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Automatic steam traps — Production and performance characteristic tests

Purgeurs automatiques de vapeur d'eau — Essais de production et essais des caractéristiques de fonctionnement

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Contents

Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 153, *Valves*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 69, *Industrial valves,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This first edition cancels and replaces ISO 6948:1981, ISO 7841:1988 and ISO 7842:1988, which have been technically revised.

The main changes are as follows:

— merging of ISO 6948:1981, ISO 7841:1988 and ISO 7842:1988;

— update of the technical content according to state-of-the-art;

— addition of the terminological entry on subcooling (3.2);

— addition of a data sheet for test methods A and B on steam trap discharge capacity in A.3.3 and in A.4.3;

— addition of a computation formula [Formula (B.4)];

— addition of a data sheet for test methods A and B on steam loss test in B.3.4 and B.4.4.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Testing of steam traps provides conformance of product performance to the intended function. This document addresses the requirements for production testing and performance testing of steam traps. Production test ensures the shell integrity to the maximum working pressure while the performance test ensures the functional requirement of steam traps. Performance test should be considered as type test.

Testing is the most reliable method to validate a product including design, material selection and manufacturing processes. It may also serve as a guide for steam traps selection. It can allow the users to compare different types of steam traps, designs and brands.

Currently the test requirements are mostly driven by the manufacturer or the users and each may have their own specification. This document will create common understanding on the qualifications, and end-user total cost-of-ownership by eliminating unintentional design flaws and planned obsolescence.

Ultimately, this document will improve performance and safety in the plants by enabling any customer to specify durable type-tested industrial valves.

Automatic steam traps — Production and performance characteristic tests

1 Scope

This document specifies the production and performance relevant test requirements for automatic steam traps used for condensate removal/recovery services for optimized utilization of energy, in refinery, power generation or other general applications where steam is used as a medium of heat transfer.

The tests can be classified as production tests and performance characteristic tests and can be conducted to ensure the correct functioning of a steam trap or to evaluate the performance of a particular design. This document specifies the tests performed relative to each one of these two categories and briefly describes the corresponding test methods.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 6553, *Automatic steam traps — Marking*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
production test
tests carried out by the manufacturer to confirm that each automatic steam trap functions correctly

Note 1 to entry: These tests may be witnessed by the purchaser or his representative. In this case, these tests are referred to as acceptance tests.

3.2
subcooling
temperature-related phenomenon which is the difference between the steam saturation temperature to the actual temperature of steam/condensate either at steam trap inlet or exit

Note 1 to entry: This may be the accountable parameter in some of the steam trap type like thermostatic steam traps.

Note 2 to entry: The water with a temperature value below the saturation temperature is called the subcooled condensate. But also, the saturation temperature always corresponds to the pressure at which the system is operating.

4 Test methods

4.1 Production test — Shell testing

Each steam trap shall be tested to confirm the integrity of its shell under pressure.

The test fluid, the choice of which is left to the discretion of the manufacturer, shall be either:

— water, which may contain a corrosion inhibitor, kerosene or any other suitable liquid having a viscosity not greater than that of water;

— steam, air, or any other suitable gas.

NOTE Various statutory authorities require specific approval of test procedures where the test is conducted using steam, air, or other gas.

Any internal trim which does not withstand the test pressure may be removed before the test.

The steam trap shall be essentially vented off air when testing with a liquid.

Steam traps shall not be painted or otherwise coated with materials capable of sealing against leakage before the shell pressure tests are completed. Chemical corrosion protection treatments and internal linings are permitted. If pressure tests in the presence of a representative of the purchaser are specified, painted steam traps from stock may be re-tested without removal of paint.

Test equipment shall not subject the steam trap to externally applied stresses which can affect the results of the tests.

The shell test shall be performed by applying pressure inside the assembled steam trap with the ends closed.

For all steam traps, the hydraulic shell test shall be performed at a pressure 1,5 times the maximum allowable pressure at 20 °C.

For steam traps with a nominal diameter less than or equal to DN 50 and with pressure range up to PN 40 or Class 300, a hydraulic shell test can be performed using gas at a pressure (gauge pressure) of 6 bar (0,6 MPa). For gas test, safety measures shall be taken.

Visually detectable leakage through the pressure retaining walls is not acceptable.

Test durations shall not be less than those specified in Table 1.

Table 1 — Minimum durations for shell tests

Nominal steam trap size DN	Minimum test duration [s]
DN ≤ 50	15
65 ≤ DN ≤ 200	60
250 ≤ DN	180

4.2 Performance characteristic tests

4.2.1 Operational check

The operational performance of the steam trap shall be checked under the steam and condensate. The test set up shall produce the steam and condensate in the desired condition. Steam shall be fed into the steam trap. Condensate shall be introduced intermittently if required.

When only steam is present, the steam trap shall close. When the steam becomes condensate, the steam trap shall open (the time taken will vary as a function of the steam trap type); when the condensate has been discharged, the steam trap shall again close. The test is complete when at least one complete cycle has been performed. The condensate can also be fed to the steam trap to quicken the cycle and to verify the performance.

Certain types of steam trap may be tested with air or water.

A manufacturer may describe the operations of a particular type of steam trap by referring to one or more of the following performance characteristic tests. A brief explanation of the derivation of each characteristic is given below.

The performance test may be considered on sample basis as type test based on the type of steam traps. Sample steam traps shall be tested to ensure that they open to discharge condensate and close satisfactorily. Further details are given in 4.2.2 to 4.2.15. This test does not apply to the labyrinth (or orifice) steam traps (see ISO 6704).

4.2.2 Minimum operating pressure

The steam trap shall be tested to determine the minimum pressure (atmospheric or above) at which the correct opening and closing will occur.

4.2.3 Maximum operating pressure (PMO)

The steam trap shall be tested to determine the maximum pressure at which the correct opening and closing will occur.

4.2.4 Maximum operating back pressure (PMOB)

The steam trap shall be tested to determine the maximum pressure permissible at the outlet of the device which allows correct functioning.

4.2.5 Air venting capability

The steam trap shall be tested to determine its ability to discharge air.

4.2.6 Operating temperature (TO)

The steam trap shall be tested to determine the temperature at which the device operates and in particular the temperature at which it passes its specified capacity.

4.2.7 Condensate capacity (QH or QC)

The steam trap shall be flow tested to determine its condensate capacity throughout its operating pressure range.

4.2.8 Live steam loss

The steam trap shall be tested to determine the amount of live steam lost via the steam trap.

4.2.9 Determination of minimum operating pressure

Operational checks, as described in 4.2.1, shall be carried out while successively reducing the test pressure until the steam trap fails to open and close correctly.

The minimum operating pressure is the lowest test pressure at which correct operation is observed.

4.2.10 Determination of maximum operating pressure

The maximum operating pressure of the steam trap may be verified by carrying out operational checks, as described in 4.2.1, while successively increasing the test pressure up to the steam trap's maximum operating pressure.

The steam trap shall open and close correctly throughout the test.

4.2.11 Determination of maximum operating back pressure

Operational checks, as described in 4.2.1, shall be carried out with the outlet from the steam trap connected to a vessel in which the pressure can be raised, independent of the test pressure upstream of the steam trap. While maintaining a reference pressure at the steam trap's inlet, the pressure at its outlet is to be raised successively until the steam trap fails to open and close correctly.

The maximum operating back pressure is the highest pressure applied to the steam trap's outlet at which correct operation is still observed.

4.2.12 Determination of air venting capability

Air shall be introduced at a specified temperature into the steam trap or upstream piping. The air venting capability shall be checked by an air flow measurement carried out at minimum and maximum operating pressures, the temperature inside the steam trap being recorded.

4.2.13 Determination of operating temperature

Steam shall be fed into the steam trap to effect closure. Condensate, at saturated steam temperature, shall then be introduced and, unless the steam trap opens immediately, shall be allowed to cool slowly at the steam trap's inlet.

The temperature of the condensate, measured at the steam trap's inlet, at which the device opens, is the operating temperature.

The operating temperatures are the temperatures of the condensate, measured at the inlet to the steam trap, at which the steam trap passes its specified capacities.

4.2.14 Determination of condensate capacity

The capacity of the steam trap shall be determined by measuring the amount of condensate that is discharged from the device under specified conditions of pressure differential and condensate temperature.

The test shall be carried out with condensate at different temperatures and at different pressures within the steam trap's operating range to be specified, according to the test requirements detailed in Annex A.

4.2.15 Determination of live steam loss

To determine the amount of live steam lost, if any, by the steam trap, use one of the test methods in Annex B.

5 Inspection

Samples of the finished steam traps shall be visually examined and dimensionally checked to ensure that the steam traps correspond to the stated specification and shall be marked in accordance with ISO 6553.

Annex A
(normative)

Test methods for the determination of discharge capacity

A.1 General

This annex specifies two test methods to determine the discharge capacity of automatic steam traps.

A.2 Test arrangements

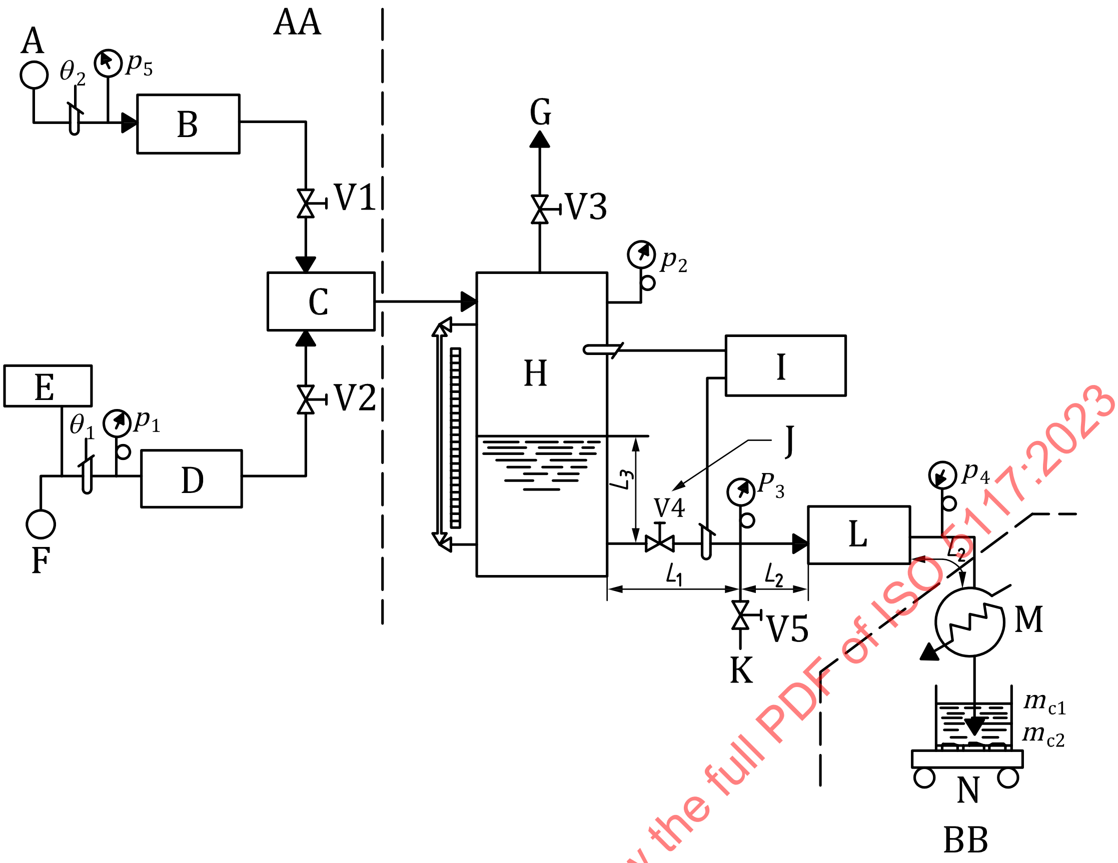
The test arrangements for condensate capacity determination are shown in Figures A.1 and A.2.

To reduce thermal losses to a minimum, all piping and equipment shall be insulated to a value *R*, in $m^2 \cdot °C \cdot h \cdot J^{-1}$, according to Formula (A.1).

$$R \geq 0{,}75 \times 10^{-3} \tag{A.1}$$

The instruments used for the measurements shall comply with International Standards, for example, ISO 4185, the ISO 5167 (series) and ISO 5168 for flow measurements.

The condensate removal device shall not be modified in any way from its commercial form.



Key

A	water supply	L	test device
B	flow meter q_{m1}	M	water-cooled condenser
C	steam water mixer	N	scale
D	flow meter q_{m2}	V1	valve 1
E	calorimeter	V2	valve 2
F	steam supply	V3	valve 3
G	steam vent	V4	valve 4
H	flash tank accumulator	V5	valve 5
I	temperature difference indicator $\Delta\theta$	AA	arrangement A
J	gate or full bore valve V4	BB	arrangement B
K	drain		

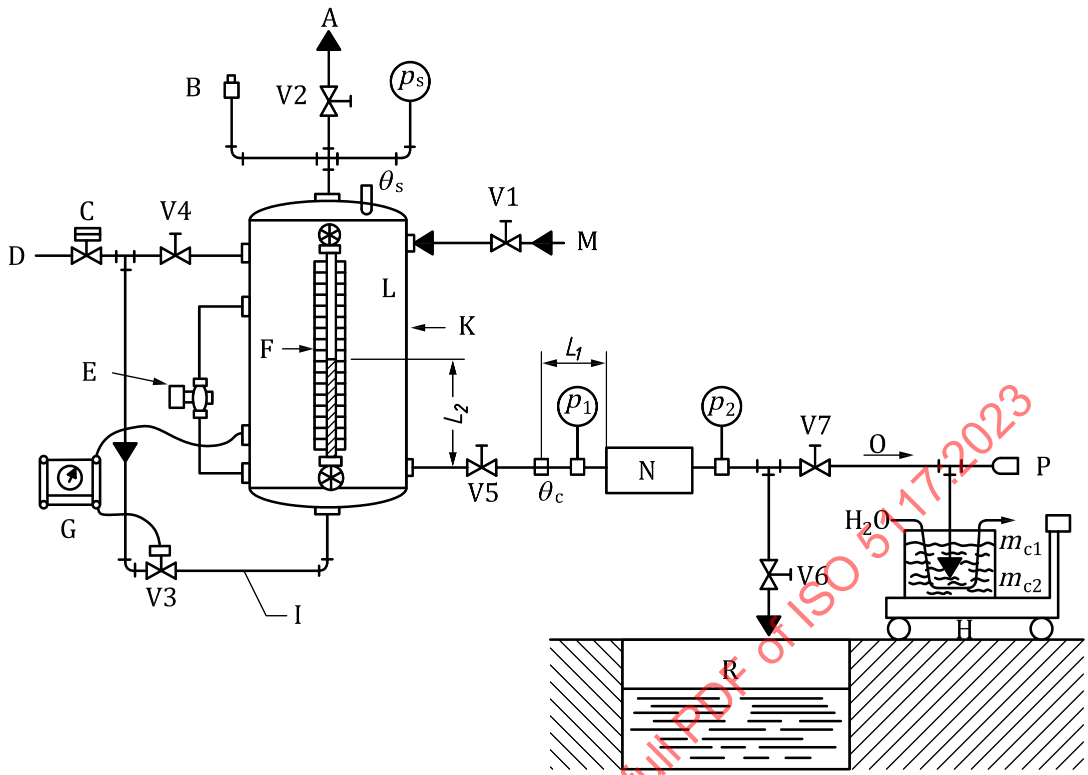
NOTE 1 The diameter of the pipework from the accumulator to the condensate removal device is the same as, or greater than, the diameter of the pipework to the inlet connection on the device.

NOTE 2 The distance L_1 does not exceed 10 internal pipe diameters.

NOTE 3 The distance L_2 is not less than 10 and not more than 20 internal pipe diameters.

NOTE 4 The distance L_3 is measured vertically from the water level to the centre of the inlet connection of the test device.

Figure A.1 — Test arrangement for test method A



Key

A vent
B safety valve
C pressure reducing valve
D steam supply
E circulator
F calibrated scale
G temperature controller (optional)
H scale
I injector line
K accumulator
L gauge glass
M cold water
N test device
O slope
P vacuum breaker
L_1 distance between sensors and test device
R open pit
V1 valve 1
V2 valve 2
V3 valve 3 – temperature control
V4 valve 4
V5 valve 5 – gate or full bore ball valve
V6 valve 6 – gate or full bore ball valve
V7 valve 7

NOTE 1 The piping from the accumulator to the test device is of the same diameter as the inlet connection on the test device. This inlet to the piping from the accumulator is well rounded.

NOTE 2 The distance L_1 between the sensors and the test device does not exceed 20 internal pipe diameters.

NOTE 3 The distance L_2 is measured vertically from the centre of the inlet pipe connection of the test device and does not exceed 450 mm.

NOTE 4 In Figure A.2, a steam injector is used for heating the water in the accumulator. It is also possible to use a steam circulating coil inside the accumulator or any other means.

Figure A.2 — Test arrangement for test method B – Continuous and intermittent flow

A.3 Test method A

A.3.1 Procedure

The method A is applicable only to continuous discharge measurement.

It is emphasized that Figure A.1 shows two alternative test arrangements for condensate measurement and that the choice is left to the test laboratory.

Start with all valves closed.

a) Warm up the system by gradually opening valves V1, V2, V3, V4 and V5.

b) Adjust valves V1, V2 and V3 with valve V4 wide open and valve V5 closed to bring the system into equilibrium. Equilibrium is defined as a steady water level in the accumulator with the vent valve V3 partially open and a difference of 3 °C or less showing on the temperature differential indicator.

c) Observe and record the following data as appropriate depending on the method of condensate determination:

p_1 = steam supply pressure, in bar(g) or MPa(g);

p_2 = accumulator steam pressure, in bar(g) or MPa(g);

p_3 = steam trap inlet pressure, in bar(g) or MPa(g);

p_4 = steam trap outlet pressure, in bar(g) or MPa(g);

θ_1 = steam supply temperature, in °C;

θ_2 = water supply temperature, in °C;

$\Delta\theta$ = temperature differential (subcooling) between steam in the accumulator and fluid entering the steam trap, in °C;

X = steam supply quality, in %;

L_3 = accumulator water level, in m;

Δt = time interval, in h, min or s;

q_{m1} = water supply flow rate, in kg/h;

q_{m2} = steam supply flow rate, in kg/h;

m_{c1} = mass of condensate and tank at the start, in kg;

m_{c2} = mass of condensate and tank at the end, in kg.

d) Record the data specified in A.3.1 c) at 5 min intervals for a minimum total of five sets of observations.

e) During the test period observations as appropriate shall not exceed the following limits:

— the difference between the maximum and minimum tank level shall not exceed 50 mm;

— the maximum value of the tank level shall not exceed 450 mm at any time during the test;

— the maximum temperature differential ($\Delta\theta$) shall not exceed 3 °C during the test;

— no individual steam trap inlet pressure (p_3) observation shall vary by more than 1 % of the average of all observations;

— the calculated vent steam flow rate (q_{m6}) shall not exceed a maximum value equal to an exit velocity of 0,31 m/s in the tank.

f) Repeat the operations specified in A.3.1 a) to e), as necessary to produce three sets of observations which result in three calculated capacity ratings, none of which varies from the average by more than 10 %.

A.3.2 Flow calculations

Flow shall be calculated according to Formulae (A.2) to (A.7).

$$q_{mf} = (q_{m1} + q_{m3} - q_{m4}) \pm q_{m8} \tag{A.2}$$

or

$$q_{mf} = \frac{(m_{c2} - m_{c1})}{\Delta t} \times 3\,600 \tag{A.3}$$

where

q_{mf} is the discharge flow rate, in kg/h;

q_{m1} is the water flow rate, in kg/h;

q_{m3} is the steam flow rate to heat water supply (q_{m1}), in kg/h.

q_{m4} is the flash steam flow rate in the accumulator, in kg/h;

m_{c1} mass of condensate and tank at the start, in kg;

m_{c2} mass of condensate and tank at the end, in kg;

Δt is the time interval, in s.

$$q_{m3} = q_{m1} \times \frac{(h_3 - h_1)}{(h_2 - h_3)} \tag{A.4}$$

$$q_{m4} = (q_{m1} + q_{m3}) \times \frac{(h_3 - h_5)}{(h_4 - h_5)} \tag{A.5}$$

$$q_{m4,max} = \frac{\pi}{4} \times \frac{D^2}{V_1} \times 0{,}31 \times 3\,600 \tag{A.6}$$

$$q_{m8} = \frac{\pi}{4} \times D^2 \times \frac{(L_{31} - L_{32})}{\Delta t} \times \frac{3\,600}{V_2} \tag{A.7}$$

where

q_{m8} is the accumulator storage rate, in kg/h;

h_1 is the specific enthalpy of the supply water, in kJ/kg;

h_2 is the specific enthalpy of the supply steam, in kJ/kg;

h_3 is the specific enthalpy of saturated water at the supply pressure, in kJ/kg;

h_4 is the specific enthalpy of saturated steam in the accumulator, in kJ/kg;

h_5 is the specific enthalpy of saturated water in the accumulator, in kJ/kg;

V_1 is the specific volume of saturated steam in the accumulator, in m^3/kg;

V_2 is the specific volume of saturated water in the accumulator, in m^3/kg;

D is the inside diameter of the accumulator, in m;

L_{31} is the initial accumulator tank level, in m;

L_{32} is the final accumulator tank level, in m.

A.3.3 Datasheet

Table A.1 provides an example of a datasheet for method A.

Table A.1 — Example of a datasheet — Test method A

Steam trap discharge capacity - Test method A											
Test n°:	**Date of test:**	**Calculation by:**						**Manufacturer name:**			
Serial n°:	**Size:**	**Description and type of device:**						**Inside diameter of accumulator, *D*:**			
Data		**Run numbers**						**Data average**	**Calculation**		
Item	**Unit**								**Item**	**Unit**	
Steam supply pressure, p_1	bar or MPa								Reference used for steam/water data		
Accumulator steam pressure, p_2	bar or MPa								Specific enthalpy of water supply, h_1	kJ/kg	
Steam trap inlet pressure, p_3	bar or MPa								Specific enthalpy of steam supply, h_2	kJ/kg	
Steam trap outlet pressure, p_4	bar or MPa								Specific enthalpy of saturated water at steam supply pressure, h_3	kJ/kg	
Steam supply temperature, θ_1	°C								Specific enthalpy of saturated steam at accumulator pressure, h_4	kJ/kg	
Water supply temperature, θ_2	°C								Specific enthalpy of saturated water at accumulator pressure, h_5	kJ/kg	
Subcooled temperature, $\Delta\theta$	°C								Specific volume of saturated steam at accumulator pressure, V_1	m^3/kg	
Steam supply quality, X	%								Specific volume of saturated water at accumulator pressure, V_2	m^3/kg	
Change in accumulator level, $L_{31} - L_{32}$	m								Steam to heat water supply, $q_{m3} = q_{m1} \times [(h_3 - h_1)/(h_2 - h_3)]$	kg/h	
Water supply flow rate, q_{m1}	kg/h								Flash steam flow in accumulator, $q_{m4} = [(q_{m1} + q_{m3}) \times (h_3 - h_5)/(h_4 - h_5)]$	kg/h	
Steam supply flow rate, q_{m2}	kg/h								Water flow rate to accumulator, $q_{m5} = q_{m1} + q_{m3} - q_{m4}$	kg/h	
Time elapsed, Δt	s								Steam flow to vent, $q_{m6} = q_{m2} - q_{m3} + q_{m4}$	kg/h	

Table A.1 *(continued)*

The trap capacity determined by this test is q_{mf} for **— an inlet pressure of p_3;** **— a discharge pressure of p_4; and** **— a subcooling at steam trap inlet of $\Delta\theta$.**	Steam flow to vent, $q_{m7} = 2\ 827 \times D^2 / V_1$	kg/h	
	Vent fraction of maximum, R $R = [q_{m6} / q_{m7}]$ (shall be ≤ 1)	-	
	Accumulator storage rate, q_{m8} $q_{m8} = [2\ 827 \times D^2 \times (L_{31} - L_{32})] / (\Delta t \times V_2)$	kg/h	
	Discharge flow rate, q_{mf} $q_{mf} = (q_{m1} + q_{m3} - q_{m4} \pm q_{m8})$	kg/h	

A.4 Test method B

A.4.1 Procedure

Start with all valves closed.

a) Open valves V1 and V2 and fill the accumulator tank to the desired level. Close valve V1.

b) Open valve V3 and heat the water in the accumulator tank to the desired temperature. Throttle valve V2 as required to obtain water temperatures above 100 °C. Leave valve V2 slightly open while venting steam to purge air from the space above the water. Close valves V2 and V3 and open valve V4.

c) Open valves V5 and V6 to heat the test pipe and condensate removal device. Monitor and adjust the system to produce the desired pressure at the test condensate removal device.

d) When thermal equilibrium is reached, begin the test. A circulation device may be necessary to ensure uniform temperature within the tank. Do not take data until the tank level complies with that shown in Figure A.3.

e) Observe and record as appropriate the following data:

— elapsed time, in h, min or s;

— ambient temperature θ_a, in °C;

— barometric pressure p_a, in bar(g) or MPa(g);

— steam pressure and temperature p_s and θ_s, in bar(g) or MPa(g) and °C;

— initial and final values of the following:

1) temperature differential $\theta_S - \theta_c$, in °C;

2) inlet pressure p_1, in bar(g) or MPa(g);

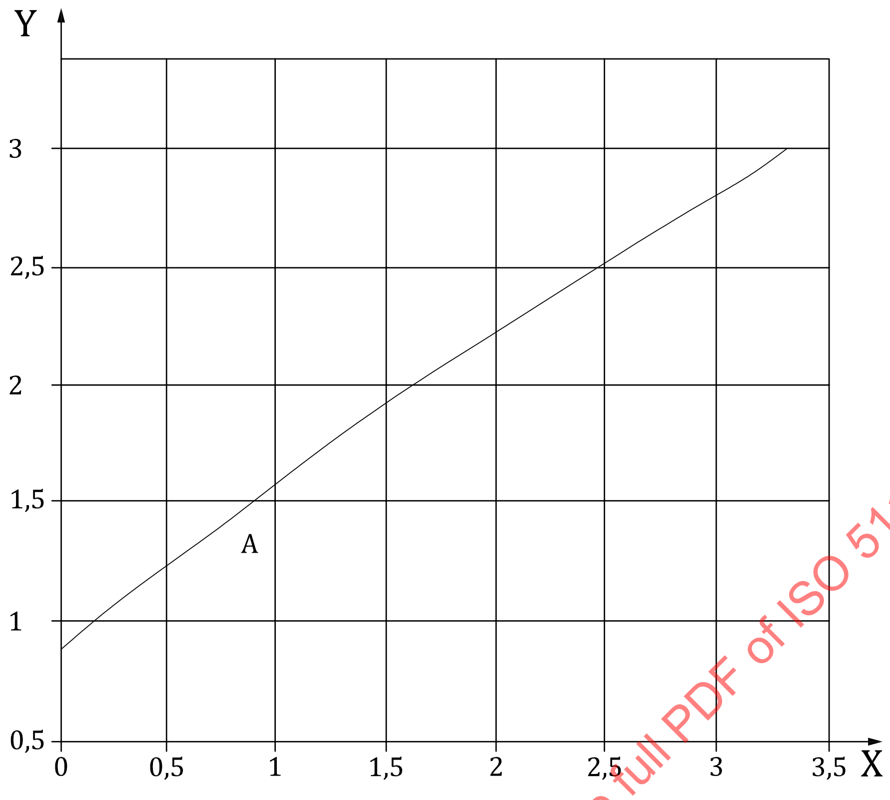
3) back pressure p_2, in bar(g) or MPa(g).

f) Observe and record one of the following data:

— accumulator tank levels L_{21} and , L_{22} in m;

— mass of condensate plus mass of tank at the start and finish m_c, in kg.

g) Repeat the operations as specified in A.4.1 a) to f) as necessary to produce three sets of observations which result in three calculated capacity ratings, none of which varies from the average by more than 10 %.



Key

X pressure [bar]

Y L_{2max} [m]

A L_{2max} = 0,641 3 × pressure + 0,919 8, but not over 3 m

Figure A.3 — Maximum submergence on steam trap versus test pressure

A.4.2 Flow calculations

Flow shall be calculated according to Formulae (A.8) and (A.9).

$$q_{mf} = \frac{\pi D^2}{4} \times \frac{(L_{21} - L_{22})}{\Delta t} \times \frac{3\,600}{V_f} \tag{A.8}$$

where

q_{mf} is the discharge flow, in kg/h;

D is the inside diameter of the accumulator, in m;

Δt is the time interval, in s;

V_f is the specific volume of water in the accumulator, in m^3/kg.

or

$$q_{mf} = (m_{c2} - m_{c1}) \frac{3\,600}{\Delta t} \tag{A.9}$$

where

m_{c1} is the mass of condensate plus weigh tank at the start, in kg;

m_{c2} is the mass of condensate plus weigh tank at the end, in kg.

A.4.3 Data sheet

Table A.2 provides an example of a datasheet for method B.

Table A.2 — Example of a datasheet — Test method B

Steam trap discharge capacity - Test method B											
Test n°:	**Date of test:**	**Calculation by:**						**Manufacturer name:**			
Serial n°:	**Size:**	**Description and type of device:**						**Inside diameter of accumulator, D:**			
Data		**Run numbers**						**Data average**	**Calculation**		
Item	**Unit**								**Item**	**Unit**	
Temperature of steam in accumulator θ_s, start	°C								Differential pressure at the start of test, $p_1 - p_2$, start	bar or MPa	
Temperature of steam in accumulator θ_s, finish	°C								Differential pressure at the start of test, $p_1 - p_2$, finish	bar or MPa	
Temperature of condensate to device θ_c, start	°C								Average differential pressure, $[(p_1 - p_2$, start) + $(p_1 - p_2$, finish)]/2	bar or MPa	
Temperature of condensate to device θ_c, finish	°C								Quantity of condensate discharged, q_w $q_w = (\pi/4) \times D^2 \times (L_{21} - L_{22})/V_f$	kg	
Temperature difference $\theta_s - \theta_c$, start	°C								Capacity, $q_{mf} = q_w \times 3\,600/\Delta t$	kg/h	
Temperature difference $\theta_s - \theta_c$, finish	°C								Amount of condensate collected, $q_c = m_{c2} - m_{c1}$	kg	
Time interval Δt	s								Capacity, $q_{mf} = q_c \times 3\,600/\Delta t$	kg/h	

Table A.2 *(continued)*

Steam pressure in accumulator p_s, start	bar or MPa								**The steam trap capacity determined by this test is q_{mf} for** **— an inlet pressure of (p_1, start + p_1, finish)/2** **— a discharge pressure of (p_2, start + p_2, finish)/2** **— a subcooling at [($\theta_s - \theta_c$, start) + ($\theta_s - \theta_c$, finish)]/2** **Remarks:**
Steam pressure in accumulator p_s, finish	bar or MPa								
Steam pressure at device inlet p_1, start	bar or MPa								
Steam pressure at device inlet p_1, finish	bar or MPa								
Steam pressure at device outlet p_2, start	bar or MPa								
Steam pressure at device outlet p_2, finish	bar or MPa								
Initial level of water in accumulator tank, L_{21}	m								
Initial level of water in accumulator tank, L_{22}	m								
Specific volume of liquid, V_f	m^3/kg								
Mass of condensate + tank mass at the start, m_{c1}	kg								
Mass of condensate + tank mass at the finish, m_{c2}	kg								

A.5 Report of results — Test method A or B

Test results may be reported only if the following additional data are reported:

a) steam trap inlet pressure;

b) steam trap outlet pressure;

c) subcooling $\Delta\theta$.

A minimum of five tests shall be used to plot any graph. The extrapolation of any graph outside of the pressure range covered by the tests shall be clearly marked and the maximum subcooling ($\Delta\theta_{max}$) and minimum outlet pressure of the tests shall be noted on the graph.

Annex B
(normative)

Test methods for the determination of steam loss

B.1 General

This annex specifies the steam loss test requirements for the steam trap. The objective of these tests is to determine the amount of live steam lost through the steam trap, if any. As a result, these tests are aimed to assess the steam trap's ability to close against steam during successive operations.

There is no measurement of the total heat energy lost by the steam trap. Such total heat loss would include radiation and convection components which can be established separately.

B.2 Test arrangements

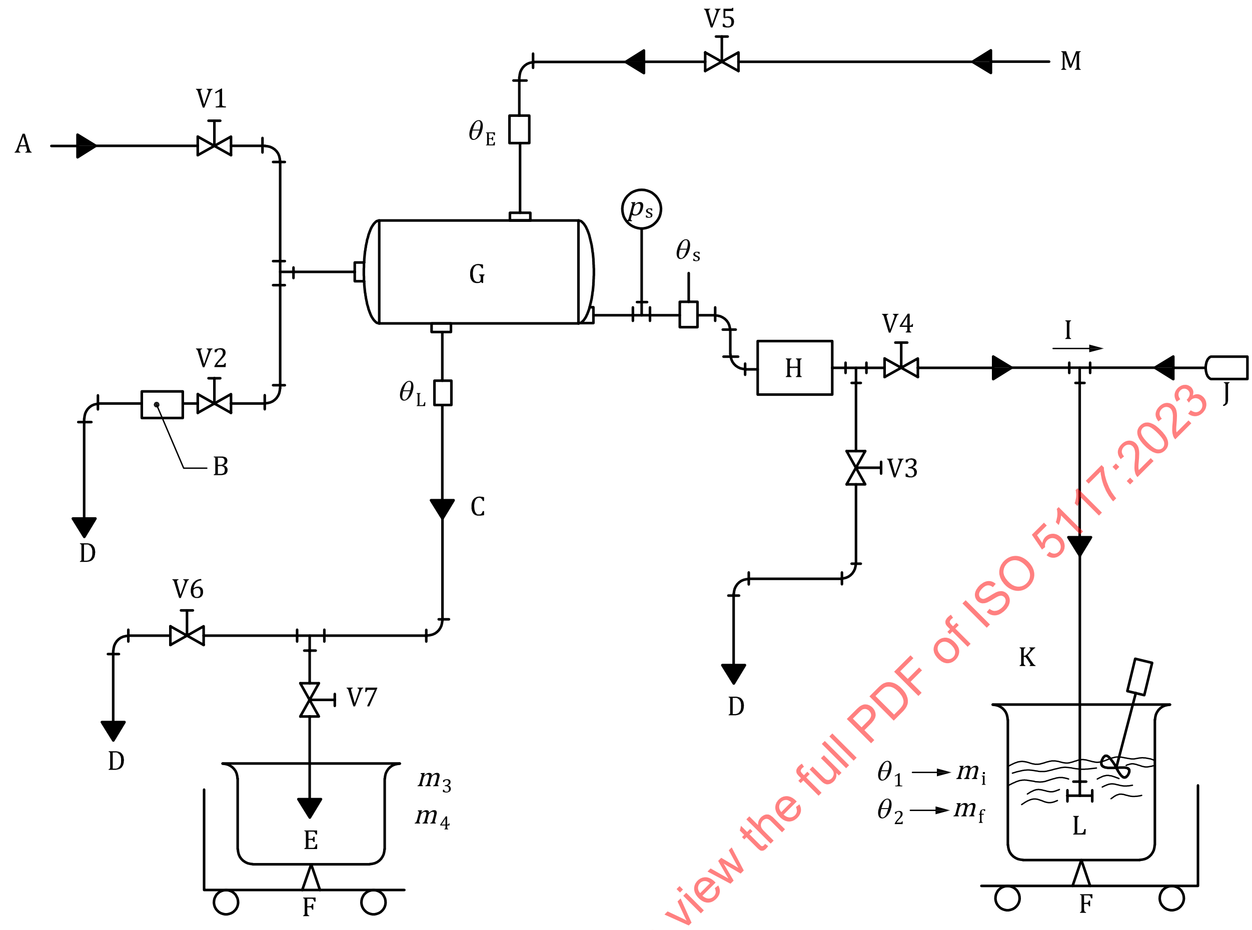
The test arrangements for steam loss determination are shown in Figures B.1 and B.2. The minimum water capacity of the calorimeter tank (see Figure B.1) shall be 0,02 m^3 or shall be filled with sufficient amount of water to result in a minimum duration of 10 min. It is most important that the condensate drainage device be fully capable of maintaining a dry line to the heat exchanger. The test device shall be located sufficiently below the heat exchanger to prevent condensate backing up into the heat exchanger, should the test device only operate infrequently.

To reduce thermal losses to a minimum, all piping and equipment (including the heat exchanger) shall be insulated to a value R, in $m^2 \cdot °C \cdot h \cdot J^{-1}$, according to Formula (B.1).

$$R \geq 0,75 \times 10^{-3} \tag{B.1}$$

The instruments used for the measurements shall comply with International Standards, if such standards exist, for example, ISO 4185 for flow measurements.

The condensate removal device shall not be modified in any way from its commercial form.

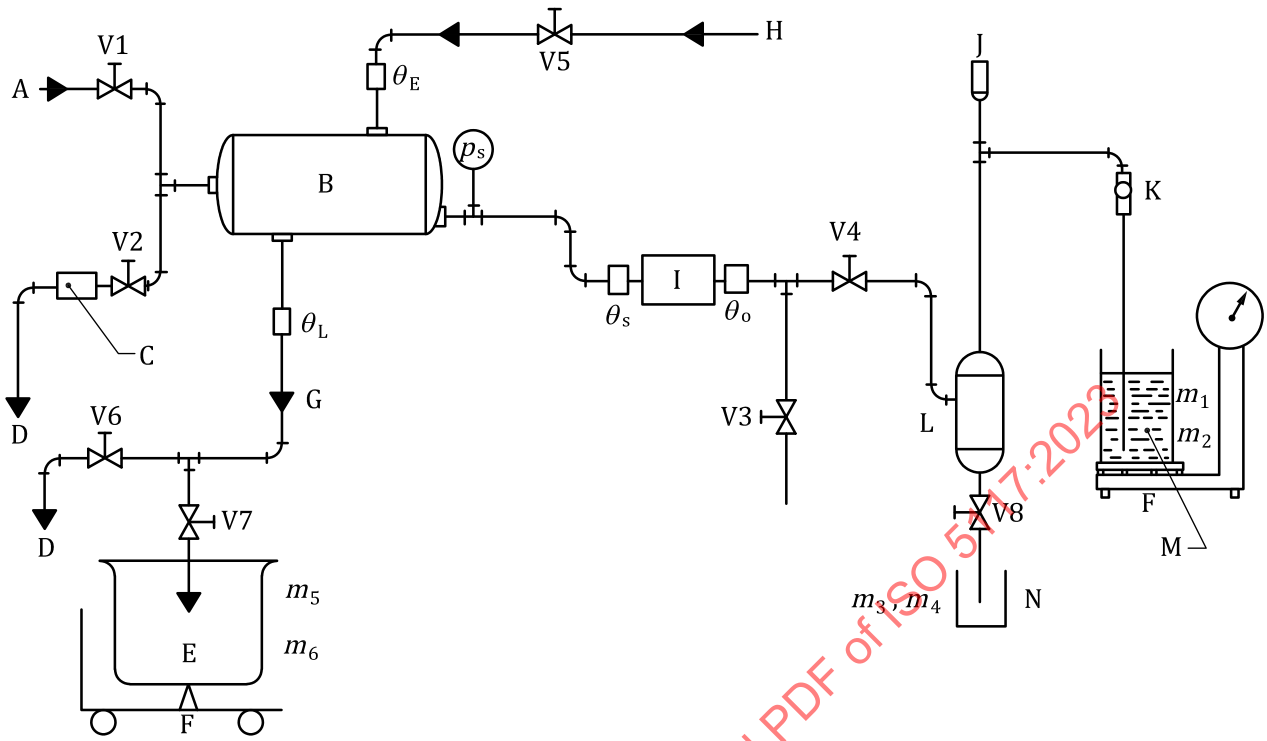


Key

A	steam in
B	condensate drain device
C	cooling water out
D	to drain
E	exchanger water tank
F	scales
G	heat exchanger
H	test device
I	slope
J	vacuum breaker
K	vented cover or plastic balls
L	calorimeter tank
M	cooling water in
V1	valve 1
V2	valve 2
V3	valve 3
V4	valve 4
V5	valve 5
V6	valve 6
V7	valve 7

NOTE The condensate drain device operates at steam temperature.

Figure B.1 — Test arrangement for test method A



Key

A	steam in	L	separating tank
B	heat exchanger	M	condensating tank
C	condensate drain device	N	measuring vessel
D	to drain	V1	valve 1
E	exchanger water tank	V2	valve 2
F	scales	V3	valve 3
G	cooling water out	V4	valve 4
H	cooling water in	V5	valve 5
I	test device	V6	valve 6
J	vacuum breaker	V7	valve 7
K	sight glass	V8	valve 8

The separating tank should be kept hot by a heated jacket or an insulating system.

NOTE The condensate drain device operates at steam temperature.

Figure B.2 — Test arrangement for test method B

B.3 Test method A

B.3.1 General

The test may be carried out at a pressure corresponding to the maximum working pressure of the steam trap, the test pressure not exceeding 32 bar with saturated steam (238 °C).

Load testing shall be carried out at 1 % of the maximum capacity of the steam trap at the corresponding test pressure with a minimum of 5 kg/h.

B.3.2 Procedure

B.3.2.1 No-load condition

The test shall be performed with steam. The process begins with the valves closed and the tanks empty.

a) Open valves V1, V2 and V3 to permit the test devices to operate at test pressure p_s. Initially, steam passes though the drain valve.

b) During warm-up, weigh and record the mass of the empty calorimeter tank m_t and record the steam pressure p_s and steam temperature θ_s.

c) Fill the calorimeter tank with sufficient water (about half-full) to result in a test run of practical duration. The initial water temperature θ_1 should be at least 8 °C below ambient temperature θ_a. Record the water temperature θ_1 and mass of water plus tank m_1.

d) When thermal equilibrium is reached in the test device, simultaneously and rapidly close valve V3, open valve V4, and start the timing interval. The use of a three-way valve is recommended to facilitate rapid closing and opening.

e) Stir the water in the calorimeter tank as needed to ensure a uniform water temperature.

f) When the temperature of the water in the tank is as many degrees above ambient as the initial temperature was below, rapidly close valve V4 and open valve V3 simultaneously, record the elapsed time, the final water temperature θ_2 and the mass of water plus tank m_2.

g) Before the measurement, trial runs should be carried out to ensure that the test conditions have stabilized and that the pressure, temperature, initial amount of water in the calorimeter tank and load conditions are those required. When testing condensate removal devices, an error calculation is made from three consecutive tests to determine the accuracy of the test result. The error calculation is based on the instrumentation used and described in this document, or the average result from three consecutive tests shall agree within 10 % or 500 g/h, whichever is the greater.

If this cannot be obtained, check the system for integrity and increase the calorimeter tank capacity.

B.3.2.2 Load condition

At load condition, the condensate through heat exchanger and the steam trap are checked for the temperature loss. The test starts with all valves closed and both tanks empty.

a) Open valves V1, V2 and V3 to permit the drain and test devices to operate at test pressure p_s.

b) During warm-up, weigh and record the mass of the empty calorimeter tank m_t and record the steam pressure p_s and steam temperature θ_s.

c) Open valves V5 and V6 to allow a flow of cooling water through the heat exchanger, to create the desired condensate load on the test device. After the system has come to equilibrium, this load can be determined by closing valve V6 and opening valve V7, to permit a known amount of water to be collected in a given time.

   Record the temperature of water entering and leaving the heat exchanger, θ_E and θ_L, the initial and final mass of water through exchanger plus tank, m_3 and m_4, and the time Δt, in s, of run on the data sheet in B.4.3. The approximate condensate load, in kg/h, on the steam trap can then be calculated using Formula (B.2).

$$= \frac{(\theta_L - \theta_E)(m_4 - m_3) C_{cw} \times 3\,600}{\Delta t \times h_{fgs}} \quad \text{(B.2)}$$

   where

h_{fgs} is the specific enthalpy of the evaporation at steam inlet conditions, in J/kg;

C_{cw} is the specific heat of cooling water at the average temperature of the cold side, in J/kg·K, that is $\frac{\theta_L + \theta_E}{2}$.

d) If the load on the steam trap as determined in B.3.2.2 c) is as desired, proceed to B.3.2.2 e). If it is not as desired, adjust valve V5 accordingly and repeat the procedure in B.3.2.2 c) until the desired load is obtained.

e) Fill the calorimeter tank with sufficient water (about half-full) to result in a test run of practical duration. The initial water temperature θ_1 should be at least 8 °C below ambient temperature θ_a. Record the water temperature θ_1 and mass of water plus tank m_1.

f) When thermal equilibrium is reached, simultaneously and rapidly close valve V3, and open valve V4, and start the timing interval. The use of a three-way valve is recommended to facilitate rapid closing and opening.

g) Stir the water in the calorimeter tank as necessary to ensure a uniform water temperature.

h) When the temperature of the water in the calorimeter tank is as many degrees above ambient as the initial temperature was below, rapidly close valve V4 and open valve V3 simultaneously, record the elapsed time, the final water temperature θ_2 and the mass of water plus tank m_2.

i) Before the measurement, trial runs should be carried out to ensure that the test conditions have stabilized and that the pressure, temperature, initial amount of water in the calorimeter tank and load conditions are those required. When testing condensate removal devices, an error calculation is made from three consecutive tests to determine the accuracy of the test result. The error calculation is based on the instrumentation used and described in this document, or the average result from three consecutive tests shall agree within 10 % or 500 g/h, whichever is the greater.

If this cannot be obtained, check the system for integrity and increase the calorimeter tank capacity.

B.3.3 Expression of results

B.3.3.1 Correction of measured variables

The values of observed variables shall be corrected in accordance with instrument calibrations and, if necessary, converted to the proper units required for calculations.

B.3.3.2 Computation formula

With load: use Formula (B.3).

$$q_{ms} = \left[\frac{m_f h_{f2} - m_i h_{f1} - h_{fs}(m_f - m_i) + C_p m_t(\theta_2 - \theta_1)}{h_{fgs}}\right] \times \frac{3\,600}{\Delta t} \quad \text{(B.3)}$$

With no-load: use Formula (B.4).

$$q_{ms} = \frac{(m_2 - m_1)}{\Delta t} \times 3\,600 \quad \text{(B.4)}$$

where

q_{ms} is the steam loss, in kg/h;

m_i is the initial mass of water in the calorimeter, in kg;

m_f is the final mass of water and condensate in the calorimeter, in kg;

m_1 is the mass of calorimeter plus water, at the start, in kg;

m_2 is the mass of calorimeter plus water, at the finish, in kg;

m_t is the mass of calorimeter tank, in kg.

h_{f1} is the initial specific enthalpy of water in the calorimeter, in J/kg;

h_{f2} is the final specific enthalpy of the condensate and water in the calorimeter, in J/kg;

h_{fs} is the specific enthalpy of the liquid at steam inlet conditions, in J/kg;

h_{fgs} is the specific enthalpy of the evaporation at steam inlet conditions, in J/kg;

C_P is the specific heat of the calorimeter material, in J/kg.K;

θ_1 is the initial water temperature in the calorimeter tank, in °C;

θ_2 is the water temperature in the calorimeter tank, in °C;

Δt is the time interval, in s.

B.3.4 Data sheet

Table B.1 provides an example of a datasheet for method A.