Using Demand Expanders in Compressed Air Systems

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Increasing the amount of air in a system doesn't have to mean adding compressors.

Artificial demand is the excess volume of compressed air created for unregulated users as a result of supplying higher line pressure than necessary. It includes all unregulated consumption, including appropriate and inappropriate production usage, open blowing, leaks, and points of use with regulators adjusted to their maximum setting. These applications track the supply pressure as though there were no regulators being used.

As the supply pressure fluctuates, artificial demand changes from a minimum to a maximum waste level. When real production demand decreases and pressure rises, artificial demand increases. Eliminating leaks causes the pressure to rise and all unregulated demand increases in proportion to the pressure rise, including remaining leads.

Many systems have as much as 80% of their total volume uncontrolled. This condition results from regulator use based on the recommendations of equipment manufacturers. Most plants have regulators on 50% of their use points, which normally represent only a small portion of the total volume. Since little care is used in the selection of regulators and filters, they frequently have high pressure drops and require high settings.

Operators increase pressure to improve equipment performance. When an operator can no longer elevate the pressure, the supply pressure limit of the system has been reached. At this point, the application follows supply pressure. The volume required is artificial demand and can represent 10% to 25% of total compressed air used.

A demand expander can correct these problems, when adjusted to the minimum required system pressure. It is a main line valve that controls the maximum pressure at which demand air can be removed from the system (Fig. 1).

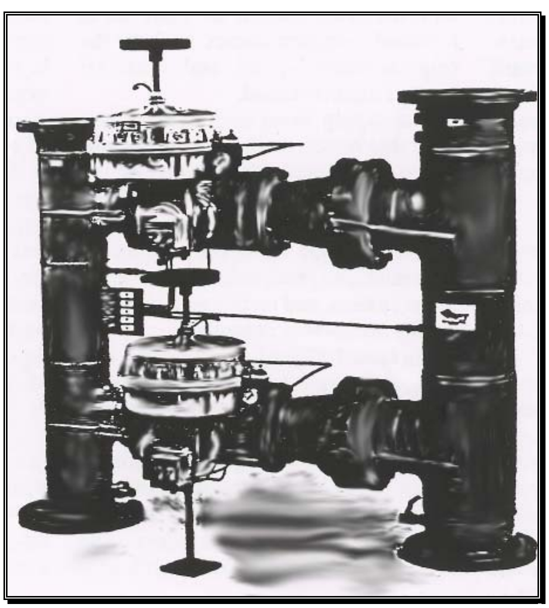

Fig. 1

A demand expander with two expansion paths has a backup valve to prevent a compressed air system shutdown.

(Courtesy APT, Inc.)

Expanders maximize air compressor and system efficiency by separating the supply side (compressors) from the demand side (users). They are designed to provide for the expansion of compressed air from storage to the system with a minimum loss of energy; results are a consistently lower plant air pressure. As pressure is lowered in the piping system, all unregulated flows and leads are reduced. The pressure dew point is also lowered as a result of expansion.

Expanders require little supply energy to function properly – as compared to a regulator that can require 5% to 10% of the system's input energy to overcome resistance to flow. It is a precise control device that has a control and response sensitivity within tenths of a psig. Using an expander allows storage to be maintained in the upstream supply system for handling variations in demand, rather than utilizing compressor power (fig. 2)

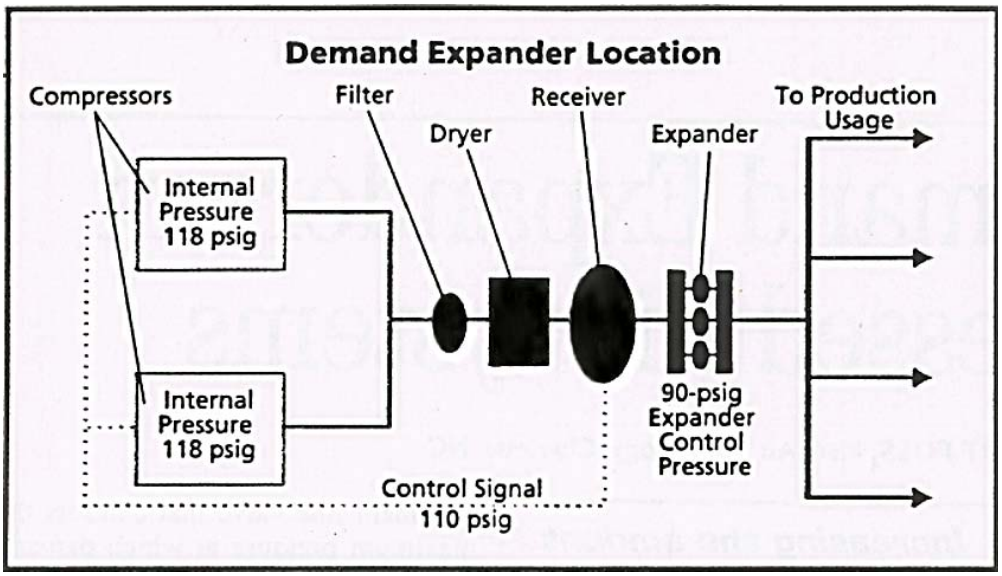

Fig. 2

Compressed air storage is maintained in the upstream supply system by a demand expander and subsequently released as required by various plant processes.

The expander allows compressed air to be stored on the upstream side and be instantly available to demand at the lower, downstream control pressure. Rather than operating the system at an elevated pressure all the time, preventing an event from dropping pressure below an acceptable level, storage is maintained for this purpose while not activating another compressor. Amount of available storage is a function of vessel size and useful pressure differential.

On the supply side, compressors that once served to dynamically meet every change in demand, now can serve storage. Compressor controls can be adjusted to a design point maximizing efficiency. Changes in demand do not result in immediate compressor activity. With proper compressor management, motor starts can be minimized and one or more compressors could be shut down.

Without an expander, demand is the same as supply pressure. Ideally, there are no leaks, everything is regulated, and all regulators are set at the minimum required pressure. However, this is not realistic.

Central or sector control of maximum demand pressures is far more reliable than hoping that all production and maintenance personnel are diligent in the installation and use of air operated equipment. If there are a number of use sectors that need different pressures, an expander can be used for each area to minimize the system's energy requirements.

When a new use of air comes on line (demand event), it can elevate operating pressures and generate a great deal of artificial demand. The excess of demand over supply energy is expressed as negative cfm. Until the supply system responds to the event, the air required is taken from the demand piping system. This action causes pressure to drop.

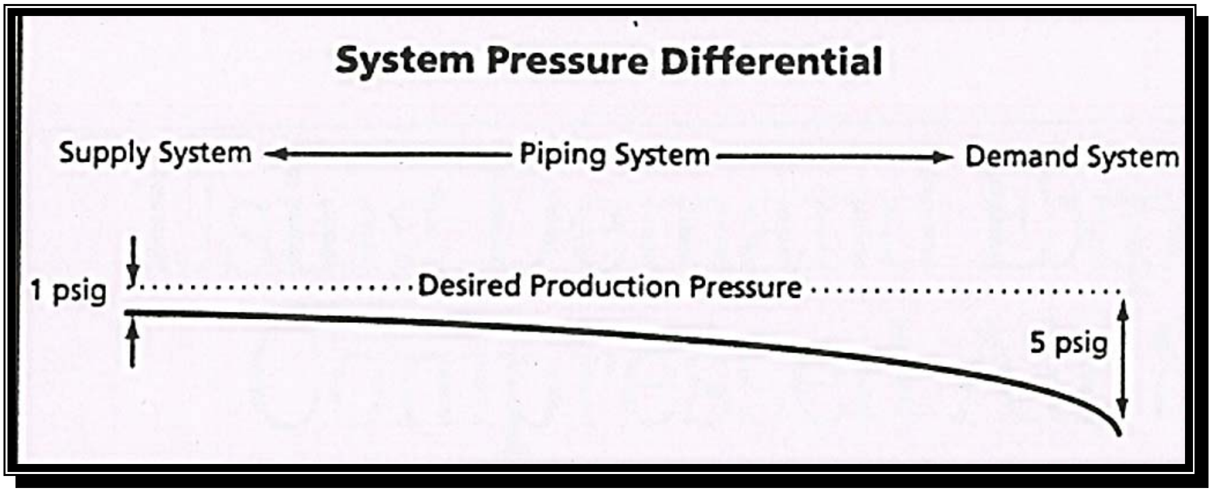

Fig. 3

Pressure decay from a demand event is greater at the point of use and causes a delay in system response, something a demand expander minimizes.

The effect of pressure decay is greater at the point of use and diminishes moving toward the supply (Fig. 3). The decay continues system wide until the supply adjusts. Next, the system assumes a positive rate of change until the event and the air removed is replaced, pressure comes back to the original control point, and a neutral point is again reached.

The supply never sees the pressure drop that occurs at the point of application, but users in the vicinity of the event do. The magnitude of the differential is a function of the size of the event, distance from the supply or transmission speed, amount of storage in the system, and response time of the supply equipment controls.

The usual way of dealing with this problem is to raise production pressure at the point of use so it never drops below an acceptable level. This approach involves adding compressors to achieve this elevated pressure, and significantly increases the artificial demand volume in the system. ‘The compressor room only knows it has to run the system at a higher pressure to avoid phone calls from production.

This problem is usually rationalized as pressure losses in the piping. If the piping system is reworked, it does not improve the situation other than provide a minimal increase in storage. If the compressor controls must see a 1 psig drop to respond, pressure at the point of use can drop more than 5 psig. If the supply must drop 2 psig for a supply control response, the demand event may see between 5 and 10 psig drop.

If an expander has a 0.1 psig response range, the event would only drop between 0.1 and 0.5 psig. An expander would see the initiation of the event an allow control storage to stop system decay. Control storage should be large enough to limit upstream pressure drop while a compressor is started up and to prevent it from loading, if the event duration is short. Responsiveness of an expander determines production side pressure fluctuations.

Why are expanders designed to maintain small pressure range differentials, typically 0.1 to 0.2 psig? Many systems, prior to using an expander, fluctuated more than 15 psig at the point of use.

The small pressure range controls the response of the expander to events that occur in the system. An expander should open to allow control storage to stop decay at the other end of a system regardless of the distance.

Because of this response, demand can always be operated at the lowest required pressure. This figure requires less power and provides support for the largest system events with minimum artificial demand and the tightest possible control of pressure to production. Supply corrects to a neutral rate of change to events that occur and production sees no change in pressure.

Aside from the accuracy maintained in the production piping system, operating costs should drop. In a supply-controlled system, support of an event diminishes volume in the system until a compressor responds. The compressor must not only match the added demand event, it must also replace the lost storage in the system. The time between the event beginning and the response occurring determines how much volume must be replaced.

Typical pressure-only controls on compressors respond as fast as they can. The next available compressor or compressors bring the system back to the unload pressure. If the supply capacity is twice that of the event, response is fast.

An electrical peak is created and rapid cycling of the compressors begins. A typical solution is to turn too many compressors on and put them in modulation. This approach stabilizes system pressure but increases operating costs. Automated operation in conjunction with an expander can use a pressure, rate of change, and time protocol to limit the response to an event volume and not require any added compressor capacity.

Reprinted with permission from R. Scot Foss, president of Plant Air Technology, Charlotte, N.C., a company specializing in system auditing and design. This article is based on his book, "Compressed Air System Solution." A portion of the proceeds from sales of the book is donated to children's charities. To order a copy of the book, please contact Southern Corporation.