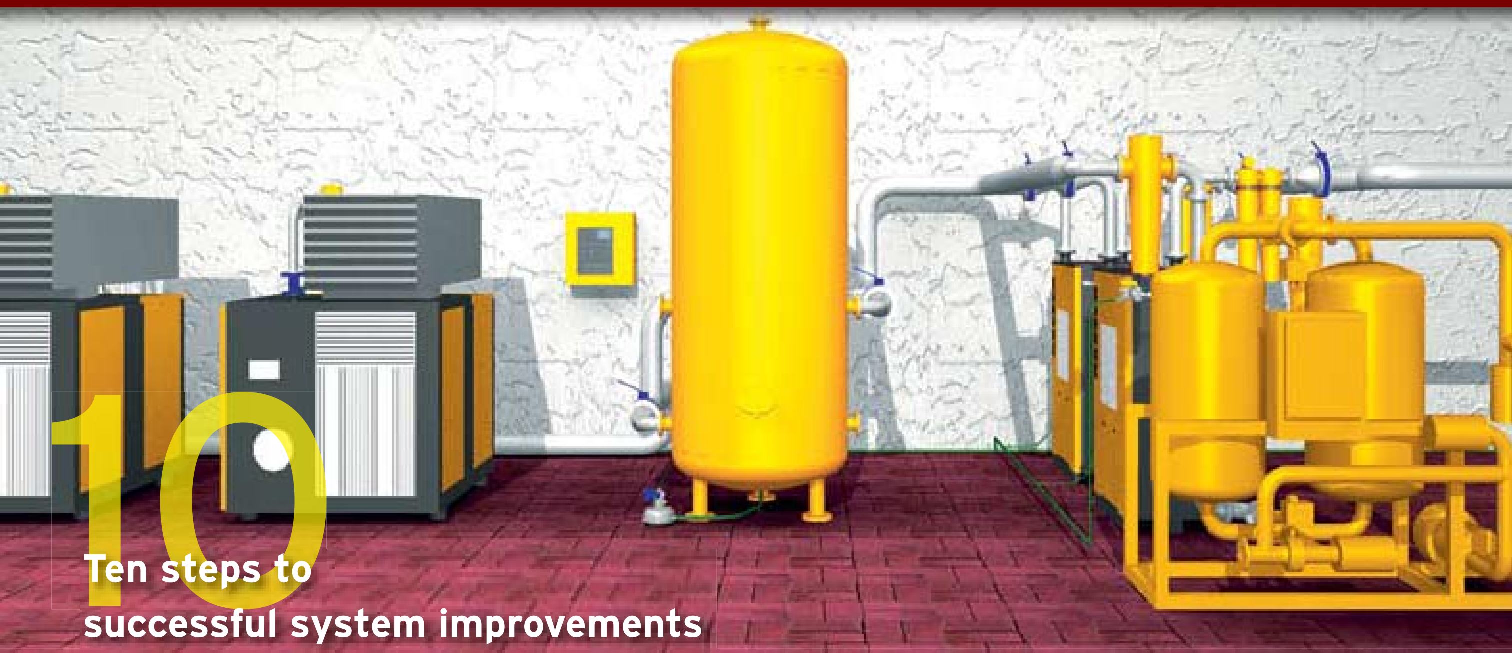

10 Ten steps to successful system improvements

PLANNING AIR SYSTEM UPGRADES

By David M. McCulloch and Bill Scales, P.E.

Most compressed air systems are relatively modest at first, but grow and develop as production, inappropriate uses and leaks increase over time. Even assuming that air leaks and inappropriate uses have been investigated and reduced, adding production equipment raises demand for compressed air. Some equipment may need a different operating pressure, and the required air quality may change. These modifications represent potential problems for the plant engineer who wonders:

- What is the required volumetric flow rate and the pressure of compressed air, and what size of air compressor should be added?
- What type of compressor and control system offers greatest reliability and lowest life-cycle operating costs?
- Where should the compressor be located?
- Is sufficient power, ventilation and cooling capacity available?
- What type of system capacity controls would be best?
- Is primary compressed air storage sufficient?
- Is distribution piping adequate?
- Is secondary compressed air storage sufficient?
- Is the current compressed air quality satisfactory?
- Does this project require professional help?

Compressor size

The current average and peak compressed air flow rates, in cubic feet per minute (cfm), should have been established before considering any proposed additions. The rated output of the existing compressor(s) also should have been established. The specifications for the proposed equipment that needs additional compressed air should state the required flow rate, pressure and air quality. This information provides the new total flow rate. Deducting the rated output of the existing compressor(s) gives the additional air flow required from a new compressor.

This calculation ignores potential leakage and increased inappropriate compressed air use. Also, it doesn't account for differences in the frequency of operation of each piece of production machinery. Individual consumption peaks might not occur simultaneously. Nevertheless, you'll need to determine the average and peak flow rates (Table 1).

Don’t add a fudge factor to the required air flow when calculating the rated capacity for the additional air compressor(s) because it could result in the new unit(s) operating at less than full capacity most of the time, robbing efficiency. Should you decide to oversize the additional compressor by 20% or more, select the compressor that combines the best full-load and part-load economy to minimize the operating cost over the full range of the compressed air requirements.

Another important consideration is standby capacity in case of compressor malfunction or needed repair. This may require at least one additional compressor. Conventional wisdom says that three 50%-capacity compressors are better than two 100% compressors, because this provides more flexibility without sacrificing system reliability, particularly during periods of reduced consumption. It’s also beneficial to operate the smallest total compressor horsepower, particularly for periods of reduced capacity requirements, such as a second- or third-shift operation. These factors, combined with reliable compressor service, are keys to maintaining energy and production efficiencies and profitable outcomes.

Compressor type

Each type of compressor has its advantages, disadvantages and preferred range of capacity and pressure. Table 2 provides a simple method for comparing different compressor types. Life-cycle cost analysis always is recommended, and should include specified maintenance.

Don’t add a fudge factor to the required air flow when calculating the rated capacity for the additional air compressor.

Compressor cooling is a major consideration. If water-cooled, the important issues include availability and quality of cooling water, disposal or recirculation, possible treatment and overall cost. If compressors are air-cooled, adequate room ventilation is essential. Heat recovery also is a potential opportunity.

Compressor size and type determines the electrical power requirements. Additional ancillary equipment may require a different voltage and current. Consider, too, the availability of the required electrical supply and its support equipment. Ensure that proper circuit protection is provided for the added electrical load.

Table 1. Basic demand worksheet				
End user identity	Minimum flow (cfm)	Average flow (cfm)	Peak flow (cfm)	Cycle time (seconds)
#1				
#2				
#3				
#4				
#5				
#6				
Totals				

Note: In some cases, the minimum flow rate may be very low or zero (cycle time - off) until an intermittent operation (demand event) occurs, when there is a large demand (peak flow rate) for a time (cycle time – on). The combination of these determines the average rate of flow. End users having a constant demand should be tabulated by the average flow rate. Peak flow events may require additional primary storage and secondary storage.

Location, location, location

Many plants have a compressor room and, in some cases, that room is shared with other equipment. Several factors must be considered if a compressor is to be added. These include the need for a foundation, space for maintenance activities, space for drying and filtration equipment, room ventilation to handle the added heat release and the sound level.

It might make sense to install the new compressor in a different location, perhaps closer to the point of greatest demand or at the application requiring the highest pressure.

Capacity controls

There are several types of capacity control for individual compressors, sequencing controls for multiple compressors and pressure and flow controls for compressed air systems. The correct selection of each determines system efficiency over the anticipated operating ranges.

Two rules for achieving optimum efficiency are (1) only the number of compressors needed to maintain the required system pressure should be in operation at any given time, and (2) all but one, a trim compressor, should be running at full capacity and pressure. The trim compressor should have an efficient capacity-control mode. If it's a reciprocating compressor, this could be unloading in a series of capacity steps.

Standby capacity in case of compressor malfunction or needed repair may require an additional compressor.

For a rotary compressor, variable-speed control or variable displacement is most efficient.

Storage and piping

The size and location of the primary air receiver affects the efficiency of your capacity control. Efficient system control may require changes in air storage volume, but adding receiver volume won't compensate for insufficient compressor capacity or inadequate distribution piping.

Many compressed air distribution systems originate at a primary air receiver in the compressor room where distribution piping moves the air throughout the plant. As production increases, another one or more buildings might be erected, but the supply of compressed air still passes through the original distribution piping. If the piping isn't adequate for the increased demand, the result can be excessive pressure losses and increased energy consumption.

The size and location of the primary air receiver affects the efficiency of your capacity control.

Intermittent high-volume demand can cause severe dynamic pressure fluctuations in the entire compressed air system that can upset manufacturing processes. Many fluctuations can be softened with an appropriately sized and located secondary air receiver that can provide enough air to satisfy the intermittent demand without compromising the pressure in the main system.

Air quality

Each piece of production equipment requires compressed air at a given flow rate, pressure and air quality. These considerations may vary significantly. A cardinal rule is to avoid drying and filtering compressed air any more than is needed for the specific application. Going overboard can result in increased pressure losses and energy consumption. Consider the idea of satisfying the major compressed air requirements

A typical compressed air system

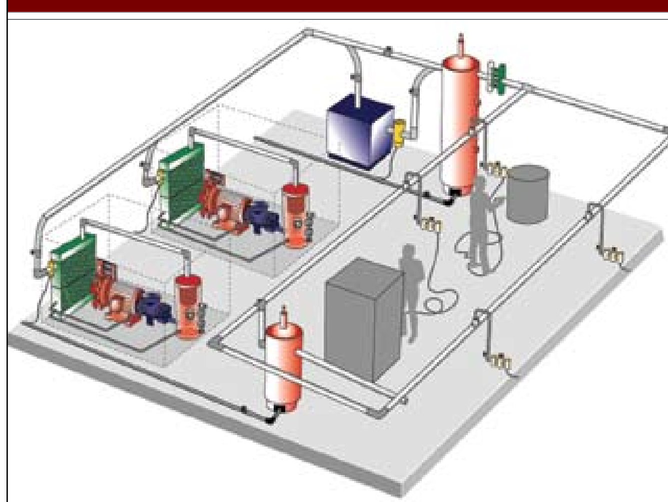

Figure 1. Compressor efficiency is a function of pipe geometry, leaks, operating pressure and other factors.

Table 2. Simple matrix for comparing compressor types[1]				
Compressor characteristic[2]	Compressor type			
	Two-stage, double-acting reciprocating	Lubricant-injected screw	Lubricant-free screw	Centrifugal
Size and weight	3	1	2	2
Compact size and complete package	3	1	1-2	1-2
Can be located close to points of use	4	2-3	2-3	3
Maintenance cost	3	2	2	1
Foundation requirements	4	1	1	1-2
Reduced capacity efficiency[3]	1-2	1-4	1-3	1-3
Lubricant-free air delivery - lube/lube-free	4/1	2	1	1
Lubricant carryover - lube/lube-free	4/1	3	1	1
Lubricant changes or makeup - lube/lube-free	4/1	3	1	1
First cost, including installation	4	1	2	2
Full-load operating cost, kW/100 cfm[4]	15 to 16	16 to 19	18 to 22	16 to 20

[1]These evaluations are general in nature and might not cover specific features of a given compressor type or manufacturer. They're intended to provide a general guide for comparing compressors. It's important to evaluate each point in any comparison of quoted equipment. Other factors to be considered include relative size and cost, warranty and service.
[2]Each compressor type is rated from 1 to 4. Key: 1 = very good; 2 = good; 3 = fair; 4 = poor.
[3]Refer to the section on compressor controls. It's important to compare kW/100 cfm at all reduced capacities.
[4]Operating costs are based on full capacity at a discharge pressure of 100 psig; a full-load motor efficiency of 92% and 0.746 kW/bhp.

centrally and supplementing these requirements locally, where needed.

Many industrial applications can be served well with a pressure dewpoint of 35°F to 38°F, which can be achieved with a refrigerated dryer. Standard regenerative desiccant dryers can drop the pressure dewpoint to –40°F, and more specialized dryers can bring it down to –100°F. Dry the air only to the requirements of the end users or to meet local ambient conditions.

Each piece of production equipment requires compressed air at a given flow rate, pressure and air quality.

Improving your air quality also requires filters to remove particulates and might require coalescing and adsorption filters to remove liquids and other contaminants. These added filters will result in increased pressure losses and maintenance requirements.

Outside help

In most cases, seeking professional help is a good idea. Equipment distributors with good local service capabilities can be helpful. An alternative approach is hiring an independent compressed air consultant to provide a product-neutral opinion or solution.

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The Compressed Air Challenge (CAC) is a national collaborative of public and private organizations dedicated to increasing the understanding and improving efficiency of compressed air systems within U.S. industry. The CAC offers Fundamentals of Compressed Air Systems and Advanced Management of Compressed Air Systems training, and in cooperation with the U.S. Department of Energy, the Compressed Air Systems Sourcebook for Industry as well as the Qualified AIRMaster+ Specialist training. CAC has built a reputation for being a reliable resource for cost-effective solutions and unbiased information, including the recent publication Best Practices for Compressed Air Systems, a comprehensive and detailed reference for plant personnel. For more information about CAC training and publications call (301) 751-0115 or visit www.compressedairchallenge.org. The authors of this article, David McCulloch and Bill Scales were also the authors of Best Practices for Compressed Air Systems.