White Paper

Gardner Denver

Compressed Air Audit

Successfully Planning & Overseeing a Compressed Air Audit

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Successfully Preparing & Overseeing a Compressed Air Audit

Topics

- Getting the Facts Straight (dispelling compressor room folklore)
- Logging Real Data (if possible log power, pressure and flow)
- System Analysis (compressors don't operate in isolation)
- Analyzing the Data (good data with bad analysis delivers bad results)
- Modeling a New System (there are many ways to skin a cat)

Where can the potential savings be found?

Getting the Facts Straight

Let's get right to the point, the application of compressed air is full of subjectivity, traditions, product or technology bias, and sometimes down right ignorance. Ask compressor suppliers and often they insist they have the best product for you without even knowing or asking for site requirements. Or talk to the maintenance managers of plants and many tell you the compressors **must** operate in a specific way and at a specific pressure when in fact this is not the case. Most likely these "requirements" are based on minimal personal experience in the compressor room, reviewing non-calibrated gauges or gleaned from maintenance personnel input over several years. I like to call this "compressor room folklore" and the reality is there is a lot of it going around.

The beauty of a properly executed air audit is that it abolishes all subjectivity, tradition and product bias. A properly conducted air audit will show the current state performance of the compressed air system with hard numbers that don't care about feelings, traditions or product/technology bias. These numbers, such as the power (in kW) to operate the system, pressure (in PSI) at which the system runs, air flow (in CFM) the system produces, and other metrics (such as dew point and temperatures), are the back bone of the audit. They are at the heart of an honest, data-driven evaluation of a compressed air system. Properly logged kW, pressure and flow are crucial when making decisions about a compressed air system. When these metrics are accurately audited, a new, lower cost system arrangement can often be planned out and thousands of dollars can be saved.

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Logging Real Data

Not all compressed air audits are equal and the old saying "you get what you pay for" doesn't necessarily hold true either. The audit data can be gathered a number of ways, not all of which are accurate or helpful. Many times a "quick" audit is conducted with the intent to understand flow requirements. In many quick audits, only the load state (i.e. whether the unit is making air or not) of the compressor is logged and then flow and kW numbers are calculated from the logged data. This process is riddled with inaccuracies that lead to suboptimal recommendations.

A better approach is to log current, or better yet kW, and then calculate flow from this data, but there still exists accuracy limitations. This method can show good results with a knowledgeable auditor that understands the control method, local set points, maintenance status, manufacturer's flow specifications and other compressor and site variables. Auditors at this level will rightfully charge compensation for their service, but still need to understand that when calculating flow or kW, even a small inaccuracy in the estimation table used to calculate flow can lead to significant deviations in the overall flow and performance of the system. Typically, only a knowledgeable, experienced auditor can ensure that data logging and the associated calculations are done correctly.

Since the primary aim of any compressed air audit should be accuracy, the best logging solution works off the assumption that *the less data that is calculated the better.* It is true that even the most precise logging gear is not 100% accurate, but the inaccuracy is in the 2–5% range, not in the 20–30% range that can result from poorly calculated kW and flow. So, the straightforward approach to accurate data is to properly install and use quality logging tools for **each of the data points** that will affect the outcome of the audit. These tools include true kW loggers, pressure loggers, temperature loggers and dedicated flow loggers. If you take this approach, you are on your way to a quality audit that can yield real results.

A Closer Look at the Tools

Although there is no excuse not to use true kW loggers and accurate pressure and temperature loggers, the use of flow loggers (meters) can be challenging. All flow logger types require some sort of interface into the pipe and a power source. Even the high quality, ultra-sonic style flow logger requires special pipe access to ensure accuracy. Although there are many types of flow meters available, the most popular in the compressed air industry is the mass flow style of meter. The following points will help you understand the challenges of adding a flow logger to an audit:

- The system will need a main header or riser where all the flow can be captured. If there is more than one pipe, a flow logger will need to be fixed to each of the pipes and totaled.

- The pipes will need to be carrying dry air downstream of the dryer. A differential pressure (dP) based flow meter can work in wet air conditions if the flows are within that specific flow meter's rated limitation.
- The meter will need smooth air flow in the pipe which requires a certain length of pipe with no bends or extra ports. Often, this requirement is difficult to meet.
- The pipe or line will need to be tapped at a calculated point to provide the smoothest flow within the pipe. If the plant cannot shut down, the line will need to be hot tapped.
- A 120V AC power source is typically required, so the use of extension cords for the duration of the audit may be needed.

If a flow meter cannot be utilized, then modeling flow from the kW logged is the only solution. When done properly, the calculation of flow from kW can be accurate if all key factors of the compressor are taken into account. As mentioned above, this can be fairly complex and a thorough understanding of the compressor is a must. The bottom line for data logging is to use quality equipment to log rather than calculate when possible and to have a strong knowledge of how the compressor operates.

System Analysis

It is standard procedure to log and gather information regarding the compressors when having an air audit conducted. What is often overlooked is **the compressed air system in total (compressors, filtration, dryers, sequencers, piping etc.)** Frequently the auditor is unfamiliar with one area of the compressed air system, and so that area is overlooked or ignored. This can leave major problems unaddressed or unaccounted for at the end of the project. The plant must understand that it is the compressed air system as a whole that it must operate, maintain, and thus financially support. At a minimum, the entire supply side should be included in any evaluation. The following list includes the components that make up the typical supply side of a compressed air system:

- Compressors
- Centralized controller or sequencer
- Wet tank (before the dryers)
- Header lines and how the compressors are piped into them
- Dryers which remove moisture from the air
- Filtration which removes particulate, moisture and oils
- Dry tank and how it is piped into the riser to the distribution system
- Distribution system from supply room to the farthest end of the plant
- Condensation drain system
- Oil-water removal system
- Ventilation of the compressor room

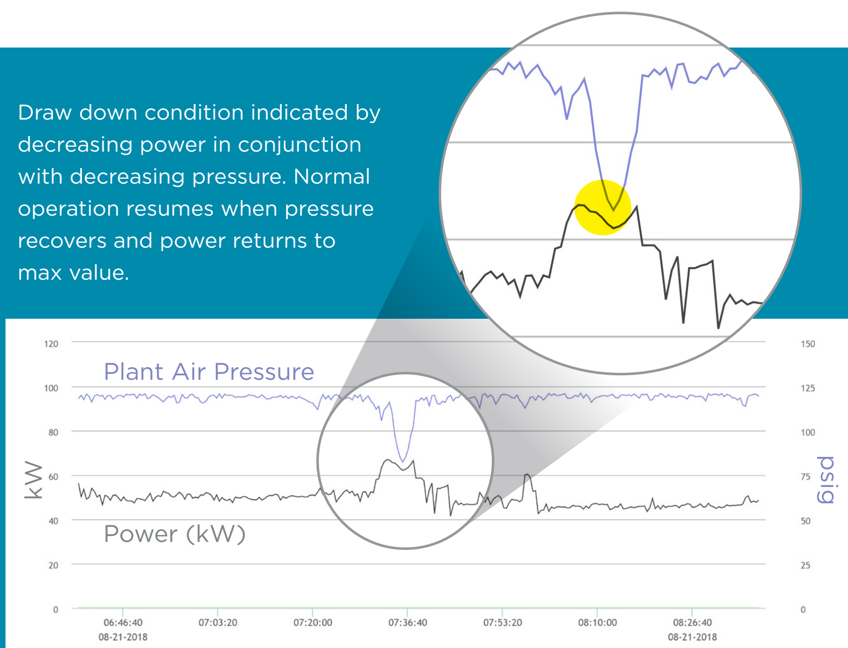
Critical supply side issues must be recognized during the walk through. These issues can include, but are not limited to, condensate removal, ventilation of the room or poor maintenance practices. To identify other problems, appropriate data logging and analysis are required. Some auxiliary data points that we capture throughout the audit and evaluate here at Gardner Denver to insure all problems are identified are distribution velocities, differential pressure across the plant's piping system, dew point, ambient conditions, rates of flow change, high flow durations, cycle times of compressors and dynamic efficiency.

An air audit that includes more than just the compressor(s) can provide insight and enhanced understanding on the true, full cost of running the compressed air system. In the next section, we will look at problems that can occur when analyzing the data.

Analyzing the Data

Logging good data is a solid start, but you must be able to properly analyze what the data is saying or the data is useless. A compressed air system's performance is typically determined by the amount of flow produced (CFM) compared against the power required to produce it (kW). These are undoubtedly the key points to performance. What is not so widely known to the client is how the auditor derives these numbers and what else is evaluated in the total system. Again, even if the auditor logs very accurate data, it is how the data is analyzed and reported that can make or break the usefulness and savings impact of the final report.

The condition of draw down (a condition where the compressors cannot keep up with the plant's air demand) is a perfect example of how missing small indicators in the data can corrupt an otherwise good report. Often, beginning air auditors or individuals that do not frequently audit compressed air systems will focus on flow and kW only. But only looking at these two variables can lead to a completely inaccurate interpretation of the system. For instance, if the plant goes into draw down significant miscalculations can occur. The only way to tell if the plant is in draw down is to look at kW and pressure at the same time with data samples taken at short intervals. Failure to look at kW and pressure simultaneously can lead to two different troublesome scenarios. If no flow logger was used, then the calculated flow will decrease as the kW drops. In this situation, the maximum flow and the time weighted flow required for the plant will not be accurately represented and replacement equipment may be sized inadequately. If a flow logger was used, then as the kW decreases from the pressure dropping, the compressed air performance will increase showing inaccurate efficiency performance data. The system may appear efficient when in fact it is not.



Draw down condition indicated by decreasing power in conjunction with decreasing pressure. Normal operation resumes when pressure recovers and power returns to max value.

Unique conditions like the above require the auditor to look at large amounts of data and analyze short periods of time at quick sample rates to locate them. As the computation power of the average personal computer increases, the ability to crunch these numbers becomes easier and easier. However, it is still no simple task when dealing with tens to hundreds of thousands of data points.

At Gardner Denver, we've taken it a step further and partnered with experts to create a program that the average user can operate to log real data, then quickly and intuitively scroll through it to look for suspected issues like the example above. We have also spent years refining our processes for quick but thorough analysis of compressed air data. In short, we have the tools, experience and expertise to properly evaluate any compressed air system.

Not all errors come from a misinterpretation of the data. Sometimes it is the simple things that can throw off data such as using flow data in SCFM with other data that is at a different SCFM or in ACFM. Perhaps the auditor forgot to compensate for elevation at the site or temperatures that will be present within the compressor room. In any case, good data can be rendered useless if careful evaluation practices are not executed.

Modeling, Modeling, & More Modeling

Now that logging has taken place and data analysis is complete, we are about half way home. The second half is solution modeling that documents improved performance from the compressed air system. So how does one decide where to make improvements?

The sky is the limit when it comes to what, where, and how to improve a system. Many times plant operations has elements of an approach they would like to implement or current assets they want to keep in operation that will provide some direction. This is acceptable as long as this input serves to improve the situation rather than limit success. Often, it makes sense to address large issues or easy-to-fix problems that the audit has uncovered first. One has to be cautious, however, of allowing the auditor to fall into a comfort zone, "standard fix" that does yield some cost savings, but leaves larger savings opportunities uncovered. Probe into the solution and see if it sounds cookie-cutter in nature.

At Gardner Denver, we work across all industries to optimize compressed air delivery and complete countless air audits a year. The audits range from the simple to the very complex. So, we don't have a singular approach to air audits because of the diversity of industries and clientele served. Regardless of the size or type of compressed air system—before even considering modeling a system—the auditor must have an understanding of the client's expectations and goals. Even before the audit starts, a meeting at the plant to identify objective is critical to final success. Solution modeling will then be focused upon satisfying the objectives as the process begins. With the client's goals in mind, the best modeling avenue can be pursued.

Although modeling has infinite possibilities, there are considerations to think about for every audit modeling exercise. The key areas to include are compressor performance, dryer performance, filtration, distribution performance (piping) and condensation removal. Each one of these variables can be looked at individually. Using the logged data from the audit, each variable can be compared to the *Best Practices* value or practice from a system of similar type and size. Poor performance will be relatively easy to recognize. Filtration, distribution, and condensate removal are the easiest areas to improve, while enhancing compressor and dryer performance is more challenging.

It is not uncommon to model a line-up of compressors and dryers that shows good performance numbers on paper, but then do not deliver the savings once installed and operating. So what goes wrong? There are several possibilities, and many of them may overlap. Here is a quick summary of common mistakes on the supply side when modeling an air system. General knowledge of these will help you converse with the auditor more effectively and ultimately end up with the results you desire.

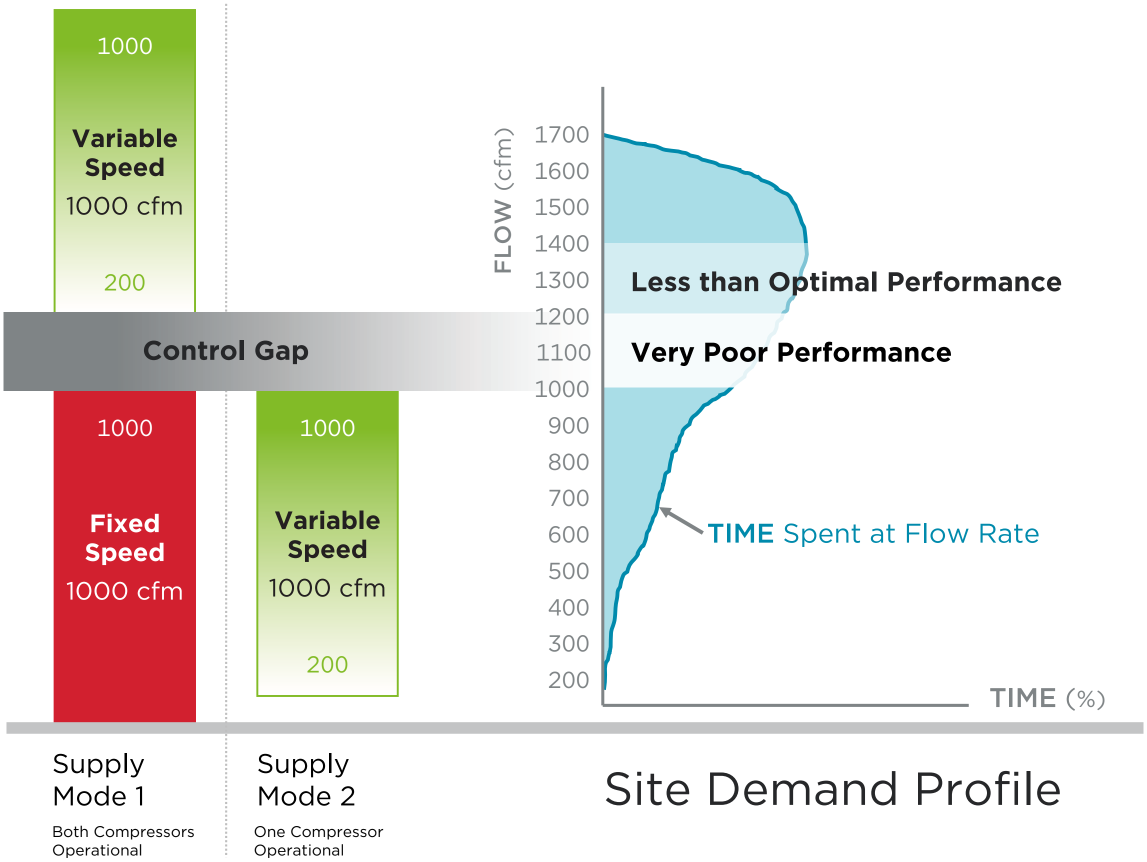
The compressors have no way to be controlled by a central computer (sequencer).

The auditor may be great at his job, but how well does he understand the control options on brand “A” equipped with a generation “X” controller? Is it easy to control? Will heavy modifications need to be put into place? Can it be controlled by a third-party sequencer? This is where a very detailed analysis of the compressors and extensive field experience pay off. Many times older units cannot be easily controlled and getting them to a controllable state will require too much money and engineering experience. At Gardner Denver, we have control engineers within our auditing group because without proper compressor control, you will never take any savings to the bank. The expertise and experience to properly control any brand or type of compressor is possible, but you need to have the right people doing the right things to the system.

The compressors as a group perform very well at a static, unchanging flow level, but when performing dynamically across a flow range, poor performance results.

This is likely the most overlooked performance issue in the compressed air industry. Engineering firms like to request bids with static flow figures and often sales groups will show just how efficient the compressor is at a static flow. Unless the flow is a static number, which is rare, these performance figures do not tell a true story.

In practice, the compressors will likely be expected to deliver air over a flow range, and how the compressors perform over that range is the critical issue and depends upon several variables. When pairing more than one compressor with others, the order that the compressors are turning on and turning off must be defined in the most efficient manner. Thus, you must know how this will be accomplished. And finally, performance must be modeled for situations where flow is increasing in the range and where flow is decreasing. If you model one of those and assume the other will be the same, there is a high probability that you will be wrong.



Control gaps commonly exist in compressed air systems, especially when the variable speed (VS) compressor is the same capacity as the fixed speed compressor.

Pairing machines together that have poor performance when sequenced together, such as a variable speed and fixed speed compressors of the same size, is another common practice in the compressed air industry with engineering firms and with different sales organizations. The problem comes from the gap between the maximum flow of the VS versus the fixed speed flow plus the minimum flow of the VS. This is the difference in flow of the fixed speed running as a baseload with the VS at min speed/flow (Mode 1), to the variable speed running by itself (Mode 2). This is usually directly in the middle of the plant's projected flow range and thus plays havoc with efficiency and compressor longevity. There are two ways to fix this: one is to replace the fixed speed with a smaller unit, and the other is to replace the VS with a larger VS compressor.

The compressors are programmed to operate within their own set points, but are not all connected to a large wet header or tank.

This is a fading issue as sequencers have come down in price and typically show a return on investment (ROI) of weeks, not months or years. However, without a centralized sequencer, a problem occurs when the compressors are not all connected to one header. Here is what happens: when a given compressor loads, it creates some back pressure due to the differential pressure across the downstream dryer and filtration components. This differential pressure is only seen by the one compressor that loaded. Additionally, all of the other compressors in the group will only see their own differential pressures across dryers and filters when they load. And when a compressor unloads, the pressure differential is eliminated for that single unit. Because all the sequenced units are not seeing the creation and elimination of the same pressure differentials at the same time, these compressors CANNOT be controlled properly, let alone in any efficient fashion.

Typically, to manage the above problem, the spread between the load and unload set points on each compressor is increased to a level that is much higher than if the group of compressors were piped together directly or if there was a central sequencer controlling the group. Whenever the spread is increased or the unload pressure is raised, you are spending more for the compressed air that is generated. The **correct solution** is to use a centralized sequencer that operates all the compressors from the same tank pressure or to connect the compressors directly to each other, so they all operate off the same pressure. The number and size of the compressors usually dictates the preferred solution. High costs can be associated with getting this issue properly corrected.

Poor piping following the compressors which generates high air velocities leading to erratic compressor operation.

High air velocities (greater than 20 feet per second) can be directly equated to high differential pressures, causing the compressor to operate at an elevated pressure to achieve a given flow throughout the plant. This decreases the efficiency of the system, which increases operating cost. Additionally, you are likely to experience the sequencing difficulties outlined in the previous point.

Lowering the air pressure or decreasing the air flow may not lead to a performance gain if the compressors are not capable of dynamic (efficient?) flow in the proposed ranges.

Lowering pressure or decreasing the flow requirement in the plant will only be effective if the compressors are capable of adjusting to and being efficient at the lower values. One will almost always see some decrease in power usage if the pressure or flow are reduced, but the critical question is: Will the power be reduced to what is being modeled? If the compressed air system cannot react dynamically to the change, the ideal or modeled performance will not be achieved.

As an example, lowering pressure (PSI) increases air velocity, so... is the pipe size large enough to manage the increased flow linearly and provide the savings modeled? On the air flow side, lowering the flow may put a compressor into a short cycle condition, decreasing its efficiency and life. For a variable speed compressor, the flow reduction could put the VS unit at minimum speed, leading to increased oil carry-over and operation at a less efficient point in its performance curve. Finally, in an extreme flow reduction example, a large centrifugal currently operating near the bottom of its flow range would just bypass all the compressed air to atmosphere with no change in performance. It is common to make an air system change designed to improve efficiency, only to find that little to no impact resulted because the details of the system were not well understood.

A lack of sequencer understanding—the right equipment has been purchased, but no one has the expertise to get it working properly.

Although all of the above listed concerns are major problems that often go unnoticed, this final issue is one of particular importance. The right equipment has been sold, but the local technicians do not know how to work with it. The equipment is on the wall, but even years later, it has yet to be set-up or correctly applied. One solution is to determine who will be installing the equipment and if that individual has a direct connection to the manufacturer. At Gardner Denver, we have a dedicated auditing and service group to ensure no questions are left unresolved during system set-up or after the system is in operation.

Believe it or not, the above was a short list of potential modeling miscues. The auditor must be able to navigate whatever complexities the system presents. To properly take into account all the air system potential pitfalls, the auditor must have an extensive understanding of the following:

- Compressor Control Methodologies
- Control Interface Options of all Compressor Brands
- Compressor Operation Characteristics
- Compressor Operating Limitations
- Dryer Characteristics
- Dryer Type Limitations
- Effects of High Velocities in Distribution
- Effects of Tank Size and Placement (both for the compressors and the dryers)
- Quality Classes of Air and the Cost and Requirements of Each

SUMMARY: Are You Ready for an Audit?

As you can see, you want the right auditor doing your audit, just as you would want the right doctor removing your blood clots. But you do not have to be a practicing compressed air auditor to have a quality conversation with perspective suppliers. Remember the following when considering an audit:

- An air audit is designed to deal with facts and numbers. In doing this it is possible to project, and then verify, energy savings from a reconfigured air system. For most audits, one objective is to lower your cost of producing/using compressed air.
- Auditing involves data logging of information about the compressor system. Ideally, you want to data log actual power (kW), pressure (PSI) and air flow (CFM) with logging equipment, rather than calculating these variables from measurements of the others. You can make calculations when necessary if you are careful and follow the correct procedures.
- You are trying to set up an efficient compressed air system, not just buy or operate an efficient compressor. A system goes well beyond the compressor into the air dryers, filters, piping and more. System efficiency is what determines what you will pay for air, thus the entire system must be evaluated.
- You want good data, but it needs to be supported with great analysis. Great analysis is what will identify big opportunities. A “canned” solution that is the recommended fix for every audit performed is a big red flag—run the opposite direction as fast as possible, and find a new auditor.
- Solution modeling can be quite complex. If it looks good on paper, take the “trust but verify” approach. Make sure that you are getting in actual performance what the model projected. This will allow you to take dollars to the bank.

And finally, remember that no audit at all is better than a poor audit. With the information presented here and some diligence, an air audit, and the corresponding air system changes, might just be one of the most profitable activities you tackle this year.

Are you ready for a compressed air audit?

Gardner Denver delivers the broadest range of compressors, blowers and vacuum products, in a wide array of technologies, to end-user and OEM customers worldwide in the industries we serve.

We provide reliable and energy-efficient equipment that is put to work in a multitude of manufacturing and process applications.

Products ranging from versatile low- to high-pressure compressors to customized blowers and vacuum pumps serve industries including general manufacturing, automotive, and waste water treatment, as well as food & beverage, plastics, and power generation.

Gardner Denver has an extensive and highly qualified network of air compressor distributors that offer 24-hour service and technical support to address your needs quickly and easily. Learn more about our air compressor product lines, request a quote or reach out to us with any questions by visiting our website.

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