White Paper

Gardner Denver

Comparing Air Compressor Performance

Using CAGI Data Sheets to Make an Apples-to-Apples Efficiency Comparison

MEMBER OF
100 YEARS OF INDUSTRY LEADERSHIP
CAGI
Compressed Air & Gas Institute
www.cagi.org

www.gardnerdenver.com/gdproducts

Introduction

The more efficient a compressor, the less it costs to make a given amount of compressed air. Since the cost of making air often goes unmonitored, attention to compressor efficiency and the cost of making air can save thousands of dollars annually. A little in-depth analysis of compressor efficiency is likely to pay you back many times over.

This discussion is focused on electric motor driven, rotary screw air compressors – the ones used in the majority of manufacturing plants. For these compressors, electricity is utilized to drive the motor. The motor is connected to the compressor's airend (the element on a compressor package that performs the compressing) via belts, gears or a coupling. As the motor drives the airend, it rotates and compresses air. Compressed air, which is stored energy ready to do work, is utilized in literally thousands of applications around the globe.

Bryan Fasano
Director, Aftermarket

Gardner Denver Industrials Group

What is Compressor Performance and Why is it Important?

Believe it or not, some think compressed air comes free of charge. However, the electricity used to run the lights in your home is the same electricity consumed by a compressor – and at last check, lighting is not provided free of charge. The fact is, the electrical cost of running a compressor is by far the largest expense associated with compressor operation over a five to ten year period. These electrical costs dwarf the costs of the initial purchase price, installation and maintenance. Thus, how efficiently a compressor makes the air is quite important. A compressor that is 3-5% more efficient can save a plant manager thousands of dollars in operating expenses per year.

The efficiency, or performance, of a compressor is defined as the amount of electricity or power (in kilowatts) used by the compressor to make 100 cubic feet of air per minute (CFM). So, if a compressor consumes 20 kilowatts of electricity for every 100 CFM of air that it makes, its efficiency measure would be 20 kW/100 CFM. This ratio, or measure, shows that a lower kW number equates to superior efficiency, since a compressor at 18 kW/100 CFM uses fewer kilowatts of power than a compressor at 20 kW/100 CFM for every 100 CFM. To calculate compressor efficiency, all you need is compressor flow in CFM and compressor power use at that flow.

Which compressor is more efficient, one making 1000 CFM of air at full load using 195 kW of power or one making 1010 CFM of air at full load using 200 kW? Let's take a look:

- Compressor #1: 195 kW/1000 * 100 CFM = 19.5 kW/100 CFM
- Compressor #2: 200 kW/1010 * 100 CFM = 19.8 kW/100 CFM

Even though compressor number two makes more air at full load by 10 CFM, it is not making air as efficiently as compressor number one per 100 CFM. Compressor number one is 1.5% more efficient than compressor number two. Obviously, when comparing two compressors, the larger the efficiency difference, the larger the cost difference to produce a given amount of air. If you use a lot of air, and you have compressor choices that are significantly more efficient, selecting the most efficient compressor can lead to electrical savings in the thousands to tens of thousands of dollars per year. From a profitability standpoint, these savings drop right to the bottom line.

What are Compressed Air and Gas Institute (CAGI) Data Sheets?

CAGI Data Sheets are compressor performance sheets that allow air users to compare the efficiencies of different compressors in a standardized format. Only CAGI member companies can utilize these sheets to present performance data. Most of the critical measures that aid the understanding of compressor performance are documented on these sheets and, most importantly, are verified by an independent third party administrator. If a compressor is tested and found to perform at a level inferior to what is shown on a company's CAGI Data Sheet, that model will be noted as a failed unit on the CAGI website (www.cagi.org) and must be re-rated or eliminated from the manufacturer's product offering. With CAGI sheets, consumers now have a standard way to compare compressor performance and the independent verification process provides assurance that the numbers are accurate. (Note: non-member companies could provide the same data, but are not permitted to do so on a CAGI sheet. Also, the data would not be independently verified following the CAGI process.)

CAGI Data Sheets should not be considered an all-encompassing feature/benefit comparison for compressors. The Fixed Speed Data Sheets only report performance at the compressor's full flow capability (this is also known as full load). Because air requirements in a plant typically vary throughout the day, compressors often produce air at levels below their full load capability. To understand the efficiency of a compressor during part load periods, you should work with a compressed air salesperson. For Variable Frequency Drive Compressors, the CAGI Data Sheets map out a complete performance curve, so you can see compressor efficiency from low flow (part load) to full flow capability. Additionally, CAGI Data Sheets do not allow for comparison of many other important compressor feature/benefits such as reliability, noise ratings, oil-carryover levels, footprint, filtration methods and more. Use the CAGI sheets to provide performance insight, but be sure to evaluate other feature/benefits critical to your installation.

[For quick and easy access to CAGI Data Sheets, a list of Performance Verification Program Participants and a listing, by manufacturer, of compressor models tested along with the corresponding test results go to the CAGI website at www.cagi.org. At the top of the homepage, hover on Performance Verification. If you select Data Sheets, you can access any participant's Data Sheets via a link to their website. Alternatively, you can select Compressor Participant Directory to gain access to the results from tested units by manufacturer. There are also other highly visible ways to access Data Sheets on the homepage dashboard]

Gardner Denver

COMPRESSOR DATA SHEET

Rotary Compressor: Fixed Speed

MODEL DATA - FOR COMPRESSED AIR			
1	Manufacturer: **GARDNER DENVER**		
2	Model Number: **ST G2 60hp, 125psi**	Date:	**4/19/18**
	[ ] Air-cooled [X] Water-cooled	Type:	**Screw**
	[X] Oil-injected [ ] Oil-free	# of Stages:	**1**
3*	Rated Capacity at Full Load Operating Pressure [a, e]	**287**	acfm [a,e]
4	Full Load Operating Pressure [b]	**125**	psig [b]
5	Maximum Full Flow Operating Pressure [c]	**125**	psig [c]
6	Drive Motor Nominal Rating	**60**	hp
7	Drive Motor Nominal Efficiency	**95.0**	percent
8	Fan Motor Nominal Rating (if applicable)	**NA**	hp
9	Fan Motor Nominal Efficiency	**NA**	percent
10*	Total Package Input Power at Zero Flow [e]	**12.9**	kW [e]
11	Total Package Input Power at Rated Capacity and Full Load Operating Pressure [d]	**55.8**	kW [d]
12*	Specific Package Input Power at Rated Capacity and Full Load Operating Pressure [e]	**19.4**	kW/100 cfm [e]

*For models that are tested in the CAGI Performance Verification Program, these items are verified by the third party administrator. Consult CAGI websitefor a list of participants in the third party verification program: www.cagi.org

NOTES:

a. Measured at the discharge terminal point of the compressor package in accordance with ISO 1217, Annex C; ACFM is actual cubic feet per minute at inlet conditions.
b. The operating pressure at which the Capacity (Item 3) and Electrical Consumption (Item 11) were measured for this data sheet.
c. Maximum pressure attainable at full flow, usually the unload pressure setting for load/no load control or the maximum pressure attainable before capacity control begins. May require additional power.
d. Total package input power at other than reported operating points will vary with control strategy.
e. Tolerance is specified in ISO 1217, Annex C, as shown in table below:

Member

MEMBER OF 100 YEARS OF INDUSTRY LEADERSHIP CAGI Compressed Air & Gas Institute www.cagi.org

Volume Flow Rate at specified conditions		Volume Flow Rate	Specific Energy Consumption	No Load / Zero Flow Power
m^3 / min	ft3 / min	%	%	
Below 0.5	Below 15	+/- 7	+/- 8	
0.5 to 1.5	15 to 50	+/- 6	+/- 7	+/- 10%
1.5 to 15	50 to 500	+/- 5	+/- 6	
Above 15	Above 500	+/- 4	+/- 5	

ROT 030

10/11 R8 This form was developed by the Compressed Air and Gas Institute for the use of its members. CAGI has not independently verified the reported data.

Rotary Screw CAGI Data Sheet

Reading and Interpreting CAGI Data Sheets

Utilizing the data sheets is the fun part. For ease of comparison, every data sheet for similar types of compressors is organized in the same way. At the top of the sheet, you will find the type of Rotary Compressor: fixed speed or variable frequency drive. Note that for fixed speed compressors, all data assumes the compressor is operating at full load, so it is important to take into account how your unit will be operating (for assistance, see your compressed air sales expert).

Following is a line-by-line description of the data that is on each line of a CAGI Data Sheet, what the data means and how to make use of the information. Once you are familiar with the contents of a Compressor Data Sheet, comparisons become quick and easy, requiring just a few minutes to identify important differences.

Line 1: This area contains the manufacturer of the compressor. Remember that any manufacturer supplying CAGI Data Sheets has committed to the third-party verification program. Manufacturers who are not members of CAGI or who do not have CAGI Data Sheets can report performance using whatever definition and tolerances they choose but do not have the accountability the third-party verification program provides.

Line 2: This area contains compressor specifics. Here you find the compressor model number, whether the unit is air or water-cooled and identification of the unit as oil-injected or oil-free. The type, number of stages and date of the information are also listed on line 2. As a rule of thumb, water-cooled units are more efficient than air-cooled compressors because an energy-consuming cooling motor/fan is not required. Also, oil-injected compressors are typically more efficient than oil-free units because the lubricant seals air gaps which improves efficiency. Other critical factors will typically determine whether an air user selects an air or water-cooled unit, or a lubricated or oil-free machine compressor.

Lines 3-12: This section addresses the actual performance or efficiency measures. All of the units of measure are listed to the right of the given data. Footnotes are also provided to help you fully understand the measurement.

Line 3: Rated Capacity at Full Load Operating Pressure tells you how much air the compressor will make at a defined full load of operating pressure (line 4 below). If you are comparing compressors on flow, be sure the comparison is made at the same pressure level. There are different CAGI sheets for different pressure levels, so determine your pressure requirement and then identify the sheets for (or closest to) this pressure. The unit of measure is **acfm**, which stands for "actual cubic feet per minute".

Line 4: Full Load Operating Pressure indicates the pressure level at which the flow in line 3 (above) was measured. Electrical consumption (line 11) is also measured at this pressure. As noted above, make sure this value is the same for the compressors you are comparing. If you cannot find sheets with the same pressure, your air compressor sales expert can assist in making the correct mathematical adjustments to the numbers.

Line 5: Maximum Full Flow Operating Pressure differs from line 4 in that this data indicates the maximum pressure at which the compressor can be operated while still delivering the full load capacity number listed in line 3. This data is useful in instances where the application requires more pressure, but you

don't want to reduce capacity. Keep in mind that at this pressure, the compressor will use more power than at the pressure shown in line 4. The efficiency of the compressor, of course, would fall off slightly.

Line 6: Drive Motor Nominal Rating tells you the size of the motor in the compressor in horsepower (HP). Although not listed on a CAGI Data Sheet, you may be interested in the service factor (SF) for the motor, such as 1.15. Additionally, you may want to know how far into the SF that the motor is operating at full capacity and pressure. Consult the manufacturer for this information.

Line 7: Drive Motor Nominal Efficiency communicates the nominal or average efficiency of the motor above. This figure could be used to determine if you would like to consider upgrading to a more efficient motor. Check with the supplier to see what options you have. If a motor with a higher nominal efficiency is utilized, compressor package efficiency will improve (the number in line 12 would decline).

Lines 8 & 9: Fan Motor Nominal Rating and Efficiency are the same information as lines 6 and 7 above, but for the fan motor. On a water-cooled unit these lines will be blank since there is no fan motor. Without the power-consuming fan motor, the efficiency of a water-cooled unit improves slightly.

Line 10: Total Package Input Power at Zero Flow is a measure of how much power (kW) the compressor uses when it stops making air, the reservoir is blown down, but the compressor is still running. You want this number to be as low as possible so that when the plant does not need air, but the compressor has not yet timed-out and turned off, you are using as little power as possible.

Line 11: Total Package Input Power at Rated Capacity and Full Load Operating Pressure is a measure of how much power, in kilowatts, the compressor is drawing when operating at full capacity. This power figure is for the compressor package as a whole, as the name states. The footnote for this line is a reminder that total package input power at other operating points is a function of the compressor control strategy employed. Your compressed air sales expert can explain control strategies and devise the optimum plan for your system.

Line 12: Specific Package Input Power at Rated Capacity and Full Load Operating Pressure is the efficiency measurement that was defined earlier. This is the most important piece of data on the sheet. The unit of measure is kW/100 CFM. This ratio – kW used for every 100 CFM produced – is your efficiency measure. It is calculated by dividing line 11 by line 3, then multiplying by 100 to convert the measure to per 100 CFM. The typical efficiency numbers you will encounter will range from 16.5 kW/100 CFM to 28 kW/100 CFM depending upon the operating pressure and type of compressor under evaluation. Remember, the lower the number, the more efficient the compressor.

Check out Gardner Denver's

CAGI Data Sheets at:

www.gardnerdenver.com/gdproducts

Additional Key Points

- Data Sheets for Variable Frequency Drive (VFD) Compressors – VFD Data Sheets are similar but not exactly like the fixed speed sheets. On the VFD sheets, you are given capacity and its corresponding specific power (kW/100 acfm) for six different points along a “performance curve”. In addition, these six points are graphed so you have a visual representation of compressor performance over a broad capacity range for the compressor.

In general, VFD compressors are designed to have better part load efficiency than fixed speed units and are thus expected to be applied more frequently at part load. Therefore, a performance curve with part load data is deemed more useful than just full capacity data. Review of a VFD Data Sheet will help clarify the differences described above.

- Tolerance Table – At the bottom of every Compressor Data Sheet, there is a tolerance table for Capacity (Volume Flow Rate), Specific Energy Consumption and No Load/Zero Flow Power. This table shows the range around which the above performance measures are reported. As the capacity (flow) increases, the tolerance range percentage gets tighter and the same is true for Specific Energy Consumption. No load power is always +/- 10%. Use this table to understand the range of flow and efficiency a compressor could supply.

Summary

Concerning Compressor Data Sheets and Air Systems in General:

- CAGI Data Sheets serve an important purpose, but they are just one piece of a puzzle. Consider other product benefits and supplier strengths when making a compressor purchase.
- For fixed speed compressors, lines 3, 4, 11 and 12 on the Data Sheet contain the most critical data. These lines tell you how much air the compressor is making at the pressure requirement you have identified, how much total power the compressor is using, and HOW EFFICIENTLY THE AIR IS BEING SUPPLIED. The lower the kW/100 CFM number, the more efficient the compressor is at full capacity.
- For variable frequency compressors, lines 3, 8 and 10 on the Data Sheet contain the most vital data. On these sheets, efficiency over a large capacity range is supplied. This performance curve is plotted on line 10. The lower the curve on the Y-axis, the more efficient the compressor.
- Most often, air demand fluctuates throughout a shift and from shift-to-shift. This means that calculating electricity use can get difficult. Your compressed air sales expert will have tools to drive this process if detailed numbers are needed.

Historically, compressor efficiency information was all over the map. Some manufacturers tested using one process while others used different processes. Some reported compressor airend performance, while others provided total package performance – and so on. Now, with Compressor Performance Data Sheets utilized by CAGI Members, compressor performance comparisons don't have to drive you crazy and can provide insights that lead to real energy savings.

Pneumatics is a fantastic utility, but it is not free. An efficient compressor, operated by a well-designed control system ensures you are getting maximum productivity at the lowest possible cost from your compressed air system. Armed with Compressor Data Sheets and a compressed air sales expert, you have the knowledge to implement the best air system for your application and to keep the system at its optimal efficiency level for years to come. Don't miss the opportunity to put your business in the most advantageous competitive position possible.

About Gardner Denver Industrials Group

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.

Our global offering also includes a comprehensive suite of aftermarket services to complement our products. Gardner Denver Industrials Group, part of Gardner Denver Inc., is headquartered in Milwaukee, Wisconsin, USA. Gardner Denver was founded in 1859 and today has approximately 7,000 employees in more than 30 countries.

For further information please visit www.gardnerdenver.com/gdproducts

Disclaimer:

WP-GD-CACP-CAGI 11/18

Gardner Denver®