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Technical Information

How to read a fan curve?

Introduction

A fan is a volume revolving machine that aims to move a mass of air. Each fan is specified by an operation curve linking airflow, pressure and speed. These fans curves gives technical and necessary information for the design and the comprehension of an installation. According to the manufacturer, the type of fan or the application, curves can be simplified or fully detailed.

Reading a fan curve – Main interesting values

Depending on the curve level of details, the following values can be obtained :

► **Operating / construction limits and kind of fan**
These limits are the maximum performances reached by the fan for a good operation. Beyond, the risk of spoiling or breakdown of the bearings exists. For a direct-drive fan, the maximum air temperature for the motor inlet and the voltage tolerances are usually indicated.

► **The fan rotation speed / speed curves (tr/min or Upm)**
Be careful : do not mix motor speed and fan speed ! Fan and motor drive at the same speed for direct-drive fan system or for the transmission ratio equal to 1.
For a pulley-belt drive and an insignificant motor slip, the fan speed is a **fixed data**, depending on the motor speed (known) and the transmission ratio (fixed). The use of a variable-frequency or variable-voltage regulator allows to go from one speed curve to another one (paralleled from each other).

► **The sound pressure or power level (dB or dB(A))**
These two different ideas can be mentioned on a curve. The sound power level is universal and measured according to the DIN 45635 acoustic standard. It depends neither on the nature of the premises nor on the distance from the fan. This common standardization allows to compare different kinds/brands of fans.
The sound pressure level unit is the decibel, dB (or dB(A)), but is equivalent to a radiated noise measurement that is done in specific conditions (reverberation, premises conditions, measurement distance, free or hemispherical field…). To compare different sound pressures, the measurement conditions should necessarily be the same (otherwise the comparison would be wrong and not valid).
These units are expressed either in dB, or weighted in dB(A) (weighting according to human ear, be careful in case of comparison).

► **The motor power output or the absorbed power (W or kW)**
Depending on the kind of curve, it means the absorbed power (at the drive shaft) of the fan or directly the motor power required to move the air to these airflow and pressure values. To go from the motor power output to the absorbed power, it is advisable to take into account the motor efficiency, transmission losses and possibly the saving.

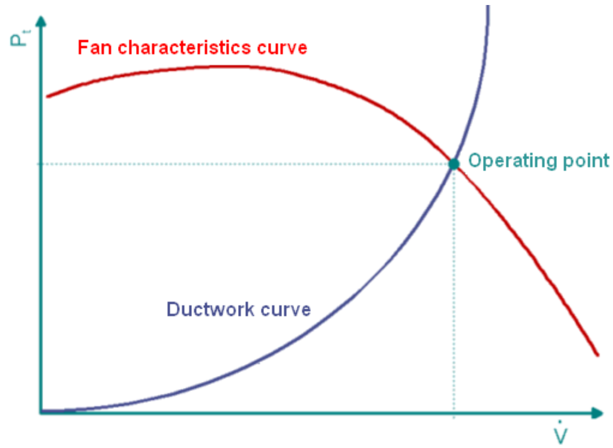
Remarks: a motor power output on a nameplate is always a **mechanical power** and not an electric power. The electric power is often higher than the mechanical one written on the nameplate

► **Ductwork curve**

Airflow/pressure drop of the ductwork (ducts, diffuser…) is described by this curve.
The formula managing the ductwork is:

$\Delta P = K \times Airflow^{2}$ K = constant coefficient function of ductwork

This curve can be described according to three different styles :
- parabolic style: while abscissa scales (airflow) and ordinate (pressure) are linear (opposite curve, VEC, T-VEC, CVEC). This curve starts from the origin.
- logarithm style: while abscissa scale is linear and ordinate scale is logarithmic (curve : Cyclone, VDA).
- straight line: while scales of abscissa and ordinate are logarithmic. This curve doesn't start from the origin.



On a current installation, ductwork is unknown and hard to determinate by calculation.

► **Fan operating point**

The fan operating point is the intersection between ductwork curve and fan curve.
It allows to confirm the fan selection and to know its potential of power saving. Following terms are often used :

❶ Selected fan « on the left »: the operating point is located on the left side of the curve. The wheel size is large for the requested airflow (a lot of saving).

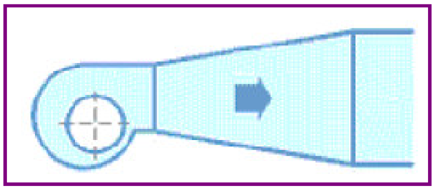
❷ Selected fan « on the right »: the operating point is located on the right side of the curve. The wheel size is small for the requested airflow (a few or no saving).

A selection « on the right » or « on the left » will be essentially led by use conditions and fan application (a smoke exhaust fan which operates for a short period will be selected « on the right » and for a tertiary and comfort application, fan will be selected « on the left »).

► **The dynamic pressure of the fan (10 Pa = 1 mm water column (mmH2O or mmWS))**

The dynamic pressure is the overpressure required to generate air velocity in the ductwork. It is proportional to the velocity square and is always positive, structural and lost.

$P_{dyn} = \frac{1}{2} . \rho . v^{2}$ ρ = density (kg/m3), v = air velocity in m/s, P_{dyn} in Pa



A divergent connection installed in the fan outlet will reduce the air speed and so, for constant total pressure, it will allow to convert a part of the dynamic pressure into static pressure. The divergent angle should be between 7°and 15°and its length should be at least 1,5 time the fan outlet diameter.

► **Airflow (m3/h or m3/s)**

Airflow, except for different specification, is always given under an atmospheric pressure (1013 mbar) and for a temperature of 20°C (293°K / 68°F). It is usually expressed in m 3/h or m3/s for high airflows.
In Anglo-Saxon countries, airflow is usually in CFM (cubic feet per minute or ft3/min), with the conversion as the following one: 1 CFM = 1,699 m3/h.

Radial and centrifugal fans

The simplified curves allow to obtain main values. They are often linked with a specific equipment and frequently indicate data in the global equipment outlet and not only on the fan. It's useful to determinate :

❶ Available pressure Pa at the outlet of the equipment (be careful about ordinate scale !)

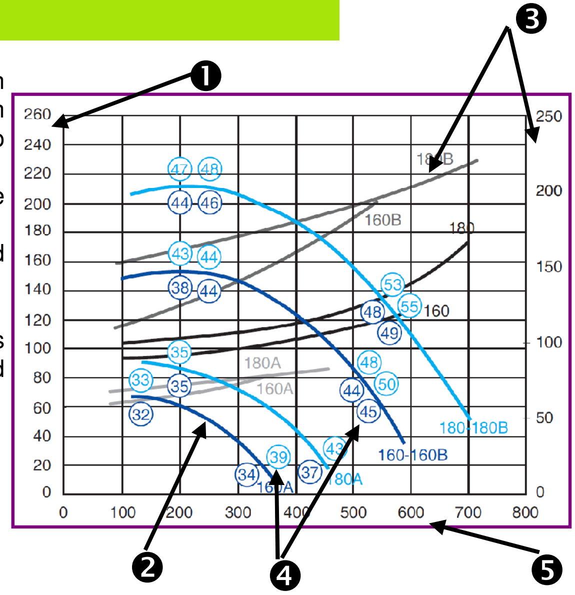
❷ Operating curve for the defined speeds (standard transmission or electrical commutation motor)

❸ Motor power output in W (not the shaft power)

❹ Global acoustic level (opposite Mini-VEC curve: it presents the sound pressure at 4 m, in dB(A), ejected side is connected and not connected).

❺ The airflow in m3/h or m3/s (be careful with the scale !)

This kind of curve is useful for a quick selection (often used for small fan (CMV))

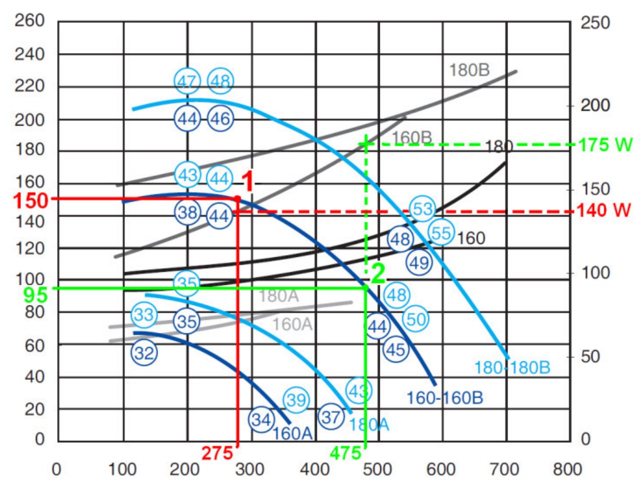


Radial and centrifugal fans

► **Example n°1**

Select **Mini-VEC type 160B** without connection on the rejected side. The calculated static pressure P1 for the ductwork is 150 Pa. The operating point is **point 1**, with an airflow of **275 m3/h**. The intersection of the abscissa with the power curve gives the motor consumed power: **140 W.** The acoustic level is 44dB(A).

If the real pressure loss P2 after the first start is under the estimate P1 (**90 Pa** instead of **150 Pa**), the operating point will slide from the **point 1** to the **point 2** (same rotation speed). The airflow becomes 475 m3/h and the motor consumed power is now **175 W.** The consequence is an over-airflow with a higher acoustic level (48 dB(A)).



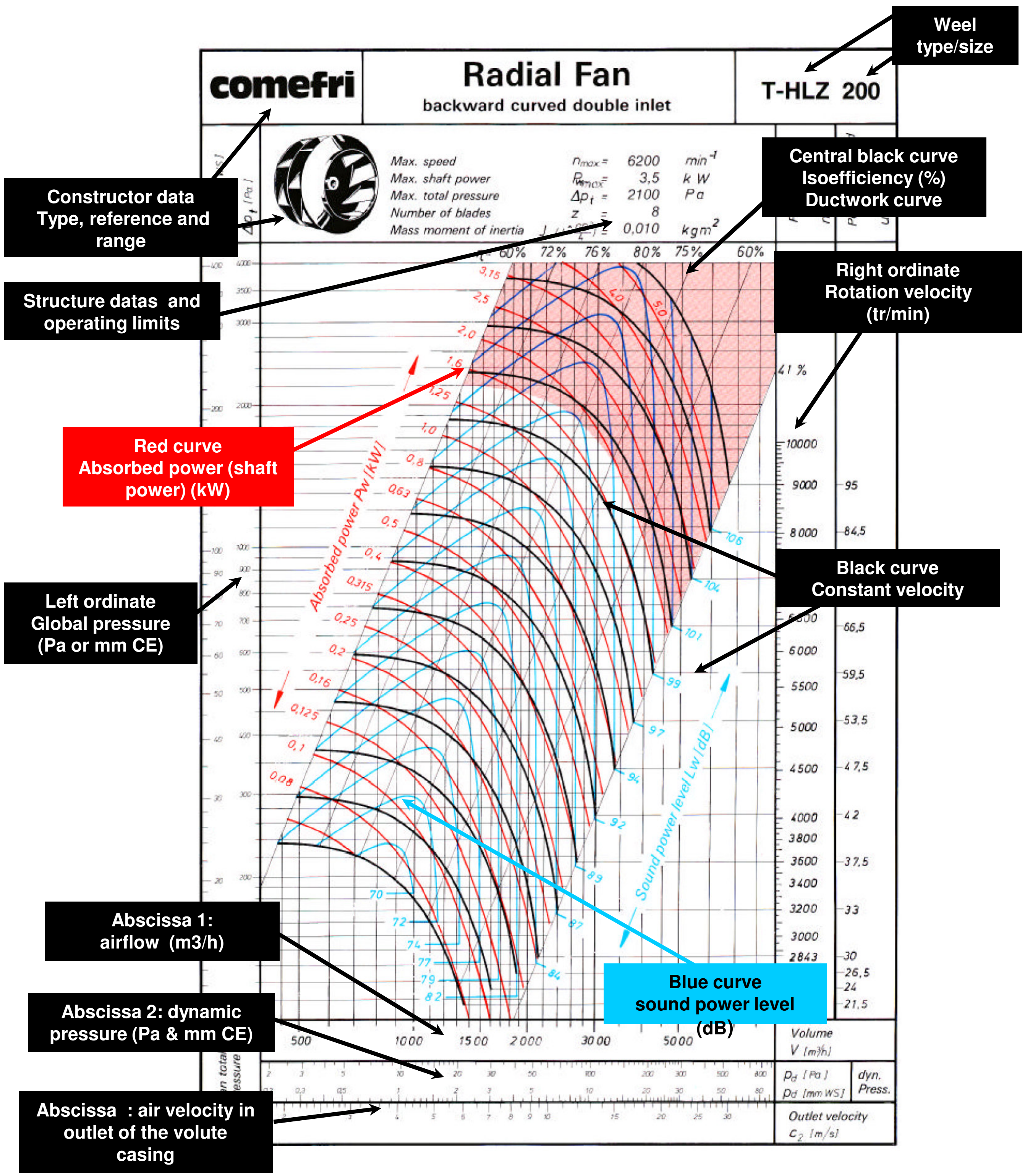
► **Example n°2**

For an installation with many stages of filters, the fan operating point is **point 2.**

After a period, filters are clogged and the global pressure loss increases. The operating point will go from **point 2** to **point 1** according to the filters clogging. The airflow will decrease with time, from **475** to **275 m3/h.**

ℹ This example demonstrates that the ductwork's characteristics calculation is necessary in the material selection to avoid technical problems.

Case n°2 – Detailed curve / COMEFRI centrifugal fan



Case n°2 – Detailed curve / Operating points

For a better comprehension of the three examples explanations below, please refer to the curve in annex (following page) :

► **Example n°1 – Point A with a constant rotation speed o f 2200 tr/min**

The rotation speed of the fan is fixed arbitrarily to **2200 tr/min**. Scales of this curve are logarithmic so the ductwork curve is a straight line that corresponds to a constant efficiency (iso-efficiency).
The fan operating point is the intersection of those both curves (rotation speed and iso-efficiency arbitrarily fixed), **point A.**
In following the vertical line to the abscissa, the corresponding airflow is **1850 m3/h.**
In following the **red curve of the power output**, the absorbed power is **0,6 kW.**
In following the **blue curve,** the sound power level is **82 dB.**

► **Example n°2 – Point B with the same rotation speed and another ductwork pressure loss**

From **point A**, pressure losses change (filter clogging, damper closing or diffuser modification). The ductwork global pressure loss increases and the « ductwork » curve » slides to the left. Because the transmission is fixed, the rotation speed is unchanged (**2200 tr/min**).
The operating point goes to the left along the « constant velocity » curve until the intersection with the new ductwork curve. The new point is **point B.**
In following the vertical line to the abscissa, the new airflow is **1200 m3/h.**
In following the **red curve**, the new absorbed power is **0,3 kW.**
In following the **blue curve**, the new sound power level is **76 dB.**

► **Example n°3 – Point C with a modification of fan velocity**

From **point A**, the fan velocity changes because of a frequency regulator or a modification of the transmission ratio. The new velocity is chosen at **1400 tr/min.**
The ductwork is unchanged, so does the ductwork. The velocity decrease with the same ductwork means a different position of the operating point, from the **iso-efficiency curve** to the new rotation speed (**point C**).
In following the vertical line to the abscissa, the new airflow is around **1200 m3/h.**
In following the **red curve**, the new absorbed power is **0,14 kW.**
In following the **blue curve**, the new sound power level is **73 dB.**

BE CAREFUL

The ductwork description by a straight line is only possible when airflow and pressure scales are logarithmics. For semi-logarithm (Cyclone) or linear (VEC) scales, this straight line is inaccurate.

In their catalogue, fan constructors frequently indicate methods to approximately calculate the motor power output, according to the mechanical power obtained on the curve. For instance, until 10 kW and for forward-curved blades such as TLZ type, the constructor COMEFRI informs on the necessity to add 20% to the obtained value from the curve, in order to reach the requested motor power.

Case n°2 – Detailed curve / Operating points