Instruction manual

HL 109 Safety Devices
Training Panel

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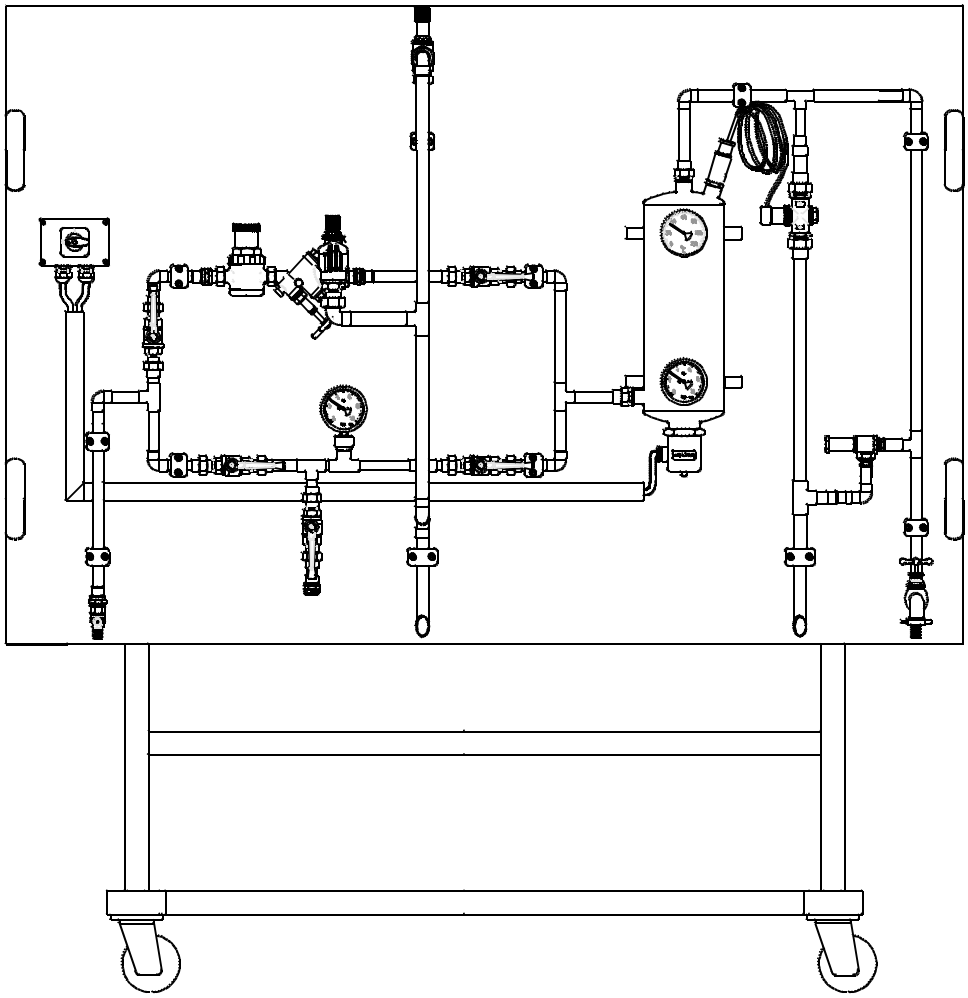

Instruction manual

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HL 109 Safety Devices Training Panel

Table of Contents

HL 109 Safety Devices Training Panel

1 Introduction

The HL109 training panel is used to demonstrate safety devices in closed domestic hot water systems and closed hot water heaters.

The following topics can be investigated on the training panel:

- Function, design and application of a membrane safety valve
- Function, design and application of a safety group consisting of pressure reducer, shut-off valve, non-return valve and membrane safety valve
- Function, design and application of a thermal protection device

The trainee also gains the following general skills:

- Preparing and performing series of experiments
- Knowledge of handling pressure and temperature measuring instruments

The Appendix to this instruction manual contains worksheets that simplify the methodical evaluation of the experiments.

The experiments on the HL109 are very well suited to team work, as various measured values are read in relatively short intervals and need to be entered in the worksheets.

The training panel can easily be installed in the HL100 universal stand or the KL 090 supply bench.

2 Unit description

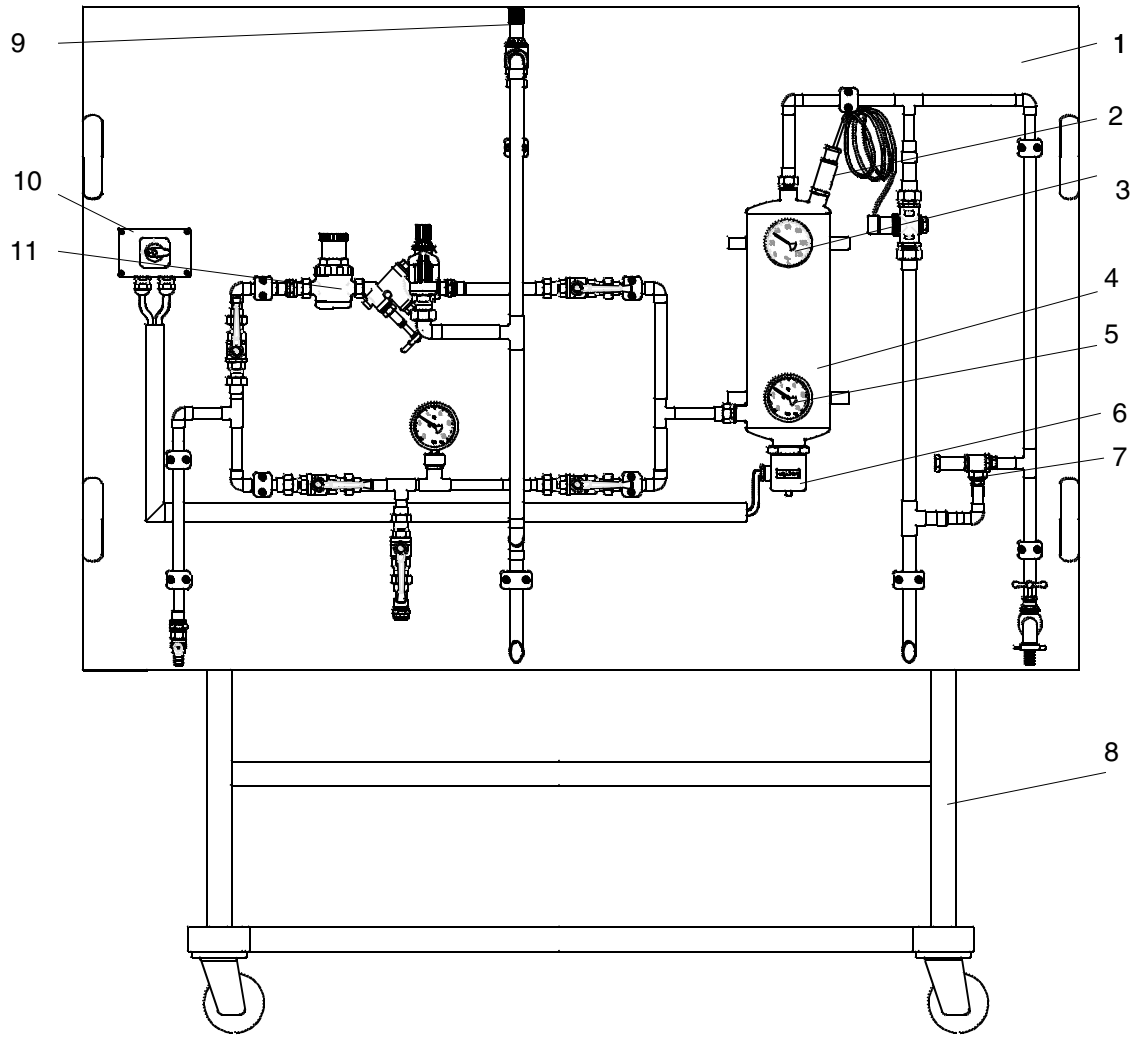
The HL109 training panel is a completely equipped experimental unit for pressure and temperature measurements on specified safety devices in closed domestic hot water systems and closed hot water heaters.

The safety devices for domestic hot water systems are different from those for hot water heaters. The two sets of safety devices can be selected as separate pipe sections using ball valves. The pressure and temperature limits for the different safety devices are recorded and compared with safety specifications.

In conjunction with the HL100 universal stand for training panels or the HL090 supply bench for training panels, the HL109 training panel provides the following features:

- The entire experimental setup is based on a single panel
- Castors allow easy movement and manoeuvring of the experimental unit
- Pressure measurement using Bourdon gauge
- Temperature measurement using bimetallic dial thermometer
- Various pipe sections selectable

2.1 Layout of training panel



1	Training panel	7	Overpressure valve
2	Thermal protection	8	HL 100 Universal stand for training panels
3	Bimetallic dial thermometer	9	Safety valve
4	Pressure vessel	10	Control cabinet for heating
5	Bourdon gauge	11	Safety group
6	Heater rod		

(This figure shows the HL 109 training panel and the HL 100 universal stand, which is not included with the HL 109.)

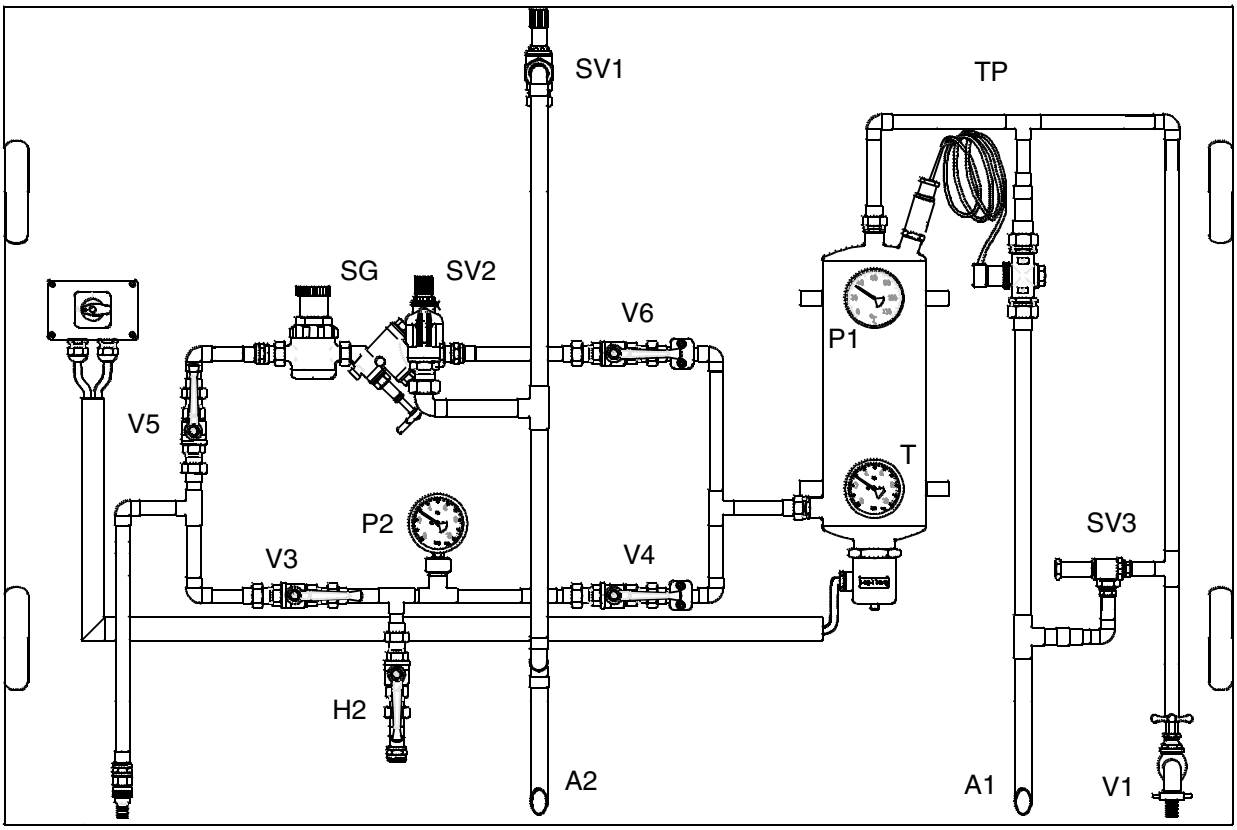


Fig. 2.1: Identification of the measuring and shut-off points

To allow the circuits in the experiments that follow to be described clearly and consistently, the following abbreviations are used:

A1 - A2:	Blow-off pipes
V1:	Outlet valve
V2 - V6:	Shut-off points (ball valves)
P1 - P2:	Pressure measuring points
SG:	Safety group
SV1:	Safety valve
SV2:	Safety valve for safety group
T:	Temperature measuring point
SV3:	Overpressure valve
TP:	Thermal protection

2.2 Function of the training panel

The system consists of two pipe sections, selected separately using ball valves, each containing the appropriate safety devices. First of all, water from the mains flows through the open pipe section and fills a tested pressure vessel. A non-return valve or ball valve prevents the water flowing back into the mains system. The content of this pressure vessel is heated using an electrical rod-type heater until the safety devices are triggered. Blow-off pipes are used to drain the hot water. Heated water can be drawn off using an outlet valve.

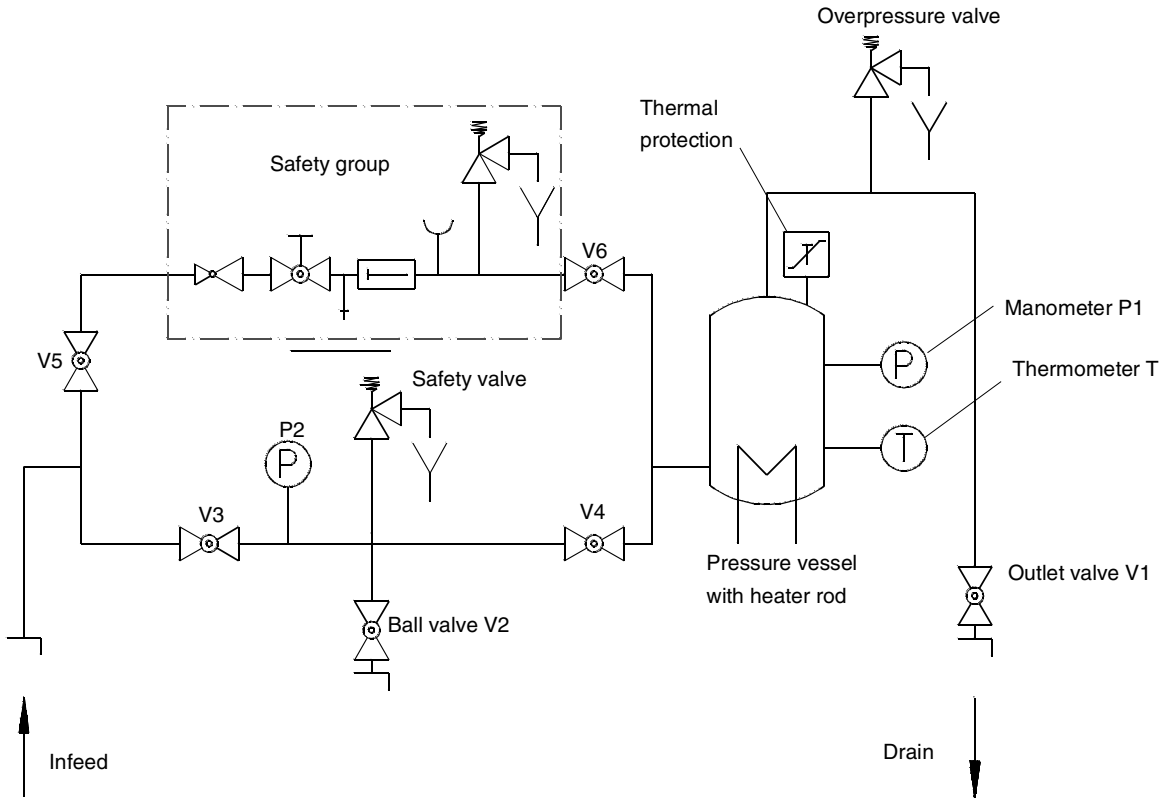


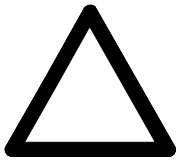
Fig. 2.2: Operating principle of experimental unit

3 Performing the experiment

3.1 Commissioning

Install the training panel in the HL100 universal stand for training panels and secure against rolling away by locking the brakes.

- Choose a level and water-resistant surface (when the safety valves SV1 and SV2 and the thermal protection TA are triggered, small quantities of water can escape unless drain hoses are connected).
- Connect water supply to infeed using rapid action coupling (H1 closed).
- Connect water drain at cock H1 to drain hose using threaded coupling.
- Ensure water is drained at blow-off pipes A1 and A2 by attaching drain hoses or placing a collecting trough underneath.
- Connect to mains electricity.



ATTENTION

Caution! Make sure that the heater rod is not switched on until the system has been filled. Otherwise there is a risk of irreparable damage to the heater rod!

3.2 Filling the system

- Close V1 and V2.
- Open all other valves V3 - V6.

  Lever in direction of flow

  - valve open,

  lever vertical to direction of flow

  - valve closed
- Carefully open V1 and allow the air to escape from the pipe system. When water with no bubbles emerges, close V1 again.

Adjust the pressure reducer for the safety group to 2 bar as follows:

- Close ball valves V3 and V4
- Open ball valves V5 and V6
- Read off the pressure on manometer P1
- If necessary, the pressure can be reduced by briefly opening V1.

If the desired pressure is not attained, adjust the pressure using the adjusting cap on the pressure reducer and repeat the process.

- Make sure that the heater rod is still switched off.
- Check again that proper drainage of the water is guaranteed by drain hoses or a collecting trough at blow-off pipes A1 and A2 and by a drain hose at outlet valve H1.
- Check that safety valves SV1, SV2 and SV3 are closed (no water escaping).

3.3 Safety

DANGER! Risk of burns when touching the pressure vessel!

There is a risk of burns from touching the pressure vessel and the pipe to the outlet valve V1 and from touching the blow-off pipe A1.

Never touch the pressure vessel, the outlet pipe or the blow-off pipe A1 during operation, as they are heated to high temperatures (up to 95C).

DANGER! Risk of burns from touching the heated water!

When discharged from blow-off pipe A1 and from the outlet valve V1, the water has a temperature of approx. 95C.

Caution! Damage to heater rod due to overheating.

The heater rod may not be switched on until the system has been filled or after ensuring that the system is already filled.

Caution! Damage to system due to frost.

The HL 109 training panel must always be stored in a frost-free location, as residual quantities of water can cause damage to the system if exposed to frost.

4 Experiments

This section describes examples of experiments that can be performed with this training panel. The choice of experiments makes no claims of completeness and is intended to serve as a stimulus for your own experiments.

The experiment descriptions are divided into two sections:

- Basic section
- Performing the experiment, recording measured values and plotting the characteristic curves.

The measured results listed represent guideline values. Depending on the design of the individual components used and the individual's experimental skill, greater or smaller variations may occur in your own experiments.

The relevant settings for the shut-off points V1 to V6 for the individual circuits are presented in tabular form to make them easier to understand.

4.1 Safety devices for closed domestic hot water systems

4.1.1 Basic principles

This experiment is designed to demonstrate the function of the safety devices specified for domestic hot water systems under DIN 4753 T.1. The triggering pressure of the safety valve is determined and compared with the preset value. The pressure is then plotted against time in a chart.

Safety group

DIN 1988 and DIN 4753 T.1 specify the installation of a safety group in the connecting pipe for the closed hot water heater (pressure vessel).

This is used to protect closed water heaters against excess pressure. The safety group includes all components specified for installation on the inlet side.

Specifically, these are:

- Pressure reducer
- Shut-off valve
- Test connections and non-return valve
- Manometer connection
- Membrane safety valve

The membrane safety valve can be adjusted for different operating conditions in a range of 0 - 6 bar. It is preset to 6 bar. The nominal size is determined by the capacity or the heating capacity. For water heaters with a capacity of up to 200 l and a max. heating capacity of 75 kW, a nominal size of 1/2" is specified. Larger systems require a nominal size of 3/4".

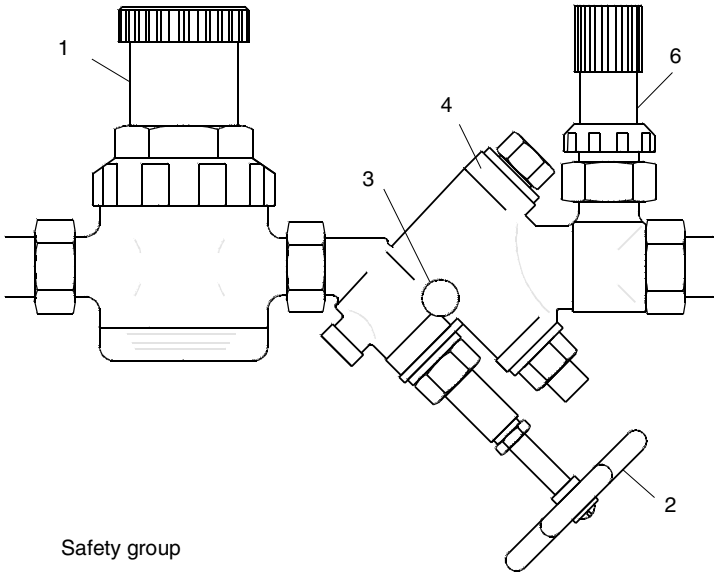


Fig. 4.1: Safety group

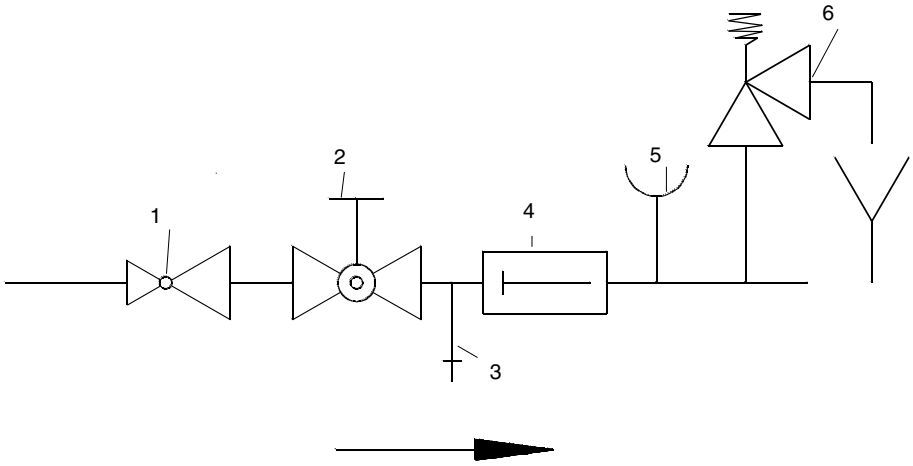


Fig. 4.1: Operating principle of safety group

1	Pressure reducer
2	Shut-off valve
3	Test connections
4	Non-return valve
5	Manometer connection
6	Membrane safety valve SV2

4.1.2 Performing the experiment

Safety device circuit for domestic hot water systems						
	V1	V2	V3	V4	V5	V6
open					X	X
closed	X	X	X	X		

- Measure the initial temperature T and the preset initial pressure P1 and enter them in the table below. Make sure that the safety valve SV2 in the safety group is closed. Otherwise, check the preset pressure of 2 bar and if necessary adjust as described in section 3.2. The preset triggering pressure for the safety valve SV2 is 6 bar.
- Now switch on the heater and read off the following values and enter them in the table at 30 second intervals:
  - Temperature T
  - Pressure P1
  - Triggering time and pressure when safety valve SV2 opens
- The pressure at which the safety valve SV2 opens is referred to as the triggering pressure. This should then be compared with the value specified on the valve spring cover.
- After the safety valve has opened, continue the measurements for another few minutes to observe and document the subsequent temperature increase and any pressure increase in the system.
- After the last measurement, switch off the heater, open valve V1 and rinse the system until the temperature T and pressure P1 have returned to their initial values.
- Close V1. The system is now ready for a new experiment.
- Plot the measured temperatures and pressures against time in a chart.

Measured results
Domestic water heating safety fittings
Initial pressure P1 = 2.0 bar
Initial temperature T = 13 C

Time t in sec	SV2 position	temperature T in C	pressure P1 in bar
0	closed	13	2.0
30	closed	16	2.4
60	closed	22	3.1
90	closed	26	4.2
120	closed	30	5.8
130	open	31	6.0
150	open	35	5.9
180	open	37	5.9
240	open	43	5.9
360	open	55	5.9

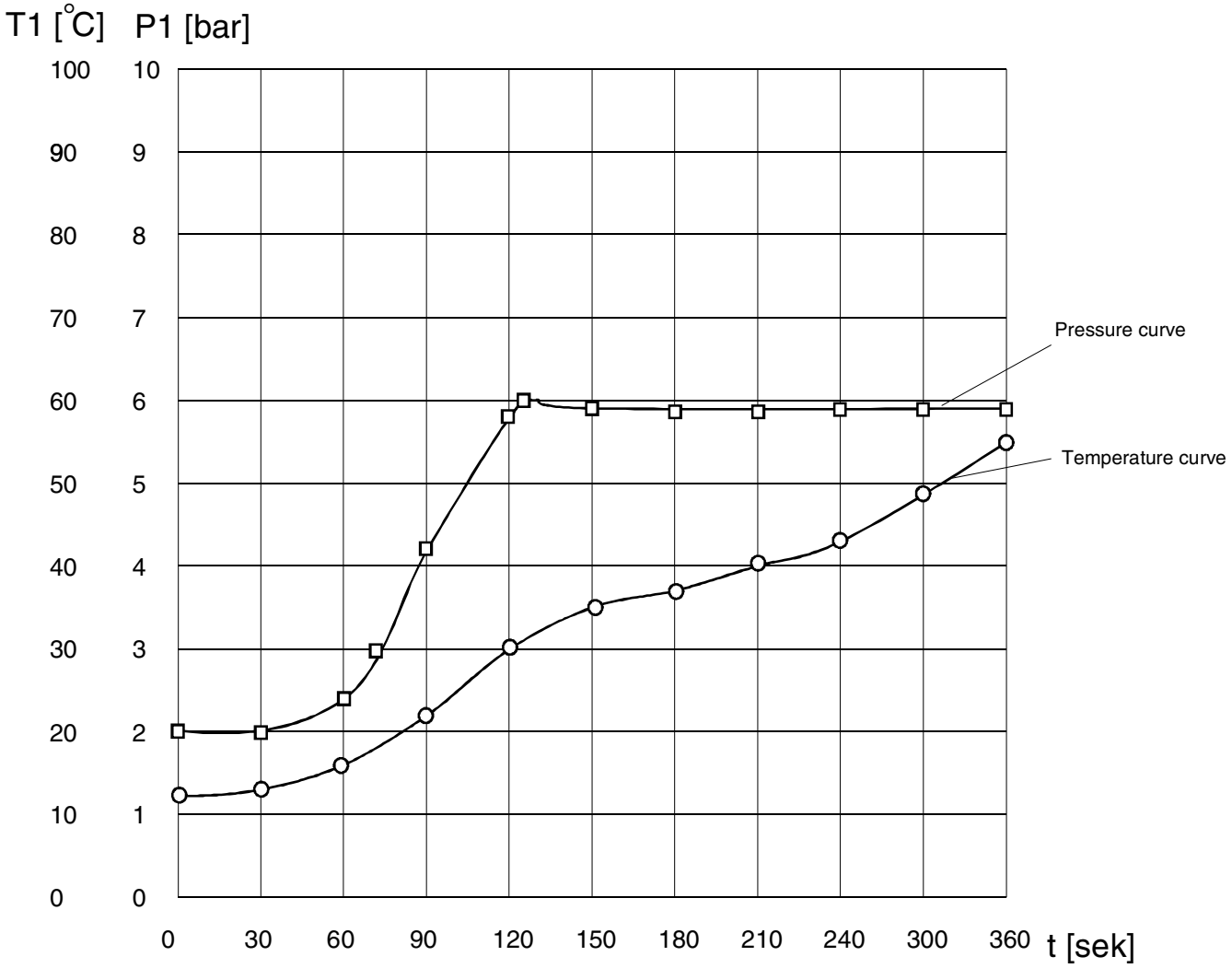


Fig. 4.1: Pressure and temperature curve in the pressure vessel before triggering of safety valve SV2

It can be seen that as the temperature increases, the pressure in the system increases very rapidly. After the safety valve opens, the excess pressure in the system remains constant despite an increasing temperature.

The safety valve SV2 opens after a time of 130 seconds at an excess pressure of 6 bar. The pressure in the system then falls to 5.9 bar and

remains at this value although the temperature in the system increases further.

It is also evident that the preset triggering pressure of 6.0 bar corresponds very closely to the measurements.

4.2 Safety devices for closed hot water heating systems

4.2.1 Basic principles

This experiment is designed to demonstrate the function of the safety devices specified for hot water heaters under DIN 4751 T.2, 3 and 4. The limit temperatures and pressures are determined and compared with preset values.

Membrane safety valve

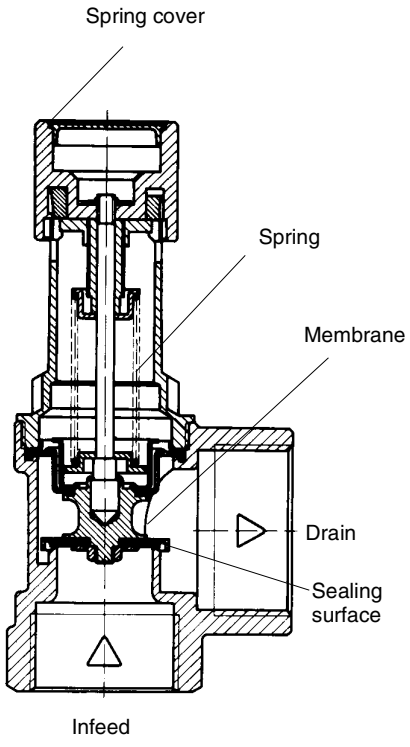


Fig. 4.3: Membrane safety valve closed

DIN 4751, sections 2, 3 and 4 specify a membrane safety valve to protect hot water heating systems against excess pressure. The connection size is determined based on the heating capacity of the heater to be protected. The safety valve used here can be used for systems with a max. heating capacity of 50 kW and has a triggering pressure of 2.5 bar. In Germany, the maximum permissible triggering pressure for the systems mentioned above is 3 bar. However, up to 3 safety valves per system can be used. As a result, it is possible to fit membrane safety valves in systems with greater heating capacities.

The safety valve must be vertical and correctly fitted for the relevant direction of flow (arrow). It must also be installed at the highest point of the heat source or in the feed flow immediately adjacent to the heat source. The connecting pipe must be straight with a maximum length of 1 m and must have the same inlet cross-section as the safety valve.

The shut-offs may not impair its function.

Caution! This is not the case for the system described here!

To ensure complete separation of the two pipe sections for experimental purposes, ball valves V4

and V6 are installed before the two safety valves. In addition, an overpressure valve SV3 is also integrated into the system circuit. This cannot be shut off and is activated at an excess pressure of 7 bar. This valve is only activated if both the ball valve V4 and the ball valve V6 are incorrectly closed, to guarantee the safety of the system.

Thermal protection

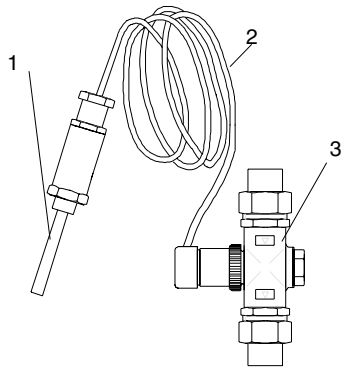


Fig. 4.4: Thermal protection

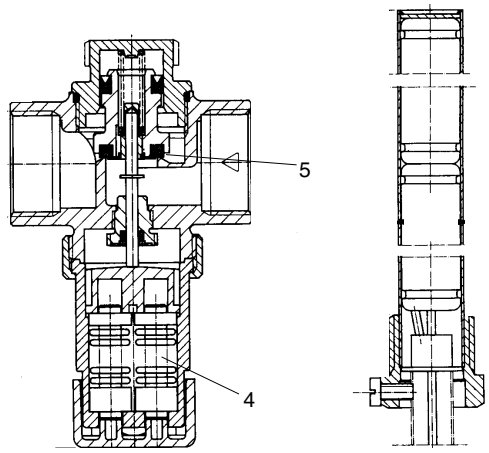


Fig. 4.5: Thermal protection - section

1 Thermal sensor
2 Supply line
3 Valve housing
4 Temperature actuator transducer
5 Sealing surface

Under DIN 4751 section 2, the thermal protection must be used to protect heat sources in hot water heating systems on the temperature side. These systems can be set up with a maximum heating capacity of up to 100 kW. In systems that are protected by a built-in, uncontrolled drinking water heater, the thermal protection must be installed in the hot water outlet from the water heater.

The thermal protection is a depressurised single-seat valve that opens as the temperature increases. Two independently operating temperature actuator transducers are triggered by a thermal sensor. The thermal sensor is screwed into the upper section of the pressure vessel and is connected via a supply line to the valve housing, where the two temperature actuator transducers are located.

If the water in the pressure vessel gets hotter than 95C, the temperature actuator transducers open the valve and allow the blow-off pipe A1 to drain water until the temperature in the pressure vessel has fallen back below 95C. The thermal protection then closes again.

4.2.2 Performing the experiment

Safety device circuit for domestic hot water systems						
	V1	V2	V3	V4	V5	V6
open				X	X	X
closed	X	X	X			

Under DIN 4751 system pressure in hot water heating systems may not be more than 3 bar. On the HL 109 training panel, the system pressure for hot water heating systems is regulated by the pressure reducer in the safety group. This ensures that the safety fittings for hot water heaters are demonstrated when the training panel is connected to the mains water supply.

If a heat exchanger and a circulating pump are available in the laboratory, these can be integrated into the system circuit as follows:

- Close valves V1 and V2
- Remove the dummy plug from the pipe at V2
- Connect the heat exchanger and pump between the outlet valve V1 and the ball valve V2
- Open V1 and V2
- Switch on the pump to fill the system
- Close ball valves V3 and V6

- Measure the initial temperature T and the preset initial pressure P1 and enter them in the first row of the table below.
  Make sure that the safety valve SV1 is closed. Otherwise, check the preset pressure of 2 bar and if necessary adjust as described in section 3.2. The preset triggering pressure for the safety valve SV2 is 2.5 bar.

- Switch on the heater and read off the following values and enter them in the table at 30 second intervals:
    - Temperature T
    - Pressure P1
    - Note the time and pressure value when the safety valve SV2 opens.
- The pressure at which the safety valve SV2 opens is referred to as the triggering pressure. This should then be compared with the value specified on the valve spring cover.
- After the safety valve has opened, continue the measurements to observe and document the subsequent temperature increase until the thermal protection is triggered.

Risk of burns! When the thermal protection opens, water emerges from the blow-off pipe A1 at a temperature of approx. 95C.

- After the last measurement, switch off the heater, open valve V1 and rinse the system until the temperature T and pressure P1 have returned to their initial values.
- Close V1. The system is now ready for a new experiment.

- Plot the measured temperatures and pressures against time in a chart.

Measured results
Hot water heating safety fittings
Initial pressure P1 = 2.0 bar
Initial temperature T = 13 C

Time t in sec	SV2 position	temperature T in C	pressure P1 in bar	TP position
0	closed	13	2.0	closed
30	closed	16	2.4	closed
60	open	22	2.5	closed
90	open	26	2.4	closed
120	open	30	2.4	closed
130	open	31	2.4	closed
150	open	35	2.4	closed
180	open	37	2.4	closed
240	open	43	2.4	closed
360	open	55	2.4	closed
480	open	67	2.4	closed
600	open	77	2.4	closed
720	open	87	2.4	closed
780	open	93	2.4	closed
824	open	96	2.4	open

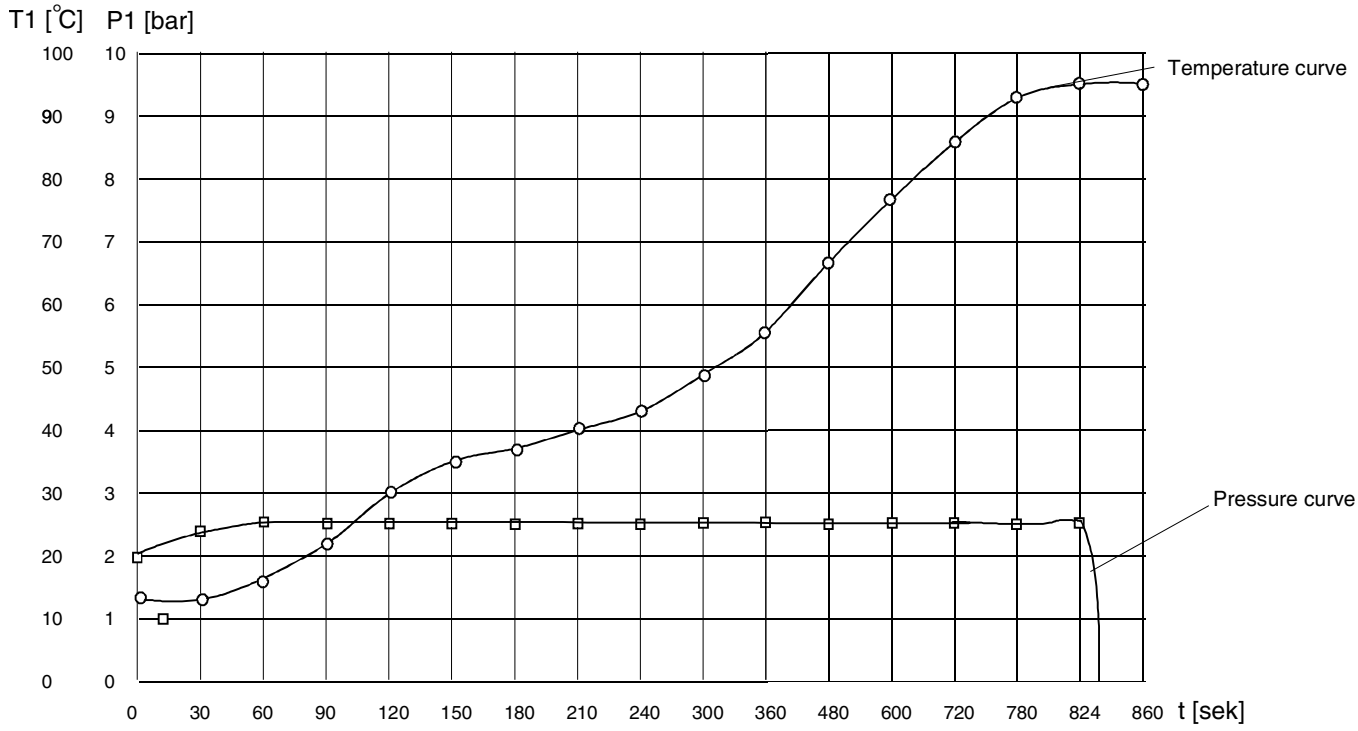


Fig. 4.2: Pressure and temperature curve in the pressure vessel before triggering of safety valve SV1 and thermal protection TP

It can be seen that as the temperature increases, the pressure in the system increases very rapidly. After the safety valve opens, the excess pressure in the system remains constant despite an increasing temperature.

The safety valve SV1 opens after a time of 32 seconds at an excess pressure of 2.5 bar. The pressure in the system then falls to 2.4 bar and remains at this value although the temperature in the system continues increasing.

It is also evident that the preset triggering pressure of 2.4 bar corresponds very closely to the measurements.

After a time of 824 seconds, the thermal protection is triggered at a system temperature of 96C. This value also corresponds very closely to the triggering temperature of 95C specified by the manufacturer.

When the thermal protection opens, the system pressure P1 falls to 0 bar excess pressure. As long as the thermal protection remains open, the entire system is "depressurised". The thermal protection does not close until the system temperature T falls below 95C.

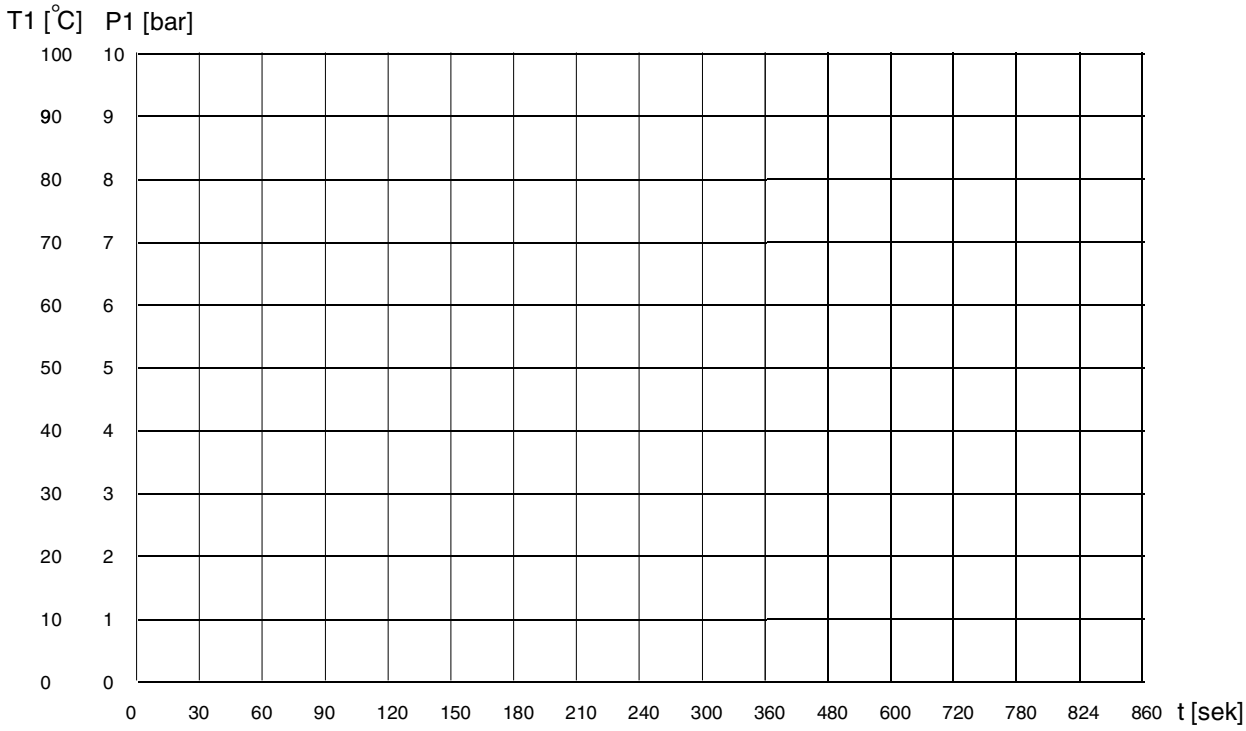
5 Appendix

5.1 Worksheets

5.1.1 Worksheet 1: Measured results

Measured results Safety fittings Initial pressure P1 = bar Initial temperature T = C				
Time t in sec	SV2 position	temperature T in C	pressure P1 in bar	TP position
				closed

5.1.2 Worksheet 2: Characteristic curve chart



5.2 Symbols and units

p:	Pressure	bar
T:	Temperature	C
t:	Time	sec

5.3 Technical data

Overall dimensions of training panel

L x W x H	1650 x 1100 x 300	mm
Weight	65	kg

Supply

Electrical power 230 V / 50 Hz
Optional alternatives, see rating plate

Connections:
Cold water:
Rapid action coupling with hose connection
Waste water:
Threaded coupling with hose connection

Screw-in heating element

Electrical supply	230 V / 50	Hz
Heating capacity	3000	W
Degree of protection	IP 65	

Pressure vessel

Material	Steel no. 1.4301	
Capacity	approx. 5	litres
Max. operating pressure	7.8	bar

Bourdon gauge P1 and P2

Measuring range	0 - 10	bar
Precision class	1.0	

Bimetallic dial thermometer

Measuring range	0 - 120	C
Precision class	1.0	

HL 109 Safety Devices Training Panel

Safety group consisting of:

Pressure reducer
Shut-off valve
Non-return valve
Membrane safety valve SV2

Triggering pressure	6	bar
Connection	G 1/2"	

Membrane safety valve SV1

Triggering pressure	2.5	bar
Connection	G 1/2"- G 3/4"	

Thermal protection TP

Triggering temperature	95	C
Connection	G 1/2"- G 3/4"	