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Automatic steam traps — Determination of discharge capacity — Test methods

Purgeurs automatiques de vapeur d'eau — Détermination du débit — Méthodes d'essai

Reference number
ISO 7842 : 1988 (E)

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 7842 was prepared by Technical Committee ISO/TC 153, *Valves.*

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

Automatic steam traps — Determination of discharge capacity — Test methods

1 Scope and field of application

This International Standard specifies two test methods to determine the discharge capacity of automatic steam traps to ISO 6552.

2 References

ISO 651, *Solid-stem calorimeter thermometers.*

ISO 652, *Enclosed-scale calorimeter thermometers.*

ISO 653, *Long solid-stem thermometers for precision use.*

ISO 654, *Short solid-stem thermometers for precision use.*

ISO 4185, *Measurement of liquid flow in closed conduits — Weighing method.*

ISO 5167, *Measurement of fluid flow by means of orifice plates, nozzles and Venturi tubes inserted in circular cross-section conduits running full.*

ISO 5168, *Measurement of fluid flow — Estimation of uncertainty of a flow-rate measurement.*

ISO 6552, *Automatic steam traps — Definition of technical terms.*

3 Test arrangements

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

All piping and equipment shall be insulated to a value of

$$R \geqslant 0,75 \times 10^{-3} \frac{\mathrm{m^2 \cdot {}^\circ C \cdot h}}{\mathrm{J}}$$

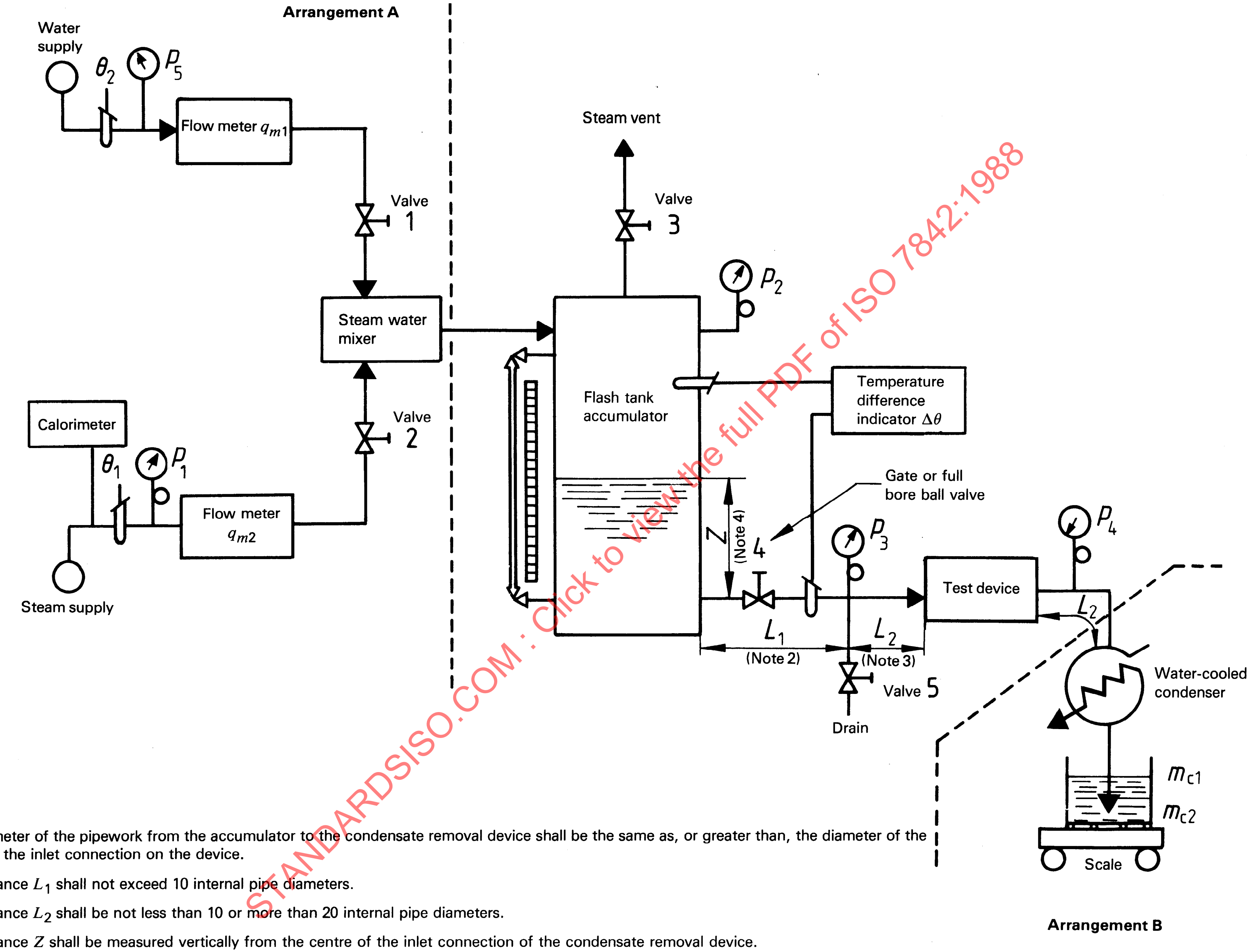
to reduce thermal losses to a minimum.

The instruments used for the measurements shall comply with International Standards, if such standards exist, e.g.

- ISO 651, ISO 652, ISO 653 and ISO 654 for temperature measurements;
- ISO 4185, ISO 5167 and ISO 5168 for flow measurements.

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

4 Test method A



NOTES

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

2 The distance L_1 shall not exceed 10 internal pipe diameters.

3 The distance L_2 shall be not less than 10 or more than 20 internal pipe diameters.

4 The distance Z shall be measured vertically from the centre of the inlet connection of the condensate removal device.

Figure 1 — Test arrangement for test method A

4.1 Procedure

NOTE — Test method A is applicable only to continuous discharge measurement.

Start with all valves closed.

4.1.1 Warm up the system by gradually opening valves 1, 2, 3, 4 and 5.

4.1.2 Adjust valves 1, 2 and 3 with valve 4 wide open and valve 5 closed to bring the system into equilibrium. Equilibrium is defined as a steady water level in the accumulator with the vent valve 3 partially open and a difference of 3 °C or less showing on the temperature differential indicator.

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

- p_1 = steam supply pressure, in bars[1];
- p_2 = accumulator steam pressure, in bars;
- p_3 = trap inlet pressure, in bars;
- p_4 = trap outlet pressure, in bars;
- θ_1 = steam supply temperature, in degrees Celsius;
- θ_2 = water supply temperature, in degrees Celsius;
- $\Delta\theta$ = temperature differential (subcooling) between steam in the accumulator and fluid entering the trap, in degrees Celsius;
- X = steam supply quality, in per cent;
- Z = accumulator water level, in metres;
- Δt = time interval, in hours, minutes or seconds;
- q_{m1} = water supply flow-rate, in kilograms per hour;
- q_{m2} = steam supply flow-rate, in kilograms per hour;
- m_{c1} = mass of condensate and tank at start, in kilograms;
- m_{c2} = mass of condensate and tank at end, in kilograms.

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

4.1.4 Record the data specified in 4.1.3 at 5 min intervals for a minimum total of five sets of observations.

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

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

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

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

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

e) 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.

4.1.6 Repeat the operations specified in 4.1.1 to 4.1.5 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 %.

4.2 Flow calculations

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

or

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

where

q_{mf} is the discharge flow, in kilograms per hour;

q_{m1} is the water flow, in kilograms per hour;

q_{m3} is the steam flow to heat water supply (q_{m1}), in kilograms per hour;

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

q_{m4} is the flash steam flow in the accumulator, in kilograms per hour;

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

$$q_{m4,\,max} = \frac{\pi}{4} \times \frac{D^2}{v_1} \times 0{,}31 \times 3\,600$$

q_{m8} is the accumulator storage rate, in kilograms per hour;

$$q_{m8} = \frac{\pi}{4} \times D^2 \times \frac{(Z_1 - Z_2)}{\Delta t} \times \frac{3\,600}{v_2}$$

m_{c1} and m_{c2} are as given in 4.1.3;

h_1 is the specific enthalpy of the supply water, in kilojoules per kilogram;

h_2 is the specific enthalpy of the supply steam, in kilojoules per kilogram;

h_3 is the specific enthalpy of saturated water at the supply pressure, in kilojoules per kilogram;

h_4 is the specific enthalpy of saturated steam in the accumulator, in kilojoules per kilogram;

1) 1 bar = 10^5 Pa

h_5 is the specific enthalpy of saturated water in the accumulator, in kilojoules per kilogram;

v_1 is the specific volume of saturated steam in the accumulator, in cubic metres per kilogram;

v_2 is the specific volume of saturated water in the accumulator, in cubic metres per kilogram;

Δt is the time interval, in seconds;

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

Z_1 is the initial accumulator tank level, in metres;

Z_2 is the final accumulator tank level, in metres.

4.3 Data sheet

Test Method A

General information

1 Test No. : .... 2 Date of test : .... 3 Calculation by : ....

4 Manufacturer's name : ....

5 Serial No. : .... 6 Size : ....

7 Description and type of device : ....

8 Inside diameter of accumulator, D : .... m

Averaged and corrected test data

9 Steam supply pressure, p_1 = ... bar

10 Accumulator steam pressure, p_2 = ... bar

11 Trap inlet pressure, p_3 = ... bar

12 Trap outlet pressure, p_4 = ... bar

13 Steam supply temperature, θ_1 .... °C

14 Water supply temperature, θ_2 .... °C

15 Subcooled temperature, $\Delta\theta$ = ... °C

16 Steam supply quality, X = ... %

17 Change in accumulator level, $Z_1 - Z_2$ = ... m

18 Water supply flow-rate, q_{m1} = ... kg/h

19 Steam supply flow-rate, q_{m2} = ... kg/h

20 Elapsed time, Δt = ... s

Thermodynamic properties

21 Reference used for steam/water data : ....

22 Specific enthalpy of water supply, h_1 = ... kJ/kg

23 Specific enthalpy of steam supply, h_2 = ... kJ/kg

24 Specific enthalpy of saturated liquid at steam supply pressure, h_3 = ... kJ/kg

25 Specific enthalpy of saturated vapour at accumulator pressure, h_4 = ... kJ/kg

26 Specific enthalpy of saturated liquid at accumulator pressure, h_5 = ... kJ/kg

27 Specific volume of saturated vapour at accumulator pressure, v_1 = ... m³/kg

28 Specific volume of saturated liquid at accumulator pressure, v_2 = ... m³/kg

Calculations

29 Steam to heat water supply, q_{m3} = ... kg/h

$$\text{Item 18} \times \frac{\text{Item 24} - \text{Item 22}}{\text{Item 23} - \text{Item 24}}$$

30 Flash steam flow in accumulator, q_{m4} = ... kg/h

$$\frac{(\text{Item 18} + \text{Item 29})\,(\text{Item 24} - \text{Item 26})}{\text{Item 25} - \text{Item 26}}$$

31 Water flow-rate to accumulator, q_{m5} = ... kg/h
Item 18 + Item 29 − Item 30

32 Steam flow to vent, q_{m6} = ... kg/h
Item 19 − Item 29 + Item 30

33 Maximum uncorrected steam flow to vent, q_{m7} = ... kg/h

$$\frac{2\,827 \times (\text{Item } 8)^2}{\text{Item } 27}$$

34 Vent fraction of maximum, R = ...

$$R = \frac{\text{Item } 32}{\text{Item } 33} \text{ (shall be } \leqslant 1 \text{ for test to be valid)}$$

35 Accumulator storage rate, q_{m8} = ... kg/h

$$\frac{2\,827 \times (\text{Item } 8)^2 \times \text{Item } 17}{\text{Item } 20 \times \text{Item } 28}$$

36 Discharge flow, q_{mf} = ... kg/h
(Item 18 + Item 29 − Item 30) ± Item 35

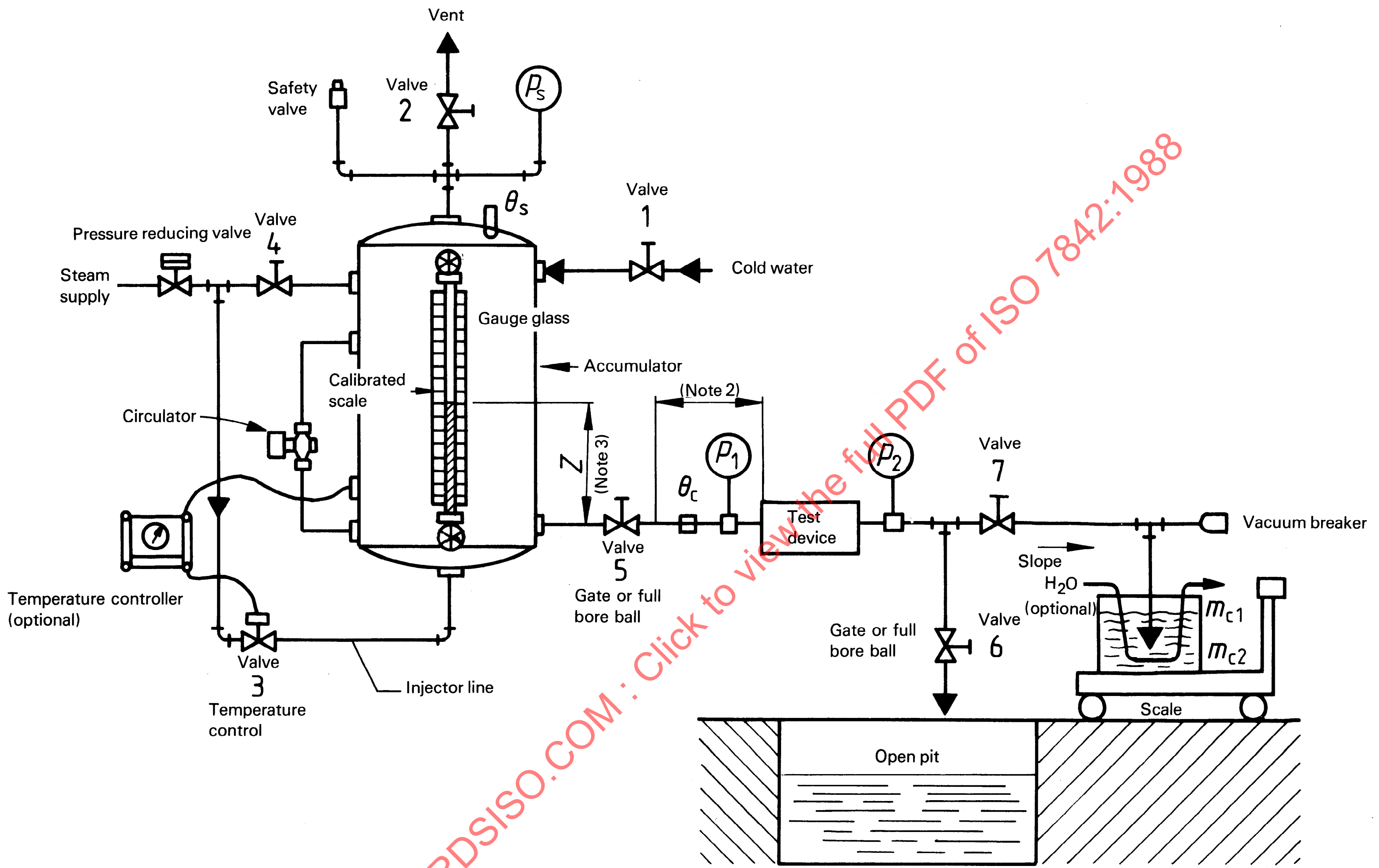
37 The trap capacity determined by this test is Item 36 for

— an inlet pressure of Item 11

— a discharge pressure of Item 12, and

— a subcooling at the trap inlet of Item 15.

5 Test method B



NOTES

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

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

3 The distance Z shall be measured vertically from the centre of the inlet pipe connection of the test device and shall not exceed the distance shown in figure 3.

4 The diagram indicates the use of a steam injector for heating the water in the accumulator. It could equally be achieved by the use of a steam circulating coil inside the accumulator or any other means.

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

5.1 Procedure

Start with all valves closed.

5.1.1 Open valves 1 and 2 and fill the accumulator tank to the desired level. Close valve 1.

5.1.2 Open valve 3 and heat the water in the accumulator tank to the desired temperature. Throttle valve 2 as required to obtain water temperatures above 100 °C. Leave valve 2 open slightly while venting steam to purge air from the space above the water. Close valves 2 and 3 and open valve 4.

5.1.3 Open valves 5 and 6 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.

5.1.4 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 3.

5.1.5 Observe and record as appropriate the following data:

a) elapsed time, in hours, minutes or seconds;

b) ambient temperature θ_a, in degrees Celsius;

c) barometric pressure p_a, in bars;

d) steam pressure and temperature p_s and θ_s, in bars and degrees Celsius;

e) initial and final values of the following:

1) temperature differential $\theta_s - \theta_c$, in degrees Celsius,

2) inlet pressure p_1, in bars;

3) back pressure, p_2, in bars;

f) one of the following:

1) accumulator tank levels Z_1 and Z_2, in metres,

2) mass of condensate plus weight of tank at start and finish m_c, in kilograms.

5.1.6 Repeat the operations specified in 5.1.1 to 5.1.5 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 %.

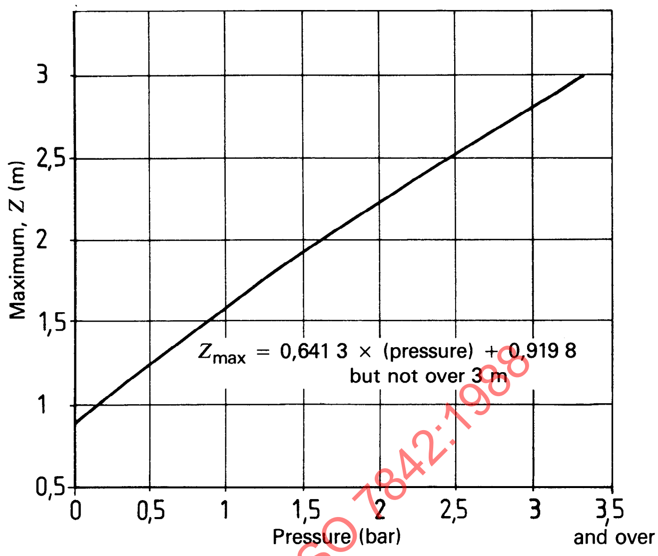


Figure 3 — Maximum submergence on steam trap versus test pressure

5.2 Flow calculations

$$q_{mf} = \frac{\pi D^2}{4} \times \frac{(Z_1 - Z_2)}{\Delta t} \times \frac{3\,600}{v_f}$$

where

q_{mf} is the discharge flow, in kilograms per hour;

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

Δt is the time interval, in seconds;

v_f is the specific volume of water in the accumulator, in cubic metres per kilogram;

or

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

where

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

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

5.3 Data sheet

Test Method B

General information

1 Test No. : .... 2 Date of test : .... 3 Calculation by : ....

4 Manufacturer's name : ....

5 Serial No. : .... 6 Size : ....

7 Description and type of device : ....

8 Inside diameter of accumulator, D = ... m

Averaged and corrected test data

9 Temperature of steam in the accumulator tank, θ_s, start = ... °C

10 Temperature of steam in the accumulator tank, θ_s, finish = ... °C

11 Temperature of condensate to device, θ_c, start = ... °C

12 Temperature of condensate to device, θ_c, finish = ... °C

13 Temperature difference, $\theta_s - \theta_c$, start = ... °C

14 Temperature difference, $\theta_s - \theta_c$, finish = ... °C

15 Time interval, Δt .... s

16 Steam pressure in the accumulator tank, p_s, start = ... bar

17 Steam pressure in the accumulator tank, p_s, finish = ... bar

18 Steam pressure at device inlet, p_1, start = ... bar

19 Steam pressure at device inlet, p_1, finish = ... bar

20 Steam pressure at device outlet, p_2, start = ... bar

21 Steam pressure at device outlet, p_2, finish = ... bar

22 Initial level of water in the accumulator tank, Z_1 = ... m

23 Final level of water in the accumulator tank, Z_2 = ... m

24 Specific volume of liquid, v_f = ... m^3/kg

or

25 Mass of condensate plus weigh tank at start, m_{c1} = ... kg

26 Mass of condensate plus weigh tank at finish, m_{c2} = ... kg

Calculations

27 Differential pressure at start of test .... bar
Item 18 – Item 20

28 Differential pressure at finish of test .... bar
Item 19 – Item 21

29 Average differential pressure .... bar

$$\frac{\text{Item 27} + \text{Item 28}}{2}$$

30 Quantity of water discharged .... kg

$$\frac{\pi}{4} \times \frac{(\text{Item 8})^2 (\text{Item 22} - \text{Item 23})}{\text{Item 24}}$$

31 Capacity, q_{mf} .... kg/h

$$\frac{\text{Item } 30 \times 3\,600}{\text{Item } 15}$$

or

32 Amount of condensate collected .... kg
Item 26 – Item 25

33 Capacity, q_{mf} .... kg/h

$$\frac{\text{Item } 32 \times 3\,600}{\text{Item } 15}$$

34 The trap capacity determined by this test is item 31 or 33 for

— an inlet pressure of $\frac{\text{Item } 18 + \text{Item } 19}{2}$

— a discharge pressure of $\frac{\text{Item } 20 + \text{Item } 21}{2}$, and

— a subcooling of $\frac{\text{point } 13 + \text{point } 14}{2}$