COMPRESSED AIR DRYER GUIDE

Sauer Compressors USA

What to Consider & Compare

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A Brief Introduction to Compressed Air Dryers

There is an endless supply of information on compressed air dryers if you look online for options. Trying to decipher it all can quickly eat up time and put you in information overload. But it is critical to making the right choice for your application. The type of dryer you chose affects not only your process but operation and maintenance costs. Do not forget your bottom line too.

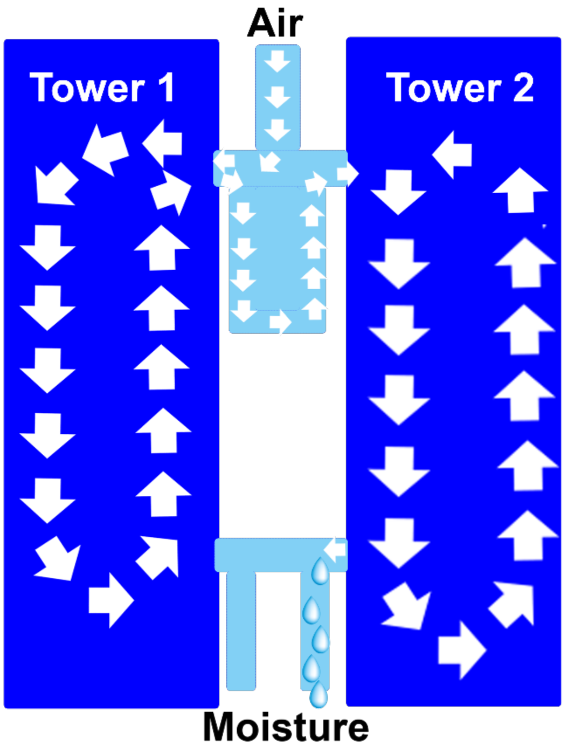
Sauer Compressors USA has developed this Compressed Air Dryers Guide to help you decipher all the information. The document covers key considerations, advantages, disadvantages of refrigerated, desiccant, and membrane compressed air dryers.

Start with the Basics

Let us begin by reviewing a few of the basics to create a background for those unfamiliar and refresh others' minds. Compressed air dryers use air that has been compressed. Compression occurs when the molecules are forced to move faster and closer together into a smaller space. The act increases the temperature in the air.

All compressed air contains naturally occurring moisture from the air used in compression. The hot air from compression can hold this moisture. If the gas cools at any point in the system, the moisture will condense into the air stream. That moisture can be a problem, and even more so if your application needs moisture-free air. Compressed air dryers separate water vapor or moisture from process air by cooling the air, adsorbing the moisture, or permeation.

As compressed air cools, water vapor condenses, steam is collected, and moisture is removed. Moisture removal reduces your odds of having problems like rust, scaling, or freezing in pipes, along with malfunctions, excessive wear, or poor performance by the equipment. You also avoid the slow or inconsistent operation of valves and cylinder control instruments. Removing condensed liquids from the gas will, in turn, remove oil liquids, which are present with oil-lubricated compressor systems, as well.



Essential Areas to Consider

There are several essential areas to consider when comparing compressed air dryers. They include dew point, compressor size, operating pressure, operating costs, etc. Performance is measured by flow rate in Standard Cubic Feet per Minute (SCFM), and dew point expressed as a temperature (Pressure Dew Point), read at operating pressure of the compressor equipment. Use the following for first level comparisons.

1. Know your dew point

Your goal is to keep your dew point temperature lower than your compressed air temperature. It is crucial because you want air dry enough so that no moisture will condense in your air lines.

2. Look at compressor size

Determine the best compressor size by looking at your dryer needs. Using a larger compressor than needed will lead to higher energy costs. You must ensure that the dryer selected is compatible with your compressor flow and operating pressure.

3. Consider your operating pressure

A top reason dryers fail is because they have not been sized correctly for the processes operating pressure. Determine the right size by looking at the flow rate and pressure of the air moving through the dryer. Find the balance between your dryer being able to handle larger CFM amounts without losing performance.

4. Match up the specific application and dryness level

Over specifying to bring all compressed air to its lowest possible dew point is expensive. It can eat into your bottom line and is usually not essential for lowering operating costs. Underspecifying can bring the dew point too high and damage the system, which also is expensive. Find a happy medium.

5. Leverage pressure reduction's drying Effects

Gain the most out of drying effects from pressure reduction by installing filters or filter regulators that will tolerate water vapor in applications using air at lower pressures.

6. Consider all costs

Dryer sizing can be smaller at a higher pressure (gas is moving slower) but rated for higher pressure. This may allow for a smaller footprint and greater pressure capabilities downstream. Dryer power consumption should be limited, controls confirmed, and maintenance regimes detailed.

7. Create the proper environment for success

Dryers typically require being paired with other ancillary equipment to ensure proper operation. Inlet gas and ambient conditions can affect dryer capacities and capabilities.

How well you align compressor size with the compressed air dryer has a direct impact on energy costs and your bottom line.

- *Start-up Costs*
- *Operating Costs*
- *Repair Costs*
- *Parts Costs*
- *Energy Costs*
- *Maintenance Costs*

Comparison by Type – Refrigerated, Desiccant, & Membrane

Next, let us look at the advantages and disadvantages of the main types of compressed air dryers. The following chart covers refrigerated, desiccant, and membrane compressed air dryers. Use the information to compare further which type is best for your application and process. In general, you will find that all three are comparable for initial installation but separate when you start looking at operating costs.

Compressed Air Dryer Comparison by Type

Type of Compressed Air Dryer		
Refrigeration	**Desiccant**	**Membrane**
Best Use: - General manufacturing applications Dew Point Range: Dewpoint suppression range from 35° to 50° F	Best Use: - Applications where outdoor compressed air piping is subject to freezing - Applications that require very dry compressed air Dew Point Range: Dewpoint suppression range of -40°F or less	Best Use: - Applications with explosive or corrosive environments - Applications requiring a consistent dew point Dew Point Range: Dewpoint suppression range is between +40°F and -40°F

Advantages			Disadvantages		
Refrigeration	**Desiccant**	**Membrane**	**Refrigeration**	**Desiccant**	**Membrane**
Low Installation Costs -A standard refrigerant air dryer can be sufficient for most plant applications	Lower Initial Costs & Setup Time -No electrical hook-ups needed. - No moving parts to install. - Simple operation.	Easy Setup & Low Initial Costs -Requires downstream of the membrane air dryer piping is clean and oil-free. -No extra parts are needed. -Installs directly into the pipeline. - Easy to operate.	Limited Dew Point Capability - Ambient temperatures below 40° F can freeze condensate. - Not a good fit for water-sensitive applications since some water vapor is left in the air.	Higher Operating Costs at High Temperatures -Consume about 2 to 3 kW of energy for every 100 cfm of dryer rating - almost four times more - than refrigeration dryers. -Desiccant must be added or replaced regularly. - Cost for disposal of deliquescent material dissolved.	Low Capacity Only -Limited to low capacity systems.
Low Operating Costs - Economical for high-temperature environments with reasonable operating costs. - Cost-effective when using electricity.	Reasonable Operating Costs - Economical for low-temperature environments with reasonable operating costs. - Reduced dependence on excessive outside services (e.g., steam, electricity, or gas) for heat. - Cost-effective when using thermal energy. - Requires no electricity.	Low Operating Costs - No consumables to replace other than prefilter. - No external power source is needed.	Indoor Use Only -Since some water vapor is left in the air, these dryers should not be used in water-sensitive applications. - High potential for failure at ambient temperatures below 40°F, or when incoming air and ambient air heat load is 15 to 20% of the rating.	Ongoing Maintenance Costs -Frequent maintenance of media to prevent corrosive deliquescent material carryover from causing a blockage.	Higher Purge Air Loss - High purge air losses as much as 15-20%.
Lower Maintenance Costs -No recurring costs other than electricity. - Not damaged by oil in the air stream. - No chemical or desiccants to add or replace. -No after filter required.	Lower Maintenance Costs - No moving parts.	Lower Maintenance Costs -Minimal maintenance is needed due to no need for replacement of moving parts. -Operates continuously with no need for adjustments or maintenance (other than prefilter maintenance)	Ineffective for Some Applications -Not effective for removing moisture for most paint applications.	Limited Dewpoint Suppression Between 20º to 30º F (average)	Membrane Fouling -A special coalescing type filter is required before the dryer, so the membrane does not become fouled by lubricants and other contaminants.
Other Advantages - A long-term solution and the lowest life-cycle cost.		Other Advantages - Suited for corrosive & explosive environments. - Suited for outdoor use. - Silent while operating.	Other Disadvantages - No energy savings at partial and zero air flow.		Application Limitations - Unsuitable for breathing air applications due to the level of reduced oxygen content of the compressed air.

Refrigerated Compressed Air Dryers

Refrigerated compressed air dryers are one of the most commonly used types of dryers. It has been the standard choice for manufacturing processes that do not have special requirements. One reason is that once installed correctly; you can almost forget them.

Refrigerated air dryers work much like a refrigerator in your home. They cool down the air to a pressure dew point of between 35°F – 50°F. As the temperature drops, water in the air becomes a vapor that condenses into water droplets. The droplets are separated from the compressed air stream, collected, and discharged. The air, now called conditioned air, continues downstream for use further down in the process.

For this process to work, temperatures must not drop lower than 32°F. If it occurs, water in the pipes will freeze, causing damage and interrupting or stopping the process. Therefore, refrigerated dryers are not feasible for every process, especially water-sensitive applications that need extremely dry air.

Initial costs for refrigerated dryers are affordable, and operating costs are reasonable if dew points are kept within the specified range. Costs for maintenance are minimal, with no need for replacement parts or repairs caused by the process. The only operating cost is electricity. Unlike the other dryers discussed here, refrigerated dryers have no purge losses to dry the air, but they are limited in the achievable pressure dew point.

Refrigerated dryers like the one below, are utilized in manufacturing facilities around the world. These products provide dry air for pneumatic equipment, bottle blowing machines, and even missile support systems.

Figure 1: Sauer USA refrigerated dryer capable of operation up to 6000 psi.

2 Kinds of Refrigerated Dryers

There are two kinds of refrigerated compressed air dryers called cycling and non-cycling. The difference between the two relates to how the refrigerant is cycled.

Cycling Dryers

Cycling dryers, also sometimes called thermal mass dryers, do what their name says. They cycle the refrigeration on and off, like your refrigerator at home, depending on demand to manage the pressure dew point within specifications (35°F – 50°F) at a varying flow rate. Heat is exchanged between the thermal mass and air entering the dryer. Air is cooled, and heat is transferred to a thermal storage media. They are used most often for manufacturing, especially in applications with fluctuating air demands.

The initial cost of the cycling dryer is a little higher than a non-cycling. However, over time cycling dryers are more cost-effective. Manufacturers often select them because cycling adds the capability to increase or decrease cooling capacity according to air use. Plus, they reduced energy costs whereby lowering life-cycle costs. Maintenance time and costs are somewhat higher because cycling dryers use additional equipment such as thermal mass or frequency controllers.

Non-cycling Dryers

Non-cycling dryers are designed to run the refrigeration compressor continuously. It makes it possible to respond faster when changes occur in moisture densities within the incoming air. Refrigerant is managed by a hot gas by-pass valve that regulates the flow to accommodate changes. A heat exchanger condenses the refrigerant.
Non-cycling dryers are used regularly in manufacturing environments where steam engines remove moisture similarly to low-moisture environments. They cost less than cycling dryers and need virtually no maintenance. However, keep in mind that repair costs can change quickly with low compressor usage, leading to freezing pipes that can cause a shutdown.

Refrigerated Compressed Air Dryer Comparison			
Cycling		Non-cycling	
Advantages	Disadvantages	Advantages	Disadvantages
Lower Operating Costs - Lower energy cost - Lower life-cycle costs	**Higher Initial Costs** - Purchased and installation costs slightly higher than non-cycling dryers.	**Lower Initial Costs** - Initial costs lower compared to non-cycling dryers	**Higher Operating Costs** - No cycling capability to lower energy costs.
More Benefits - Known for performance and reliability. - Easy to install - Low noise - Smaller footprint	**Higher Operating & Maintenance Costs** - Additional costs due to additional parts.	**Comparable Operating Costs** - Maintains a consistent dew point. - Capable of continuous operation.	**Potential for Higher Maintenance Costs** - Low usage can cause pipes to freeze, resulting in potential failure and a need for maintenance.

Refrigerated Dryer-Specific Considerations

There are several key areas to consider when deciding whether to purchase cycling or non-cycling refrigerated compressed air dryers.

1. What is the dryer's maximum pressure?
Check the maximum pressure when considering non-cycling or cycling dryers. The dryer's specifications must be the same or higher than the compressor for safe and efficient operation. The dryer is the most efficient when used at the highest operating pressure allowable by the dryer and the compressed air system.

2. What is the maximum flow?
Look at air flow rates. The highest flow rate for air moving through the dryer must be higher than the compressor can distribute.

3. What is the maximum room temperature (outside the dryer)?
Dryers are prone to overheat if placed in a hot room. Check the specifications of the compressor and make sure it can handle the room's temperature. Be sure to consult any correction factors for the capabilities of the dryer.

4. What is the maximum inlet temperature?
If the parts within the dryer exceed specified inlet temperatures, damage can occur. Plus, the dryer will be unable to reach the desired dew points. Check the inlet temperature specifications for cycling or non-cycling

dryers under consideration to ensure you do not exceed capabilities. Depending on the temperature of the gas from the compressor, additional cooling may be required.

5. What to do with condensate?
Refrigerated dryers produce condensate (water and oil) from cooling the air. This is collected within the dryer and must be disposed of per local regulations. Drainage methods are typically utilizing automatic no loss drains for medium pressure and below, and timer solenoid drains for higher pressure applications.

6. Protect your equipment.
Consult the dryer manufacturer's installation instruction as pre-filtration is typically required. Getting particulate into the dryer piping can bring costly damage expenses.

Refrigerated Dryers Advantages & Disadvantages

Beyond matching the specifications with your application's needs and process, look at the advantages and disadvantages. These can be indicators for initial, operation, and maintenance costs. Below is a comparison chart with the advantages and disadvantages of and non-cycling options. Overall, if you are looking at purchase and installation costs, non-cycling is the more affordable option. For operating costs, cycling is the better option.

Desiccant Compressed Air Dryers

Desiccant compressed air dryers remove moisture by absorbing it from the air with porous desiccant beads. The most common media used for the beads is Silica Gel. It is like the bead packs often used in product packaging.

The desiccant beads are housed in two towers. The first tower absorbs moisture through the desiccant beads and drying the air. The second tower completes regeneration. Towers are alternated to create a continuous steady stream of dry air. Overall pressure dew point ratings range from -40 to -100 degrees F.

Desiccant dryers are required when a plant needs instrument-quality compressed air. Examples of these critical applications are the Pharmaceutical, Food, and Breathing Air industries where very dry air is needed. Desiccant dryers are also often used in the Construction industry and High-Speed Wind Tunnel test facilities. A typical application is media blasting and metal surface prep work by painting contractors.

Desiccant dryers are a bit more expensive to purchase than a refrigerated dryer, but the electrical load is negligible. Operating costs are considered reasonable but keep in mind that desiccant beads will need to be replaced periodically, per the manufacturer's instructions. Plus, desiccant dryers require regular maintenance to ensure no loss in performance or even a shutdown from dislodged desiccant beads.

Regenerative dryers use purge air, while there are also non-regenerative, cartridge-style options, which do not use purge air. However, the cartridges are limited in the amount of air it may process before the elements require replacing. These are not ideal for continuous operation applications.

3 Kinds of Regenerative Desiccant Dryers

Energy costs vary by type of desiccant compressed air dryers. The three types used most often are heatless, heated, and blower purged. The amount of energy used is tied to the manner of regeneration used for the desiccant material. For heated and blower purged types, they can become more cost-effective by using thermal energy.

Heatless Desiccant Dryers

Heatless desiccant dryers, sometimes called pressure swing absorbers, rely on the retention of heat for reducing moisture. Desiccant beads or beds absorb water during the drying process. Some of the flow from the dry side of the processing tower is recirculated at reduced pressure to the regenerating tower, providing purge flow from top to bottom. This dry purge air pulls the desiccant's moisture, forcing it to exit from a purge silencer.
Regeneration and purge cycle times can be controlled via dew point monitoring to reduce further purge losses in the system (typically 15-20%).

Heated Desiccant Dryers

Heated desiccant dryers have a heater in the dryer regeneration circuit and require little or no process air. In the first tower, ambient air passes through the heater and becomes hot regeneration air. As it moves through the second tower, moisture is absorbed by the desiccant adsorption beads. Because of the simple design, desiccant dryers are the preferred choice for extreme environments. Plus, heatless dryers are more affordable to operate than heated desiccant dryers due to the higher electrical load from a heating element.

Blower Purged Desiccant Dryers

Blower purged desiccant dryers eliminate the need for compressed air purge. By adding a blower, they use ambient air from the outside (room) environment and augment it with heat. The hot, dry air removes moisture in the first tower, absorbed by the second tower's desiccant beads. Operating costs go down from the elimination of the need for compressed air. However, energy costs go up from the need for electricity to power the blower's electric motor.

Figure 2: Sauer USA desiccant dryer on a custom-engineered skid-mounted package.

Desiccant Compressed Air Dryer Comparison					
Heatless		Heated		Blower Purged	
Advantages	Disadvantages	Advantages	Disadvantages	Advantages	Disadvantages
Low Dew Points - Low dewpoints can be reached without potential freezing.	**Desiccant Replacement Costs** - Desiccant beds/beads must be replaced on average every 3-5 years. - Desiccant beds/beads are more challenging to change.	**Low Dew Points** - Low dewpoints can be reached without potential freezing.	**Desiccant Replacement Costs** - Desiccant beds/beads must be replaced on average every 3-5 years. - Desiccant beds/beads are more challenging to change.	**Low Dew Points** - Low dewpoints can be reached without potential freezing.	**Desiccant Replacement Costs** - Desiccant beds/beads must be replaced on average every 3-5 years. - Desiccant beds/beads are more challenging to change.
Lower Initial Cost - Initial capital costs are lower as compared to other regenerative types.	**Purged Air Cost** - Purged air is required, expensive, and will increase operating costs.	**Less Purged Air** - Less purged air is required as compared to other desiccant dryers.	**Prefiltering Costs** - Desiccant require prefiltering, so oils do not coat the desiccant beds/beads making them not useable.	**No Purged Air** - No purged air is required keeping down operating costs.	**Desiccant Replacement Costs** - Desiccant beds/beads must be replaced on average every 3-5 years. - Desiccant beds/beads are more challenging to change.
Remote/Mobile Operation - Heatless dryers can be designed to function pneumatically for remote and mobile locations.			**Purged Air Used** - Even though the amount of purged air required is less, it is still required. Purged air is an expensive addition to operating costs.	**Available Compressed Air** - All compressed air is available for plant use.	**Higher Energy Cost** - Blower uses electricity, which creates higher energy costs.

Desiccant Dryer-Specific Considerations

When considering purchasing a desiccant compressed air dryer, keep in mind the hidden costs beyond the purchase price. Also, the purge is typically 15 to 20 percent of the dryers' rated flow.

1. **Keep an eye on the pressure**
   The dryer could create an extra pressure drop, which may draw more energy and increase your production cost. To keep down the cost, align the compressor size with the dryer.

2. **Weigh-in energy costs**
   Compare the costs of unheated, heated, and blower purged desiccant dryers concerning energy costs. Unheated dryers need negligible energy. However, they have high purge consumption rates and waste 15-20% of compressed air. Heated dryers use energy for the heater and have medium purge consumption rates at approximately 7.5% of capacity less than of heatless. Purged blower dryers use energy for the blower and have lower purge consumption rates. Non-regenerative dryers use no energy but are limited in their processing capabilities.

3. **Protect the equipment**
   Many desiccant dryers require the use of wet tanks to protect the dryer from incoming pulsations. Cooling systems may be necessary to reduce the supply air temperatures as desiccant become useless at inlet temperatures above 130°F. Filtration is also required to avoid any slugs of liquid or condensing oil from reaching the desiccant. The oil will hinder or prevent the adsorbing process.

Figure 3: Sauer USA Desiccant Dryer capable of operation up to 7250 psig.

The dryer in Figure 3 is used to dry high-pressure air up to 7250psig. Prefiltration is fitted to accept air from a high-pressure compressor while ensuring any bulk liquid is coalesced before reaching the desiccant. This product also comes with dew point demand capabilities to reduce the purge and regeneration cycle times, which reduces your purge losses.

Desiccant Dryer Advantages & Disadvantages

Looking at the desiccant compressed air dryer advantages and disadvantages, you will find all three deliver low dew points. But they lose a few points when you look at operation and maintenance costs. Keep in mind that purged air is expensive to produce.

Membrane Compressed Air Dryers

Membrane is the newest type of compressed air dryer. They were designed for processes using pneumatic equipment that is more sensitive to contaminants like oil. Membrane dryers rely upon selective gas component permeation during migration. The compressed air passes over a selectively permeable membrane. The membrane is structured so that gases such as oxygen pass through faster than others like nitrogen. Moisture builds upon the membrane and is discharged.

Controlling the lowering of dew points can be tricky. Membrane dryers dew points can vary from day-to-day, week-to-week, month-to-month, etc. If the dew point of air entering the dryer is lower than the targeted range, the outlet dew point will become lower than specified. Pressure can complicate things too. If the pressure is higher than intended, the outlet dew point will be lowered because of the extra time spent in the membrane. Membrane dryers are limited to low capacity systems and experience high purge air losses as high as 15-20%.

But there are also advantages, including being reliable, quiet, and requiring no electricity. Membrane dryers are designed to run continuously 24 hours a day, seven days a week, and produce low dew points. Standard compressed air moisture removal applications are laboratories and medical facilities. Membrane dryers are also used in food packaging where the separated nitrogen is stored and used later in the process. They are also used in plastics manufacturing.

They have lower start-up costs with being easy to install and requiring no extra parts. Operating and maintenance costs are affordable other than needing a special coalescing type prefilter and related maintenance. Before air enters the dryer, the prefilter must avoid the membrane becoming fouled by lubricants and other contaminants.

Membrane Dryer-Specific Considerations

Membrane dryers have no moving parts, so they require very little maintenance. However, costs for filtration and maintenance should be considered.

1. Look at filter costs
Avoiding and managing contaminants is imperative to gaining and maintaining high performance. That means having quality prefilters and replacing them regularly.

2. Consider piping costs
When piping ages, it is often contaminated with water and oil downstream. The contamination travels to the end of the system long after the dryer is installed. It brings new costs to your calculations for replacing and cleaning pipes.

3. Understand the temperature specifications
Membrane systems require that the incoming air not exceed 135°F.

One last thing to keep in mind is reference points for determining dryer performance. Changes in temperature or supply pressure can hinder performance. Typical, expected ambient conditions are 80-100°F and inlet air temperature of 100°F. It has always best to follow the manufacturer's recommendations to ensure proper design and sizing to meet your desired specifications.

About Sauer Compressors USA

Sauer Compressors USA specializes in manufacturing medium and high-pressure air and gas compressors for naval, commercial maritime, offshore, research & development, and demanding industrial applications. Industries worldwide rely on Sauer piston compressors for pressures of up to 7,250 PSI to control process and production using high-pressure air or gas. In addition to air, Sauer Compressors is saturated in the CNG, N2, He, and inert gas markets. Sauer USA, located in Stevensville, MD, is an affiliate of J.P. Sauer & Sohn, headquartered in Kiel, Germany.

Rated for continuous duty, all compressors have been field-tested in the most demanding applications and extensively refined to provide true 24/7 reliability supported by the Sauer Lifetime Warranty. Sauer Compressors is the global leader in the medium and high-pressure compressor markets with a reputation for reliability and life cycle product support.

QUALITY ASSURANCE

Sauer Compressors is ISO-9001 Certified. Our inspection process has been qualified to U.S. Department of Defense MIL-I-45208A requirements. Our parent company, J.P. Sauer and Sohn, is ISO 9001 certified.

COMPLIANCE WITH CLASSIFICATION SOCIETY STANDARDS

Sauer Compressors USA Inc. equipment is type approved by all major classification societies (ABS, Lloyds, GL, DNV, etc.). Most of our military grade compressors are shock tested to US Navy Grade A shock requirements.