(ALMOST) EVERYTHING YOU NEED TO KNOW TO SELECT THE RIGHT COMPRESSED AIR SYSTEM DRYER

By Brian Mann, Air Systems Manager

Compressed air treatment, or contaminant removal, sometimes seems like an afterthought. How many times do we see a specification, with capacity, delivery pressure and site conditions clearly defined, but the air quality is defined as "clean and dry," "plant air," or "instrument quality air?" One time is more often than we should.

ISO 8573-1 defines classes of air quality based on particulate, moisture and oil purity in terms of concentration and particle size. Generally, a refrigerated compressed air dryer will provide air quality that meets Class 4 criteria, or pressure dew point of less than or equal to 38°F.

So, when selecting a dryer, decide whether a refrigerated dryer will meet the requirement, size one to match the compressor capacity and you're off to the races, right? No. Not so fast! There is a lot more to consider when selecting and sizing a refrigerated dryer. Thermal mass cycling, non-cycling or VSD controlled? Air-cooled or water-cooled? And what about sizing? Do you need to just match the compressor capacity, or go up one size? The following is (almost) everything you didn't know you needed to know when choosing your compressed air system dryer.

Compressor Capacity and the Ambient Air Factor

Before considering various refrigerated compressed air-drying technologies, let's briefly consider sizing the compressed air dryer. Compressed air dryers are typically rated at the "Three 100s"; 100°F inlet air temperature, 100°F ambient temperature and 100 psig inlet air pressure.

As operating conditions vary from these conditions, the capacity of the dryer changes. The ability of air to hold moisture varies with temperature and inversely with pressure. The ability of the refrigerated compressed air dryer to reject heat from the condenser to the ambient air is reduced as ambient air temperature increases. What does all of this mean to the person selecting a compressed air dryer?

Let's start with the inlet compressed air conditions. A common rule of thumb is that for every 20°F that the temperature of air increases, its ability to hold moisture doubles. In many climates, the discharge temperature from an air-cooled air compressor can easily reach 120°F, meaning that the dryer must remove nearly twice as much water as compared to an inlet air temperature of 100°F. A dryer whose capacity rating equals that of the compressor likely will not provide the desired dew point.

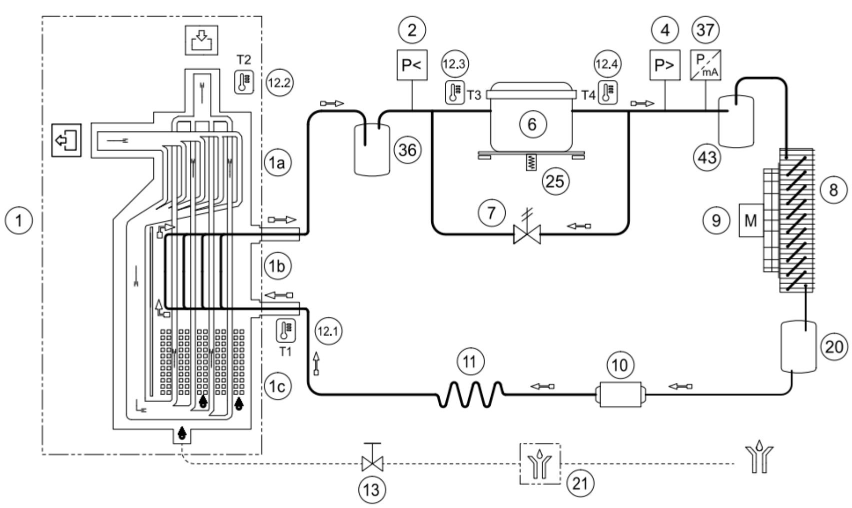
Alternatively, the ability of air to hold moisture varies inversely with pressure. As the pressure increases, the voids between air molecules become smaller, and the moisture is no longer able to stay in vapor form. It condenses and comes out of the air as liquid condensate. The impact on the dryer is that there is less water to remove, so the effective capacity of the dryer is increased with increased pressure.

The ambient conditions in the compressor room will impact the dryer in two ways. First, the temperature difference between the condenser and the environment is reduced, negatively impacting the performance of the condenser, and the refrigeration cycle as a whole. Second, if the compressor is air-cooled, elevated ambient temperatures typically result in elevated compressed air discharge temperatures. Ambient temperature, therefore, plays a key role in the dryer discussion.

Most manufacturers publish correction factors for their dryers, and an end-user, equipped with the right information, can properly size a compressed air dryer. In many cases, in order to provide the desired dew point in all conditions, the dryer nameplate capacity will exceed the compressor capacity—and often by a large margin.

To Cycle or Not to Cycle

Moving on to the comparison of drying technologies, let's start with the basic non-cycling refrigerated dryer. Non-cycling means that the refrigeration compressor and condenser fan motors do not stop if the dryer is operating. As the thermal load varies, the hot-gas bypass valve regulates the flow of refrigerant through the system to prevent freeze-up. The hot-gas bypass valve may require seasonal adjustments to offset the effects of differing ambient conditions on the refrigeration cycle. A very straightforward, durable approach to drying compressed air.



Item	Description
1	Aluminum heat exchanger
1a	Air to air exhanger
1b	Air to refrigerant exchanger
1c	Condensate separator
2	LPS: Refrigerant pressure switch
4	HPS: Refrigerant pressure switch
6	Refrigerant compressor
7	Hot gas bypass valve
8	Condensor
9	Condensor fan
10	Filter drier
11	Capillary tube
12.1	T2: Temperature sensor (dewpoint)
12.2	T2: Temperature sensor (air in)
12.3	T3: Temperature sensor (compressor suction)
12.4	T4: Temperature sensor (compressor discharge)
13	Condensate drain isolation valve

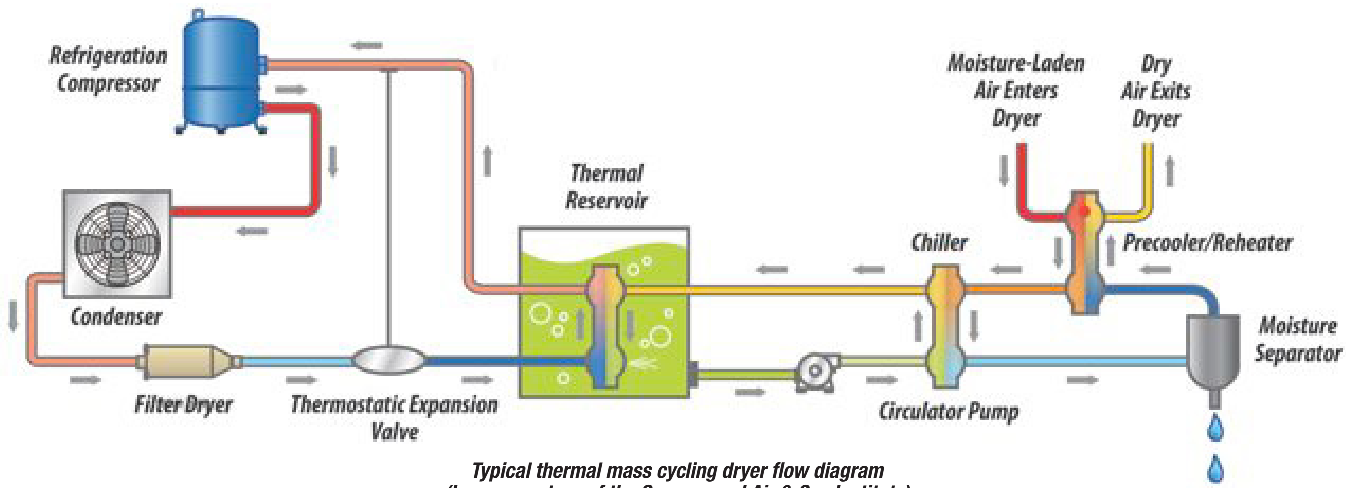
Typical refrigerated compressed air dryer flow diagram

On lower-capacity dryers, the loss of efficiency at low loads is acceptable. The additional energy cost is low, and the ROI on more sophisticated controls is not sufficient to justify the investment.

As the capacity of a refrigerated dryer increases, the compressor and condenser fan motors become larger, and energy efficiency can become an area of consideration. Like rotary screw air compressors, variable speed drives (VSD) can be used on the compressor and condenser fan motors on refrigerated compressed air dryers.

The glycol/water fluid is cooled by the refrigerant. Typically, there is an insulated reservoir of fluid that acts as the thermal mass. At part-load conditions, while the refrigerant cycle is active, the temperature of the water/glycol fluid will fall. Once the temperature reaches a set point, the compressor and condenser fan motors shut off (cycle), providing an opportunity for energy savings.

As the compressed air continues to be dried, the glycol/water mixture temperature will rise until an upper set point is reached, and the compressor begins to run again.



Typical thermal mass cycling dryer flow diagram
(Image courtesy of the Compressed Air & Gas Institute)

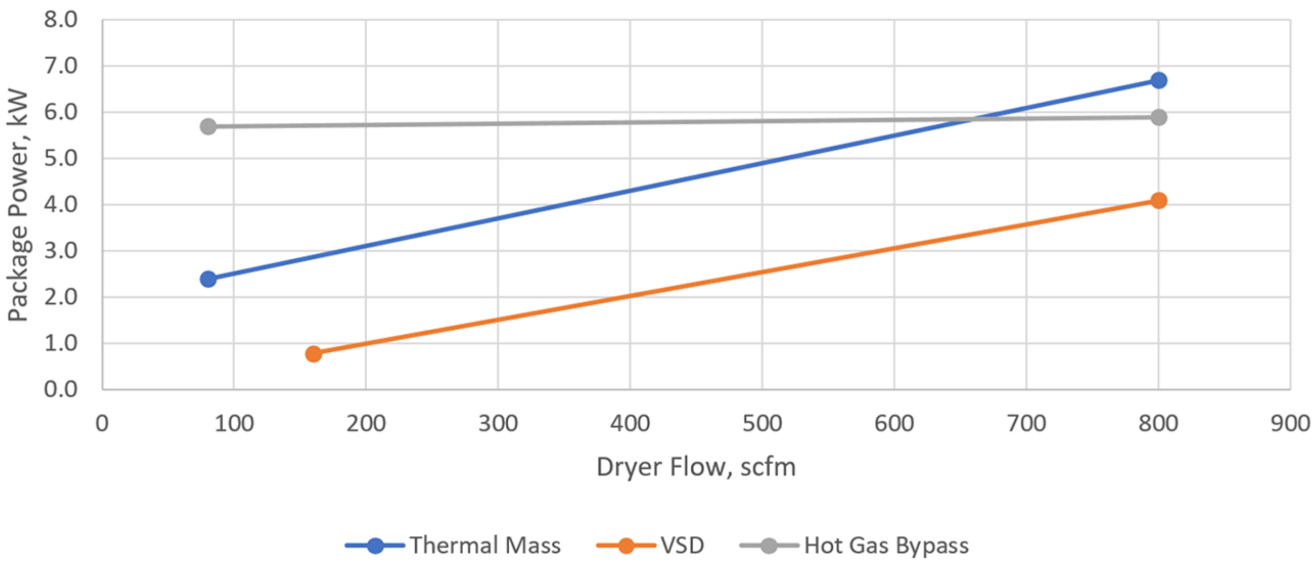
The speed of the VSD controlled compressor and condenser fan motors varies as the temperature of the refrigerant rises and falls—matching the refrigeration capacity to the load. Minimum speeds are established, below which the motor shuts off. With the very low inrush current associated with a variable speed drive, the motors can start whenever needed, providing better efficiency.

Another approach to matching drying capacity to demand is the thermal mass cycling refrigerated air dryer. In a cycling dryer, there is a third fluid circuit containing a glycol/water mixture that used to absorb heat from the warm and moist compressed air.

Shutting off the compressor and condenser fan motors provides the energy savings associated with the thermal mass cycling dryer as compared to the non-cycling dryer. However, the circulating pump on the cycling dryer continues to run while the compressor and condenser fan motors are off, so the dryer always consumes power.

As the water/glycol mixture temperature increases, the compressed air discharge dew point increases as well.

The question becomes whether the thermal mass cycling dryer or the VSD controlled dryer is the more efficient solution. As it turns out, the VSD controlled dryer offers significant energy efficiency benefits as compared to the cycling dryer.



Dryer Type Control Technology	Cycling, Air-cooled, Thermal Mass[1]		Cycling, Air-cooled, VSD[2]		Non-cycling, Air-cooled, Hot Gas Bypass[1]	
Flow	Full	10%	Full	20%	Full	10%
Tested Flow	800 scfm	80 scfm	800 scfm	1600 scfm	800 scfm	80 scfm
Outlet Pressure Dew Point	39°F	39°F	38°F	Not provided	40.5°F	40.5°F
Pressure Drop	3.2 psi(d)	0.9 psi(d)	2.8 psi(d)	Not provided	3.2 psi(d)	0.9 psi(d)
Total Dryer Input	6.7 kW	2.4 kW	4.1 kW	0.8 kW	5.9 kW	5.7 kW
Specific Power	0.84 kW / 100 scfm	2.94 kW / 100 scfm	0.51 kW / 100 scfm	0.50 kW / 100 scfm	0.74 kW / 100 scfm	7.13 kW / 100 scfm

1. Data from CAGI data sheet

2. Data provided by manufacturer

Comparing part-load power consumption of 800 scfm thermal mass cycling, VSD controlled and non-cycling refrigerated compressed air dryers

The difference in power consumption between the thermal mass cycling dryer and the VSD cycling dryer is attributable, in large part, to the circulating pump that continues to run at even very low loads in the thermal mass cycling dryer.

Summary

As with every component in the compressed air system, implementing the right solution for the application is the key to success. Factors to consider when selecting a refrigerated compressed air dryer include: dew point stability, operating environment, capital cost, energy cost and available space. Understanding the nuances within these factors will help you select the right dryer system for your unique needs and environment.

Your compressed air system service provider is always an excellent source of information and can help guide you through the process. Now you know.