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CAGI
Compressed Air & Gas Institute

TECHNICAL BRIEF

Technical Brief - Sizing Compressed Air Equipment

Introduction

Proper sizing of the compressed air system for your facility will determine if you have enough air to adequately supply your production equipment. To function cost effectively, without an interruption in productivity, several design criteria must be considered. Desired outcomes of stable pressure and efficient operation are common; however, each application is unique and therefore requires a unique solution. Choosing the right equipment and how the air will be used are important considerations in determining the size of the air system. For example, where intermittent users of air exist, storage can compensate for the need versus larger compressors.

Size for the Demand Flow

Understanding your constituents of demand is the first step to properly sizing your system. Whether you are increasing the demand of a current facility or beginning with a new system, determining the demand in your compressed air system can be difficult due to rate of change as air demand fluctuates with each user. Nonetheless, understanding demand begins with summing the flow of each user.

Each user will likely have a full flow requirement and an average flow. Consider air driven tools for example. A ½" impact tool would average 4.2 cfm, but if the tool was used continuously at load, it would require 22 cfm, more than 5 times the average. So the usage factor is important in considering the sizing. Additionally, for intermittent users, the possibility of all users consuming at the same time (at full flow) is a possibility but not a common occurrence and can be handled with storage. While it is usually safe to consider the average consumption, a safety factor can also be included for margin. Additionally, air system leaks are inevitable with compressed air systems, and a healthy air system would not leak more than 5 to 10% of its air supply. It is not uncommon to see leaks in air systems exceeding 30% however, so consider how efficiently the system will be designed and maintained.

If you have an existing system and you wish to baseline your current usage, consult an air system assessment engineer who utilizes a flow measurement device to help you understand how the air is consumed currently. Once you have baselined the current flow, you would begin to address the additional load from the plant expansion or new air consuming equipment using manufacturer's specifications. Consider each of the following requirements: Average flow rate, Maximum flow rate, Minimum pressure, and Maximum pressure (Note that overpressurization can impact reliability)

Develop a chart of the constituents of demand and total the flow requirement.

Constituents of Demand	Required Pressure (psig)	Required Flow (cfm)			Intermittent Use Time	
Production Area		Constant	Average	Max at load	Time on (min)	Time off (min)
Assembly	80	250	250	250	-	-
Drying/Blowing	90	100	100	100	-	-
Air Wands (blowing)	90	-	75	150	0.2	0.2
Pneumatic Cylinders	80	50	50	100	-	-
Overhead air winches	80	-	32	400	6	35
Venturi Vaccuum	90	100	100	100	-	-
Electrical Cabinet coolers	80	80	80	80	-	-
Paint Spray Booth	80	-	150	200	-	-
Other users for production	80		150	250	-	-
Waste/Leaks	90	250	250	250	-	-
TOTAL	-	830	1237	1880	-	-

Special consideration should be given to large intermittent users such as bag houses. Calculating the usage of air with the interval allows for sizing a dedicated storage tank with metered recovery for any intermittent user. Metered recovery is a design to minimize capital investment in equipment and provide the buffer between the distributed supply and an intermittent user. Without metered recovery the demand placed on the system by the intermittent user who consumes air in "large gulps" will create a drop in system pressure and may result in a low system pressure alarm. Providing a dedicated storage tank for this use allows for the large gulp to be provided by the tank while not drawing down the system pressure. A needle valve between the distribution ring and the tank will insure air cannot be rapidly streamed into the tank once the tank has expired its volume for the large gulp. Instead the valve is sized to fill the tank slowly during the off time of the user. This metered recovery solution allows for the compressed air equipment to be sized for average use instead of peak demand.

Consideration for Pressure

Once you understand the flow requirements, determine the highest pressure requirement. The highest pressure requirement is usually what your system pressure will likely be. (There are ways around designing for unusually high pressure requirements which shall be addressed in the next paragraph.) Challenge manufacturers who compensate for flow restrictions by specifying higher pressure requirements for their air using equipment. Anything over 90 psig should be reviewed and analyzed for possible lowering of delivered pressure. Often a piece of air using equipment has a series of regulators lowering the article pressure (actual pressure at point of impact) to the device to as little as 40 psig. To size an entire system for a higher pressure of one or two pieces of equipment creates what is known as artificial demand. Constituents of demand will consume more flow at higher pressure especially air which is openly blown to atmosphere. Note that air open to atmosphere for blowing or drying is not recommended for maximized efficiency.

Consider the air flow through an orifice of 0.25" at 90 psig which is 95 cfm. Raise the pressure to 125 psig and the amount of air flow leaving the orifice increases 30% to 124 cfm. Leak loads increase with higher pressure as well, so minimizing air pressure to a narrow band at the lowest possible acceptable figure is desirable for maximized efficiency and minimized investment for equipment.

Designing for high pressure users

To address the needs for a low volume high pressure user without increasing the overall system pressure, you may specify a dedicated pressure intensifier or amplifier at the point of use. A pressure intensifier uses the system pressure of 90 to 100 psig and can boost the pressure to as much as 10 times the incoming pressure.

Most compressor manufacturers can provide this device. For larger volume high pressure users, consider a booster compressor or dedicated compressed air system to feed the requirement. A dedicated compressed air system makes economic sense when the air demand is more than half of the overall demand in the system.

Once you understand flow and pressure requirements for your constituents of demand, consider how the system will be utilized throughout a full production cycle. A full production cycle would include changes in demand based on shift changes and/or weekend demand. Typically a full cycle is one week. Variations in demand will be a determining factor for what equipment to choose for the various load profiles. Develop an average load profile for each shift or sustained variation in demand. The greater the variability, the better likelihood you will want multiple compressors or variable speed controlled compressor(s).

Redundancy

Most compressed air systems are designed with redundancy built in, however, is the choice of the user based on criticality of the compressed air system to the operation. Once total flow and variations are determined, equipment selection may begin. For low variation, simply purchasing 2 compressors rated for 100% of the total flow is one strategy. This provides 100% backup. Another strategy to reduce capital costs and better manage variations in demand is to purchase 3 compressors rated at 50% of the total flow required. 2 compressors can manage the peak with one compressor in backup mode. Additionally, if the variation is significant, one compressor could be a variable speed design to act as trim. If variation is greater, then the logic could follow to install 5 compressors rated at 25% of the demand providing one back up. Consider the efficiency, maintenance costs, and acquisition cost to determine if this is the right strategy. Also, real estate becomes a factor for multiple systems, so insure enough floor space is available. Finally, think about the future. If capacity doubled, would you want another (5) 25% compressors, and need to maintain 10 compressors? Would you buy now for the future?

Designing for future changes in demand

Do I choose something which fits my needs today or plan for something that will fit with my changing needs over the next few years? Whether it be buying a house, a car, or a compressed air system, it is fair to say that the considerations are the same, and there is no definitive rule on how to answer the question.

Ideally, you want to think about it in the same way that you would approach changeable weather – adopt layers; depending on what is happening you have the ability to add some or take some away.

If you believe that your manufacturing activity could ramp up or down during the coming years, then a good option might be purchasing multiple smaller compressors as opposed to purchasing one or two larger ones. This way you are maximizing your energy efficiency in the short term, but you have capacity to cope with fluctuations in demand down the road. The ongoing need to balance the initial purchase cost and the energy-efficiency payback are also in play when you look at this equation.

Summary

Consider the total flow and pressure required. If expanding an existing system, then baseline using flow and pressure measurement. Challenge your high pressure users and determine alternate strategies other than increasing system pressure. Create a chart of demand constituents and address variations in demand over the production cycle. Determine the equipment strategy with a mind on the future. Common systems are (3) 50% compressors. Consider amount of flexibility desired.

Finally, look at the technologies available. Is rotary, centrifugal, or reciprocating right for this application? Contact your local compressed air representative or the CAGI website for more information and assistance in determining the right equipment for your application. Compressed air specialists possess the knowledge and tools to assist in ensuring that the components of the systems are working in concert to achieve the desired production result most economically and efficiently.