PHYWE

Heat pump, compression principle

04373-93

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Operating instructions

The unit complies with the corresponding EC guidelines

Fig. 1: Heat pump, compression principle 04373-93 (P2360202)

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1 SAFETY PRECAUTIONS

Attention!

- Carefully read these operating instructions completely before operating this instrument. This is necessary to avoid damage to it, as well as for user-safety.
- Check that your mains supply voltage corresponds to that given on the type plate fixed to the instrument.
- Install the instrument so that the on/off switch and the mains connecting plug are easily accessible. Do not cover the ventilation slits.
- Take care that no liquids or objects enter in through the ventilation slots.
- Only use the instrument in dry rooms in which there is no risk of explosion.
- Do not operate if there are visible signs of damage to the unit or the connection cord.
- Only use the instrument for the purpose for which it is intended.

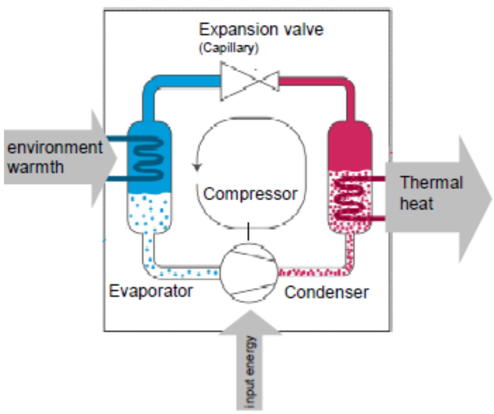
2 PURPOSE AND CHARACTERISTICS

A heat pump extracts energy from a low temperature environment and adds this energy to an environment which has a higher temperature. The work required for this is performed by a compressor.

The heat pump 04370-93 is a symmetrical set-up demonstration model used to demonstrate that refrigerators and heat pumps operate according to the same principle.

3 FUNCTIONAL AND OPERATING ELEMENTS

The compressor presses a special refrigerant (here isobutane R600a) into the condenser. The capillary, which leads from the condenser to the evaporator, accumulates this refrigerant. Pressure is built up in the condenser, and the gaseous refrigerant condenses and liquefies. When compressing a substance, compression heat is generated, the condenser gets warm, then hot, and gives off heat to the environment. Simultaneously with the overpressure in the condenser, a negative pressure is created in the evaporator, since the compressor sucks off the refrigerant flowing through the capillary into the evaporator. When the refrigerant liquefied in the condenser injects into the negative pressure of the evaporator, it is forced to vaporize by the negative pressure. However, the transition from the liquid to the gaseous state always requires a lot of thermal energy. If this is not specially supplied from outside, it is simply withdrawn from the environment: the evaporator gets cold. In the present model, the 6mm copper tube acts as an evaporator; the inside width of the capillary is 0.7mm. The interesting thing about a heat pump is the fact that when heat exchangers are used appropriately, the heat energy given off to the environment or the heating circuit is about three to four times as great as the electrical energy required to operate the compressor. The energy obtained comes from the environment; this can be the ambient air, water from lakes or rivers, geothermal heat or waste heat from industry.



4 EXPERIMENTS

1. Thermal energy transfer

- Place two containers filled with water so that both the evaporator and the condenser are covered with water. 1000 ml beakers, for example, are suitable for this.

- Switch on the heat pump and observe how the water in the evaporator tank is cooled by 5°-10°C over a few minutes and at the same time the water in the condenser tank is heated by 10°-20°C.

2. Quantitative demonstration experiment

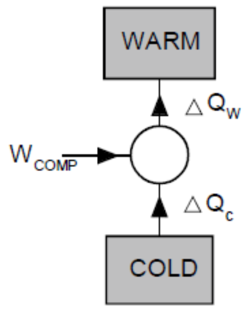
- The two water tanks should be insulated in such a way that heat exchange with the surroundings is avoided during the experiment. For example, use rock wool supplemented with some kind of fabric cover.
- About 5 minutes after switching on, the heat pump has reached the working pressure values and the working temperature and you can start with the measurements. You can use slowly flowing tap water from the tap as a heat source.
- Use temperature sensors to track temperature evolution over time. (Stir in the containers, otherwise there will be a significant temperature gradient in the two containers).
- The thermal energy released can be calculated from the amount of water, e.g. 1 liter, and the measured temperature difference. It should be noted, that the glass vessel and the 2.5 m copper pipe (outer diameter 6 mm, inner diameter 4 mm) must also be heated. The electrical output of the compressor can be measured with a wattmeter.
- With the data collected at specified time intervals, the coefficient of performance (COP) of the model can be calculated. Careful experiment arrangements result in a COP value of up to 3.

COP - The coefficient of performance

The performance figure results from the ratio of output to input, i.e. from the ratio of useful power to the power supplied. So the following applies:

$$COP = \frac{\textit{useful performance}}{\textit{supplied power}}$$

The useful output is the actual heat, that is provided and usable by the heat pump. Heat losses in the distribution system reduce the useful output.



The coefficient of performance, the so-called COP, is often used to evaluate the efficiency of heat pumps. COP stands for **C**oefficient **O**f **P**erformance. Formally, the **COP** is the quotient of the amount of heat generated Q_W and the amount of electricity used W_{Comp} in a specific operating condition at a specific point in time.

$$COP = \frac{Q_{warm}}{W_{comp}} = \frac{Q_w}{W_{comp}}$$

5 NOTES ON OPERATION

This high-quality instrument fulfils all of the technical requirements that are compiled in current EC guidelines. The characteristics of this product qualify it for the CE mark.
This instrument is only to be put into operation under specialist supervision in a controlled electromagnetic environment in research, educational and training facilities (schools, universities, institutes and laboratories).

6 TECHNICAL DATA

Refrigerant:	Isobutane R600a
Working pressure in the evaporator:	0-3 bar
Working pressure in the condenser:	6-15 bar
Power of the compressor	50-60 W
Supply voltage	see type plate
Mains frequency	50 Hz
Power consumption	approx. 120 VA
Housing dimensions (mm³)	650 x 470 x 250
Weight	approx. 13 kg

7 DATA OF THE WORK EQUIPMENT R600A

Specific heat capacity (liquid, 25 °C)	1,4189 J/gK
Spec. heat capacity (gaseous	0,8323 J/gK
Spec. heat of vaporisation	177,33 J/g

Physical state at 20 °C: :	Gas
Colour:	Colourless Gas
Odur:	Sweetish
Low warning effect at low concentrations.	
Mostly odorant added.	
Molecular weight	58
Melting point:	-159°C
Boiling point:	-12°
Critical temperature:	135°C
Vapour pressure (20°C):	3 bar
Relative density, gas (air =1):	2
Relative density, liquids (water=1)	0,59
Solubility in water:	54 mg/l
Flammability limits [% by volume in air]	1,8 bis 5,8
Ignition temperature:	460°C

Refilling the refrigerant
The system is sealed in such a way that the refrigerant quantity remains the same for years. If the gas pressure should drop at any time, all screw connections of the Mano-meter connections must be checked, possibly tightened a little and refrigerant must be refilled:

Procedure:
1. Disconnect the device from the mains
2. Evacuate the heat pump
3. Top up with isobutane (R600a) until the evaporator gauge reads approx. 1.2 bar (approx. 25 g.)
4. Connect the heat pump to electricity, switch on the electricity.
5. Set the pressure in the evaporator to 0 bar (the working pressure in the evaporator must be 0 bar).
6. After 5 minutes of operation, switch off the heat pump, disconnect the filling station from the heat pump and close the valve with the lid.

8 NECESSARY ACCESSORIES

- Temperature meter digital, 4-2 — 13618-00
- 2x Lab jack, 150 mm x 150 mm — 02074-02
- 2x Glas beaker, 1000 ml — 46057-00
- Power meter digital — 07049-01

9 WARRANTY

We give a warranty of 24 months for units supplied by us inside the EU, and a warranty of 12 months outside the EU. The following is excluded from the warranty: Damage that is due to non-compliance with the operating instructions, improper use, or natural wear.
The manufacturer can only be held liable for the function and safety-relevant properties of the unit, if the maintenance, service, and modifications of the unit are performed by the manufacturer or by an institution that is expressly authorised by the manufacturer.

10 WASTE DISPOSAL

The packaging mainly consists of environmentally-friendly materials that should be returned to the local recycling stations.

Do not dispose of this product with normal household waste. If this unit needs to be disposed of, please return it to the address that is stated below for proper disposal.

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