Information D 1.1

Issue Date 10/01

Description of the Demonstration Test Stand for Steam Traps and Test Stand Demonstration Programme

The test stand consists of several systems and is mainly used for demonstrating and training purposes. This test stand makes it possible to preset the various operating conditions and to demonstrate the mode of operation and the field of application of all steam traps on the basis of these conditions. The demonstration encompasses all details required for practical operation.

System Description

1. "Open" System – Schematic representation 4 BSK 2600

to demonstrate the mode of operation of steam traps.

Drainage takes place visibly into the open.

Test possibilities:
Steam pressures up to 25 bar; condensate flowrates up to 200 kg/h.

Pressures and temperatures can be read at several points upstream of the trap and they can be recorded. When changing over the system from steam to condensate and vice versa, the mode of operation of the trap can be observed at the free outlet, and when blowing in air, it is possible to recognize at the trap outlet as well as by the temperatures whether the trap deaerates or not.

2. "Closed" System – Schematic representation 4 BSK 2601

The stream pressures can be varied up to 25 bar and the condensate flowrates up to 200 kg/h. Drainage is effected optionally into an open condensate tank or into a flash vessel. In the latter case, overpressure can be generated or vacuum produced when using a condenser.

The amount of flash steam formed inclusive of potential live steam losses as well as the condensate flowrate can be measured. Temperatures and pressures can be read and recorded directly. Air (6 bar) can be supplied to the system for deaeration tests.

3. Steam Loss Measuring Systems

3.1 With Zero Condensate Formation – Schematic representation 4 BSK 2602

The trap is exclusively fed with steam. A minor quantity of condensate is formed as a result of radiation losses which is discharged through the purge valve upstream of the trap; this valve is always open. Steam escaping through the trap (steam loss) is condensed in the condenser and the quantity measured in a graduated vessel.

3.2 With Simultaneous Condensate Formation – Schematic representation 4 BSK 2603

Traps of sizes 15/20/25 mm can be tested. The condensate flowrates produced by the heat exchanger can be varied between approx. 2 and 50 kg/h, and the pressures up to 12 barg.

Test programme:
Drainage into the open until the pressure and temperature in the system as well as the amount of condensate formed remain constant. The graduated vessel is first fully filled with water and then emptied so that the vessel wall takes the temperature of the water. The vessel is then again filled with water, but in part only. Determination of the amount of water takes place directly with a weighing unit and with the vessel weight compensated. The actual measurement starts with setting the change-over valve to "passage into the vessel".

The measured values are entered in form 4 BSK 2485 (at the beginning, the initial values of the water temperature, the water weight, the pressure and temperature upstream of the trap and the ambient temperature).

The condensate flowing out of the trap to be tested is conducted into the vessel below the water level, together with the flash steam and any live steam that might escape at the same time. As a result, the steam fully condenses in the cold water. The condensate flow into the vessel ensures a continuous circulation of the water in the vessel. An additional stirring ensures a uniform water temperature without stratification. Condensate is supplied to the vessel only until the temperature of the heated water has as many degrees Kelvin above the ambient temperate as the cold water had below the ambient temperature at the beginning of the measuring process. In doing so, the water absorbs approximately as much heat from the environment during the first half of the measuring period as it returns to the environment during the second half. Radiation losses upstream of the trap do not influence the measurement as they enter into the amount of condensate formed.

Based on the values entered in form 4 BSK 2485 the thermal balance is made up and the potential steam loss determined therefrom.

4. Glass Test Stand – Schematic representation 4 BSK 2604

The test stand consists of a steam generator, heat exchanger, steam and condensate lines and of the steam traps installed in the system. Steam generator and heat exchanger are provided with sightglasses.

The steam and condensate lines consist of glass in order to make the flow processes visible. Steam is generated in the steam generator at a pressure of up to 1 barg. The steam flows through a glass pipe to the heat exchanger; different condensate quantities can be produced by adding more or less cooling water.

The condensate first flows vertically down, then through a horizontal pipe section, and finally upwards. Depending on the selection made, it proceeds through the individual condensate pipe legs to the traps. The traps to the individual pipe legs are installed at different levels, with the condensate upstream and downstream of the trap rising. The problem of lifting the condensate in connection with the various flow conditions can be clearly recognized in the glass pipes.

Test Stand Demonstration Programme

Prior to starting the demonstration, the design and mode of operation of the various trap systems are explained. The various test possibilities with the individual facilities and pertaining measuring equipment are explained direct at the test stand. The next step is to check the temperature measuring instruments by feeding them with saturated steam. In this connection, the temperature indicated must be in accordance with the corresponding saturated steam temperature (t_S) relative to the applied pressure.

The various kinds of demonstrations are explained in the following. The measuring tape records made in the course of the demonstration will be available to the parties interested.

1. Demonstration at the Open System – Schematic representation 4 BSK 2600

To demonstrate the mode of operation of the trap to be tested, the operating pressure is steadily and slowly increased. In doing so, the trap is alternately supplied with steam only (in which case it must close) or with condensate (in which case it must open). Checking float traps and thermodynamic traps is effected visually with the aid of sightglasses and at the free outlet. The Vapophone, an ultrasonic measuring device, is an additional means for checking.

The mode of operation of thermostatic traps can be checked by means of temperature and pressure measurements upstream of the trap, with the aid of special sightglasses (Vaposcopes) and, at the free outlet, in addition with the Vapophone. The temperatures upstream of the trap and the respective saturated steam temperature can be registered with a line recorder. In the event of condensate formation and correct operation, the temperature upstream of the trap must always be lower than the saturated steam temperature. An X-Y recorder may be used instead of the line recorder which records the saturated steam temperature (X) via the pressure (Y) as well as the discharge temperature of the condensate.

The discharge temperatures produce the working characteristic of the trap. With thermostatic traps, it must always be below the saturated steam curve. The measurements indicate that the thermostatic traps of GESTRA, BK and MK, can be used without any restriction for the pressure range referred to by GESTRA; the BK range traps with Duo stainless steel regulator operate properly without any readjustment of the regulator. For the BK measurements are repeated with modified adjustment. In doing so, it can be recognized that minor readjustments hardly influence the regulating process.

In addition to the measurements referred to, the temperatures can be measured direct at the trap. Furthermore, the mode of operation of the BK and MK traps can be observed through glass covers.

When setting the facility into operation from the cold condition, the start-up characteristics of the trap systems can be easily recognized. Thermostatic traps drain and deaerate the heating surface within short time, as the cold water capacity is 3 to 5 times higher than the hot water capacity.

Ball float traps without thermostatic deaeration have to be deaerated manually. As compared with thermostatic traps with the same hot-water capacity, the start-up process takes more time, because there is not much difference between cold-water and hot-water capacities.

UNA 23/26, Duplex, deaerate automatically. Starting up virtually takes place as quickly as with thermostatic traps. The start-up process with inverted-bucket traps and thermodynamic traps takes much more time. In this case, the minimal venting capacities, particularly those of the thermodynamic traps, play a certain role as well as the minimal difference between cold-water and hot-water capacities.

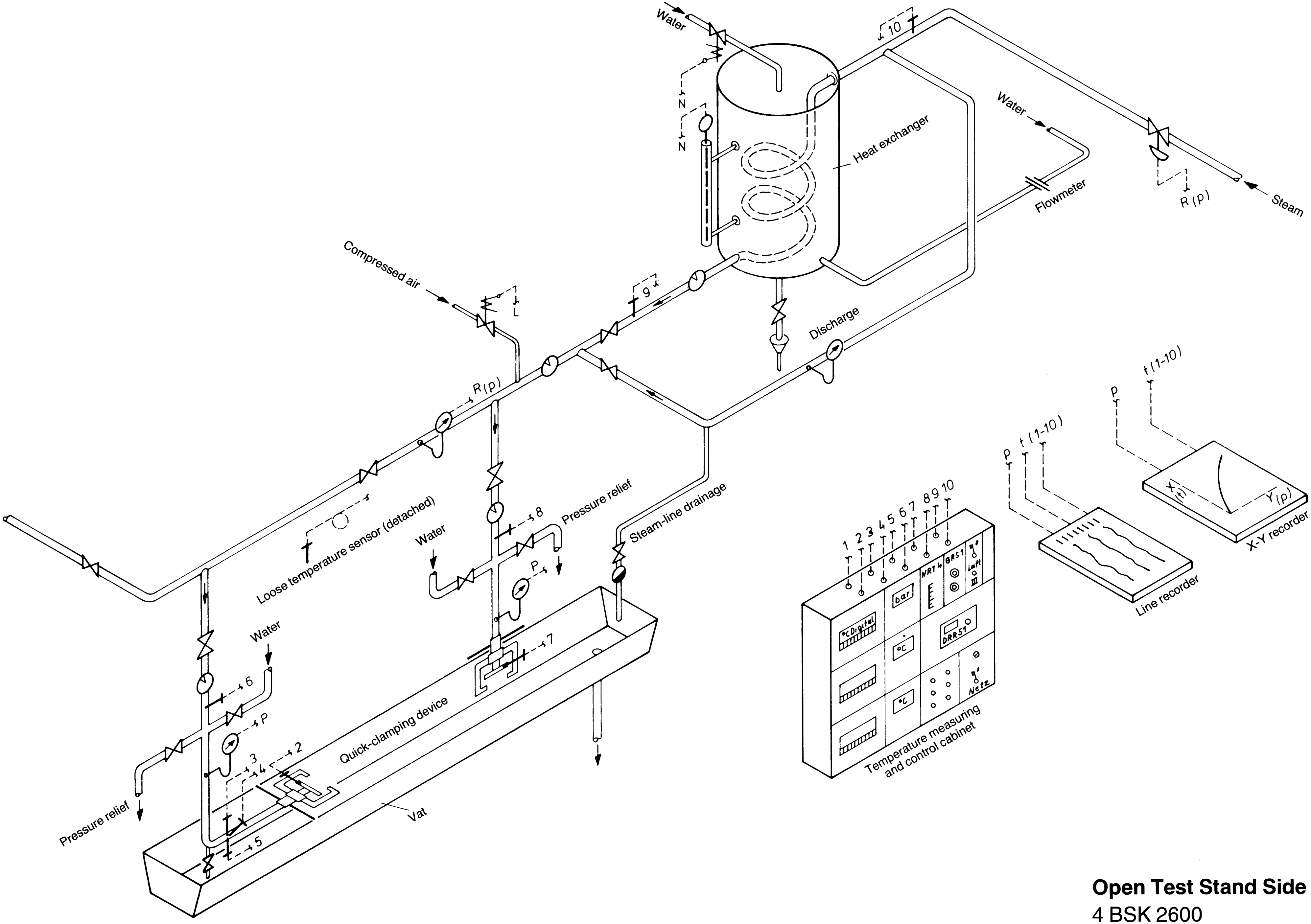
By cooling the traps with a water jet, it is demonstrated as to what extent the operation is influenced by changed environmental conditions. The operation of all float traps and inverted-bucket traps is unaffected. With thermostatic traps it is hardly recognizable that they are influenced in any way. With thermodynamic traps the working rhythm considerably increases. Sometimes, it is also possible that the trap does not close any more. An increased steam loss is found in that case. The operating mode of this trap is thus a function of the environmental conditions.

By blowing air into the steam line, one can recognize the different venting capacity of the trap systems. Thermostatic traps react nearly instantaneously and discharge the air quickly. They can therefore also be used as thermal deaerators. Ball float traps with thermostatic deaeration respond somewhat delayed, but then discharge the air very quickly. With inverted-bucket traps deaeration takes more time as a result of their low venting capacity. Thermodynamic traps remain closed over a prolonged period of time. Cooling down the trap body with a water jet or even applying a forceful blow with a hammer does not bring about any improvement. Even after opening the condensate line, the trap will remain closed. Only a heavily worn thermodynamic trap features a better venting capacity, but on penalty of increased steam losses.

When quickly changing the pressures, the different mode of operation of the different trap systems can be observed easily.

The thermostatic traps open instantly in the case of a pressure increase, but they also close quickly. All other systems remain uninfluenced by the pressure increase. An exception herefrom is UNA 23/26 Duplex. In this case, the Duplex control responds to an increased pressure which opens the trap for a short time. Thermostatic traps close when the pressure drops; as a result of the flashing of residual condensate, thermodynamic traps close, too. Ball float traps remain virtually unaffected.

Inverted-bucket traps, however, open and discharge live steam, because the water filling required for the operation of these traps evaporates.



Open Test Stand Side
4 BSK 2600

2. Operating Sequence of the Closed System – Schematic representation 4 BSK 2601

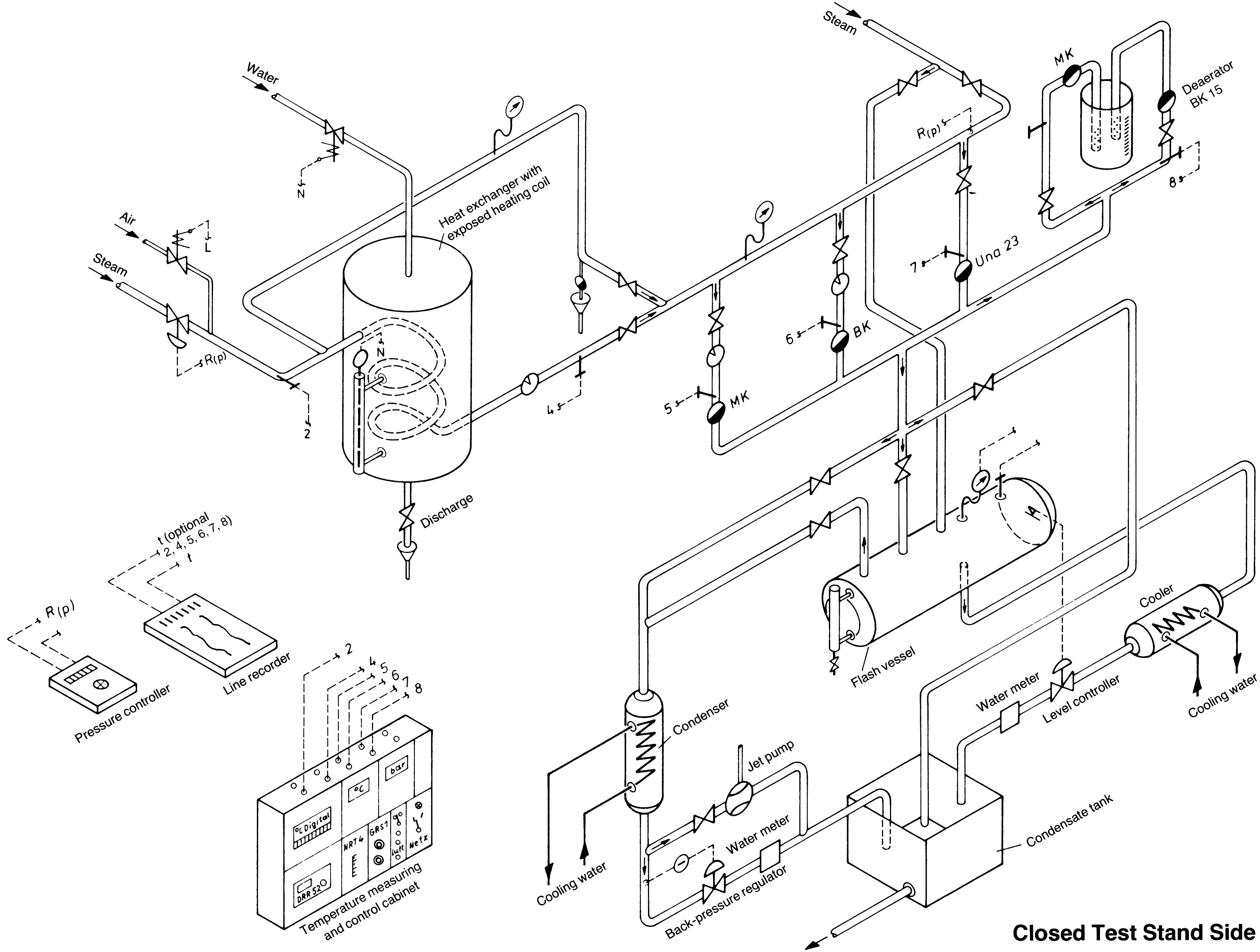
In this case, the operation of the trap systems is demonstrated at different upstream pressures and back pressures. The function of the float traps remains unaffected by back pressure, no matter how high these pressures are. The same applies to the GESTRA membrane traps MK. Thermostatic traps with bimetallic regulators close at lower temperatures, the higher the back pressure. When readjusting the regulator, the working characteristic - even at an increased back pressure - may take a similar course as with an operation free from back pressure. As regards the GESTRA steam traps BK, the influence of back pressure up to 30% is so minimal that it may normally be neglected. Only with higher back pressures a readjustment is necessary. It can be seen that the BK properly drains the heating coil at a high back pressure with a corresponding readjustment. With increasing back pressure, there also increases the working rhythm of thermodynamic traps. The steam loss increases. The trap will not close any more as from back pressure of 50%, approximately.

This facility furthermore shows the negative influence of air on the heat exchange and demonstrates the operation of thermostatic traps as deaerators. The air is blown into the heating coil which is located in an open tank filled with water. As compared with pure steam heating, the inferior heat transfer from the heating coil to the water is clearly to be seen. Only a small amount of water evaporates. Together with the condensate, the blown-in air is discharged from the heating coil by the thermostatic trap (BK or MK). The air then passes to the deaerator, the thermostatic trap BK or MK, which discharges the air from the facility. The air is then conducted into a glass tank filled with cold water and the difference between non-condensing air bubbles and condensing steam can clearly be seen.

The deaerator is forced open for reasons of comparison and the escaping steam causes waterhammer in the glass tank, which is optically and acoustically recognizable. Flowing air does not cause waterhammer.

To demonstrate the mode of operation of the Vaposcopes, live steam penetration, banking-up of condensate and correct drainage can be simulated.

The Vapophone (an ultrasonic measuring device) is also demonstrated in this facility. The closed system is used for this purpose to avoid outflow noises caused by a free outlet and which might influence the results. The Vapophone helps to recognize quickly whether traps let pass live steam or not.



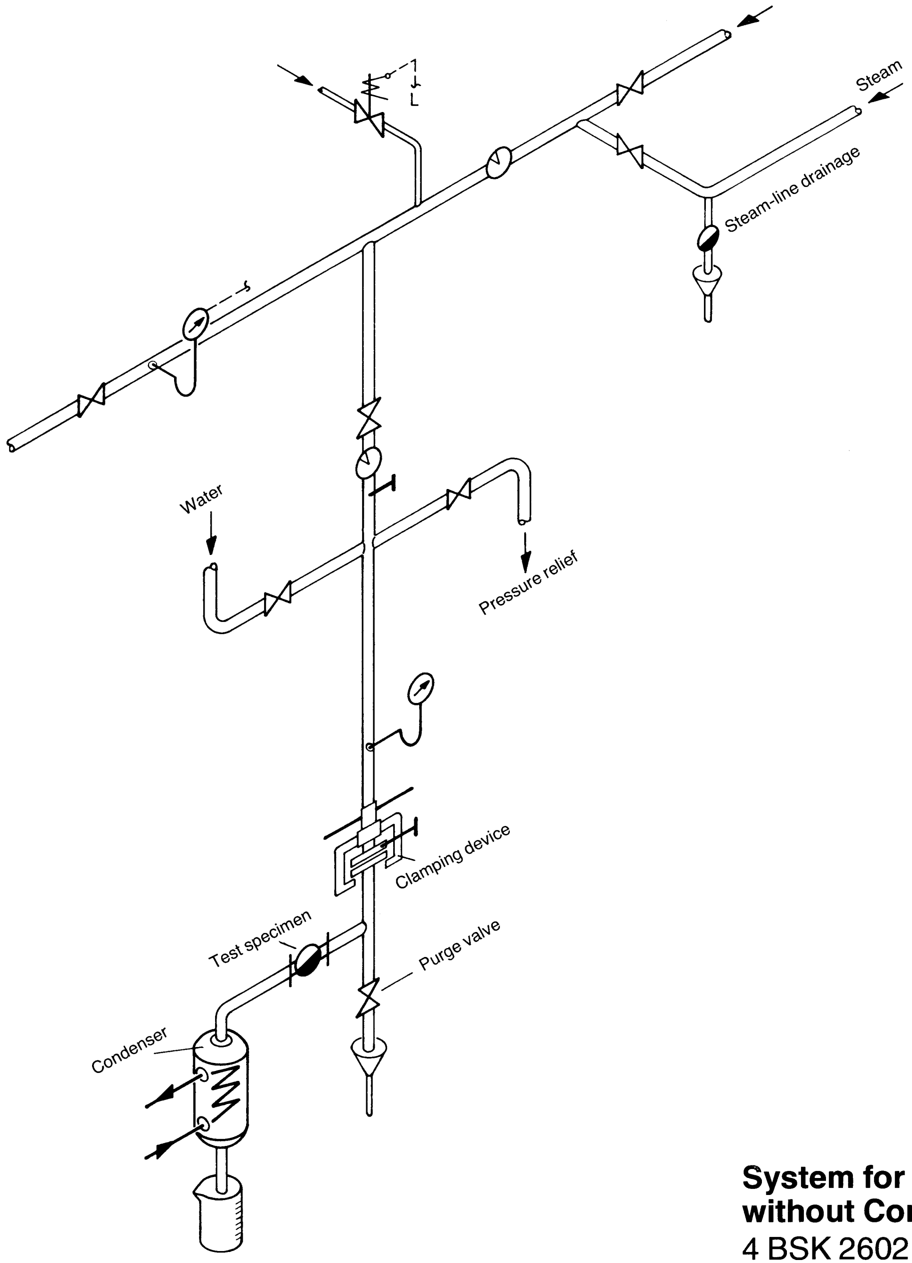
Closed Test Stand Side
4 BSK 2601

3. Sequence of Steam Loss Measurements

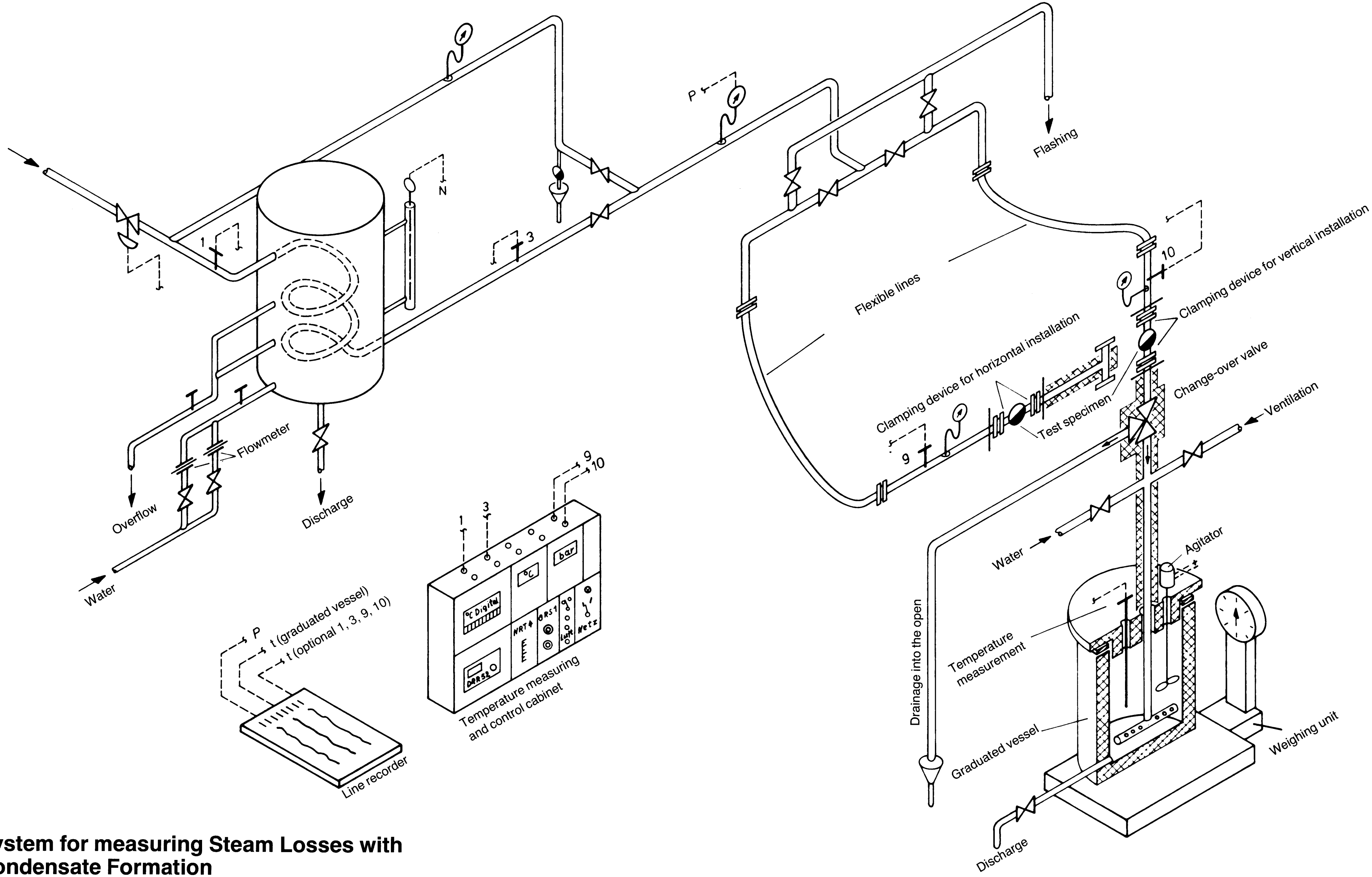
If visitors (project engineers and plant operators) are interested in steam loss measurements, they will be carried out in their presence. The traps to be tested can be taken from the GESTRA stock by the interested person himself or may be placed at our disposal by him.

Measurements as per 4 BSK 2602 (only saturated steam without condensate) are mainly of theoretical importance, as such a case hardly exists in practice.

For this reason, most measurements are in accordance with 4 BSK 2603. The party interested is to state the operating conditions and the facility is then set correspondingly. The measurements are realized as described in section "System Description", item 3.2. The original of the evaluation form with the corresponding entries will be made available to those interested.



System for measuring Steam Losses without Condensate Formation
4 BSK 2602



System for measuring Steam Losses with Condensate Formation
4 BSK 2603

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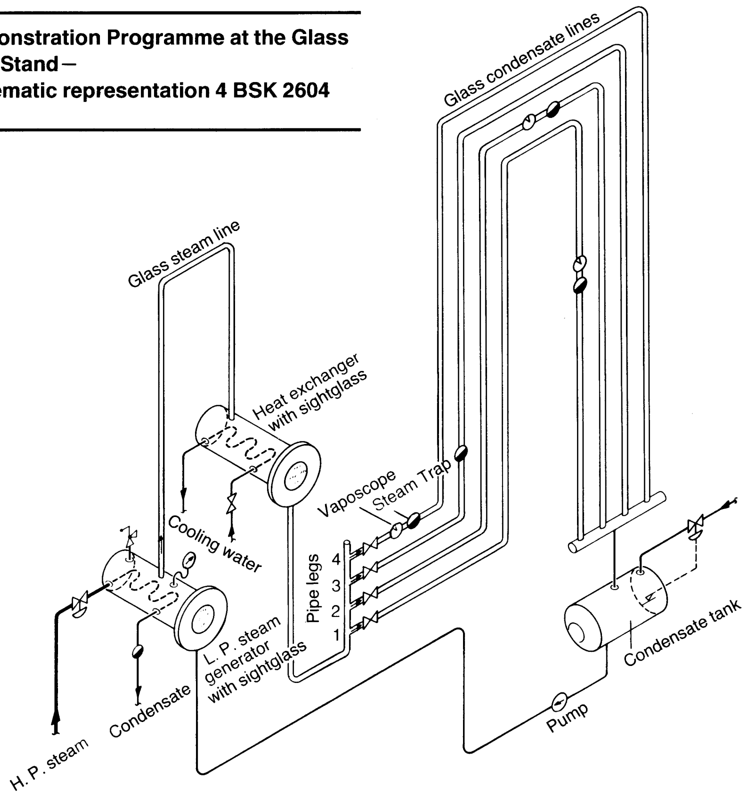
4. Demonstration Programme at the Glass Test Stand – Schematic representation 4 BSK 2604



Lifting the condensate to a higher level is possible. The condensate can be lifted downstream of the steam trap. A certain upstream pressure is required for this purpose. It may also be lifted upstream of the trap. In this case a particular problem results because of the two-phase flow in the rising line upstream of the trap and the question arises whether lifting of the condensate is possible without any banking-up. The answer is furnished by making the flow processes visible, particularly in the rising line. (For more details, see GESTRA Information "Trapping of Steam Tracers with Elevated Steam Traps") which permits also the drawing of conclusions as to the lifting of condensate in other systems.

The demonstration begins by first producing a small amount of condensate and then more and by effecting the drainage through pipe leg 1. After changing over from pipe leg 1 to the other legs (2 through 4), the facility is drained by a trap installed each time in a different position. At different operating conditions, a perfect drainage takes place. In the horizontal lines of the individual legs, different flow conditions are to be observed before the rise, depending on the kind of deflection from the straight line to the vertical position. The smoothest flow is obtained in pipe leg 1, because a pipe loop is installed upstream of the rising section. Application of a condensate dampening pot is recommended if larger condensate flowrates are involved.

Further possibilities for the testing of traps are available. Thus, for example, it is possible to measure flowrates up to 40 t/h.

An HP facility also allows operation with pressures up to 250 bar.

Steam Loss Measurement of Steam Traps as obtained on the Basis of the Thermal Balance	*4BSK 2485e*

Steam trap type: *DN*

Operating data:

Pressure upstream of trap	$p =$, bar abs.	Boiling temp.	$\vartheta_s =$ °C
Temperature upstream of trap	$\vartheta =$ °C	Enthalpy (steam)	$h_{fg} =$ kJ/kg
Ambient temperature	$\vartheta_A =$ °C	Enthalpy (water)	$h_f =$ kJ/kg
		Spec. heat	$c_p =$ 4.2 kJ/kg,K

Heat Measuring Vessel Values:

Before Measurement		After Measurement	
Water content	$M_1 =$ kg		$M_2 =$ kg
Temperature	$\vartheta_1 =$ °C		$\vartheta_2 =$ °C
Measuring time	$t =$ min		
Amount of heat			
$Q_1 = M_1 \cdot c_p \cdot \vartheta_1 = \cdot \cdot =$ ____ kJ		$Q_2 = M_2 \cdot c_p \cdot \vartheta_2 = \cdot \cdot =$ ____ kJ	

Condensate flowrate $M_c = (M_2 - M_1)\frac{60}{t} = (\; - \;)\,60 =$ ____ kg/h

Plant heat loss (heating + convection) as per diagram 4BSK 2485, sheet 2: $Q_v =$ ____ kJ/h

Thermal balance:

$Q_{actual} = (Q_2 - Q_1)\frac{60}{t} + Q_v = (\; - \;)\,60 + \; =$ ____ kJ/h

$Q_{theor.} = M_c \cdot h_f = \; \cdot \; =$ ____ kJ/h

Conclusion:

$Q_{actual} < Q_{theor.}$ → no steam loss

Undercooling $\Delta\vartheta = \frac{Q_{theor.} - Q_{actual}}{c_p \cdot M} = \frac{-}{\cdot} =$ ____ K

$Q_{actual} > Q_{theor.}$ → steam loss

$M_s = \frac{Q_{actual} - Q_{theor.}}{h_{fg} - h_f} = \frac{-}{-} =$ ____ kg/h

The diagram 4 BSK 2485 sheet 2 will be placed at your disposal.