SHOW PRESSURE
COMPRESSED AIR CHALLENGE

Pressure Drop and Controlling System Pressure

Office of Industrial Technologies

Compressed Air Systems Fact Sheet #4

Pressure drop is a term used to characterize the reduction in air pressure from the compressor discharge to the actual point of use. Pressure drop occurs as the compressed air travels through the treatment and distribution system. A properly designed system should have a pressure loss of much less than 10% of the compressor's discharge pressure, measured from the receiver tank output to the point of use.

Excessive pressure drop will result in poor system performance and excessive energy consumption. Flow restrictions of any type in a system require higher operating pressures than are needed, resulting in higher energy consumption. Minimizing differentials in all parts of the system is an important part of efficient operation. Pressure drop upstream of the compressor signal requires higher compression pressures to achieve the control settings on the compressor. The most typical problem areas include the aftercooler, lubricant separators, and check valves. This particular pressure rise resulting from resistance to flow can involve increasing the drive energy on the compressor by 1% of the connected power for each 2 psi of differential.

An air compressor capacity control pressure signal normally is located at the discharge of the compressor package. When the signal location is moved downstream of the compressed air dryers and filters, to achieve a common signal for all compressors, some dangers must be recognized and precautionary measures taken. The control range pressure setting must be reduced to allow for actual and potentially increasing pressure drop across the dryers and filters. Provision also must be made to prevent exceeding the maximum allowable discharge pressure and drive motor amps of each compressor in the system.

Pressure drop in the distribution system and in hoses and flexible connections at points of use results in lower operating pressure at the points of use. If the point of use operating pressure has to be increased, try reducing the pressure drops in the system before adding capacity or increasing the system pressure. Increasing the compressor discharge pressure or adding compressor capacity results in significant increases in energy consumption.

Elevating system pressure increases unregulated uses such as leaks, open blowing and production applications without regulators or with wide open regulators. The added demand at elevated pressure is termed "artificial demand", and substantially increases energy consumption. Instead of increasing the compressor discharge pressure or adding additional compressor capacity, alternative solutions should be sought, such as reduced pressure drop, strategic compressed air storage, and demand/intermediate controls. Equipment should be specified and operated at the lowest efficient operating pressure.

What Causes Pressure Drop?

Any type of obstruction, restriction or roughness in the system will cause resistance to air flow and cause pressure drop. In the distribution system, the highest pressure drops usually are found at the points of use, including in undersized or leaking hoses, tubes, disconnects, filters, regulators and lubricators (FRLs). On the supply side of the system, air/lubricant separators, aftercoolers, moisture separators, dryers and filters are the main items causing significant pressure drops.

The maximum pressure drop from the supply side to the points of use will occur when the compressed air flow rate and temperature are highest. System components should be selected based upon these conditions and the manufacturer of each component should be requested to supply pressure drop information under these conditions. When selecting filters, remember that they will get dirty. Dirt loading characteristics are also an important selection criteria. Large end-users that purchase substantial quantities of components should work with their suppliers to ensure that products meet the desired specifications for differential pressure and other characteristics.

The distribution piping system often is diagnosed as having a high pressure drop because a point of use pressure regulator cannot sustain the required downstream pressure. If such a regulator is set at 85 psig and the regulator and/or the upstream filter has a pressure drop of 20 psi, the system upstream of the filter and regulator would have to maintain at least 105 psig. The 20 psi pressure drop may be blamed on the system piping rather than on the components at fault. The correct diagnosis requires pressure measurements at different points in the system to identify the component(s) causing the high pressure drop. In this case, the filter/regulator size needs to be increased, not the piping.

Minimizing Pressure Drop

Minimizing pressure drop requires a systems approach in design and maintenance of the system. Air treatment components, such as aftercoolers, moisture separators, dryers, and filters, should be selected with the lowest possible pressure drop at specified maximum operating conditions. When installed, the recommended maintenance procedures should be followed and documented. Additional ways to minimize pressure drop are as follows:

- Properly design the distribution system.
- Operate and maintain air filtering and drying equipment to reduce the effects of moisture, such as pipe corrosion.
- Select aftercoolers, separators, dryers and filters having the least possible pressure drop for the rated conditions.
- Reduce the distance the air travels through the distribution system.
- Specify pressure regulators, lubricators, hoses, and connections having the best performance characteristics at the lowest pressure differential.

Controlling System Pressure

Many plant air compressors operate with a full load discharge pressure of 100 psig and an unload discharge pressure of 110 psig or higher. Many types of machinery and tools can operate efficiently with an air supply at the point of use of 80 psig or lower. If the air compressor discharge pressure can be reduced, significant savings can be achieved. Check with the compressor manufacturer for performance specifications at different discharge pressures.

Demand controls require sufficient pressure drop from the primary air receiver into which the compressor discharges, but the plant header pressure can be controlled to a much narrower pressure range, shielding the compressor from severe load swings. Reducing and controlling the system pressure downstream of the primary receiver can result in a reduction in energy consumption of up to 10% or more, even though the compressors discharge pressure has not been changed.

Reducing system pressure also can have a cascading effect in improving overall system performance, reducing leakage rates, and helping with capacity and other problems. Reduced pressure also reduces stress on components and operating equipment. However, a reduced system operating pressure may require modifications to other components, including pressure regulators, filters, and the size and location of compressed air storage.

Lowering average system pressure requires caution since large changes in demand can cause the pressure at points of use to fall below minimum requirements, which can cause equipment to function improperly. These problems can be avoided with careful matching of system components, controls, and compressed air storage capacity and location (see the Fact Sheet titled *Compressed Air System Controls*).

For applications using significant amounts of compressed air, it is recommended that equipment be specified to operate at lower pressure levels. The added cost of components, such as larger air cylinders, usually will be recouped quickly from resulting energy savings. Production engineers often specify end-use equipment to operate at an average system pressure. This results in higher system operating costs. Firstly, the point of use installation components such as hoses, pressure regulators, and filters will be installed between the system pressure and the end-use equipment pressure. Secondly, filters will get dirty and leaks will occur. Both result in lower end-use pressure. This should be anticipated in specifying the available end-use pressure.

If an individual application requires a higher pressure, instead of raising the operating pressure of the whole system it may be best to replace or modify this application. It may be possible to have a cylinder bore increased, gear ratios may be changed, mechanical advantage improved, or a larger air motor may be used. The cost of the improvements probably will be insignificant compared with the energy reduction achieved from operating the system at the lower pressure.

It is also important to check if manufacturers are including pressure drops in filters, pressure regulators, and hoses in their pressure requirements for end-use equipment, or if the pressure requirements as stated are for after those components. A typical pressure differential for a filter, pressure regulator, and hose is 7 psid, but it could be much higher in poorly designed and maintained systems.

When demand pressure has been successfully reduced and controlled, attention then should be turned to the compressor control set points to obtain more efficient operation, and also to possible unloading or shutting off of a compressor to further reduce energy consumption.