities. The discharge compressed air, which is at a temperature above 135°C (in the case of reciprocating compressor) is used to regenerate the desiccant. Generally, there are no electrical heaters and no purging loss. This makes the dryer very attractive in terms of operating cost. The desiccant can be Activated Alumina or Silica gel depending on the dew point required.

The dryer consists of two vessels - `A' and `B'. Vessel `A' will be in service for 4 hours. Meanwhile vessel `B' is reactivated which involves heating for 2 ½ hrs and cooling for 1 ½ hrs. After this, vessel `B' is taken into service and vessel `A' is reactivated. The regeneration cycle consisting of heating and cooling cycle as explained in the diagram:

Vessel `A' in service, vessel `B' in heating: Air from compressor enters 4-way valves V2 and V1 and directly to vessel `B' so as to start the heating process. From vessel `B' the air through valve V3 and V2 enters after cooler AC1, where it loses some of the moisture. Through V3 again air enters vessel `A' where moisture is adsorbed by the desiccant and finally leaves through V1 to an aftercooler AC2 where it is cooled to about 35 to 40°C.



Vessel 'A' in service and vessel 'B' in Heating mode

Drum Type Dryers:

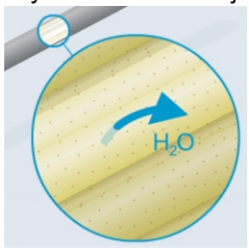
There are adsorption dryers for oil free screw compressors that use the heat from the compressor to regenerate the desiccant. These types of dryers are generally fitted with a rotating drum with desiccant of which one sector (a quarter) is regenerated by means of a partial flow of hot compressed air (160–200°C) from the compressor stage. Regenerated air is then cooled, the condensation drained and the air returned via the

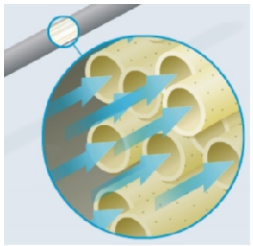
ejector to the main air flow. The rest of the drying drum's surface (three-quarters) is used to dry the compressed air from the compressor's aftercooler. The system gives no compressed air losses. The power requirement for such a dryer is limited to that required for powering the drum. For example, a dryer with a capacity of 1000 l/s only requires 120 W. In addition, no compressed air is lost and neither oil nor particle filters are required.

Membrane Dryers:

Membrane dryer provides the lowest pressure drop and the lowest purge air use providing real energy savings without compromise in production reliability and efficiency.

These dryers contain thousands of hollow fibers with a pioneering inner coating. As wet compressed air enters, the membrane coating allows water vapour to permeate and collect between the fibers, while the dry air continues its journey.





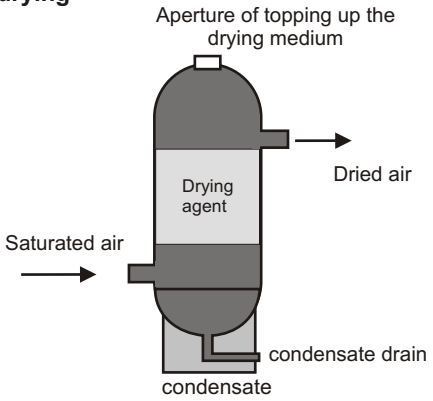
Membrane dryers are available upto 60 cfm.

Membrane dryers can perform in a wide variety of harsh and critical conditions

- In small spaces
- In areas where flexible mounting is required
- In high vibration areas
- In widely fluctuating temperatures

How do we select desiccants?

Adsorption drying



Desiccant Selection

Adsorption property is exhibited by some forms of silica, alumina (including bauxite), carbon and certain silicates (molecular sieves). Silica and alumina are used primarily to remove moisture while carbon is used for organic vapours. Molecular sieves can give very low atmospheric dew points, as low as -80° C while activated alumina gives about -40°C. While using desiccants, it should be noted that attrition (grinding) occurs due to air pressure surges. This desiccant powder is carried away by air because of which afterfilters needs to be installed before the dry air is taken for use. Molecular sieves have the capacity of adsorbing small molecules of water. Extremely low dew points can be achieved by passing an air stream over molecular sieves. Normally, air is passed through a standard desiccant before it is passed through molecular sieves.

Dryer manufacturers select their own desiccants as they have expertise in the same. A good quality desiccant should ideally give 4-5 year of life

Desiccant Life

Adsorbing capacity of desiccant materials decreases with age. Contaminants like oil or dust particles will add to this effect. Heat is also one of the factors, which contributes to desiccant ageing. Many manufacturers recommend a desiccant life of three to five years, based on the operating conditions. The condition of the desiccant should be checked periodically. Any effort to monitor the desiccant condition will give significant benefits in the form of high quality air, reduced frequency of desiccant change and reduced maintenance cost.

How do I select the right dryer for my application?

To select dryers for specific application following questions must be answered

- What quality of air (according to ISO 8573) does my application need?
- What is the ambient temperature of the place where I want my dryer installed?
- Which compressor do I have and technical details of the same?

Usually thumb rules apply:

1. If the pipe work is laid indoors a refrigeration dryer is generally sufficient for a PDP of 3-10°C. Around 80% of all dryers are refrigeration. But for special applications with negative PDP, desiccant dryers are a must.

2. Almost without exception, desiccant adsorption dryers are used where pressure dew points below 0ºC are required.
3. Few critical applications require pressure dew point around -40ºC. Leading manufacturers have dryers delivering -40 °C PDP for certain critical applications.

Compressor technical parameters like outlet temperature, pressure, flow affects dryer selection hence compressor manufacturers should be consulted for selection of dryers.

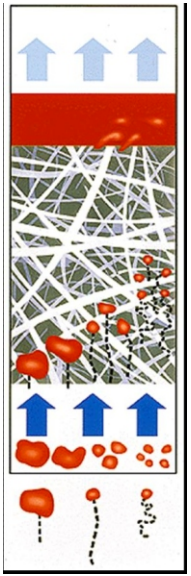
For desiccant dryers sometimes we might have to oversize compressor to ensure optimal flow and pressure requirement post dryer as there shall be purge losses within the dryer

What are Compressed Air filters?

Compressed air filters are simple devices that are used to remove water, oil, oil vapour, dirt, and other contaminants from a compressed air supply.

Filter size rating, maximum air volume, maximum inlet pressure, and operating temperature are the most important performance specifications for compressed air filters.

How is Filtration achieved?



Filtration is achieved in the following three steps:

Inertial impaction

Particles traveling in a fluid have a mass and velocity. The fluid will follow the path of least resistance. Some particles will impact onto the filter medium and be caught due to their inertia driving them into the filter. This is not a primary mechanism for particle retention. It is more common in gas streams.

Diffusional interception

Extremely small particles will bounce around randomly in a gas stream as they strike liquid or gas molecules. This motion is called Brownian Motion and is more pronounced in gases. The random path of the particle increases the chance it will strike the compressed air filter and be captured.

Direct Interception

If the particle is larger than the pore of the filter, it is retained. For example, the screen on your screen door is mesh. It allows air to pass but keeps insects

and anything larger than the mesh out. Compressed air filters work in the same way; however, the flow path is not necessarily straight. The pores can be infinitely smaller, and there can be layer after layer of media for the liquid/gas to pass through. Direct interception is the most common form of retention in both gas and liquid service. Most filters maximize their direct interception with torturous flow paths, which increase the filter's retention capability.

What are the different types of Air Filters?

Following filters are used within the compressor canopy for removal of contaminants:

Compressor Intake Filter

The first line of defense is the intake air filter, which reduces the bulk contaminant load protecting the compressor from dirt and solids. Generally, these are cartridge type filters with a greater than 98% air efficiency rating at 10µm. There has been a recent move to 3µm filtration. Over 80% of the contaminants challenging an intake filter are less than 2 µm and therefore the majority of these contaminants enter the compressed air system with the intake air. Other compressed air filters are available to remove particulate contaminants down to 0.3 µm and to remove chemical contaminants.

Compressor Air/Oil Separator

Oil injected rotary screw compressors have an air/oil separator. Generally, these separators are 3µm cartridge style compressed air filters. The air/oil separator allows compressed air to continue downstream and recycles the compressor lubricant to the compressor's oil sump. Some compressor lubricant does continue downstream; however, improvements in compressor design and air/oil separation has minimized lubricant carryover on newer models.

Following filters are used outside the compressor canopy for removal of contaminants:

Coarse Coalescer Filter

A coarse coalescing filter separates large water and oil droplets from the compressed air stream before the coalescing filter. The coarse coalescer also removes large solids. Typically, the coarse coalescer is a 3µm coalescer. By using staged filtration you protect the more expensive coalescer filter, making it last longer online. The idea is to change the less expensive coarse coalescing filter more often to

reduce overall filtration cost. A coarse coalescer filter is optional equipment. Not all air systems utilize it.

Coalescing Filter

A high efficiency coalescer filter removes water and oil aerosols and solid particles to a specified level. Many compressed air coalescers are rated at a liquid removal efficiency of 0.001 ppm by weight and by liquid aerosols down to 0.01µm. A coalescer stops particulate contamination through direct interception. Its main function is to remove water and oil aerosols by coalescing the aerosols into droplets. This happens partially because of torturous path and membrane characteristics and partially due to pressure drop. Coalescers remove both water and oil aerosols from the air stream.

It is important to realize that a coalescer is excellent at removing aerosols and liquids but not vapours. Vapours are organics like hydrocarbons and odors. A vapour filter removes vapours with an adsorbent.

Particulate Filter

Located downstream of a desiccant dryer, a particulate compressed air filter typically 1 to 3µm stops desiccant fines from migrating downstream in the air system. The particulate filter protects piping and pneumatic equipment from particulate damage by removing rust, pipe scale, metal oxides, and desiccant particles.

High Temperature Particulate Filter

Temperature spikes are common downstream of a heated desiccant dryer. Spikes happen when a regenerated tower comes back online. The heat generated during regeneration is picked up by the compressed air. Often these heat spikes are considerably higher than the maximum operating temperature of a particulate compressed air filter and housing. The particulate filter can catch fire and damage your air system and pneumatic devices.

A high temperature particulate filter protects against this risk of fire. A particulate compressed air filter operates at 38°C and has a maximum temperature of 66°C. A high temperature particulate filter can operate daily at 177°C and has a maximum operating temperature of 232°C. The level of protection with a high temperature particulate filter and housing is significant.

Vapour Filter (Charcoal Filter)

A vapour filter removes organics from the air stream. Organics, like tastes and odours need to be removed from breathing air systems. In general, industrial

applications of vapour compressed air filters remove hydrocarbons and other organic chemical vapours from the air system. Depending on the airflow, vapour filters need to be replaced every few months because the effectiveness of the activated carbon degrades as it adsorbs.

Final Filter (Activated Carbon Filter)

Pharmaceutical and microelectronics are examples of industries that require ultra-clean, compressed air. To protect these critical processes from contamination, activated carbon filters are used. The filter is located as close to the pneumatic application as practical to minimize pipe scale and the possibility of contamination occurring downstream of the final compressed air filter.

How should a filter be installed and maintained?

- Compressed air filters should be installed in a level pipeline, mounted vertically, the bowl downward with one element length clearance for element removal.
- The filter should be installed at the highest pressure point available, before any pressure reducing valve and as close to the equipment being protected.
- Pressure drop is used to determine when to change a filter. Contaminants, pressure, temperature and other variables affect the service-life of a filter.
- Generally in a compressed air system, in a year, a filter should be changed.
- It is critical to drain the filter housing daily to release condensate that gathers in the bottom of the filter bowl. Automatic drain valves simplify this process and protect your system from water re-entrainment.

It is important to note that if cartridge is not changed in downstream filters it results in power wastage due to pressure drop in the system. This cost can be sometimes equal to the cost of a new filter

How are filters selected?

• Inlet Flow and Inlet/Outlet Piping

The compressed air filter has to be rated for the inlet flow. Inlet flow is generally measured in scfm. Locate the filter at the highest pressure point available that offers an acceptable temperature. Match the inlet and outlet pipe size of the filter assembly to avoid generating excessive pressure drop across the

compressed air filter.

• Temperature

Filters have a maximum operating temperature. General use compressed air filters are designed for use at 100°F (38°C). It is a best practice to locate compressed air filters where the temperature is the lowest possible. There are filters designed to operate at high temperatures. For example, high temperature particulate filters. High temperature operation increases the rate of corrosion and can reduce the life of compressed air filters and other system components.

• Pressure Drop

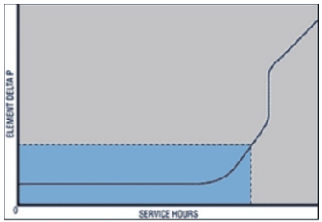


Figure F1-2, Typical Filter Service-Life

The filter housing and filter itself create some resistance to the flow of the compressed air. There is a pressure drop between the upstream and downstream sides of a filter. This is called Delta P. When you size a new compressed air filter and housing, you want a Delta P that is as low as possible. This is because the life of your filter is related to its Delta P. For 80% of typical filters service-life pressure drop will stay approximately the same. Over the last 20% of the filter's service-life the delta P rises. There is a point of diminishing returns. The filter plugs to the point where air pressure loss is too great. If a compressed air filter is not changed pressure will continue to build until a terminal Delta P is reached and the filter collapses. Delta P monitors are standard on most compressed air filters. Delta P monitors allow you to watch the filter's pressure. Some have alarms when change-out Delta P is reached.

• Filter Pressure Drop Microprocessor Controls

Manufacturers have started to incorporate microprocessor controls into compressed air filter design. Traditional gauges indicate when to change a filter by a pressure or by a color indicator. Microprocessor controls monitor the filter's condition considering the hours of operation, cost of compressed air, cost of the filter, and filter pressure to determine the most cost effective point to change the filter. Microprocessor controls reduce compressed air utility's costs by reducing how long a compressed air filter stays online creating excessive pressure drop.

Several types of microprocessor filter controls are available. Some models calculate the most economical time to change a filter based on the cost of compressed air versus the cost of the filter element. Other microprocessor control features

include:

• Time monitoring

• Pressure differential monitoring

• Filter performance monitoring

In addition, remote monitoring capabilities are available. These units use the latest, state-of-the-art technology to provide quality air with substantial cost savings.

Generally compressor manufacturers know the technical details for the design of the downline filters. Inlet pressure (arrived through correction factors), right filtration medium, maximum temperatures attained in the system hence they should be contacted for these details before the selection of filters.

What is an air receiver?

A compressor plant is normally provided with one or more air receivers. The size of the air receivers are selected to suit the compressor capacity, the control system, the compressed air pressure and the anticipated variations in the air consumption. The air receiver serves to:

- act as a buffer for pressure variations which would otherwise occur in the pipe network

- provide additional cooling and collect possible residual condensate

- store compressed air

How do you select the right size of receiver for your compressed air system ?

When determining the size of the receiver, consideration should be given to:

• Compressor capacity

• Pressure

• Control system,

• Volume of the entire pipe work downstream of the receiver,

• Number of points of air consumption.

The control cycle of the compressor should not be too short, since it will then cause unnecessary wear of the components of the compressor and the electrical equipment, and will give rise to unnecessarily heavy variations in the load on the electric power supply.

Following Thumb rules generally apply:

Airflow Capacity		Recommended Receiver Volume		
(cfm)	(m3/h)	(cu ft)	(gal)	(m3)
100	170	13	100	0.4
200	340	27	200	0.8
300	510	40	300	1.1
400	680	54	400	1.5
500	850	67	500	1.9
750	1275	101	750	2.9
1000	1700	134	1000	3.8
1500	2550	201	1500	5.7
2000	3400	268	2000	7.6
3000	5100	402	3000	11.4
4000	6800	536	4000	15.2
5000	8500	670	5000	19.0
7500	12750	1005	7500	28.5
10000	17000	1340	10000	38.0

Automatic starting and stopping of the driving motor by means of a pressure switch is usual on small compressors with capacities below 20 l/s, and a large receiver volume is then necessary. An inadequate capacity of the receiver will cause an excessively high frequency of starting on this type of operation. This may cause damage to the motor starter contacts and the motor windings.

How do you install an Air Receiver?

The air receiver should be located outdoors, and in the shade, if possible. Sufficient space should be provided for inspection. The receiver should be mounted on a suitable concrete foundation, or on some other flat surface in a temporary installation.

Generally vertical air receivers are available which save space. However small sizes of compressors are available mounted on the receiver tank itself.

What are different standards followed in Air Receiver Design?

All receivers must be designed in accordance with the requirements of local requirements of local authorities (the appropriate pressure vessel code)

Special requirements may sometimes have to be met, e.g. conformance with the requirements of Lloyd's Register of Shipping. The inlet and outlet openings of the air receiver are sometimes provided with pipes which project into the receiver, in order to prevent condensate from entering the openings. The air receiver is usually installed vertically. Receivers are often designed with the inlet opening at the bottom, and this arrangement allows the warm compressed air entering the receiver to melt any ice formed in sub – zero weather.

Safety regulations for pressure vessels

In most countries, all integral parts of a compressed air system are defined as pressure vessels, and this is taken to mean any boiler, receiver, pipe or any other comparable device for steam, gas or liquid at a pressure higher than atmospheric.

The materials, design, construction, manufacture, inspection, testing and certification for the manufacture of pressure vessels are governed by regulations issued by special authorities in the relevant country.

In India ASME code and IS code for construction exist for Air receivers, which specify the thickness of the receiver. Reputed manufacturers stick to this code which avoids hazards. It is also important to know the source of the material, some manufacturers buy old material from ship building units to cut cost which can be prone to wear and tear or explosion.

What is condensate management?

Condensate is a by-product of all compressors. This oil/water mixture also contains particulates and hydrocarbons, and is concentrated during the compression process. Federal and local regulations prohibit discharging this contaminated water into surface drains and municipal water systems. Special handling and disposing of condensate is therefore essential and needs to be addressed.

Condensation formation takes place at after coolers, air receivers, filters, pipe lines, drop legs etc. The effective removal of condensate will reduce the moisture load on the air dryers and ensure the quality of air at the user ends.

Removal of condensate is done by condensate drain. There are two types of condensate drains:

- Manual
- Automatic

In an automatic drain trap there is no need for manual intervention. The automatic drain valves can be classified as follows:

a. Electronic timer controlled drain trap

b. Condensate level sensing drain trap

a. Electronic timer controlled drain trap

This drain trap is controlled by an electronic timer. The opening of drain valve is based on the preset timings. The cycle time of the drain valve opening is adjustable. The cycle time can be set based on the condensate formation rate.

b. Condensate level sensing drain traps:

In condensate sensing drain trap the operation is based on the level of condensate collected. The condensate is collected in the drain trap container.

They are usually of two types:

1. Mechanical Float type: This has a mechanical float to sense the level of condensate. Once level is reached, a mechanical valve opens to discharge the condensate.

2. Electronic Controlled Drain with Sensor: There is a probe kept inside that senses the level of condensate. Once the level of condensate reaches the set value, the controller activates the solenoid valve and discharges the condensate. As the level of condensate drops, the probe again senses the lower level and the solenoid valve is shutoff. This discharges only the condensate and eliminates passing of compressed air through the valves. The condensate sensing drain valves are more energy efficient since there is no compressed air loss.

Another important aspect of condensate management is to remove oil from the water. Oil/water separators process condensate to a residual oil content as low as 5 ppm, allowing the processed water to be discharged into most municipal waste water treatment systems.

Electronic control drains are expensive compared to Timer Controlled but they have a short payback period. Also, they are more sturdy and long lasting

What is Air Distribution?

Compressed air layout should be selected, to minimize the length of piping between the air compressor and the farthest user of compressed air user.

In systems with a large distribution network, it is preferable to have compressor centrally located, to minimise the length of piping between the compressor and the farthest end in the plant.

The following points should be considered while locating the compressors.

- Low humidity to reduce water entrainment
- Adequate ventilation especially for air cooled unit.
- Minimum suction piping
- Minimum of bends

Suction pipe work

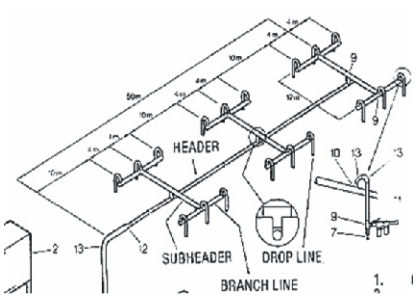
The suction pipe work plays an important role in terms of improving the operation and performance of the compressor. The following points should be considered while designing the suction pipe work for

air compressor installations.

- The piping should be kept short to avoid excessive condensation and pressure loss.
- A high efficiency filter should be fitted to collect particulate matter. Generally filters with dry disposable elements are suitable.
- Sufficient access should be provided for inspection and cleaning of filters. The intake silencer fitted with filter should be located upstream of the silencer to minimize the effect of pulsation.
- The piping should be large enough to avoid excessive energy losses.

For every25 m bar pressure lost at the inlet, the compressor efficiency is reduced by approximately 2%.

Discharge pipe work



The following points have to be considered while designing the discharge pipe work for the compressor.

- Discharge piping should be full bore, i.e. the size of the compressor outlet. Pipework should fall in direction of flow towards the air receiver and after cooler.
- The air receiver should be located close to the air compressor and the pipe work should be as short as possible.
- Safety valve should be fitted for positive displacement compressors normally; it is set to release when the line pressure exceeds the operating pressure by 5-10%.

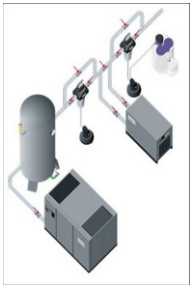
How can quality of air be maintained through effective distribution?

The following points should be considered for the distribution pipe work.

- The drainage points should be installed with the aid of equal ‘T’s. Due to sudden change in direction of flow these fittings assist the separation of water drops from the air.
- The pipe work should fall in the direction of flow. The gradient can be kept at approximately 1 in 100.

- Distribution branch connections should be taken from the top of the main to reduce water entrainment in the air.
- Drain traps should be provided at all low points
- The drain traps should be protected from the ingress of foreign matter by installing a strainer.
- The drain traps in the main line can be installed at every 30-40 m for effective water removal.
- Install pressure gauges in various sections of the entire distribution system for monitoring the pressure in different sections of the network
- The number of joints and bends in the distribution network should be minimum possible. Further to minimizing the joints, it should be ensured that joints are welded, instead of flexible or screwed joints wherever possible. This facilitates in minimizing the leakages and pressure drop.

Some leading manufacturers have introduced aluminium piping systems that ensures good and constant quality clean compressed air continuously without being affected by corrosion. Components are removable and interchangeable and allow immediate and easy installation and modification of production facilities at any point. They also reduce energy cost due to least pressure drop.



What is compressed air package?

With today's technology, an efficient, cost-effective compressed air system can be designed to provide years of reliable service if the proper air treatment and control equipment is installed.

Operating and maintenance costs can be significantly lowered by removal of most contaminants (dirt, rust, pipe scale, oil aerosols, liquid water and water vapor, microscopic particles and oil vapor). With a well-designed air system and the use of quality air treatment and control products, you can realize extended service life of components, increased flow capacity with minimum pressure loss and improved production efficiencies in your manufacturing processes.

Some leading manufacturers provide all the components of a compressed air system in the form of a package. It is reliable for customers to deal with such manufacturers as:

- It ensures one point responsibility
- No blame game during crisis
- The system is designed appropriately as they . . Know the various temperature and pressure points

hence avoiding over or under design.

• Service support

All the components in a compressed air system can be bought in isolation but they are interdependent in operation and should be selected by specifying the quality of air required at the end of the package. Compressor is most critical in designing the system to avoid over or under sizing.

What is Compressed Air Audit?

A Compressed air system audit analyzes:

• Compressed air system demand

• Energy consumption and overall operating costs

• Optimization of plant processes

• Reduction of “artificial demand” and leaks

Equipment reviewed during the audit include:

• Compressor package

• Filters

• Aftercooler

• Compressed air dryer

• Automatic drain valves

• Air receivers

How is an audit important for Quality of Air?

Level of Air Treatment – An air treatment level is selected based on the application and system components requirements.

Leaks – Identifies and quantifies leaks in the system and recommends a leak management program.

Controls – Evaluate the control system to see if an upgrade or modification will improve performance based on the system demand profile

Piping System – The layout of the piping system is reviewed. Pressure drop and efficiency are measured and condensate removal is reviewed. Simple changes that can enhance system performance are suggested.

Artificial Demand - A common practice is to increase system pressure to meet compressed air need thus creating artificial demand. 25 to 30% of the horsepower used to generate compressed air is a result of unnecessarily high system pressure. By analyzing the compressed air systems load profile a strategy can often be devised to reduce horsepower

and wasted energy thereby increasing the quality of Air.

What is initial cost and life cycle cost for your compressed air system?

The total cost incurred on the compressed air system through the life of all the components is called the life Cycle cost or total cost of ownership for the compressed air system.

Total cost of Ownership = Initial Purchase Price +

Cost of Energy (Power)+

Cost of Maintenance+

Opportunity cost (Down Time)

Savings in initial investment in the short-term could end up in more expenses in the long term. Initial cost should normally be the least important choice criteria for a compressed air system.

If your enterprise uses procurement procedures which do not take into account reliability, quality and life cycle cost, these procedures are almost certainly wasting money.

Points to remember to maintain quality air in your system

- Review compressed air applications and determine the required level of air quality for each.
- Review the compressed air treatment equipment to determine whether it is operating satisfactorily. If it is not, consider improved maintenance or an upgrade.
- Check condensate traps for effectiveness. If stuck closed, they will not remove condensate, if stuck open, they will leak air.
- Group-end uses having similar air quality requirements in reasonably close proximity and install the appropriate air treatment equipment to serve these end uses with a minimum of distribution piping.
- Maintain a low dew point, but not lower than what is needed.
- Consider a desiccant dryer for only part of the system, if only a small part is exposed to the outdoors.
- Check pipe line and system for leaks to save power

. In case of oil injected compressor installed oil

removing filter before desiccant dryer to enhance performance and life of dryer

A Name you can Count on

Many players have appeared in the compressor industry today. Many compressor or compressor accessory manufactures are selling their products to the customers and making a lot of money.

Atlas Copco is a company that has created a leadership position in the compressor industry by setting standards of Innovation which force customers to look beyond the Horizon. Our core values of developing long term relationships with customer's processes, needs and objectives through continuous interaction and commitment

FX- Refrigerant Dryer

FD- Refrigerant Dryer

CD-Heatless Dryer

SD- Membrane Dryer

DDx-PDx-Oil Removal Filter

EWD- Electronic controlled Drain valve

Air Receiver

help us to innovate and bring new landmark products in the market for the sake of customer's bottom line and peace of mind.

Our purpose in writing this book is to provide the consumer with information that will improve the performance of their compressed air systems, resulting in higher overall operating efficiency and lower energy costs. Ultimately, we aim at increasing net profits through compressed air system optimization for our Customers.

Atlas Copco offers Quality Air Products in a wide range. It is our commitment to offer the right Quality air solution for the right application.

We also offer integrated dryers , where the dryer is integrated inside the compressor skid for space saving.

BD-Blower
Reactivated dryer

CDX- Dessicant dryer

XD-Heat of compression Dryer

MD-Drum Type(HOC Dryer)

OSC-Oil
water separator

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