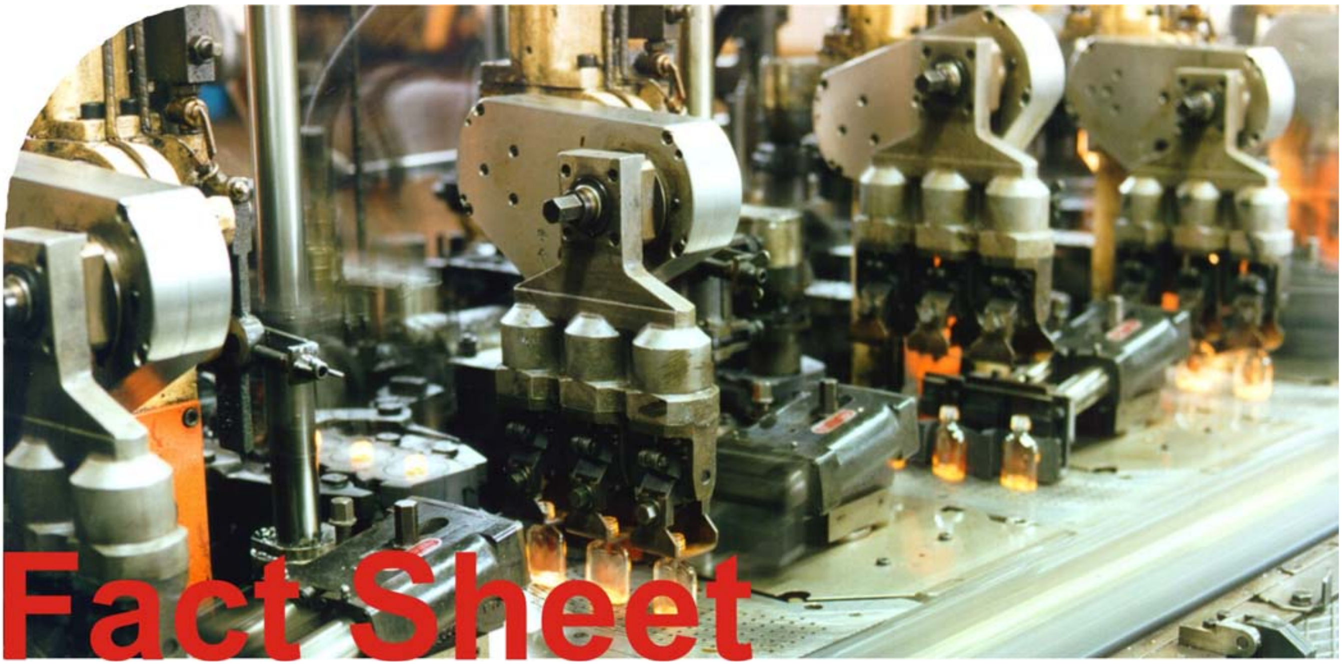

Fact Sheet
Production

What type of compressor?

In practice, piston, screw, and turbo compressors are the main types. In addition, there are membrane, sliding vane, helical, rotary tooth and rotary piston compressors.

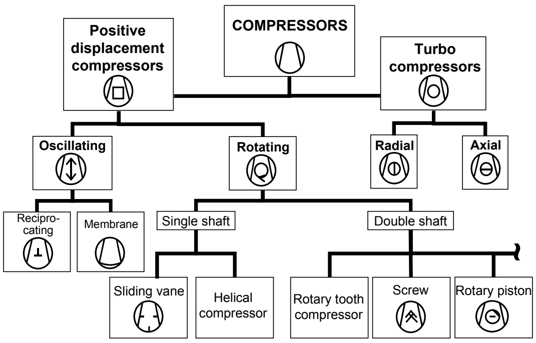

Fig. 1: Types of compressors

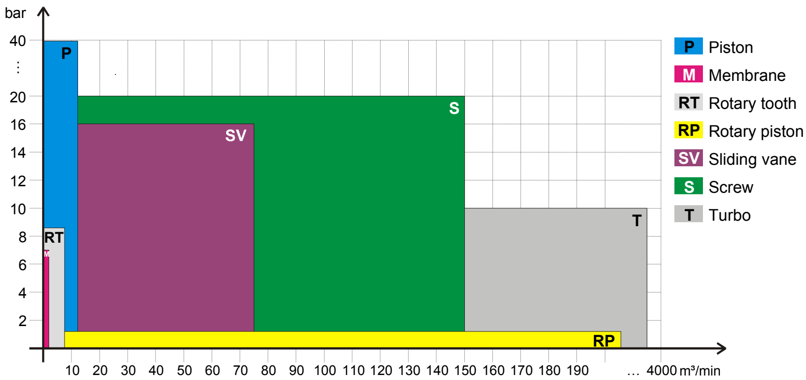

Fig. 2: Potential power of compressor types

Compression principle

Piston compressors

Reciprocating compressors function according to the positive displacement principle. When moving downwards, the piston sucks air in from the atmosphere via the suction valve. When the upstroke begins, the suction valve closes. The air is expelled via the

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discharge valve. Piston compressors are multiple-cylinder (higher capacity) or multiple stage (high pressures).

Fig. 3: Piston compressor

Screw compressors

Screw compressors function according to the positive displacement principle. Two parallel rotors with different profiles counter-rotate within a common housing. There are screw compressors with capacities up to 1000 kW. They are powered directly or with transmission or V-belts.

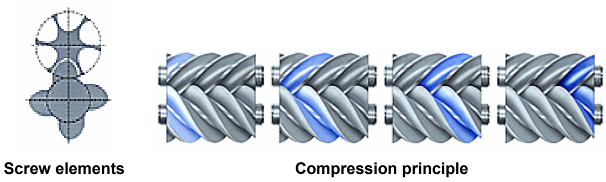

Fig. 4: Screw elements and compression principle

Injection-cooled screw compressors work in a single-stage up to 15 bar and in two stages up to 20 bar max. pressure. Oil-free screw compressors work up to 3 bar in a single-stage of compression and up to 10.5 bar in two-stages with intercooling. The main and auxiliary rotors are driven by a synchromesh gear in oil-free screw compressors to avoid contact.

Turbo compressors

Turbo compressors are dynamic, the rotating element (called impeller) has blades to accelerate the gas to be compressed.

Fixed control devices on the blades transform the kinetic energy into pressure energy. Turbo compressors usually have large capacities and compress oil-free. They compress up to 2 bar in a single stage and up to 7 bar in two stages. Twenty-stage compression is possible.

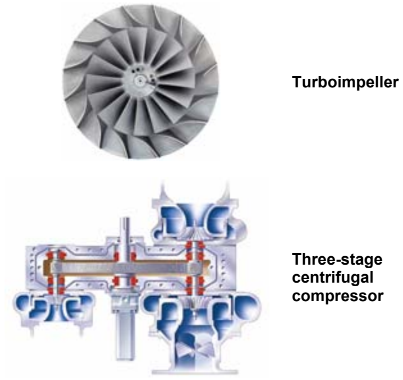

Fig. 5: Turboimpeller and centrifugal compressor

Pressure ranges of screw compressors

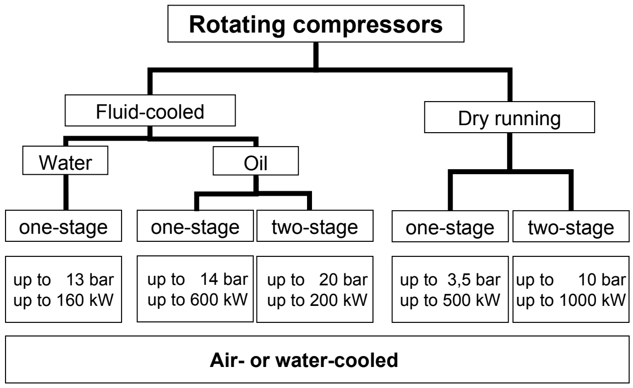

Fig. 6: Pressure ranges of screw compressors

Performance testing ISO 1217 Appendix C

Performance testing for screw compressors under ISO 1217 is described in Appendix A. Appendix B describes the performance testing of the compression stages, while Appendix C is to be used for complete screw compressor systems.

Volume flow rate

The volume flow rate (quantity delivered) of compressors is measured in accordance with the given measurement method at max. pressure at the compressed air outlet of the entire system and projected backwards to the inlet conditions.

Inlet conditions:

Inlet temperature +20 C
Inlet pressure 1 bar
Relative humidity 0%
Cooling water temp. +20 C

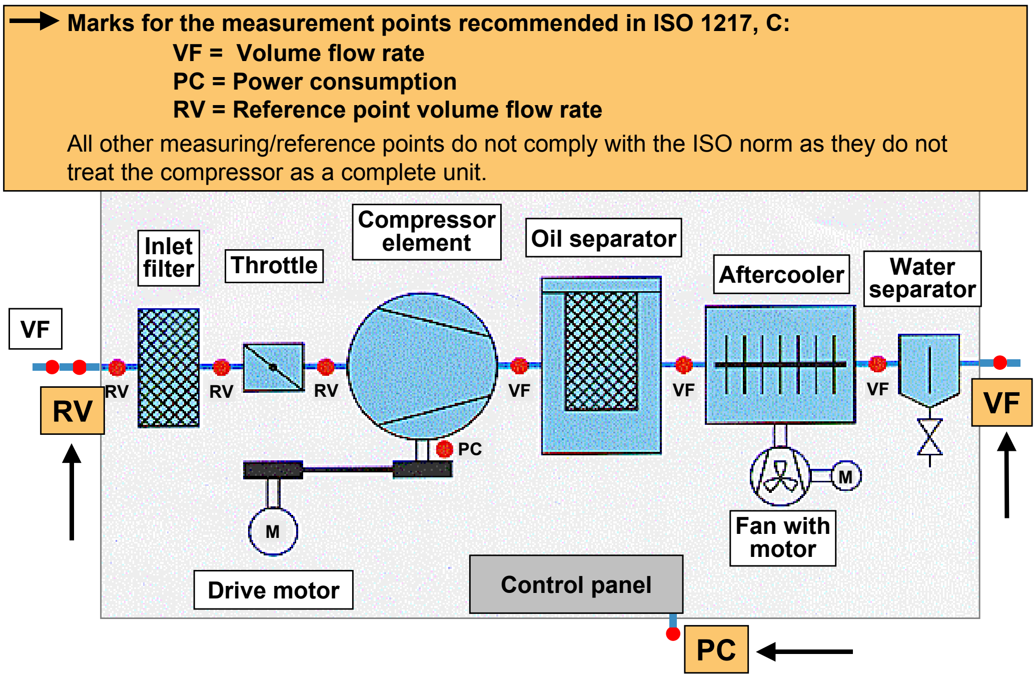

Fig. 7: Performance testing under ISO 1217

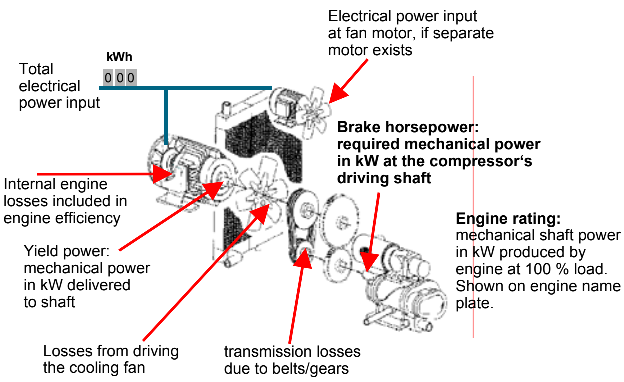

Fig. 8: Power flow in compressors

ISO 1217: 1996 (PN2 CPT)			
Volume flow rate at given conditions	**Volume flow rate**	**Specific power input**	**Power input no-load operation*)**
below 0.5 m³/min	+/- 7 %	+/- 8 %	+/- 20 %
0.5 – 1.5 m³/min	+/- 6 %	+/- 7 %	+/- 20 %
1.5 – 15 m³/min	+/- 5 %	+/- 6 %	+/- 20 %
above 15 m³/min	+/- 4 %	+/- 5 %	+/- 20 %

The tolerances shown contain the manufacturing tolerances of the compressor incl. the measurement tolerances for the values obtained during the inspection.
*) if povided by manufacturer

Table 1: Specific power requirements under ISO 1217

Power consumption

The electrical power consumption means the total power consumption of all motors (drive and fan) taken from the electrical mains.

Specific power requirements

The tolerances of the specific power requirement permitted (electrical power consumption divided by quantity delivered) are fixed in the performance testing standards.

Compressor rooms and compressor assembly (VDMA 4363)

The heat produced during compression – which is almost all the energy entering the compressor from the mains – has to be discharged. The permissible temperatures in the compressor room are fixed in the German Engineering Federation VDMA standard sheet 4363. They range between +5 °C and +40 °C. If the temperature is too low, there is the danger the compressor's safety devices will freeze. If it is too high, there can be problems with components overloading.

Depending on the on-site conditions, air-cooled compressors can be used up to approx. 250 kW capacity.

If there is no possibility to remove heat using air because the volume required is too large, the heat must be removed using water. The operating costs of water-cooled compressors are about 30 % higher than air-cooled ones.

Ventilation of compressor rooms

Supportet convection (with fan, without ducts)

- Low investment costs
- Minimal technical input
- Automatic space heating in winter

Note:

- Only applicable in small/medium compressors
- Room temperature increase by Δ t = 5-10 K, therefore increased volume of cooling air requested
- Risk if inlet air is warm.

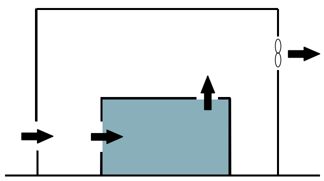

Fig. 9: Natural ventilation for small capacities

Ventilation via duct

- Average investment costs
- Average technical input
- Cooling air heated by Δ t = 25 K, therefore small volume of ventilation air necessary
- Compressor room only heated slightly
- Heating possible due to hinged vent
- Noise reduction.

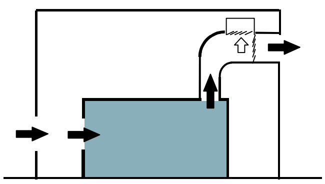

Fig. 10: Ducted discharge air in larger compressors

Air cooling

The simplest kind of heat removal is via cooling air. The cool air has to enter the compressor and the heated air then exit it. The volume required has to be supplied by the user. The cooling air can be fed in and discharged through free openings. If this natural ventilation, which is usually found in small compressors, is not sufficient, then either the injection or the discharge has to be supported using a fan. If this is also no longer sufficient, then the air supplied/discharged has to be fed via a duct. An additional fan is necessary in long ducts to bridge pressure losses in the duct. Special controls permit a mixed air operation in winter. Warm air from the compressor room is mixed with cold air drawn from outside through a louver. Drawing cool air in from outside through ducts is also recommended if the air in the compressor room is not clean.

Water cooling

It can be difficult to supply the necessary amount of cooling air if large amounts of heat have to be discharged, i.e. in large compressors, or if several compressors are positioned in one room. The machines then have to be cooled using water. Of course, the operator has to have a supply of cooling water at hand. Fresh water cannot be used on account of the high costs involved. Compressors can easily be connected to open or closed circuit cooling water systems. Before the decision is made for water cooling, it has to be ensured that the compressor's cooler is correctly designed for the water quality. Aggressive cooling water requires coolers made of resistant material.

Another point is often overlooked: in spite of water cooling, the heat emitted by the individual components in the compressor still has to be removed. Cooling air is still required for this, although a relatively small amount.

Heat recovery

Space heating

The most economic type of heat recovery is to exploit compression heat for space heating. Prerequisite is an air-cooled compressor over which the cooling air can be channelled. This kind of heat recovery is economic because all the heat, including that emitted in the compressor, can be used. The heated air has to be transported via a system of ducts. Care should be taken to keep the distances as short as possible. Firstly, long distances mean pressure losses in the duct, which in turn can only be compensated using an additional fan, and secondly, heat losses occur if the air is in the duct for a long time. Insulated ducts are an alternative but would also involve higher investment costs.

It must be borne in mind that only winter months can be used for the amortisation time of heat recovery through space heating. In summer, the waste heat is discharged outside through a hinged vent.

Heating water

For screw compressors with oil injection, the oil removes approx. 72 % of the electrical energy supplied. This energy can be recovered. It is irrelevant whether the screw compressor is air- or water-cooled. To recover the thermal energy, the oil passes through a heat exchanger which can heat water by 50 K up to 70 °C. The heat exchanger is usually a plate-type heat exchanger which is capable of very high heat utilisation, can be housed compactly and makes these high water temperatures possible.

It must be noted that water is only heated if the compressor is operating to capacity. Since this is not always the case, and thus hot water will not always be produced, heating water using heat recovery can only supplement the heating circuit. The amortisation of heat recovery in this case is only possible in the winter months.

Hot water production

If the plates are defective, there may be a breakthrough in the plate heat exchangers used to heat water so that water and oil mix. To avoid oil-polluted wastewater, a safety heat exchanger is used when heating sanitary or process water. The pressure of a carrier fluid between the oil and the water side changes if oil breaks through.

A signal is sent through a pressure switch to turn off the system. In this system, water can be heated by about 35 K to approx. 55 °C. In contrast to the production of heating water, an amortisation is possible over the whole year.

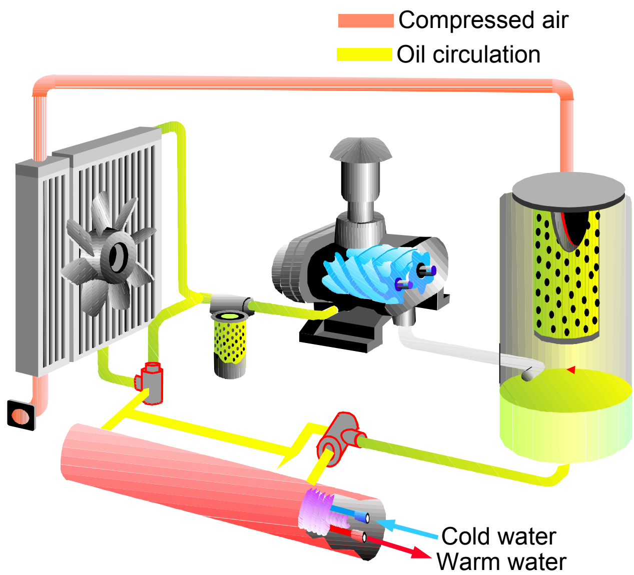

Fig. 11: Heating sanitary or process water by an oil-injected screw compressor

The "Druckluft Schweiz" campaign (efficient compressed air in Switzerland) motivates and supports the operators of compressed air systems in Switzerland in implementing measures to increase the energy efficiency of compressed air supply. The campaign is led by the Fraunhofer Institute for Systems and Innovation Research and sponsored by the Swiss Federal Office of Energy and the "Electricity Saving Fund" of ewz, the electricity company of the city of Zurich. It is part of the "EnergieSchweiz" Programme. Co-sponsors are the following companies from the compressed air sector: Airtag, Atlas Copco, Donaldson, Dopag, Kaeser, Oetiker, Prematic, Servatechnik, Vektor.

Further information can be found at **www.druckluft.ch**

This information sheet was compiled as part of the "Druckluft effizient" campaign, which was conducted in Germany between 2001 and 2004. The campaign was carried out by the German Energy Agency (dena), the Fraunhofer Institute for Systems and Innovation Research (Fraunhofer ISI, project management) and the German Engineering Federation (VDMA) with the support of the Federal Ministry of Economics (BMWi) and industrial enterprises (http://www.druckluft-effizient.de/kontakt/partner/industrie.php).

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