COMPRESSED AIR — PART II: COMPRESSED-AIR SYSTEM AUDITS

Part I of this article, which appeared in *PBE*'s May issue, discussed reframing your facility's compressed-air issues with a return on investment in mind to avoid unnecessary expenditures. Part II describes what a compressed-air system audit entails and how it can help you identify issues in your system and prioritize solutions.

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A compressed-air system audit is the first step in eliminating waste and inefficiencies in your compressed-air system. An air audit should be a comprehensive look at all costs associated with a particular facility's compressed-air system and how those costs can be reduced. In this way, an air audit is a road map for how the plant's air system should evolve in both the short term and the long term.

It's often said that a well-formulated question amounts to 50 percent of the answer. If you or your compressor supplier don't know the right questions to ask during a compressed-air audit (starting with what you want the audit to accomplish), the audit results may not be particularly helpful (and probably won't solve any of your compressed-air issues). A compressed-air system audit should be performed by an experienced, professional auditor, who knows how to identify a system's vulnerabilities and inefficiencies in order to lay out a prioritized action plan that effectively tackles their root cause and exploits cost-reduction opportunities. Without an audit, many plants will opt to purchase additional compressors to address a compressed-air problem, but this requires additional capital, installation, energy, and maintenance costs while failing to address or eliminate the problem's root cause.

An air audit also provides the knowledge a plant requires to make better business decisions concerning its compressed-air supply at all levels. Most of the engineered waste (waste from deliberate initiatives created by compressed-air users to work around a real issue) arises from a lack of understanding of the problem at hand. At the same time, ignorance of actual compressed-air costs prevents companies from looking at more efficient, alternative solutions.

Unfortunately, for many companies, an air audit is whatever an expert tells you it is. This approach almost automatically guarantees that money that your company or plant could use elsewhere will be left on the table. Rather than passively seeking proposals for an audit, you should define for potential bidders your minimum expectations for the audit while allowing those bidders to offer additional ideas you may not have thought of.

Having clear objectives

In most audit inquiries we receive, the company's goals are muddled. Often, there's a single underlying issue driving the desire for an audit — the pain of workarounds has become so bad that something finally needs to be done.

Most compressed-air systems aren't managed efficiently, but by being proactive and engaging both your equipment and service suppliers, you can build an air audit road map to lower costs. If you don't have a clear understanding of all the potential goals a project could achieve, there's nothing wrong with asking for help in developing the *scope of work* when searching for an audit provider. The scope of work is an agreement about the work to be performed on a project. If you have a singular goal, such as ensuring that new production equipment won't tax the existing system, then it's more than reasonable to limit the scope of work even though that might have a lower *return on investment* (*ROI*). ROI measures the amount of money spent on maintaining a major financial investment in relation to the investment's original implementation costs. This information is then used as a performance measure to determine the investment's efficiency.

Therefore, it makes sense to define the audit with a goal of reducing costs in any of these questionable areas where it may be possible. The plant should define its specific goals in each of these areas and then require the

bidder to explain their recommended scope of work and how that would achieve the company's goals.

Considering the variables

When thinking about the scope of work for a compressed-air audit, two variables that are important to consider are the breadth of the audit's goal and the audit's depth.

Breadth of the audit's goal. First, determine whether the audit should be designed to deal with one specific issue or to develop a long-term plan. For example, assume you want to incorporate a new piece of production equipment into your process, which will increase demand to a compressed-air system that you're concerned is already taxed. If that production equipment is being delivered sooner rather than later, it may make sense to limit the audit's scope so that you can understand the compressed-air system's capacity before the production equipment arrives.

Depth of the audit. The second variable to consider is how deeply the audit should examine your system, which can be broken into two broad categories. The first category concerns how much of your compressed-air system the audit will encompass. For example, should you focus solely on the compressor room or on leaks? What about applications that may be using excessive amounts of air? What about the pressure drop in the piping system? In most material handling systems, it pays to look at the entire system, especially when devising a long-term plan for system evolution. This would include looking at the compressed-air supply, distribution, and demand as well as the infrastructure that supports the technologies in the various areas. That infrastructure is broadly defined as procedures and people.

For example, if you want to reduce your facility's electricity consumption, is it better to turn off unnecessary lights or leave them on and just install more efficient light bulbs? With light bulbs, as with compressed-air systems, it's good to start with demand. If your consultant is only focused on installing a better compressor in the compressor room and not on how to use your existing compressed-air capacity more efficiently, you'll be missing one- to two-thirds of the potential savings.

The second category concerns the depth of the data the audit should develop in terms of which and how much data to collect. An example of this occurred at a mine processing facility, as shown in Figure 1. When auditing that facility, a compressor was found to be oversized by a factor of five. In this particular case, the client not only spent too much money on the equipment but also ran an oversized power supply up half a mile of rugged mountain terrain. The project should have cost $50,000 but instead cost in excess of $200,000. When asked how the compressor was sized, the salesperson replied that he just matched the size of the portable compressor that was running the site at that particular time. Clearly, this is an exaggerated case, but it illustrates the point that insufficient data collection and analysis can lead to very bad economic consequences.

What an audit looks like

A compressed-air system audit usually has three stages: preaudit, field stage, and analysis.

Preaudit stage. The preaudit stage is when the audit scope and objectives are defined. As mentioned previously, this is necessary so that the scope of work is specific to your compressed-air system issues and your goals are in focus throughout the entire audit. Usually, this stage is effectively done via a preaudit conference call or meeting that includes people with plant operations knowledge. However, major or highly complex audits might require an on-site preaudit.

Field stage. The field stage is when inspections and measurements take place. This stage includes installing sensors and data loggers and inspecting the compressor room, compressed-air distribution, and compressed-air points of use.

Analysis stage. The analysis stage is when the auditing team creates a model using the collected data from the field stage to understand the system's behavior and how that's reflected in terms of cost. From that, an optimal solution based on the existing system is developed.

Once the audit analysis is done, the auditor generates an output report and presentation of their

FIGURE 1

This mine's compressor building housed a compressor that was five times too big.

FIGURE 2

An example of the fully costed portion of an output report from a compressed-air system audit.

Action Plan — Compressed-air System			
Item No.	**Description**	**Capital Equipment**	**Installation / Expense**
	Central Compressed-air System		
1	Upgrade distribution piping from central-air system feeding cement mills. Upgrade from 2 inches to 4 inches to alleviate pressure drop issue.	€3,000	€4,000
2	Install new 30,000-liter dry receiver tank in central distribution header.	€30,000	€10,000
3	Automate compressors using existing PLC network for remote load and unload function.		
4	Develop logic for control of six central compressors using a common single-point pressure.	€10,000	€10,000
5	Use compressor with lowest unloaded horsepower for primary trim service.		
6	Evaluate installing a VSD compressor for central system when major repair (air end) is required for a failed unit. Improved part-load efficiency.		
7	Evaluate installing a two-stage compressor after next compressor required major repairs (air end) for improved full-load efficiency.		
8	Repair bad amp meter on 13360 compressor. Amp meter always read 0.		€500
9	Complete installation of flow meters located in the central-air compressor rooms.	€6,000	€2,000
	Cement Mill #4		
10	Purchase and install new 50,000-liter receiver tank downstream of the refrigerated air dryer.	€40,000	€20,000
11	Install an inlet control valve (open/closed) and a modulating discharge valve. Flow meter at the discharge to meter com-pressed air during transport. Integrate into local Siemens PLC.	€10,000	€5,000
12	Upgrade system controls to stage compressors using a single-point control from the dry header.	€5,000	€5,000
	Packing Plant Compressor System		
13	Cross-connect sulphate pump compressed-air dry header with the packing plant compressed-air header.	€1,000	€1,000
14	Shut off sulphate pump compressor and utilize excess capacity of packing plant compressor.		
15	Install back-pressure control valve in line between packing plant and central air. Set at 7.1 bar. Control valve to fully open in event packing plant compressor fails or is unavailable.	€3,000	€2,000
16	Automate compressors using existing local Siemens PLC for start, stop, load, and unload functions.	€4,000	€4,000
	Gas Conditioning Tower (GCT) System		
17	Purchase and install a new 1,000-scfm thermal mass refrigerated air dryer to treat excess air from GCT compressor.	€15,000	€8,000
18	Install a new 500-gallon receiver and back-pressure valve to spill excess air to central-air system.	€3,000	€2,000
19	Cross-connect GCT dryer to existing compressed-air dry header. Approximate run is less than 15 meters.	€1,000	€1,000
	Maintenance Issues and Lubricant		
20	Install ion resin filters on compressors 160 kilowatt and higher to extend the life of the lubricant.	€11,600	€2,000
21	Replace lubricant based on oil analysis results instead of operating hours.		
22	Investigate alternative polyolester- (POE-) and polyalphaolefin- (PAO-) blend lubricants with extended life up to 16,000 hours to replace the original 8,000-hour PAO OEM lubricants.		
	Sustainability of Compressed-air System		
23	Human machine interface development of compressed-air screens on plant's DCS system. Use metrics for efficiency and tolerance levels for various parameters as outlined in the provided report.		€10,000
	Measure 6 – Demand Side Reductions		
24	Demand side modifications.	€20,000	€25,000
	Measure 7 – Leak Reduction		
25	Repair leaks as outlined in the provided ultrasonic leak report (276-scfm reduction).	€6,000	€6,000
	Engineering and Project Management		
26	Detailed engineering.		€16,000
27	Project management.		€16,000
	Subtotals without contingency	**€168,600**	**€149,500**
	Contingency 15%	**€25,290**	**€17,625**
	Project totals	**€193,890**	**€167,125**
	Project total	**€361,015**	
	Electricity savings	**€151,222**	
	Total annual operating savings		**€164,145**
	Simple payback (months)		**26**

findings. At a minimum, the report and presentation should include the following:

Fully costed action plan. A fully costed action plan should detail the recommended equipment, installation, and services, as shown in Figure 2. One area to scrutinize very carefully is the estimated installation cost, especially its electrical component. Electrical estimates are often significantly low, as the industry doesn't always have a good appreciation of how expensive these costs can be.

ROI calculation. The payback or ROI calculation should show the savings broken down by category based on the audit's initial objectives, as shown in Figure 3.

Figures. Drawings and diagrams should be presented (as required) to explain all aspects of the system's operation.

Plant-issues write-up. The report should include a written description of all the issues the plant faces, which ultimately becomes the backbone for the system evolution. If funding the project will take a year, the write-up can be used in the future to remind everyone why you're doing what you're doing. The write-up can also become the training backbone for all employees, which is a critical step in changing the plant culture and necessary if you want to retain the savings.

The previous information should be part of the purchase order, which contractually guarantees that the auditor will provide you with this information.

What an audit shouldn't look like

When setting up a compressed-air system audit, there are two traps to avoid, both of which have selling equipment as the primary goal and reducing costs as the secondary goal. This distinction is critical, and you have to look at the ROI calculation to understand why.

The first trap is the adviser who has a vested interest in selling you their equipment. They'll determine which of their equipment will reduce costs up to the point that

FIGURE 3

An example of the ROI calculation portion of an output report from a compressed-air system audit.

Financial Analysis — Annual Cost of Operation								
Component	**Hours**	**Present hp**	**Present Cost**	**Proposed hp**	**Proposed Cost**	**Annual Savings**	**Existing kWh's**	**Proposed kWh's**
Electricity								
Profile 1: Full production raw & finish mills operating								
Compressors & dryer – summer	1,943	1,361	$98,616	745	$53,972	$44,644	1,972,321	1,079,446
Compressors & dryer – spring/fall	1,943	1,361	$98,616	745	$53,972	$44,644	1,972,321	1,079,446
Compressors – winter	1,943	1,361	$98,616	745	$53,972	$44,644	1,972,321	1,079,446
Profile 2: Raw mill down								
Compressors – summer	957	1,317	$46,997	704	$25,139	$21,857	939,935	502,787
Compressors – spring/fall	957	1,317	$46,997	704	$25,139	$21,857	939,935	502,787
Compressors – winter	957	1,317	$46,997	704	$25,139	$21,857	939,935	502,787
Total hours of operation	8,700							
Subtotal			$436,838		$237,335	$199,504	8,736,769	4,746,698
Average cost/kWh			$0.0500					
Average kWh reduction			3,990,071					
Annual cost per 1 scfm leak			$76					
Annual cost per 1 scfm leak (all costs)			$91					
Simple ROI			10 months					

the ROI is met. Please note that not every audit in our industry is done by competent and honest advisers. To put this into perspective, if an auditor is going to "prescribe" the medicine to fix your facility's compressed-air system issues, does it make sense for the auditor to own the pharmacy they're sending you to? Unfortunately in some cases, plants end up going to the "pharmacist" for their compressed-air system diagnosis.

This first scenario is a trap because the adviser could either inflate the total equipment price or increase the scope to sell more equipment to the maximum extent your ROI requirements would allow (as opposed to maximizing the project return).

An independent adviser, on the other hand, doesn't have a vested interest in selling equipment. They'll still use the same ROI or payback requirement, but they're free from the bond of focusing on selling their products. This allows them to focus on reducing system demand as well, and in my experience, the vast majority of audits miss opportunity on the demand side. Also, independent auditors have access to any product from every original equipment manufacturer (OEM) and service provider and can access those products for all areas of the compressed-air system.

The second trap is the automated survey. An automated survey for a compressed-air system audit is an online questionnaire that an equipment supplier sends out in an attempt to diagnose your system's issues without actually inspecting the system. To be clear, these automated surveys are better than a compressor salesperson picking a solution out of a hat, but they'll never give you an optimal solution from a financial perspective. By design, the survey's solution is always to sell equipment. For instance, there are compressors out there operating in what's called "modulation mode." When one of these compressors is analyzed, the result that inevitably comes back is "buy a variable-speed drive compressor." What the supplier neglects to tell the customer is that there's a switch on their current compressor that can typically result in a 50 to 80 percent savings of the drive at no cost. Now, the real world isn't that simple, as there can be reliability issues with just flipping a switch. However, the automated survey process doesn't allow you to make a fully informed decision by design.

An unofficial survey of independent auditors provided rough estimates of the percentages of audits conducted by advisers with a vested interest in the outcome. Independent auditors estimated that between 90 and 99 percent of the audits they see by compressor companies include suggestions for new compressors. To be fair, equipment that's getting long in the tooth and utility incentive programs in part drive those numbers. However, when asked what percentage of audits conducted by independent auditors result in recommendations for new compressors — and there's no incentive program or old equipment — the range given was 5 to 20 percent.

Finally, some companies are promoting remote audits. This is a shining example of the imprecise use of the word "audit." These services can provide some of the value that a live audit provides, but until there's remote viewing with a high degree of freedom that allows the auditor to explore every nook and cranny of a system, a remote audit will never supplant a live auditor on-site. For example, a kiln at a cement manufacturing plant has a camera that allows operators to view the inside of the kiln during operation. This camera requires one supply of compressed air to create a barrier that protects the camera lens from overheating and a second supply of compressed air that operates a cylinder that retracts the camera to protect it in the case of an internal positive-pressure event in the kiln. At one cement plant, an in-person audit revealed that these compressed-air supply lines had been switched, which could have led to the camera burning up and costing $10,000 or more to repair. A remote audit alone wouldn't have caught such a mistake.

Conclusion

A comprehensive compressed-air system audit can help you optimize your system beyond solving current issues or achieving a cost reduction within a couple of business cycles. An independent auditor can lay out long-term solutions in advance for different scenarios that will materially impact both cost and productivity. However, ownership of the process ultimately lies with you. It's your process and your money — keep it that way. It isn't that difficult if you keep an open mind and ask the right questions. **PBE**

Editor's note: Part III of this article, which will be published in July's issue, will describe a post-project-implementation plan to help a plant retain its savings for the long haul.

For further reading

Find more information on this topic in articles listed under "Compressed air" in the article archive on *PBE*'s website, www.powderbulk.com.

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