Over-sized

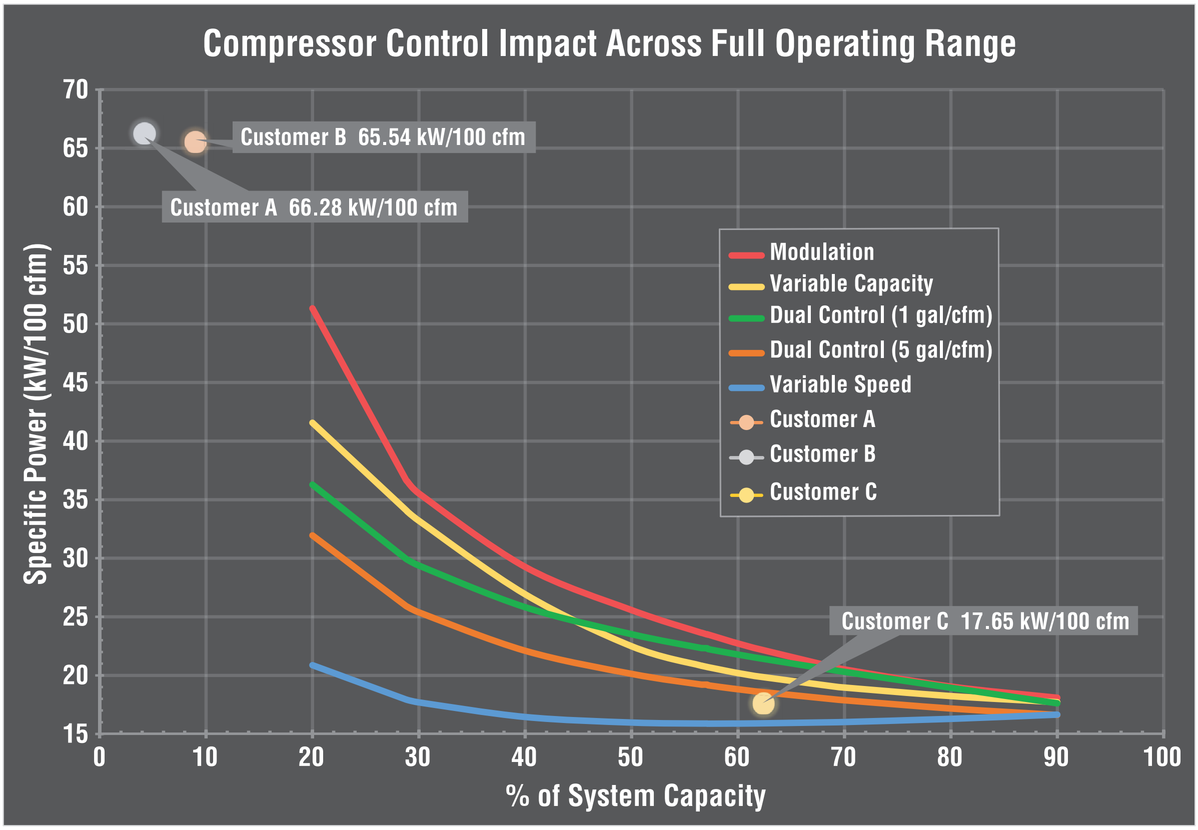
and Under-utilized: An Epidemic

By: Matt McCorkle, Kaeser Compressors, Inc.

With over ten thousand air system audits under our belt, we've seen it all and learned a few things. One of the most common problems we see is that most systems have far more capacity than needed. On average, users operate at 44% of peak capacity. It's so common, we'd say it is an epidemic, and even our own customers are not immune despite our efforts to inoculate with education.

How does this happen? In many cases, users select compressors based on what they already have, adjusted with some prognostication about whether they expect to grow, add or eliminate production lines, etc. Generally, very little measurement and analysis goes into it. Plant operators are usually comfortable up-sizing a compressor for the safety factor. They don't want to hear complaints of equipment with low pressure alarms, nor do they want to re-revisit compressed air system design every few years as they grow. So they purchase as big as their budget allows at the outset. When involved, consulting engineers may add to the problem by making conservative assumptions that all pneumatic equipment will operate fully loaded, all the time. Then they take this bad estimate and add a safety factor. In nearly all cases, there's fudge factor on top of fudge factor. All believe they are acting in the interest of reliability, without understanding the significant negative impact on energy consumption.

Compressed air efficiency is best measured in terms of specific power, which is kW/100 cfm, and the Compressed Air and Gas Institute (CAGI) has an excellent program that encourages compressor makers to publish the specific power for each compressor. This is a great point for comparing two compressors side by side, but it cannot be used to predict what the user's actual system performance will be. As the car sellers say: "your mileage may vary." So much depends on how the compressors are run. The CAGI datasheets for fixed speed machines assume 100% load, which rarely happens in practice. From our many system studies we know that systems are grossly over-sized. Whether a single machine or multi-compressor system, under-utilized compressors do not operate at their datasheet spec.



Let's look at some actual examples of over-sized systems and the costs that resulted.

The chart above shows how the performance of compressed air systems declines dramatically as demand decreases (shown for the most common types of screw compressors in the field). This is measured in specific power (kW/100 cfm), which increases as compressors operate further away from their full output capacity. We've added data points showing where a few actual customers operate on this curve to show that this graph is actually showing ideal (e.g. laboratory) conditions. As you can see, some are off-the-charts inefficient, but achieving efficient operation is certainly possible.

Shoemaker

This is a greenfield plant (i.e., new construction) where the company specified dual 125 hp compressors, (2) 230 cfm refrigerated dryers, 1000 gallons of storage, an air main charging valve, and a master system controller. They spent $1.10/1000 cubic feet! Their system could be replaced with a pair of 15 hp units.

Cabinet manufacturer

The current facility operates with a 50 hp screw compressor, a 285 cfm refrigerated dryer, and a 400 gallon receiver tank. Typical operation showed the facility running ~11 hours a day Monday through Thursday, with no operation Friday through Sunday. According to the data on the screw compressor's controller the average system pressure was approximately 115 psig. The peak demand measured was 65 cfm and the average flow was 22 cfm. This unit is oversized for the current demand. The calculated system specific power was 65.54 kW/100 cfm. The company would be much better off with a pair of 10 hp compressors. They spend $1.09/1000 cubic feet for their air!

Retail equipment manufacturer

The facility currently operates with (3) water-cooled 200 hp compressors, (3) 1000 cfm refrigerated dryers, and 3,800 gallons of dry storage. The data was provided from the master system controller. This system is highly variably in demand (891 to 2417 cfm) but was designed with 3 units to supply this full range efficiently. While this is an outstanding example of a well-designed system, they could get even better specific performance if they drop their pressure below the average of 115 psig that they currently maintain. They spend $0.35/1000 cubic feet including their cost of cooling water.

Knowing all the costs

The cost per unit of compressed air goes up as the % load goes down, which means that your yield on this costly input goes down as well. That said, while energy may be the easiest cost per unit of air to recognize and measure, it's not the only component of cost, and it may not be the most significant cost in your operation.

Increased cycling associated with under-utilization has several negative effects on compressors, and we've found that for under-loaded systems, maintenance and repair costs increase as a portion of total operating cost. A review of service records showed that units with duty cycles had a significantly shorter mean time between failure (MTBF). Because compressors are usually serviced based on total run time rather than actual load time, a machine that idles a lot costs more in parts and labor per loaded (i.e.

productive) hour. If you calculate the service costs based on cfm produced rather than hours of run time, you'll find that PM and repair costs per cfm rises also.

Like highway miles vs city miles

Think of your car. Cost per mile for gas and maintenance goes down if most miles are highway miles. But highway miles are also gentler on your car (fewer starts and stops, etc.). City miles are notoriously inefficient with fuel, but they also accelerate wear on the motor, the brakes, steering and suspension.

Likewise, low-loaded compressors are more likely to show wear at an accelerated rate. Inlet valves, vent valves, and others, cycle many more times at low load. Motors starts are more frequent which can affect bearing and winding life. On direct drive units with polymer couplings, frequent cycling can reduce coupler life. Frequent starts and stops put more wear on thrust bearings in the airend.

Further, if the unit doesn't run enough, it may not reach proper operating temperature, which results in moisture accumulation in the lubricant. This is a common cause of premature airend failures. Frequent changes in temperature can also cause metal fatigue on aluminum coolers. These conditions call for increased frequency of preventive maintenance and the likelihood of downtime for repairs.

Downtime and Scrap

Another downside to poorly sized systems is pressure fluctuation. Swings in pressure may result in defective products, and more sophisticated production machinery have sensors that will shut down the equipment if pressure is outside of design specifications. Depending on the cost of raw materials and value of finished product, the costs of downtime and scrap may far exceed the losses in energy efficiency and service costs.

Will your facility benefit from a Kaeser Air Demand Analysis?

	Yes	No
• Have you calculated the energy costs associated with your air system?	☐	☐
• Do you have a pressure/flow/energy profile, so you know what is actually happening in your air system?	☐	☐
• Do you know what your air demand is?	☐	☐
• Have you ever measured pressure drop in your piping?	☐	☐
• Have you ever tested for leaks?	☐	☐
• Do you have secondary storage or controls separating air supply from distribution?	☐	☐
• Do you have a stable supply of air at the required pressure at all points of use?	☐	☐
• Have you eliminated high scrap rates or eliminated lower product quality caused by malfunctions in air-operated equipment?	☐	☐
• Has adding compressors to a low-pressure problem improved system performance?	☐	☐
• Have you contacted your local utility or energy service company to see if rebates or other incentives for energy reduction projects are offered?	☐	☐
• Do you know your system specific performance baseline in kW/100 cfm?	☐	☐

If you answered "no" to any of these questions, it's highly likely your operation will benefit from a Kaeser Air Demand Analysis.

Take the Next Step

To start realizing energy cost savings, lower maintenance/repair costs, and increased productivity through a more stable supply of compressed air, contact your local authorized Kaeser representative today about a Kaeser Air Demand Analysis. Or visit **us.kaeser.com/ada** for more information.

Meeting the Challenge

If you are planning a compressed air system for a new plant or expansion, you may only be able to estimate your compressed air demands. So the smart money is spent splitting the estimated demand among multiple compressors and having good controls (and ample storage). Using variable output compressors as trim machines is part of a good strategy.

For existing systems, the first step is an accurate air system assessment to determine how well your system is sized and controlled. If your budget allows for replacing compressors, the ROI from lower energy consumption, lower service expenses and reduced downtime may justify replacing over-sized compressors and adding controls. In some cases, just adding one smaller machine can make the difference.

If your budget cannot accommodate new compressors, there are lower cost investments that can help mitigate oversized compressors. Adding storage often reduces compressor cycling and can stabilize pressure. In some cases, flow controls may further improve the effect of storage. For systems with multiple compressors, adding a modern multi-unit controller will definitely help reduce starts/stops while stabilizing pressure and provide additional benefits such as remote monitoring and energy consumption information.

Downtime and scrap caused by pressure fluctuations, high service and repair costs, and high energy costs, are problems that many plants simply live with as expected costs of operating compressors. But they don't have to be. The first step is an honest assessment of how well your compressed air system is working.

Don't be yet another statistic with an oversized and inefficient compressed air system. Educate yourself on the benefits of multiple unit systems that will provide low costs, high efficiency and reliability. Take that first step.

This article was originally published on Kaeser's blog, Kaeser Talks Shop. For more blog posts on compressed air topics, visit www.kaesertalksshop.com.

About the Author

Matt McCorkle lives in Fredericksburg, VA where he works as the Manager of Branch Operations for Kaeser Compressors. He holds a Bachelor's degree in Mechanical Engineering from the US Air Force Academy, and a Master's of Engineering in Industrial and Systems Engineering from the University of Florida. Matt has worked as a licensed Professional Engineer and as a Certified Energy Manager through the Association of Energy Engineers. Matt's focus is on helping manufacturers continually reduce production costs in the competitive and changing marketplace.

KAESER COMPRESSORS®

Built for a lifetime.

Kaeser Compressors, Inc.
511 Sigma Drive
Fredericksburg, VA 22408 USA
Telephone: 540-898-5500
Toll Free: 800-777-7873
us.kaeser.com
info.usa@kaeser.com