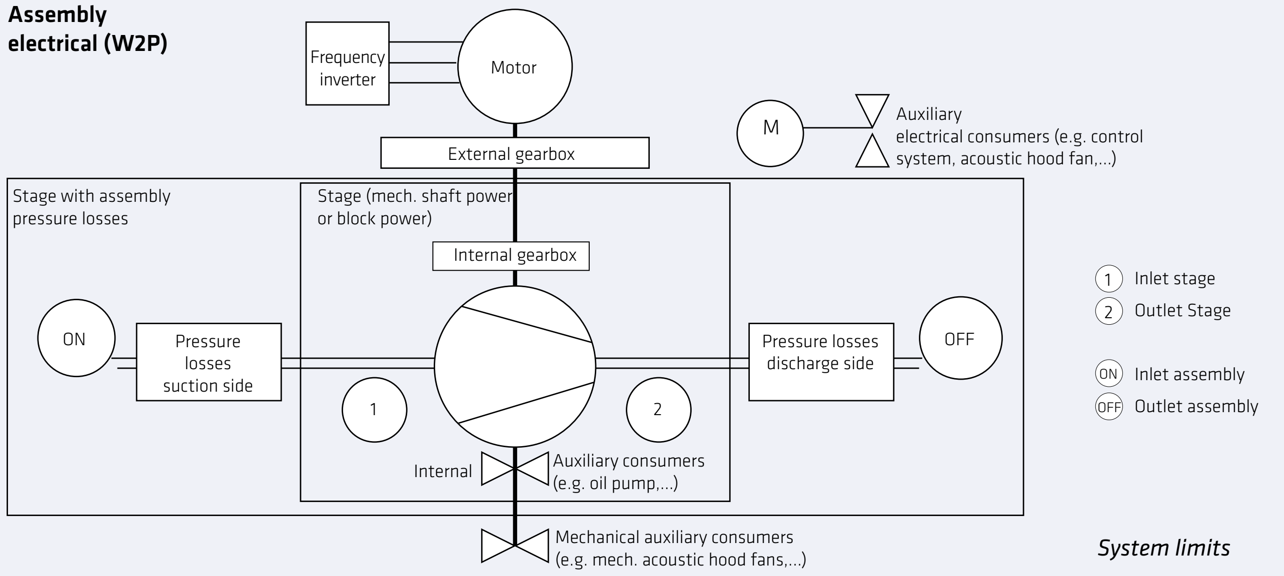
STANDARDS FOR POWER MEASUREMENT

and notes on comparability

AERZEN

INFLUENCE OF SYSTEM BOUNDARIES, STANDARDS AND REFERENCE CONDITIONS ON THE COMPARABILITY OF PERFORMANCE DATA



Observe different system limits.
In principle, the different system limits already give rise to different performance specifications. For comparability it is, therefore, important to assume that the system boundaries are the same.
Starting from the smallest system, in the above picture that of the stage including integrated components such as oil supply and gearbox (if available) up to the fully equipped assembly including drive motor and frequency converter (if available) and all auxiliary consumers such as acoustic hood fans or the control system, the power consumption continues to increase.

The different possible system limits are also reflected in the scope of delivery of AERZEN

- Assemblies without motor
- Assemblies with motor
- Assemblies without frequency inverter
- Assemblies with external frequency inverter (for installation in a separate room)
- Assemblies with internal frequency inverter

Power consumptions at different system limits.

- **Shaft power of the stage (block power)**
  Describes the mechanical power that is taken directly at the drive shaft of the stage.
- **Power consumption (with assembly pressure losses)**
  In addition to mechanical power, takes into account the suction and discharge pressure losses of the components of the assembly. These are e.g. intake filter, intake and discharge silencer and non-return valve.
- **Electrical power assembly ("W2P"*)**
  Losses in efficiency due to the motor and all auxiliary consumers in the assembly are taken into account. The total output to be used by the operator for process air generation is recorded.
- **Electrical power assembly with frequency inverter ("W2P"*)**
  If a frequency inverter is available, its losses are taken into account in addition to the electrical power consumption of the assembly.

*"W2P" = "Wire to Process"

Typical national and international standards for power measurement

- ISO 1217:2009-07
  Positive displacement compressors - Acceptance tests
- ISO 1217 AMD 1:2016-04
  Positive-displacement compressors - Acceptance tests - Amendment 1: calculation of isotropic efficiency and correlation with specific power
- ISO 5389:2005-12
  Turbo compressors - Thermodynamic acceptance and performance tests
- DIN 1945-1:1980-11
  Positive displacement compressors; thermodynamic acceptance and performance tests (has not been changed for a long time and has lost importance)
- ASME PTC 10:1997
  Performance Test Code for Compressors and Suction Blowers (Original text: Performance Test Code on Compressors and Exhausters)
- ISO 18740:2016-07
  Turbo compressors - Performance test method - Simplified acceptance test

In addition to these standards mentioned above, there are other standards for power measurement, some of which are very specific, including some that have not yet become established. All of the above standards specify boundary conditions and methods for performance measurement based on measurements of mechanical or electrical power consumption and the associated volume flow at specific operating conditions.

If requested, AERZEN is able to determine and specify your performance values in the offer according to the standard you require. Go ahead - challenge us!

In the following, we would like to explain the most common standards in more detail or to deal with their special features:

ISO 1217.
This international standard refers exclusively to positive displacement compressors. The standard, which applies to any other gases, is divided into a detailed main part and seven appendices, four of which describe simplified acceptance tests:

Appendix B: Simplified acceptance test for compressor stages
Appendix C: Simplified acceptance test for electrically driven compressor packages with fixed speed
Appendix D: Simplified acceptance test for compressor packages equipped with an internal combustion engine be driven
Appendix E: Simplified acceptance test for electrically driven compressor packages with variable speed

In contrast to the main part, the above mentioned appendices are only valid for such compressors which are manufactured in batch or series production. The standard specifies the permissible measuring methods for the individual variables required, such as pressure, volume flow, temperature and power consumption, and the minimum accuracies of the corresponding measuring instruments. In addition to carrying out the tests, the extent to which the test conditions may deviate from the guarantee point conditions and how the conversion of measurement results to the guarantee conditions is to be carried out are also defined. Derived variables are also calculated from the converted measurement results, such as the specific power consumption (kW/(m³/min)) or the isentropic efficiency. Finally, the converted measurement results are compared with the specified values. The permissible tolerances for measurements according to appendices B to E depend on the specified volume flow:

Volume flow range* (m³/min)	Permissible tolerance of the usable volume flow (%)	Permissible tolerance of the specific power consumption (%)
< 0.5	± 7	± 8
0.5 to 1.5	± 6	± 7
1.5 to 15	± 5	± 6
> 15	± 4	± 5

According to appendix C.2.4, electrically driven compressors must be measured as completely mounted assemblies (as specified by the customer) and evaluated with their terminal power («Wire-to-process»).

ASME PTC 10 - 1997.
This standard applies to North and South America. It describes the procedure for determining the thermodynamic power of axial and centrifugal turbo compressors under specific conditions. ASME PTC 10 tends to be more suitable for testing stages than for testing complete assemblies.

ISO 5389 and ISO 18740.
This international standard defines the test conditions for compressor packages that include a centrifugal compressor.

ISO 5389 is similar in principle to ISO 1217, but there are no appendices for simplified test procedures.
The standard also applies to any gas. It provides information on the measuring methods and their equipment. In addition to carrying out the tests, the extent to which the test conditions may deviate from the guarantee point conditions and how the conversion of measurement results to the guarantee conditions is to be carried out are also defined. Finally, the converted measurement results are compared with the specified values. The permissible tolerances here are +/- 4% on the volume flow and +/- 5% on the specific power consumption.

As ISO 5389 is unnecessarily complex for many applications, ISO 18740 was published in 2016, which describes simplified performance tests for electrically driven, centrifugal turbo compressor packages with fixed speed for the compression of air.

* Corresponds to the delivery volume flow measured according to ISO 1217 and converted to the reference suction conditions according to the (informative) appendix F of ISO 1217 [inlet pressure = 1.0 bar / inlet temperature = 20°C, RH = 0%])

Standard conditions and volume flows

A standard volume flow is a volume flow related to a standard condition. It is, therefore, a different description of a mass flow. In the practical application of different industries, there is a large number of different standard conditions and other reference conditions, such as those specified in non-standard parts. Finally, any thermodynamic state can be used as a reference state. The terms "reference", "standard", "norm" and "reference conditions" are usually used synonymously.
In the following some frequently used ones are presented.

- **DIN 1343:** "Physical standard state", standard conditions: T1=273.15 K, p1=1.01325 bar, rF=0%
- **ISO 2533 or ICAO 7488-2:** "Standard atmosphere", for altitude 0 m results in: T1=288,15 K, p1=1.01325 bar, rF=0%
- **ISO 1217:** Reference condition in non-standard appendix F (identical with DIN 1945): T1=293,15 K, p1=1.000 bar, rF=0 %
- **ISO 5389:** Reference condition from paragraph E. 4.2 of the non-standard appendix E, T1=273.15 K, p1=1.01353 bar, rF=0%

Example

Medium			Air
Volume flow at t1=20°C, p1=1.02 bar, rF=0%	Q_1	3,000	m³/h
Standard volume flow according to DIN 1343	Q_N	2,814	Nm³/h
Standard volume flow according to ISO 2533	Q_N	2,968	Nm³/h
Volume flow at reference conditions of ISO 1217	Q_N	3,060	Nm³/h

At AERZEN, the customers receive a volume flow rate in the offer which takes into account all losses, even pressure losses of the assembly components. This is a delivery volume flow or also a usable volume flow, with the special feature that it is specifically related to the suction conditions of the customers, e.g. t1= 30 °C, 80 % RH, p1 = 0.950 bar.
This delivery volume flow can, of course, be converted to any requested standard or reference condition. It is important to note that the actual intake conditions of the customers may differ significantly from the above-mentioned standard conditions, and, therefore, misinterpretations can quickly occur. For this reason, it is recommended that comparisons are always made under real operating conditions and, therefore, also under real suction conditions. Standard conditions are used reasonably if real conditions are not known.

Comparability of performance data

The above table shows how differently selected reference conditions affect the numerical values for the standard volume flows. Therefore, only standard volume flows with the same reference conditions may be compared with each other. However, as explained above, the selected standard conditions can differ considerably from the real conditions. Therefore, it is strongly recommended to compare the performance data of different machines under real conditions, of course, with the same system limits. The highest informative value is obtained by determining and comparing annual energy consumption. For the specific application, a typical distribution of the respective operating hours under different operating conditions is taken as a basis, ideally based on measurement data. Only this consideration covers idle, partial load and full load operations as well as seasonal and other changes in operating conditions.

If the distribution of operating hours is known, we will be pleased to calculate the annual energy consumption for all our products under your real conditions. If this is not known, we will support you with our AERAUDIT in recording it.

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