



Advantages of Using Flow Meters to Reduce Pressure Drop

How to optimize your air flow system by making smart measurements

INTRODUCTION

Plant operators rely on plant air pressures to maintain properly working equipment and systems. One of the most common problems affecting processing plants that utilize compressed air systems is the ability to maintain reliable air pressure throughout the distribution system.

Insufficient air pressures may be due to undersized distribution piping, but it's more commonly found that the cause is flow restrictions in the distribution system such as filters, check valves, and fittings, as well as flow meters and gauges. Leaks in the distribution system actually rank low as the common cause of "pressure drop". Pressure drop is the loss or reduction of pressure from the compressor discharge to the actual point of use. The system will appear like there is a lack of air pressure but the real problem is pressure drop, which will cause excessive energy consumption. This white paper will explain the causes of pressure drop, a variety of solutions and ultimately how to eliminate costly downtime.

CHALLENGE

Unfortunately, the solution is not as easy as just cranking up the air pressure at the delivery point, as this will cause other issues such as leaks, excessive component wear and maintenance. Every 1 PSI of excess operating pressure increases air compressor power consumption by around 0.5 percent. As can be seen from the pressure drop formula in figure 1, increasing the system pressure will actually increase the pressure drop. Unregulated equipment on the system will increase demand and increase inefficiency of the system.

SOLUTION

PROPER EQUIPMENT

Minimizing pressure drop can be obtained by selecting equipment such as air treatment equipment, filters, dryers, flow metering and instrumentation with the lowest amount of pressure drop. Additional ways to decrease pressure drop would be to maintain air filtering and air treatment to reduce moisture that can create corrosion and increase friction on the piping system. Also, reduce the distance the air travels through the distribution system so as to create the shortest runs possible to reduce loss. Select the correct pipe sizes and pipe material with the effort to stay away from hoses or corrugated products that will reduce pressure. Sizing pipe is critical for efficiency with the goal of keeping air velocities in the distribution header less than 20 to 30 ft./sec. Increased velocities will increase pressure drop.

FIGURE 1: EMPIRICAL FORMULA

The calculation for pressure drop is called the “empirical formula”. The formula is:

$$dp=7.57 q^{1.85} L10^4/(d^5 p)$$

Where:

- dp is the pressure drop measured in kg/cm²
- q is the air volume flow at atmospheric conditions measured in m³/min
- L represents the length of pipe measured in meters(m)
- d is the inside diameter of pipe measured in millimeters(mm)
- p shows initial absolute pressure in the system measured in (kg/cm²). This is the rating of your compressor, which gives the pressure expected at its outlet valve.



Figure 2. Processing plant that relies on plant air pressures to maintain properly working equipment and systems.

AIR FLOW QUALITY

Another big influence to pressure drop has to do with the quality of the air flow. Air that flows in a swirling and turbulent path inside the pipe is called “turbulent flow.” Turbulent flow is the most inefficient flow condition as the air molecules spend so much energy bouncing off of pipe walls in all directions that they spend much of their energy away from moving down the pipe. The ideal flow condition is for the air molecules to all move in a straight forward path down the pipe together. This flow condition is called “laminar flow.” Turbulent and laminar flow can be calculated as well, using the following formula to determine what is called Reynolds Number:

FIGURE 3: REYNOLDS NUMBER

$$Re = \rho v d / \mu$$

Where:

- Re is the Reynolds number.
- ρ is the air density.
- v is the mean velocity.
- d is the diameter of the pipe.
- μ is the dynamic viscosity.

The efficient air flow system should have a Reynolds Number of less than 2,300. If the Reynolds Number is greater than 3,000 the air flow in the pipe will be turbulent and corrections should be made to correct the condition.

RELIABLE MEASUREMENT

Making smart measurements of the compressed air system will reduce maintenance, energy cost, and will ensure proper operation for all equipment requiring consistent air delivery. The measurement equipment is relatively inexpensive. Monitoring power use, air flow, and air pressure is all that is required to assure a properly working system. Other measurements like dew point and temperature can also help make your system operate with better results. By measuring the air flow, pressure, and energy use you can generate a baseline of the system operation. Typical flow data in a compressed air system is measured in Cubic Feet per Minute (CFM). By knowing the volume of air use, system pressure measured in Pounds Per Square Inch (PSI) and energy use measured in Kilo Watt per Hour (KWH), you can create a baseline of efficiency for the system.

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Volumetric flow meters, also termed Variable Area (VA) Flow meters, are typically used to measure compressed air as they do not require any straight runs of pipe before or after the meter installation. They also are unaffected by such phenomena like turbulent flow conditions which will create inaccurate or no flow readings in a velocity type of flow meter. Some volumetric flow meters, such as FLO-CORP's MEMFlo™ flow meter, will read accurate flow readings even with differing system pressure by using pressure compensation into a flow monitor. One of the greatest benefits for using a VA meter in your compressed air system is that the meter is totally unaffected by water or moisture in the compressed air. Unlike velocity meters or thermal mass flow meters, volumetric technology is only able to read flow ranges within a 10:1 flow ratio, also known as the “effective flow range” of the flow meter. The exception to this is the MEMFlo™ VA flow meter which will read flow ranges all the way up to 30:1. The MEMFlo™ flow meter is ideal for compressed air applications as they have extremely low (typically 1.0 psi or less) pressure drop across the flow meter.

Thermal Mass flow meters are also an excellent choice for measuring flow in the compressed air line as long as the meter is installed after the air dryer and the air dryer is functioning properly. Thermal Mass meters will typically measure a flow range of 100:1 so they can read very low flow rates which enable detection of air leaks in the system. Some Thermal Mass meters, such as the FLO-CORP CalFlo™ flow meter, will insert into the pipe and even have hot-tap ability for easy installation without shutting the system flow down for installation. Since there are no moving parts, the meters are easy to maintain, and the flow system, when inserted into the pipe, will provide accurate flow with almost no pressure drop across the flow meter. Insertion type thermal mass flow meters can also be used as a portable meter that can measure flows at many different locations by insertion through isolation ports installed throughout the system. The meters will detect velocities well over 30 fps and as low as 0.05 fps.



Figure 4. FLO-CORP's MEMFlo™ MFVC Volumetric (VA) Flow Meter installed on a compressed air system.

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RELIABLE MONITORING

When smart metering is implemented, the system optimizes velocity and operating pressure to reduce pressure drop. Typically, a flow meter is used to measure plant demand and not the full load of the compressor output. The baseline of the operating system can be generated with flow, pressure and electrical load measurements taken on a continual bases through customized meters like FLO-CORP's CONNEX 3D™ flexible process meter. This flexible process meter will calculate the baseline with time and date stamped data that is stored in the memory of the unit. The data can also interface with a PC based monitoring software for use when analyzing data during production or when flow data analysis is convenient. Some benefits to utilizing a flexible process meter is that leaks can be easily detected. This happens when the flow reading is indicating something besides zero flow when the plant is not in operation. The pressure trend will also indicate a loss of pressure at a greater rate than historically trended if the air leak(s) have increased over time. Logged data can also be analyzed to evaluate system performance and provide predictive maintenance on the compressor head, vanes and lower unit to prevent loss of pressure. It is possible for the compressor to consume the same amount of energy and even appear to be working properly but not produce any pressure or air flow. These operational and maintenance issues can be reduced by smart metering analytics and system alarming strategies.



Figure 5. FLO-CORP's CONNEX 3D™ CD3D Flexible Process Meter

ABOUT FLO-CORP

FLO-CORP is a flow, level, and monitoring solutions provider. Starting in 1989 as a distribution company, FLO-CORP quickly grew to manufacture their own product lines after seeing how frequently their customers needed more than off-the-shelf solutions. As a U.S. manufacturer, FLO-CORP has control over origin of product, quality, and lead times as well as creative control in the development of new products. FLO-CORP is unique in that every product and system is calibrated for the customer's exact application for accuracy and easy start-up. FLO-CORP strives to produce best-in-class products with customized measurement solutions of the finest quality and highest value on the market.

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