WHITE PAPER

The Challenges and Solutions of Air Leak Sensing

Boston Dynamics

Detecting and fixing compressed air leaks in miles of industrial process pipelines is important in maintaining efficient systems. Isolating the source of such leaks could save companies tens or hundreds of thousands of dollars in wasted energy each year and facilitate data delivery and digital transformation in asset-heavy sectors. Quadruped robots can help fill the gap.

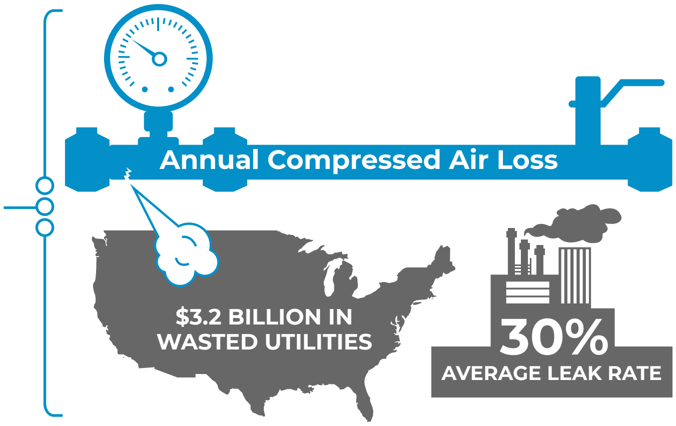
Manufacturing, and processing plants have miles of high-pressure compressed air piping running through them. These asset-heavy industries are working towards digital transformation and data-driven processes to deliver unprecedented efficiencies. But aging lines, as well as routine wear and tear, lead to leaks, resulting in losses and increased costs. Companies have limited time and resources to check for leaks, so compressed air is literally slipping through the cracks. Automated robot-driven monitoring can proactively identify and address the problem.

The Cost of Leaks

Compressed air is a safe and effective solution in a range of industrial processes. Compressed air is popular because it is versatile, accessible, and low risk. However, the costs of operating and maintaining these systems can add up—and leaks are one of largest operating costs.

Compressed air leaks pose several compounding issues. First, the energy costs from even small leaks add up quickly, according to the Compressed Air and Gas Institute:

"Estimates indicate that poorly designed and maintained compressed air systems in the United States account for up to $3.2 billion in wasted utility payments every year. A conservative estimate is that the average leak rate in United States manufacturing facilities is as high as 30 percent."



In addition, when there are leaks in the system, the air pressure drops and it takes even more power to do the job. This increases costs for already expensive resources, necessitates more maintenance, and in turn increases the risk of downtime.

Air leaks are also a challenge for companies that have to comply with environmental, safety, and governance (ESG) standards. Adopting the ISO 50001 standards is a path to energy management and compliance, and saving on energy costs is a critical component of ESG measures.

Leaks lead to greater consumption of material resources and energy, as well as increased wear and tear on machines. As a result, monitoring for leaks is vital, especially over the lifespan of a system. Proactive leak detection and repair can reduce costs significantly.
The Compressed Air Challenge, an industry advocacy group focusing on improved performance of compressed air systems, estimates that a proactive leak detection strategy can reduce leakage to less than 10 percent of compressor output.

As a result, in industrial facilities, compressed air systems are a hot spot for cost reduction—as organizations look to find and fix leaks before they lead to significant problems.

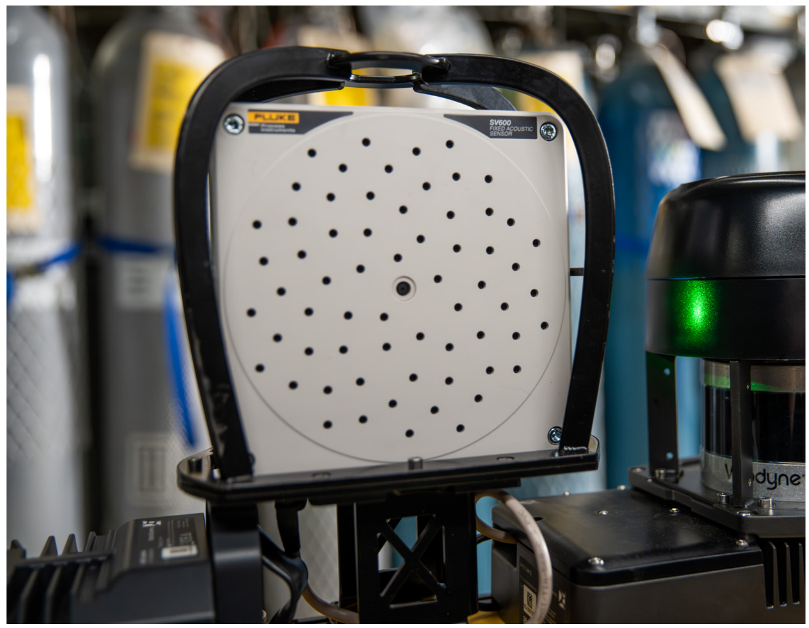
Leak Detection Methods

Traditionally, there has not been a single, simple solution for detecting air leaks. One of the primary methods was looking for signs of performance degradation in the compressed air system and working backward to find a leak that might have caused it. Facility personnel checked piping lines, inspecting them for any visual or auditory indicators of a leak.

While this method might be simple in its execution, it depends almost entirely on the knowhow of workers and their familiarity with the equipment. In addition, it is only deployed when personnel already suspect a leak, by which time it might be too late.

Today, leak detection methods fall into distinct categories based on:

- Sensor types (human/biological, direct, and indirect)
- Inspection types (hand-held, fixed, and dynamic)
- And alert types



Sensors to detect gas leaks in general can be as simple as people using sight, smell, or sound to recognize an issue. More technological solutions like direct sensors detect the presence of gasses by measuring their concentration in a sample. Unfortunately, both these methods have limited effectiveness for detecting air leaks specifically, as the leaking gas is largely indistinguishable from the surrounding environment.

Indirect sensors work on the principle that the presence of a leak will show up as related indicators—for example, a compressed air leak will manifest as a drop in pressure. Leaks can also be detected by using flow meters, where a change in values can signal trouble. While this is often effective in identifying a systemic issue, operators still need to locate and repair the source of the leak.

Sensors also require time and resources to set up and operate. Hand-held sensors need staff to carry them from inspection site to inspection site, while fixed sensors need to be mounted at repeating distances so they can test for leaks at predetermined intervals.

Leak detection sensors can deliver individual standalone readings or they can tie into a system-wide management system. They can be programmed to alert workers when readings exceed a preset threshold.

Acoustic imaging

Acoustic imaging is a newer leak detection method that picks up audible and visual indicators of a leak. Workers scan equipment with an ultrasonic sensor to see if it picks up a signal. The exact location of the leak can be pinpointed as the signal gets stronger the closer the sensor gets to it. While basic ultrasonic sensor is not very precise—the signal is easily corrupted by nearby ultrasound-emitting equipment for example, acoustic imaging leverages beamforming to cut through the noise.

This method uses a specific amount of directional microphones to create beamforming data which is visualized into a heat map that appears on the camera screen, allowing workers to pinpoint where leaks are located. Especially relevant to the process of digital transformation, this information can be recorded and uploaded to the cloud for long-term storage and trend analysis. The acoustic imaging sensors also zero in on the source of leaks irrespective of additional signals that might potentially corrupt the feed. While traditional methods require workers to use tags to mark the location of leaks, they can instead use the acoustic imager to zoom in on specific areas of interest around an asset (such as header valves), and if there is an abnormal event (or a possible leaking valve) the location is pinpointed and recorded with a still image or video.

Automating air leak detection with acoustic imaging

While acoustic imaging is an efficient method for detecting air leaks, it still depends on workers carrying the equipment from site to site and manually scanning for leaks. Manual inspections, even with better technology can impede digital transformation.

- **Time-intensive manual inspections**
  Skilled maintenance professionals are required to walk the facility with the acoustic imager and manually scan equipment for anomalies. Faced with competing priorities and time constraints, these inspections can be delayed, rushed, or skipped altogether.

- **Risk of errors**
  Manual procedures are difficult to repeat exactly the same way every time. There's a greater chance of errors or inconsistencies in manual readings or measurements compared to more automated processes.

- **Decentralized data**
  Manual inspections require manual recording of data. This requires more work from an already busy team and introduces an additional opportunity for human error. More importantly, manual data entry poses a barrier to data centralization and enterprises lose the opportunity to evaluate system-wide or long-term trends for further insights into equipment health.

- **Reliance on institutional knowledge**
  When daily decisions about equipment maintenance have to be made without access to past performance data, enterprises end up over-dependent on the expertise of in-house personnel. This irreplaceable knowledge can be easily lost when employees leave or retire.

All of these factors add up to difficulty making informed data-driven decisions about asset maintenance—falling short of the goal of digital transformation. To bring leak detection into the modern era of data-driven processes, enterprises need to automate.

Mobile robots extend reach

Compressed air lines in factories can run over large areas and leaks can occur anywhere, so it's key to have an automated solution that can cover a large area. Robots can complete a survey of compressed air lines effectively and efficiently. To gather relevant data about leaks consistently and regularly—wherever the leaks might occur—robots carry the acoustic imaging payload, following specific inspection routes on predetermined schedules.

The biggest advantages of using robots for leak detection are that they can be fitted with the latest ultrasonic imaging technology and they automate the related data gathering process. Robots can capture the same kind of data from the exact same locations every day and this information can be input into data aggregators. Using edge computing, the robots can be used to process problem readings onsite and programmed to alert workers if certain conditions are met. Consistent data aggregation, the pillar of digital transformation, can feed into machine learning algorithms processed in the cloud. A history of banked data over months and years can provide insights into problems before they worsen and cause expensive disruptions.

Automation through robots enables a multiplication of effort. Not only are maintenance teams better able to prioritize repairs, but they are able to dedicate more time to higher-priority tasks. Additionally, robotic air leak detection rounds can be coupled with other automated inspections.

For example, high heat can cause compressed air systems to deteriorate more quickly. The same robot performing acoustic inspections can also be equipped with a thermal camera for predictive maintenance purposes or sensors to read gauges or visually inspect equipment along its route. Executing these routine maintenance tasks together saves time and money while generating the reliable, accurate, and frequent data that machine learning-driven predictive algorithms need.

Automated inspections offer the best of both worlds—regular high quality data and time back to actually repair leaks.

Changing the landscape

Digital transformation and Industry 4.0 are changing the landscape of many industrial sectors, including chemical processing plants, oil and gas refineries, paper mills, manufacturing, and more. The combination of advanced sensors and automated inspections delivers the data volume and consistency that is key for success.

Especially as the need for sustainable business operations grows, finding and repairing every leak no matter how seemingly insignificant becomes increasingly important. Asset-driven industries need machines to speak—to generate data about their health that can be analyzed and acted upon. Dynamic acoustic sensing gets the job done.

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