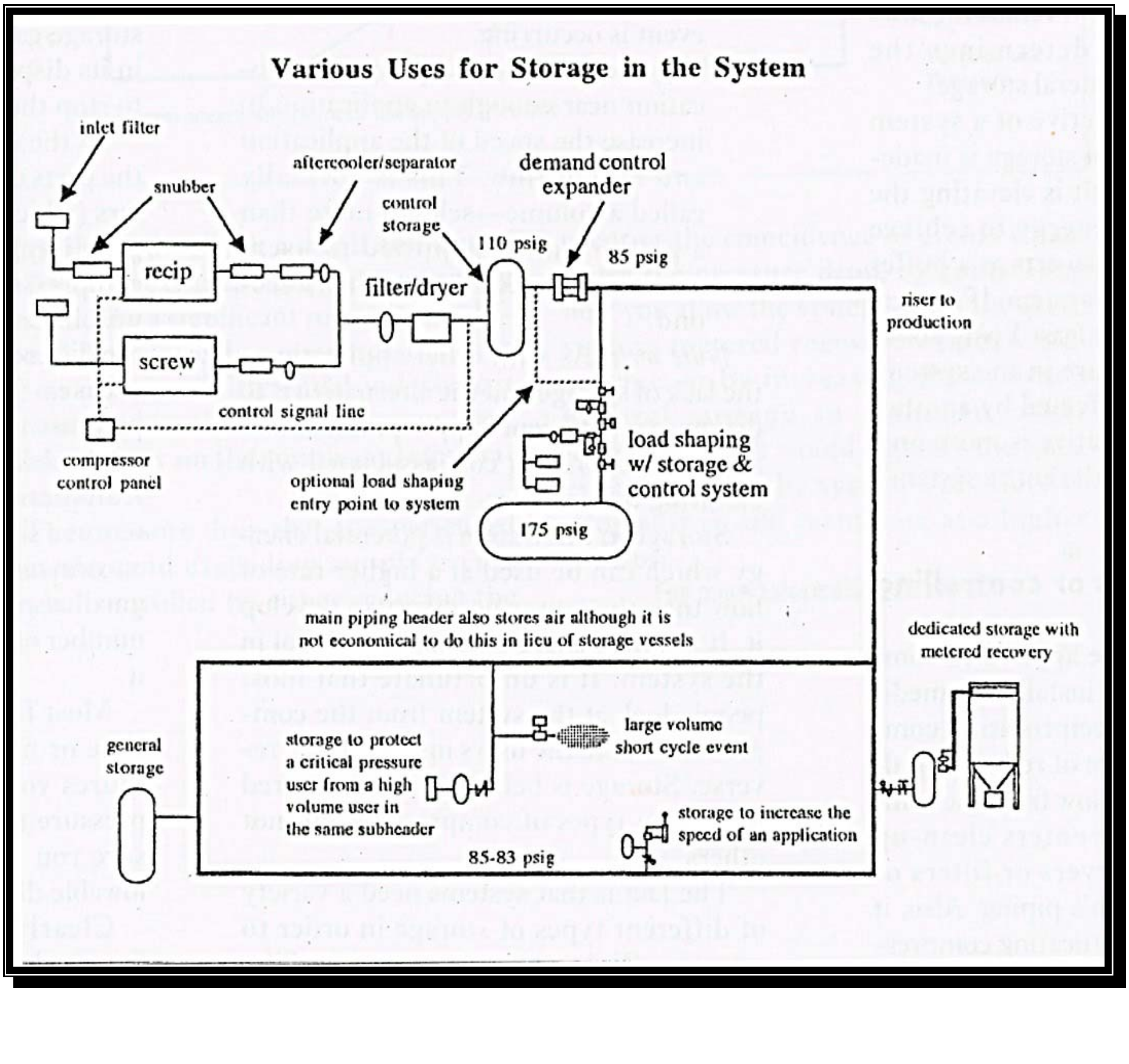
Compressed Air Storage Systems

Potential for savings in storage solutions

By R. Scot Foss, Plant Air Technology

Storage is one of the most undervalued and misunderstood aspects of the compressed air system. It is capacitance, as you would use it in an electric system. It is the tower reservoir in a water system. The amount of storage in the system determines the rate of change in the system. This is the relationship of pressure drop or rise versus time. The more storage capacity, the slower the rate of change in the system. Storage can play many essential roles in the efficient operation of the system. The following is a list of the uses of storage in the system and how it is applied.



Control Storage:

This is the volume of storage on the supply side of system which is used to maintain the rate of change and pressure drop or rise relative to the events that occur in the system. Control storage is sized to manage the impact events relative to the control permissive on the compressor's available to the system. The longer it takes to wind the motor and get the compressor to displace its capacity, the more storage is necessary to control how fast and how far the pressure will drop. The larger the events that occur, the more storage is necessary. The alternative to events managements is to operate one or more added compressors (partially loading all compressors) so that when an event occurs capacitance which is not in storage will be available in "on line" power. This type of storage can be used to match events also in the system to the shortcomings of the compressor controls.

An excellent example would be to prevent rise to surge problems associated with centrifugal compressors. The alternative is expensive and exotic control alterations to the compressors to allow them to operate closer to the optimum performance pressure of the unit.

Load Shaping Storage:

This is a large volume of storage that is maintained off-line from the system at considerably higher pressure than the use pressure in the system. This volume is introduced into the systems based on events management. When the rate of change exceeds a preset value or the demand pressure drops below a set point, the volume is metered in to the system at a controlled or limited rate of flow to prevent the addition of a compressor or compressors. The air is replaced in the off line storage with a very small compressor, usually 5 – 20 horsepower which operates virtually continuously. It is most important that the manner of introducing the air to the system does not cause the pressure to rise. It should only maintain or control the amount of pressure drop. It is not unusual to use a 10,000 to 30,000 gallon storage tank for a load shaping application.

Typical load shaping pressures are 150 psig to 250 psig. The off-line volume can be introduced on the supply or demand side of the system.

As an example, if you are storing at 200 psig and using 80 psig, the useful storage is (200 – 80 psig) atmospheric pressure x the capacity to store. If the capacity of a 30,000 gallon tank is 4,010 cubic feet per atmosphere, you would have (120 / 14,696 x 4,010) = 32,749 cf to use to reduce on line capacity, you could use a 10 hp compressor operating all he time to reduce the need for an on-line compressor that could be 50 to 100 times larger.

General Storage:

This is the volume of storage in the overhead piping system from the discharge of the compressor room to the point-of-use pipe drops. Its purpose is to support point-of-use events instantly until control storage or compressor capacity can service the event. Since air has a finite speed or velocity based on the pressure differential in the piping, general storage supports the user during the seconds it takes to stop the decay of an event and support the user during the delay. The amount of useful storage, the transmission time supply, and the size of the event determines how much the pressure will drop.

The highest critical pressure of any user in the system, and the largest volumetric event in the system versus the lowest supply pressure determines the amount of necessary general storage.

The normal perspective of a system with inadequate general storage is inadequate supply. The result is elevating the supply pressure and energy to achieve this. General storage also acts as a buffer between the user in the system. If general storage is maintained at least 1 psig above the

highest user pressure in the system, no user will ever be affected by another user. Again, the alternative is more on-board power to elevate the entire system's pressure.

Baffling Harmonics or Controlling Pulsation:

Most receivers that are applied to compressed air systems are installed immediately downstream of reciprocating compressors for the purpose of reducing pulsation in the discharge flow from the compressor before the air enters clean-up equipment such as dryers or filters or continues in the system's piping. Also, it is used to isolate a reciprocating compressor from other types of compressors, which would not respond well to discharge pulsations. Usually this is guessed at and not engineered. In addition, this is not the best approach to snubbing pulsations.

There are harmonics baffles or snubbers which are designed specifically for the inlet and discharge for reciprocating compressors for this purpose which are not only more effective, but use a great deal less space. One of the by-products of storage immediately downstream of compressors and upstream of dryers and filters is high flow and velocities which can overload cleanup equipment and degrade the cleanliness of compressed air users.

Dedicated Point-of-Use Storage:

This is storage, which is checked to a specific point-of-use application for one of the following purposes:

- **Service an application with added storage so that the rest of the system does not experience the effect of the user. This is normally to protect another high critical pressure user.**

- **Provide the needed volume for a high volume short cycle application where the recovery of the storage vessel is metered to a longer time period than the use period to a lower rate of flow. Without this, you would have to supply the necessary power to support the high volume, short cycle user all the time so that when the event occurred, you would not allow pressure to drop below a minimum value.**

- **Support a critical pressure user while another larger event is occurring. You need only store enough volume to control the pressure drop of the user during the time when the other event is occurring.**

- **Increase the cubic feet per psig at a location near enough to application to increase the speed of the application and rate of flow. This is normally called a volume – seldom more than a gallon – and is applied to users with a cycle speeds of less than a second.**

Note Well**: As with other applications, the lack of storage and the alternative is to diagnose insufficient supply pressure and apply the operating cost associated with elevating the pressure.**

Storage in the system is potential energy, which can be used at a higher rate of flow than the power necessary to develop it. It is a time energy management tool in the system. It is unfortunate that most people look at the system from the compressors out to the users instead of the reverse. Storage is believed to be required by certain types of compressors and not others.

The fact is that systems need a variety of different types of storage in order to operate efficiently and accurately. The more storage in a system, the more accurately you can control pressure fluctuations and provide stable operating pressure to all users.

Useful storage equals the capacity to store air times the useful differential divided by the atmospheric pressure. Without a useful differential, storage serves no purpose.

In most systems, the only way to use storage is to allow the pressure to drop at the production end of the system. If you are managing the system on a minimum-only pressure only basis, the problem is that you must get the pressure high enough to avoid the minimum results. This involves more supply energy plus the effects of pressure fluctuations on production quality. By managing the demand pressure you can allow the differential on the supply side with no effect on production results and minimum energy based on volumetric need.

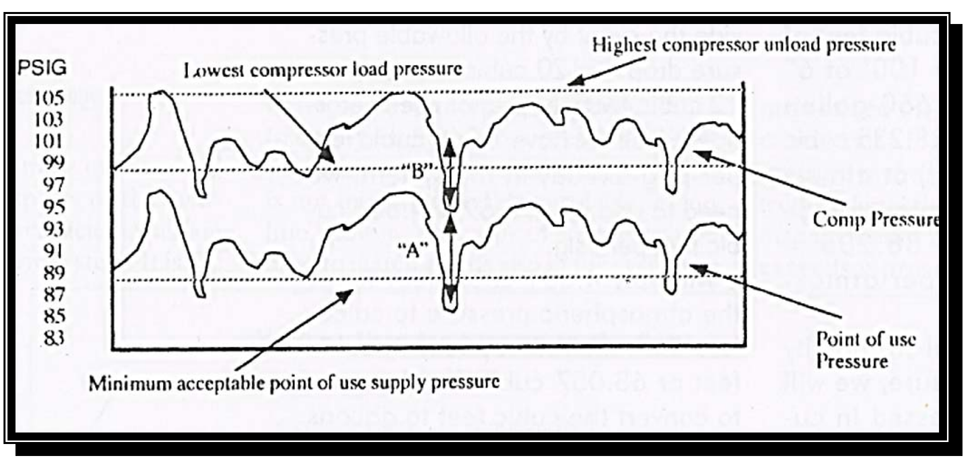
Figure 1 indicates the compressor pressure as it fluctuates with the changing demand and the compressor loading and unloading. You will notice that point-of-use pressure tracks with the compressor pressure. This is because of the differential across the filters, dryer, valves, and piping between the compressors and the point-of-use. The differential is “A”. “B” is the system’s pressure drop from events that occur n the system when demand exceeds supply for short periods of time. How much pressure drop occurs is based on the relationship between the size of the event in standard cubic feet/second, the storage capacity in the system or increase in its displacement capacity to the system to stop the decay.

As the system’s flow capacity, including the parts therein, is fixed except for the filters (which increase in differential as they get dirty), when the flow increases the compressor pressure drops until the next unit loads. As the supply pressure drops, the differential across the components increases. This causes the point-of-use pressure to drop at a more than linear rate on the downstream side of the differential. Automation can operate the supply system at a single set point, which can prevent an unnecessary low supply pressure regardless of the required volume or the number of compressors needed to support it.

Most filters cartridges are changed on time or maximum differential. This requires you to operate at a high enough pressure to tolerate the worst delta pressure you would experience in time or allowable differential.

Clearly, you should select the filter for the lowest differential (higher initial cost) so that you can change the cartridge based on system’s needs and operating energy needed to support the differential. Increasing the system’s capacity for useful storage in standard cubic feet/psig would limit the amount of pressure drop that would occur between the time when the size and duration of the demand event and the control permissive time for the compressors from the time a signal seconds from 6 – 120 seconds depending on the type of compressors, type of starter and the operating mode of the controls.

Additionally, you could reduce the differential across the equipment and piping between the supply and the demand. The reduction would increase the point-of-use pressure without increasing or adjusting their supply energy. Usually, you do not have to replace the equipment or piping. Also, you can parallel enough capacity to reduce the differential.



Since differential is exponential rather than linear, diverting a small amount of air from the existing equipment or piping can produce a significant reduction in differential pressure. In some cases, depending on amount of differential and where it is, you can increase the use pressure and reduce energy on the supply end simultaneously.

The pressure drop that is experienced from demand exceeding supply events can be controlled by either reducing the event or the coincidence of events which cause the pressure drop, by controlling how you allow the system to see the event such as metered recovery of dedicated storage, or by increasing the system's general storage in standard cubic feet/psig which would support the same event allowing the system's pressure to drop slower and terminate at a higher pressure..

R. Scot Foss is president of Plant Air Technology, Charlotte, N.C., a company specializing in system auditing and designing. This series of articles is based on his book, "Compressed Air System Solution Series". A portion of the proceeds from sales of the book is donated to children's charities. The book can be ordered through Southern Corporation.