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A Cost Effective Management Strategy For Controlling Leaks in Compressed Air Systems

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Leaks in a compressed air system cause more problems than are normally recognized. For instance, the imbalance of pressure in most air systems is a function of the level of unregulated demand of which leaks are the greatest contributor. The inability of the system to maintain consistent pressure throughout the header piping is also function of the unregulated demand. The increased power and elevated pressures that are required as a system ages are a result of a combination of factors including leaks at the point of use. Identifying and fixing leaks is the most obvious means of reducing compressed air costs but it is also the least permanent reduction. In fact, we classify leak repair in most systems as pointless, frantic activity. We have witnessed countless plants identify and repair leaks throughout their systems only to see the air demand return in a few weeks. Most leak control programs are short lived because of the temporary nature of the improvement and the difficulty of quantifying the value of the repairs. To effectively control leaks on a long term basis, we need to understand why the leaks reoccur with such persistence.

Lets examine the impact of leaks from a systemic point of view. The flow through a leak is similar to an orifice in that the flow is determined by the pressure immediately upstream of the opening. The pressure drops in the line supplying air to the leak based on the line's ability to support the rate of flow. For example, the air flow across a 1/4" orifice at 90 psig is 94 scfm but the flow through ten feet of 1/4" I.D. copper tube at 90 psig will be less than 40 scfm because the pressure will drop to 35 psig in the tube. If you attempt to raise the pressure at the discharge of the tube, the flow increases and the pressure will not rise at the discharge as fast as it does at the inlet to the tube. Leaks in an air system make it impossible to equalize pressure in an air system for the same reasons. When a new user enters the system, it is called a demand event. The air to support the event is removed from the header which causes the pressure to drop in the header from the application back to the compressors. The size of the drop in pressure is a function of the size of the event, the transmission time from the application back to the compressors, and the capacitance of the system. When the compressors respond with increased delivery to the system, the pressure will rise from the compressors out. Unfortunately, as the pressure increases so does the demand for air in all users which are unregulated including leaks, open blowing, and users with the regulator cranked all the way open. This phenomenon is called artificial demand and it prevents the compressors from being able to equalize the pressure throughout the header. The pressure will rise to the modulation or unload setpoint at the

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compressors before the pressure in the piping system will equalize. In systems with high levels of artificial demand, the system can actually absorb the increased power and flow. In either case, the pressure cannot be equalized from the supply side of the system and the droop in pressure from the supply to demand is the result.

The reaction of operators to the lower header pressures is to crank open the regulator to the maximum setting on any critical pressure applications. This will increase the article pressure (the pressure at the inlet to the device) up to the level allowed by the header pressure minus the differential on the regulator and filter. It will also cause the article pressure to track the header pressure. Effectively, this increases the artificial demand in the system by increasing the percentage of volume in the system that is a function of the system pressure. The Diagram below depicts the droop in pressure that exists in most systems and the impact on operating pressures.

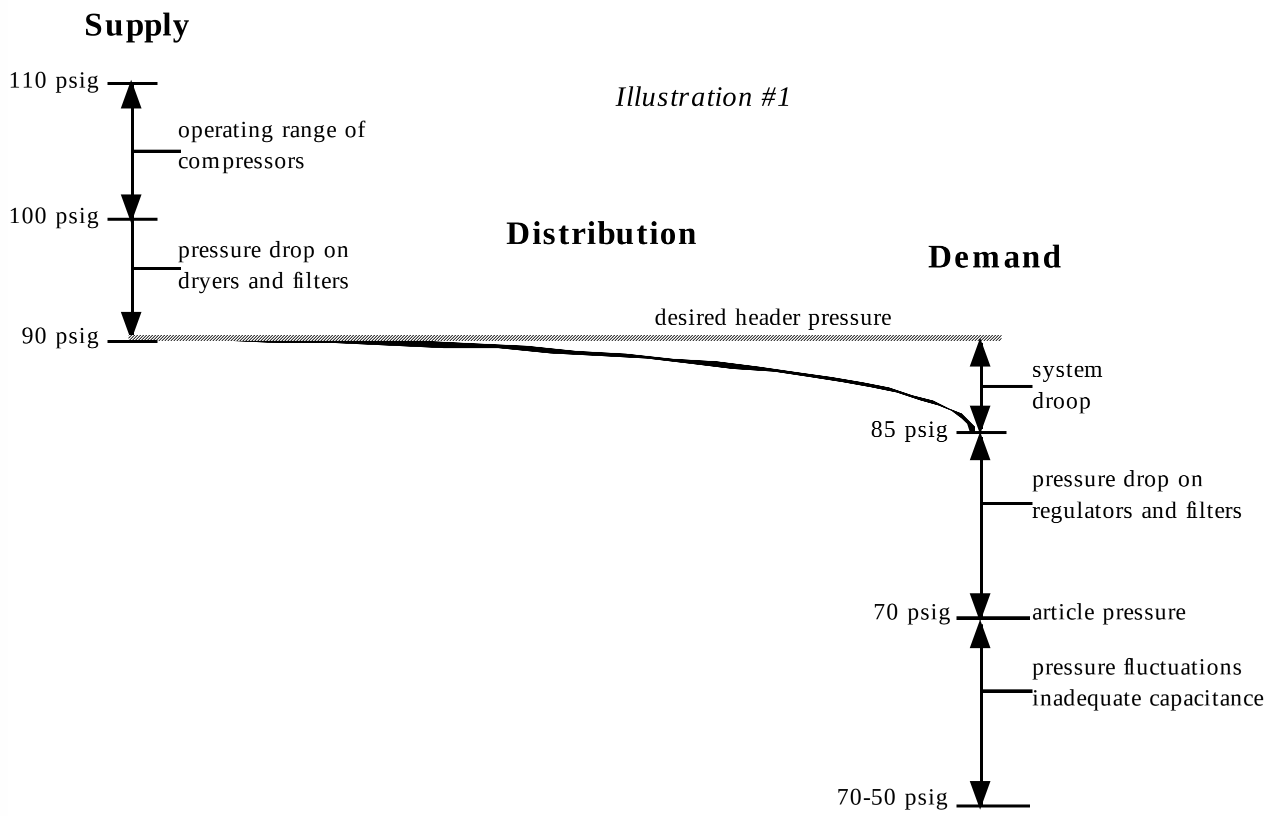

Illustration #1

The article pressure on critical applications now fluctuates with any variation in header pressure. When this impacts the quality of the results, production operators will request higher system pressures to elevate the minimum article pressures above the requirement. The pressure will continue to fluctuate at a higher level and the higher operating pressure will increase artificial demand across the entire system. The size of the pressure fluctuations will actually increase as the artificial demand increases as a percentage of the total system demand. Repairing the leaks runs into similar problems.

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When leaks are repaired, the pressure will rise in the vicinity of the repairs. The higher pressure increases the flow through any remaining smaller leaks. The velocity through the leaks increases exponentially to the increase in flow. The scale inside the pipe of most compressed air systems aggravates the problem by acting as a grit blasting compound when carried along by the increased velocity of the compressed air. The result is dramatically increased propagation of the remaining leaks which in a short period of time, returns leaks to the original level. The long term solution to these problems requires controlling the demand pressure with extraordinary resolution so that decreases in leak load will not cause increases in localized pressure. Compressor controls and sequencers, even PLC based systems, can not possibly provide this type of resolution. The only device we are aware of that can respond in this manner is a flow controller.

A flow controller uses precise control of a very low differential control valve to expand the air from the supply pressure down to the lower demand pressure without a detectable loss of energy. Constant pressure is achieved by controlling flow to continuously match the demand for air which is very different from a regulator that restricts pressure with mechanical springs or pilot air. The typical flow controller as shown in here, consists of a primary electronic PID controlled valve with a manual bypass circuit. A fully redundant pneumatic PID controlled circuit can be added for critical systems. A flow controller separates the supply side of the system from the demand side of the system. The pressure in the supply system can be set to maximize the efficiency of the compressors independent of any impact on the demand pressure. In fact, this is a critical factor in the proper operation of an expander controlled system. Maintaining a higher pressure on the supply side creates effective storage which can be used by the expander to respond in fractions of a second to changes in demand. The maintenance of this potential energy in the supply system can be designed to support intermittent increases in demand without necessitating the use of additional horsepower. A number of parameters must be considered to make a controlled system function appropriately. The maximum and minimum system demand, the size of the largest demand events, the rate of decay upon failure of the largest compressor, the capacitance of both the demand and supply systems, the longest transmission time of large events in the system, and other issues, depending on the system must be weighed to insure appropriate design. Once the system is controlled, the rate of leak growth will be limited as much as possible. It is then important to determine the appropriate leak level to maintain. This benchmark should be established based on

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economic factors. The goal is to minimize the labor costs of repairing the leaks and maximize the reduction in online compressor horsepower.

The labor costs will be determined by the type and quantity of leaks in the system. An assembly plant with hundreds or thousands of points of use will have many more leaks than a process facility with more pipe and fewer points of use. Some leak problems are specification and purchasing issues. For example, certain fittings, hoses, and disconnects are available which are markedly more leak resistant. The reverse is also true, some hardware is markedly more leak prone. While there is a higher initial costs for the better hardware, it is relatively small when compared to the costs of the leaks or the future repairs required. The use of a quality ultrasonic leak detector is the best tool to minimize labor costs in locating leaks which can often be most time consuming part of the process. Leaks should be reduced to a level which allows one or more compressors to be turned off. Any other goal is a waste of time. With an average of 4 scfm/hp (if the compressor is operating well), it does not take long to justify a leak control program with an appropriate budget. At $.06 per kWh, the costs to support 100 scfm or 25 hp of leaks will be more than $10,800 per year. The key to this approach is that if 100 scfm of leak repair allows you to turn off the next compressor the savings will be much greater.

Leaks are inevitable in a compressed air system and left unchecked they will cause production and quality problems. The cost of supporting leaks in a system makes a leak management program appear attractive, but efforts to repair or control the level of leaks actually increase the rate of reoccurrence. Definitely a case of diminishing returns. The application of some effort at understanding the actual critical article requirements and the proper application of system controls, such as a flow controller, can make leak control a manageable and financially attractive effort.

Dean Smith is the Director of Marketing for Quincy Compressor and was the Principal of Air-Science Engineering a consulting firm specializing in auditing and designing compressed air systems which was purchased by Quincy. He is a member of the Technology Core Group which wrote the training materials for the Compressed Air Challenge of the DOE. He has performed complete system audits on over 400 plant compressed air systems providing recommendations that have improved quality and productivity while reducing plant operating costs. For further information, Mr. Smith can be reached at (678) 355-1192 or email at Dean.Smith@quincycompressor.com.