

Selecting the optimal blower for the water industry

Qualified quotation comparison



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Qualified quotation comparison: Selecting the optimal blower for the water industry

The use of blowers in water industry applications plays a decisive role when it comes to establishing an efficient and sustainable water supply. Blowers are used for a multitude of different applications in the water management sector, whether it's supplying oxygen for biological purification processes at wastewater treatment plants, filtration and cleaning of water treatment systems, or maintaining the pressure in the pipework at wastewater pumping stations.

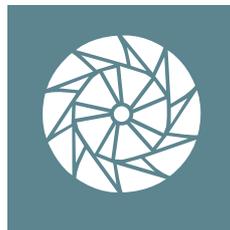
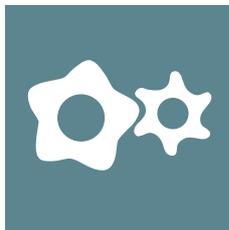
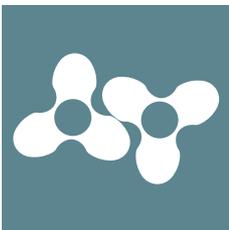
The product range is every bit as diverse as the applications for which blowers can be used, which therefore begs the following question before making an investment: rotary lobe, rotary screw or turbo blower? Here, the operator must focus on the individual requirements in terms of pressure, flow rate and operating hours, in order to achieve the highest possible energy savings by meticulous selection of the right blower type.



In this white paper, we will drill down into which technology has particularly proven itself in terms of energy efficiency in the water industry. In addition to decision-making aids for selecting the optimal blower, we will also demonstrate how to objectively select the most efficient blower based on a comprehensive quotation comparison.

Rotary lobe, rotary screw or turbo blower: Which is the correct blower?

Low-pressure applications in the water industry generally range from a differential pressure of 0.4 bar to 0.8 bar. This requirement can be achieved by a number of different compressor technologies, but beware: energy, maintenance and investment costs can often vary considerably. Therefore, a precise analysis of the prevailing operating conditions and resulting life-cycle costs is absolutely essential. Only when the operator's exact requirement is known can the right decision be taken in view of energy consumption, dependability and operating costs.



For the low-pressure range, rotary lobe, rotary screw or turbo blowers may be used. Each of these three technologies has its own distinct advantages, but to be frank, one or two disadvantages as well.

The data for the different blower types are often not far apart, and the decision as to which is the best in terms of energy can only be made following a calculation and comparison of the life-cycle costs. This calculation must be based on comparable performance data.

Rotary lobe blowers

Rotary lobe blowers operate by compressing air inside a rotating housing, usually via a three-lobe rotor. The primary and secondary rotors have the same cross section. Pressure build-up does not occur in the blower block, but in the downstream process line by means of the constant pushing of the air mass against the prevailing resistance in the subsequent process.

Rotary lobe blowers are durable, less cost-intensive systems recommended for differential pressures up to 0.5 bar. Depending on the model size, blower speed is from 2,000 to 6,000 rpm. A maximum control range of 1:3 is achievable, and on systems equipped with a frequency converter, isentropic efficiency is between 45 and 60%.

This type of blower is characterised by its robustness and low initial investment costs; however, due to energy reasons, in the water industry it is best suited to applications with low to medium pressure requirement and short run times.

Advantages	Disadvantages
Very durable	Less efficient at high pressures
Less cost-intensive	Higher noise levels

Rotary screw blowers

Rotary screw blowers operate with a helical primary and a secondary rotor that rotate in opposite directions to one another, thereby compressing the air within the screw threads. This means that the air is pre-compressed inside the blower airtight before being expelled into the pressure piping. If this internal pre-compression has been well matched to the required pressure in the process piping, less compression work is needed – this makes the rotary screw blower more efficient.

These high-efficiency systems are suitable for differential pressures between 0.5 and 1.1 bar, and achieve a flow rate control range of 1:4. Rotary screw blowers equipped with integrated frequency converter attain an isentropic efficiency significantly higher than that of rotary lobe blowers at 60 to 78%, which remains very stable even with a varying flow rate. Currently, models are available with a flow rate range of 5 to 165 m³/min. Depending on the model size, blower speeds from 3,000 to 12,000 rpm are usual.

These blowers are known for their high performance. In the water industry, they are suited to applications with medium to high pressure requirement. They are recommended for aeration processes that combine the requirements of a high number of operating hours, a broad control range and a constant efficiency curve over the flow rate.

Advantages	Disadvantages
High, extremely constant efficiency	Maximum flow rate limited
Broad control range	Some models still fitted with belt drive
Continuous air delivery	

Turbo blowers

Unlike rotary lobe and rotary screw blowers, turbo blowers are dynamic compressors. Pressure build-up occurs due to an increase in the flow velocity through the turbo impeller and its subsequent conversion to pressure in the diffuser.

Single-stage turbo blowers are suitable for differential pressures between 0.4 and 1.3 bar. Impeller speed ranges between 20,000 and 30,000 rpm. Magnetic bearing turbo blowers achieve an isentropic efficiency between 60 and 78%. In contrast with positive displacement blowers, peak efficiency is achieved in a narrower range and is more heavily dependent on the respective pressure and flow rate. The flow rate control range on turbo blowers also varies more heavily with the pressure; at design pressure, a maximum control range of 1:3 is achievable. This must be taken into account in advance during the planning stage, in order to select a blower with the most efficient and complete overlap possible within the station network.

Turbo blowers are especially efficient and powerful, and are best suited for applications with very high air demand – such as aeration processes in the water industry, where the flow rates that can be achieved using rotary screw blowers may not be sufficient.

Advantages	Disadvantages
Reduced footprint	Higher investment costs
Low maintenance costs	Narrower control range

Challenge: Establishing comparability

Unfortunately, it's not just a question of selecting the right blower type. This is because when comparing different quotations, numerous stumbling blocks remain hidden. The reason? Quotations are often anything but transparent. In many cases there is no direct comparability between performance data, such as the usable flow rate at the discharge port or the power consumption at the blower supply terminals.

This lack of clarity often has expensive consequences – a blower's actual energy consumption can be up to 20% higher than originally predicted. This makes a critical evaluation of the specified performance data absolutely essential.

The first important step is to establish comparability. For a qualified and objective examination of quotation data, the following must be ensured:

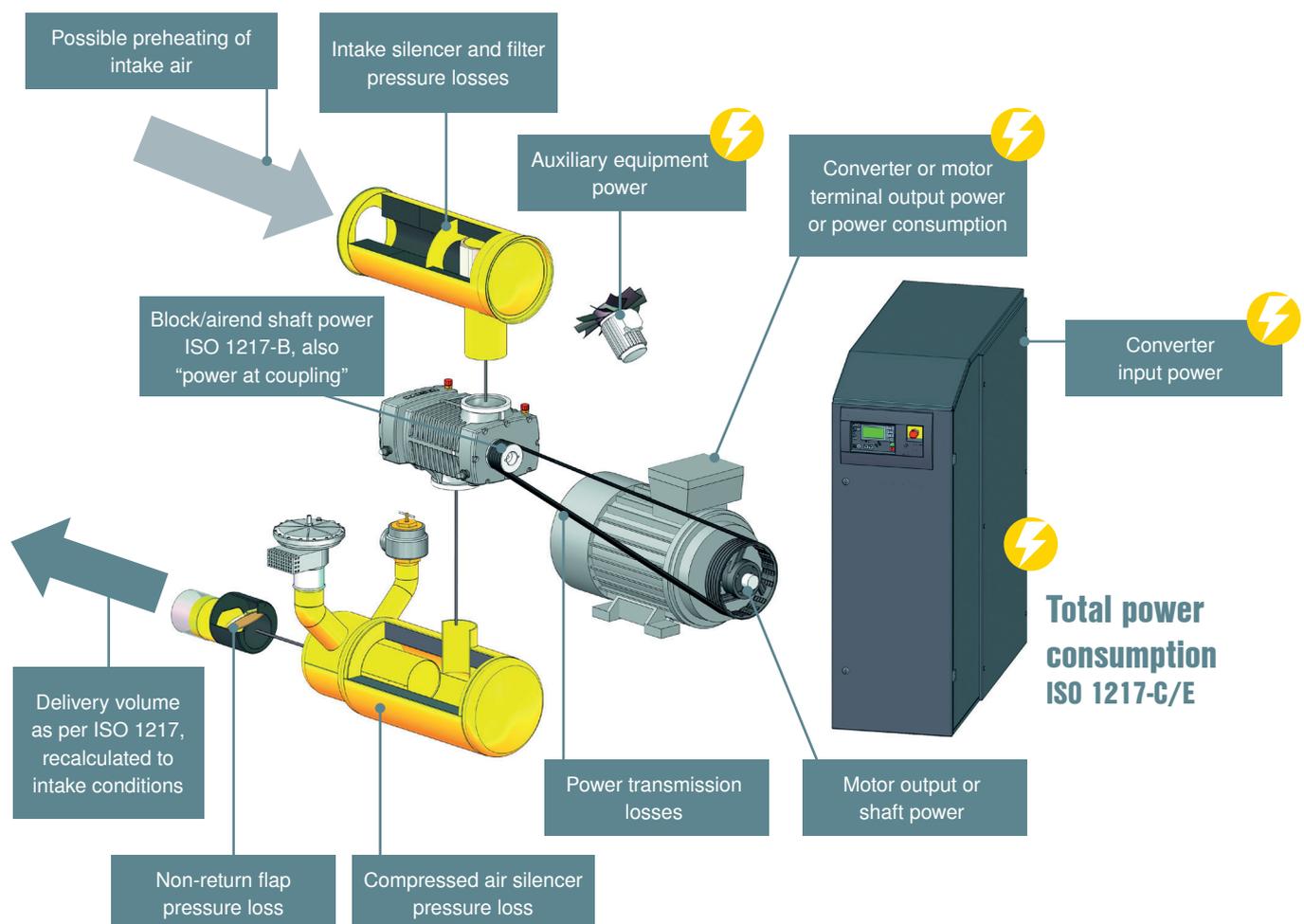
- The performance data provided must include all performance-related electrical and air-conveying components with which the blower will subsequently be operated.
- Clear terminology to identify interfaces for flow rate and electrical power consumption in order to avoid confusion.
- A sufficient number of operating points across the control range to calculate the annual electrical consumption [kWh] and energy costs from the power requirement and efficiency profile of the machine for each flow rate and its associated operating hours.
- Where blowers such as air bearing turbo blowers do not allow for a true motor speed stop, but rather blow off when there is no process air demand, then the power consumption during this period of idle operation should be known.
- Identical and complete intake and operating conditions, including intake pressure and temperature, humidity, and pressure differential.
- Reference to the existing standards for determination and provision of performance data.
- Tolerances in relation to usable flow rate (rotary lobe and rotary screw) or delivery rate (turbo) AND total power consumption, preferably even specific package input power or isentropic efficiency.

Because it is exceptionally difficult for non-expert personnel to establish the correct requirements in this respect, organisations such as the US-based Compressed Air and Gas Institute (CAGI) provide templates on their website for a qualified data enquiry regarding different air compressors.

Design and correct reference to interfaces and their designation

In the field of blower technology, there are an abundance of key figures that can be used to express the performance, flow rate and energy efficiency of a blower. But without knowing the precise origin of the data, there exists the risk of comparing apples with oranges. Therefore, it is essential when comparing quotations always to use the correct interface reference and the correct designation for the interfaces listed.

As there are different points to which performance parameters can be assigned, it is important to know precisely to which points the values in the quotation relate. The diagram below shows a commonly used layout for a rotary lobe – or sometimes rotary screw – blower deployed in the low-pressure range for aeration purposes. This provides a helpful overview of the scope of the components relevant to performance.



Including performance-relevant components:

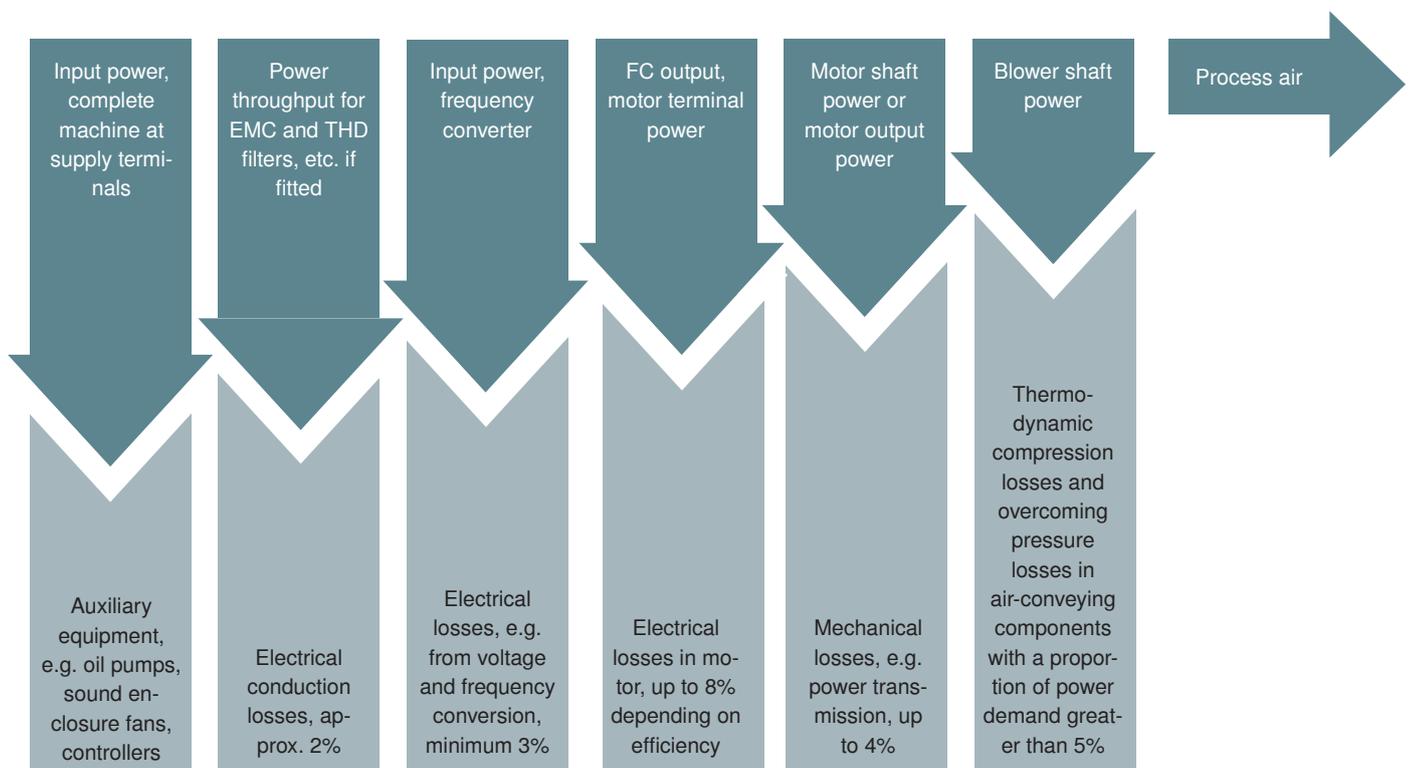
At one point or another, caution is advised: not every blower manufacturer provides all of the values for the full scope of delivery in their quotation. Often only the power consumption for the compression stage or blower block/airend is mentioned, which is not the correct way. Ultimately, a much more expansive final version is delivered and commissioned, resulting in a higher actual power consumption.

This is because a significant portion of energy is lost between the supply terminal and the process air. The highest losses are caused by the blower's mechanical components, such as the intake air filter, silencer and non-return flaps, therefore these performance-relevant air-conveying components must not be forgotten. Differences in performance of 5 to 10% can quickly accumulate.

Losses from the operation of auxiliary equipment, use of a frequency converter and operation of the motor must also be taken into account.

The most reliable approach to a performance comparison is to use the total power consumption of the complete machine that matches the intended scope of installation or operating conditions. In the USA this is known as "wire to air", which refers to the total power consumption at the electrical supply terminals of the complete machine that is needed to generate the required usable flow rate and pressure for a given application.

The following diagram illustrates the energy flow from the supply terminal to the process air:

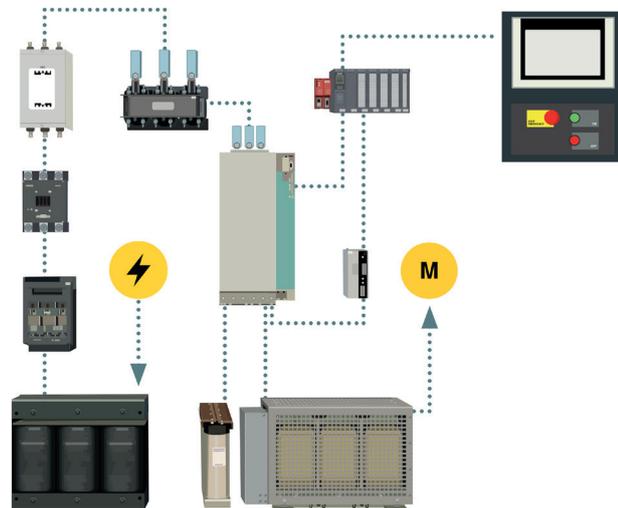


Example turbo blower with primary electrical components in drive train:

In the case of directly coupled air or magnetic bearing turbo blowers with a high-speed permanent magnet synchronous motor, consideration of coupling power is straightforward – mechanical power transmission from the motor to the blower is direct, without losses.

Due to the high-frequency technology and necessary mains filters and throttles, components between the FC input terminal and the actual electrical supply terminal must also be considered, since they introduce electrical transmission losses.

Once all of the additional electrical auxiliary components – as well as all air-conveying accessory components – have been taken into account, the comparison basis for a reliable energy balance has been established.



Precisely defining flow rate:

When undertaking a qualified quotation comparison, it is not enough simply to consider the energy flow. A precise assessment of the air volume / mass flow is also essential.

The first thing to check is whether the blower's process air intake components are located inside or outside the sound enclosure, since the temperature difference between these two points can be up to 10 °C. The resulting difference in air density has a direct impact on the delivered mass flow or usable flow rate at the compressor outlet. This quickly produces a difference of 4%, with far-reaching consequences: if the air mass flow (usually expressed in [kg/h or m³/h]) is required for a biological aeration process, for example, the resulting temperature increase and accompanying reduction in intake air density must be compensated for by an increase in blower speed. This increases the blower's power consumption and therefore leads to a significant rise in energy usage. Thus the intake temperatures and pressures provided in quotations and data sheets must relate directly to the inlet of the blower block/airend.

Similarly fundamental is the precise definition of flow rate. For the water industry and all biological processes, the following reference values are relevant: the air mass flow [kg/h] and the flow rate, with the latter calculated using the air density at standard physical conditions of temperature and pressure in accordance with DIN 1343 – 0 °C (273 Kelvin), 1013 mbar and 0% relative humidity – including the unit [usually m³/min]. In North America, the equivalent to mass flow is the flow rate at standard conditions in accordance with CAGI BL 300, which is measured at 20 °C, 1013 mbar, 36% relative humidity, and expressed in the unit [scfm].

In order to correctly provide the reference values, the flow rate must be converted to inlet conditions at the blower's intake port – above 0 °C, the required intake flow rate is inevitably always higher than the flow rate at standard physical conditions of temperature and pressure.

If the flow rate calculation and therefore the dimensioning of the blower is based on incorrect reference values, there is ultimately often a shortfall of more than 7% in the usable air mass flow available for the aeration process. This deficit must then be expensively compensated for by higher speeds and the associated increase in power consumption.

Owing to the frequent over-dimensioning of blowers, particularly in the water industry, this is often not immediately apparent, as the process does not normally lack air.

Support: Referring to standards



When it comes to blower technology, certain guidelines apply. Whereas some provisions represent a legal requirement, standards are merely recommendations. They do, however, enable an objective comparison of the quotation and delivery scope in relation to power and flow rate. In order to impose a certain quality level, they reflect the current state of the art, thereby providing more security for the operator.

As a normative basis for performance data, the following international standards apply to blower technology:

- Standard ISO 1217 for positive displacement compressors such as rotary lobe and rotary screw blowers, and
- Standard ISO 5389 for dynamic compressors such as turbo blowers.

Advantage of the normative basis: Both standards initially define the correct terms in relation to operating and performance parameters, designate the normative measurement methods, establish the measured variables and their tolerances, and specify the correct conversion method for the measured values from laboratory to project conditions. In the case of ISO 1217, the standard also includes the tolerable deviations between measured and quoted values.

Standard ISO 1217:

Standard ISO 1217 for positive displacement compressors specifies permissible deviations, depending on the flow rate range, for the usable flow rate at the blower's discharge port, converted to intake conditions at the inlet. The maximum deviation for the associated specific package input power [kW/(m³/min)] (power / flow rate) is also defined.

Within the framework of a power measurement on the basis of ISO 1217 in order to confirm the performance data provided in the quotation, the rotary lobe or rotary screw blowers are measured at the same speed and compression ratio (discharge pressure to inlet pressure) after reaching a thermal steady state, and the determined performance data are compared between the quoted project conditions and the measured laboratory conditions following normative correction.

ISO 1217 also incorporates a number of annexes: Annexe B relates to the individual blower block or airend, Annexe C to non-variable-speed machines, and Annexe E to variable-speed machines (e.g. with frequency converter). It prescribes the respective power specification for these machines at five evenly distributed performance points across the speed range.

Standard ISO 5389:

ISO 5389 for dynamic compressors pertains to the blower shaft power. Specification of the total electrical power consumption at the turbo blower's supply terminal is, therefore, a voluntary disclosure by the manufacturer, as are the tolerances for power and flow rate. The standard focuses on the correct measurement and conversion of the performance values from laboratory to project conditions.

In the case of dynamic compressors, comparability of efficiency and specific package input power is established when the so-called 'peripheral Mach number' and the delivery and work rate at the turbo impeller are the same. These parameters are also referred to as similarity numbers: they serve to establish identical flow characteristics at the impeller for both project and laboratory conditions and thereby provide us with a corrected blower speed.

This means that a comparative measurement for dynamic compressors is not performed at identical blower speed, pressure and flow rate, but rather at revised values for pressure and flow rate in accordance with the standard. This is because these are not proportional to the flow rate as is the case with positive displacement blowers.

The corrected impeller speed results from the impeller's peripheral velocity to be adjusted and its diameter. The flow rate at the inlet is derived from the impeller speed and the delivery rate.

By keeping the work or pressure rate constant, the compression ratio (discharge pressure to inlet pressure) to be set for the laboratory measurement can be calculated.

- **The peripheral Mach number is the ratio of the impeller's peripheral velocity to the speed of sound at inlet conditions.**
- **The delivery rate is the ratio of the inlet flow rate to the impeller's cross section and peripheral velocity.**
- **Keeping the work or pressure rate constant is the ratio of the specific stage or compression work to the peripheral velocity squared.**

Taking performance value tolerances into account

For positive displacement compressors such as rotary lobe and rotary screw blowers, the following tolerances apply for performance specification deviations as per ISO 1217:

Usable flow rate at intake conditions in m ³ /min	Flow rate	Specific power consumption	Power consumption at idle *)
Under 0.5	+/- 7%	+/- 8%	+/- 10%
0.5 - 1.5	+/- 6%	+/- 7%	+/- 10%
1.5 - 15	+/- 5%	+/- 6%	+/- 10%
Over 15	+/- 4%	+/- 5%	+/- 10%

The above-mentioned tolerances comprise the manufacturing tolerances for the compressor, including the measurement tolerances for the measured values recorded during acceptance. *) If relevant and provided by the manufacturer

No specified tolerances apply to ISO 5389. Here, the permissible deviation for the usable flow rate and the power consumption, and thus ultimately the specific package input power and the efficiency, must be agreed between the operator and the manufacturer.

When it comes to turbo blowers, there are a large number of reference points for the power and therefore a broader tolerance range in quotations. There are usually insufficient specific details regarding possible deviations in the flow rate or delivery rate.

A sensible tolerance would be as follows:

- Measurement, as well as Mach number, delivery rate and work rate as per ISO 5389.
- Total electrical power consumption +/- 5%.

If an efficiency rating is specified, it must be stated exactly which one it is, since there are many differing ones from a thermodynamic, mechanical or electrical point of view.

The most proven one is isentropic efficiency, i.e. the ratio of ideally loss-free compression performance to electrical power consumption. In addition to the specific package input power (power consumption according to flow rate), this is accorded high significance in draft standards.

Approach for establishing a robust data comparison solution

On its website www.cagi.org/performance-verification, the US association CAGI offers a helpful solution for making the quoted performance data for blowers and their components comparable. All of the parameters required for a thorough quotation review can be recorded in one practical form. A few manufacturers have taken on this format and designed their blower data sheets accordingly, so as to provide their customers with transparent and reliable performance data. Empty form templates are available if required for use with your quotation requests.

Using these form templates to request specific performance data ensures that:

- a) Performance-relevant electrical and flow-conveying components necessary for subsequent operation are included in the performance data.
- b) The full range of intake conditions are mentioned – pressure, temperature, humidity.
- c) A precise interface reference for the values relating to power and flow rate is provided.
- d) The designation of the performance parameters is unambiguous and comprehensible, and the correct standard reference for the usable flow rate or air mass flow is used.
- e) Information regarding the standard according to which the values were measured or generated is provided.
- f) Extensive, correct tolerances for the deviations between quotation/project values and actual measured values (e.g. in a laboratory) are provided.
- g) In the case of variable-speed blowers, the performance data should be provided for at least five evenly distributed operating points across the control range, so as to understand their characteristics during partial load operation.
- h) Information is provided regarding idle power for machines that, in the absence of demand for process air, do not stop the drive motor but instead blow off the excess air generated.

Ambitious planners and operators can also easily adopt the data sheet format into a spreadsheet program, in order to make objective comparisons at the push of a button in future.

Data Sheet Turbo Blower (complete machine)		Performance verification template					
Data sheet ID							
Created by							
Contact							
Date							
Project description							
Blower Model and Type							
Operation mode		Pressure operation	Medium	Air			
Performance-relevant components:							
<input type="checkbox"/> Filter intake air G4		<input type="checkbox"/> Non return valve		<input type="checkbox"/> Frequency converter			
<input type="checkbox"/> Silencer intake air		<input type="checkbox"/> Sound enclosure		<input type="checkbox"/> EMC filter			
<input type="checkbox"/> Diffuser straight		<input type="checkbox"/> Cooling air ventilator					
Rated data machine at mains operation:							
Electrical grid [V/Ph/Hz]							
Rated power motor [kW]							
Max. Lp(A) / Lw(A) [dB(A)] ^h							
Intake conditions of process air into machine:							
Intake pressure p ₁ [mbar]							
Altitude a.s.l. [m]							
Differential pressure Δp ^a [mbar]							
Discharge pressure p ₂ [mbar]							
Intake temperature θ ₁ [°C]							
Relative humidity φ [%]							
Performance data at project conditions:							
Data for Volume flow at:		1 (V' _{min})	2 (V')	3 (V')	4 (V')	5 (V' _{max})	Design point
n _{blower shaft}	min ⁻¹						
m' _{dry}	kg/min						
V' _{i.N.} ^f	m ³ /min						
V' ^b	m ³ /min						
P _{blower shaft} ^c	kW						
P _{overall} ^d	kW						
p _{specific} ^e	kW/(m ³ /min)						
eta _{isentropic} ^e	%						
θ ₂ ^g	°C						

If stop of air flow is not solely acquired by stop of motor, but also by idling possibility, state power consumption in idling mode [kW]: _____

a: Machine pressure differential between inlet and outlet (compensator)
b: Air mass flow at machine discharge port, converted to usable volume flow at inlet. Measured as per ISO 5167 and corrected as per ISO 5389 within permissible deviation for flow coefficient. V' _{max} ± 2%.
c: Including all pressure losses from machine components through which compressed air flows. Calculated value determined as per ISO 5389.
d: Total electrical power consumption of the machine, including all relevant electrical components and components through which compressed air flows. Electrical power consumption ± 5%. Determined as per ISO 5389 (within permissible deviation for mach no., flow and work coefficient), with electrical efficiency rating as quotient of shaft power and total electrical power consumption.
e: calculated from P _{overall} and V'
f: DIN 1343: in physical standard state 1013mbar, 273 K, dry air 0% r.H. (V' _{i.N.})
g: Discharge temperature (calculated value)
h: DIN EN ISO 2151 and ISO 9614-2, 1m distance, figures ± 3 db(A), with sound isolated pipework
When measuring performance data, the values quoted under project conditions will be converted to test conditions as per the specified standard (ISO 5389).

Performance data specifications at KAESER: Transparency is an obligation

As a customer-oriented organisation, KAESER places the highest priority on transparency when it comes to the performance data of our blowers. When collating data, we adhere to the current standards in order to ensure dependable comparability. Furthermore, when creating data sheets we follow the specifications of the US association CAGI.

KAESER data sheets not only enable the comparison of apples with apples in terms of blower performance, they also provide you with confidence that the information is correct.

Power measurement provides security:



For KAESER, the dependability of the performance data listed in the quotation is of immense importance. Why? Because honesty creates trust. For this reason, our blowers are rigorously put through their paces prior to delivery, in order to make sure that they perform as we have promised.

To rest completely assured, there is also the option of being present for a power measurement in one of our state-of-the-art test rooms at our production facilities in Germany. Following the successful measurement, you will receive a certificate confirming the performance data for your machine. Of course, the measurements can also be carried out in the presence of independent experts.

Contact

Contact

Whatever your concern, **KAESER** will be glad to assist you. Want to optimise your existing station? Or plan a completely new one? No problem – Contact us! We'll take care of the rest.

Simply use our contact form at

<https://nz.kaeser.com/services/contact/>



Blog

All the latest compressed air news, as well as interesting information about new products, services, the company and relevant industry topics are available in our **KAESER** blog.

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