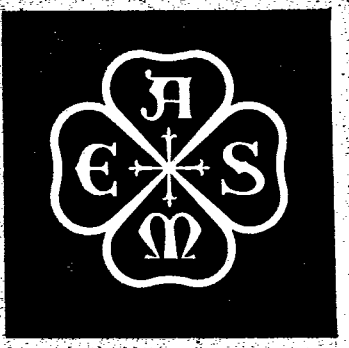
AN AMERICAN NATIONAL STANDARD

ANSI/ASME
PTC 39.1-1980

Condensate Removal Devices for Steam Systems



PERFORMANCE TEST CODES

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
United Engineering Center
345 East 47th Street New York, N.Y. 10017

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FOREWORD

The Performance Test Codes Supervisory Committee, at its June 1974 Administrative meeting, authorized the formation of a Code Technical Committee to explore the possibility of writing a test code on condensate removal devices. This committee was organized January 15, 1975. At its organizational meeting, the committee proposed the writing of two codes:

PTC 39.1 on Condensate Removal Devices for Steam Systems
PTC 39.2 on Condensate Removal Devices for Air Systems.

This proposal was approved by the Performance Test Codes Supervisory Committee.

This Code for Condensate Removal Devices for Steam Systems was approved by the Performance Test Codes Supervisory Committee on April 1, 1980. It was further approved as an American National Standard by the ANSI Board of Standards Review on July 3, 1980.

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ASME PERFORMANCE TEST CODES
Code on
CONDENSATE REMOVAL DEVICES FOR STEAM SYSTEMS

SECTION 0 — INTRODUCTION

0.01 This Code provides for the testing of condensate removal devices for steam systems in order to determine performance characteristics. It is based on the use of accurate instrumentation and the best analytical and measurement procedures currently available.

0.02 A study of the Code on General Instructions, PTC 1 is recommended as an introduction to essential procedures necessary for the proper use of this Code. The mandatory requirements contained therein are incorporated in this Code in Section 3.

0.03 The Code on Definitions and Values, PTC 2, defines certain technical terms and numerical constants and their use is mandatory when applicable.

0.04 Reference is made to Performance Test Code Supplements on Instruments and Apparatus, PTC 19 (abbreviated I&A) for general information and instructions on instrumentation. The specific directions of this Code, however, shall prevail for any instrument, procedure or measurement which may differ from that given in another ASME publication.

0.05 This Code is recommended for use in conducting acceptance tests of condensate removal devices for steam systems. If so used, any deviations from Code Procedure must be agreed upon in writing. In the absence of any written agreement, the Code requirements shall be mandatory.

SECTION 1 — OBJECT AND SCOPE

1.01 This Code covers devices used in removing condensate and non-condensibles from steam systems. It covers devices used for intermittent or continuous removal of fluids such as steam traps, orifices and valves.

1.02 The purpose of this Code is to specify and define the practice of conducting tests of condensate removal devices to determine:

(a) *Condensate discharge capacity,* for specified conditions of saturated and subcooled condensate and back pressure.

(b) *Steam loss,* under specified conditions.

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SECTION 2 — DEFINITIONS AND DESCRIPTIONS OF TERMS

2.01 General. For terms and definitions not included in this section, reference should be made to PTC 2 — Code on Definitions and Values.

2.02 Condensate Removal Device. A device which permits the removal of condensate and air and other non-condensible gases, for steam systems at or below saturated steam temperature and prevents or limits the discharge of live steam.

2.03 Capacity of condensate removal devices is the amount of condensate per unit time which will be discharged continuously from the removal device under specified conditions of pressure differential and inlet subcooling. Capacity is expressed in units of pounds mass per hour or kilograms per hour.

2.04 Pressure is expressed in units of pounds force per square inch or pascals.

2.04.1 Absolute pressure is the algebraic sum of the atmospheric pressure and gage pressure.

2.04.2 Atmospheric pressure is the force per unit area exerted by the atmosphere. Standard atmospheric pressure is 760 mm of mercury at 0°C. This is equivalent to 101.325 kPa and 14.695 949 psia.

2.04.3 Gage pressure is pressure measured with respect to the atmospheric pressure.

2.04.4 Inlet pressure is the gage pressure measured at the condensate removal device inlet.

2.04.5 Discharge pressure is the gage pressure measured at condensate removal device outlet.

2.04.6 Differential pressure is the difference between the inlet pressure and the discharge pressure.

2.05 Inlet subcooling is the difference between saturated steam temperature corresponding to the inlet pressure and the temperature of the condensate at the condensate removal device inlet. Inlet subcooling may be expressed as degrees Fahrenheit or degrees Celsius.

2.06 Subcooled condensate is water whose temperature is below that of the saturated steam temperature.

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SECTION 3 — GUIDING PRINCIPLES

3.01 Items on Which Agreement Shall Be Reached. The parties to the test shall reach agreement on the following items prior to conducting the test:

(a) Object of the test.
(b) Parties to the test.
(c) Test site and date.
(d) Condition of steam and condensate.
(e) Methods of measurement, instrumentation, and equipment to be used.
(f) Number, size, type, condition, source, inlet and discharge pressures, condensate temperature and capacities of the condensate removal device(s) to be tested.
(g) Person who shall be responsible for the test.
(h) Written test procedure which shall include the data to be taken and recorded to comply with the object or objectives of the test.

3.02 Qualifications of Person Responsible for the Test. Person who has, as a minimum, any or all of the following qualifications:

(1) Registered Professional Engineer.
(2) A degree from an accredited school of engineering or engineering technology.
(3) At least two or more years experience in the testing of steam traps.

3.03 Duties of Person Responsible for the Test. The person responsible for the test shall insure that all persons who are involved in the testing perform their duties properly. He shall sign and date the test results, thereby certifying to the best of his knowledge, their accuracy, and that the test was conducted in accordance with the written test procedures.

3.04 Procedures and Test Apparatus. Procedures and the arrangement of test apparatus shall be in accordance with Section 4.

3.05 Tests. Sufficient preliminary tests shall be conducted to insure that test personnel are completely familiar with test equipment and their respective assignments. Preliminary test shall include the recording of all data necessary to the completeness of an actual Code test.

3.06 Calibration of Instruments. Each instrument used during the test shall be serialized or otherwise identified. Each instrument shall be calibrated in accordance with Section 4. Spare instruments if intended for use during the test shall be also serialized and calibrated. Records of calibrations shall be available for review by the interested parties at all times.

3.07 Data Sources. The properties of steam and water used for calculations shall conform with the latest ASME Steam Tables.

3.08 Adjustments During Test. No adjustment to the condensate removal device shall be made during the test. Following any change or deviations of the test conditions, a sufficient period of time shall be allowed to permit the rate of flow, pressure and temperature to attain steady conditions before readings are taken.

3.09 Records and Test Results. The test records shall include the observations, readings, recordings and instrument calibration records required to attain the test objective(s). Copies of all records shall be furnished to each of the parties to the test. The test report shall conform with the requirements of Section 6.

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SECTION 4 — INSTRUMENTS AND METHODS OF MEASUREMENT

4.01 General. In the absence of special agreements to the contrary, this section presents the mandatory requirements for the instruments, methods, and precautions which shall be employed. The I&A Supplements should be consulted if sufficient information is not included in this section. By mutual agreement of the parties to the test, advanced instrumentation or instrument systems, such as those using electronic devices or mass-flow techniques, may be used as alternatives provided that the application of such devices or systems has demonstrated accuracy equivalent to that required by this Code.

4.02 Calibration of Instruments and Apparatus. Instruments and apparatus used for determination under this Code shall be calibrated in accordance with their respective I&A Supplement.

4.03 Temperature measurements shall be carried out in accordance with accepted practices and procedures as discussed in the I&A on Temperature Measurement, PTC 19.3. Temperature shall be measured to within ±0.75°F (0.4°C). To meet this accuracy requirement, temperature shall be measured with resistance thermometers or calibrated thermocouples used with precision reading instruments. Liquid-in-glass thermometers may be used for such secondary readings as ambient temperature for manometers and barometers. If liquid-in-glass thermometers are used to measure other variables they must be calibrated and stem corrections must be applied and graduations must be such that a precision of 0.2°F (0.1°C) is observable. Stagnation thermometer wells shall be used or computed velocity correction applied when the average steam velocity at the sensing point exceeds 300 ft/sec (100 m/s).

4.03.1 When the degree of subcooling is 10°F (6°C) or less, the difference shall be measured by differential temperature sensing devices as prescribed in PTC 19.3 on Temperature Measurements.

4.04 Pressure measurements shall be carried out in accordance with the I&A on Pressure Measurement, PTC 19.2. Manometers, deadweight gages or calibrated elastic gages shall be used for reading constant or slowly varying pressures.

4.04.1 Manometers shall be of the vertical U-tube or single leg type with a minimum bore of 5/16 in. (8 mm). Spacing between scale graduations shall not be more than 1/8 in. (3 mm). In a single leg manometer means shall be available for adjusting the scale zero while the instrument is in use. Manometers shall be selected such that the scale length and the manometer fluid density permit a reading accuracy to within ±0.5 percent of the measured pressure or pressure differential.

4.04.2 Deadweight gages shall be selected with weights suitable for the pressure range to be measured in accordance with PTC 19.2 on Pressure Measurement.

4.04.3 Bourdon gages or other elastic gages may be used for measurements of pressure provided that they are calibrated against a deadweight gage before and after the test. The ambient temperature of the gage during calibration shall be within 20°F (10°C) of the ambient temperature prevailing during the Code test. The diameter of the scales and the arrangement of graduations shall permit readability to within ±1.0 percent of the pressure being measured.

4.04.4 Barometric pressure shall be measured to an accuracy within ±0.1 in. (2.5 mm) of mercury. The barometer shall be located in a stable environment at the test site and shall sense the same pressure as that of the gages and manometers used for the Code Test. PTC 19.2 should be used for the procedure for care and maintenance, use and the application of appropriate corrections.

4.05 Flow measurements shall be made in accordance with the following paragraphs.

4.05.1 Weigh Tanks. Suitable tanks and scales shall be calibrated prior to use and caused to weigh to a measurement accuracy of within ±0.5 percent in the range of the loads to be weighed. Design, construction, calibration and operation of weighing tanks shall be in accordance with the I&A on Weighing Scales, PTC 19.5;1.

4.05.2 Volumetric tanks shall be calibrated prior to use and caused to measure to a measurement accuracy within ±0.5 percent in the range of volumes to be measured. Volumetric tanks shall be calibrated with weighed increments of water at a constant temperature to within ±2°F (1°C). In the use of volumetric tanks, density corrections

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shall be made for water temperature differences between Code test and calibration. Corrections shall be made for the change in tank volume due to thermal expansion of the tank metal and scales used to indicate volume.

4.05.3 Flow meters may be used to measure the steady flow steam or water. For steam flow the flow nozzle and thin-plate orifice may be used and for condensate flow, the Venturi tube may be used in addition to the flow nozzle and orifice. Measuring devices shall be calibrated prior to and after the test and caused to measure to within an accuracy of ±3.0 percent of the flow being measured during the Code test. The recommendations of the I&A on Flow Measurement, PTC 19.5 Series, shall be followed with reference not only to the design, construction, calibration and use of flow measuring primary elements, but also, to their location in the pipeline and the installation of the connecting piping systems between the manometer and the primary element. All computations of flow rates from observed differentials, pressures and temperatures shall be made in accordance with the provisions of PTC 19.5 Series. Primary elements shall be designed or selected such that the minimum differential pressure at any Code test output as indicated by the manometer is 10 in. (250 mm) of manometric liquid. Differential pressure caused by the primary element shall be measured by two independent differential manometer systems which shall agree during the Code test to within ±0.2 percent of each other. Both manometers shall be in accordance with paragraph 4.04.1.

4.05.3(a) Other flow metering devices that are covered in PTC 19.5 that meet the above requirements, may be used.

4.06 Time intervals shall be measured in accordance with the accepted practices and procedures discussed in the I&A on the Measurement of Time, PTC 19.12. Stop watches or other timing devices shall be selected to have an interval accuracy to within ±0.2 percent of the interval time.

4.07 Steam Loss Tests

4.07.1 Test Arrangement. The recommended test arrangement for steam loss determination is shown in Fig. 7.1.1. The minimum water capacity calorimeter tank shall be 2 ft^3 (0.06 m^3). It is most important that the condensate drain device be fully capable of maintaining a dry line to the heat exchanger. The test device should be located sufficiently below the heat exchanger to prevent condensate backing up into the heat exchanger in the event the test device cycles infrequently. The heat exchanger and lines to the test device shall be insulated to reduce thermal losses to a minimum.

4.07.2 Code Test Procedure — No Load Conditions

Start with all valves closed and tanks empty.

(a) Open valves 1, 2, and 3 to permit drain device and test device to operate at test pressure P_s.

(b) During warm up, weigh and record weight of empty calorimeter tank W_t, and record steam pressure P_s and steam temperature T_s.

(c) Fill calorimeter tank approximately half full with water whose temperature T_1 is at least 15°F (8°C) below ambient temperature T_a. Record water temperature T_1 and weight of water plus tank, W_1.

(d) Rapidly close valve 3 and open valve 4. Start timing interval when valve 4 is open. Use of a 3-way valve is recommended to facilitate rapid closing and opening.

(e) Agitate the water in the tank as necessary to insure 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 4 and open valve 3, simultaneously recording the elapsed time, then the final water temperature T_2, and weight of water plus tank, W_2.

(g) When testing condensate removal devices, average results from three consecutive tests must agree within 10 percent or one pound per hour, whichever is greater. If this cannot be obtained, check system for integrity and increase condensate barrel capacity.

4.07.3 Code Test Procedure — Load Conditions

Start with all valves closed and both tanks empty.

(a) Open valves 1, 2, and 3 to permit drain device and test device to operate at test pressure P_s.

(b) During warm up, weigh and record weight of empty calorimeter tank W_t, and record steam pressure P_s and steam temperature T_s.

(c) Open valves 5 and 6 to allow flow of cooling water through heat exchanger to create desired condensate load on test device. After system has come to equilibrium, this load can be determined by closing valve 6 and opening valve 7 to permit collecting a known amount of water in a given time. Record temperatures of water entering and leaving heat exchanger T_E and T_L, weight of exchanger water plus tank, initial and final, W_3 and W_4, and time of run on Data Log Form 4.07. The approximate condensate load on trap may then be calculated by the following formula:

$$\text{Load (lbm/hr)} = \frac{(T_L - T_E)\,(W_4 - W_3) \times 3600}{(\text{time in sec})\,(h_{f_g})}$$

(d) If load on trap as determined in (c) is as desired, proceed to (e) below. If not as desired, adjust valve 5 accordingly and repeat procedure (c), until desired condensate load is obtained.

(e) Fill calorimeter tank approximately half full with water whose temperature T_1 is at least 15°F (8°C) below ambient temperature T_a. Weigh and record water

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DATA LOG FORM 4.07

STEAM LOSS TESTS — NO LOAD or CONDENSATE LOAD

Test No. _____ Date of Test _____ Data Taken by _____ Ambient Temp. (T_a) _____ Manuf. Name _____

Serial No. _____ Size _____ Barometric Pressure (P_a) _____ Description & Type of Device _____

DATA		RUN NUMBER												DATA AVG.
ITEM	UNITS													
Time														
P_S — Steam Pressure														
T_S — Steam Temp.														
T_1 — Water Start Temp.														
T_2 — Water Finish Temp.														
T_E — Cooling Water Entering Temp.														
T_L — Cooling Water Leaving Temp.														
W_1 — Water+Calorimeter Starting Weight														
W_2 — Water+Calorimeter Finish Weight														
W_3 — Cooling Water + Tank Start Weight														
W_4 — Cooling Water + Tank Finish Weight														

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DATA LOG FORM 4.08

CAPACITY TEST – SATURATED CONDENSATE – PROCEDURE "A"

Test No. _____ Date of Test _____ Data Taken by _____ Manuf. Name _____

Serial No. _____ Size _____ Description & Type of Device _____

DATA		RUN NUMBER															DATA AVG.
ITEM	UNITS																
Time																	
P_1 – Steam Supply Pressure																	
P_2 – Accumulator Steam Pressure																	
P_3 – Trap Inlet Pressure																	
P_4 – Trap Outlet Pressure																	
P_5 – Water Supply Pressure																	
T_1 – Steam Supply Temp.																	
T_2 – Water Supply Temp.																	
ΔT – Subcooling																	
X – Steam Supply Quality																	
z – Accumulator Water Level																	
W_1 – Water Flow Rate*																	
W_2 – Steam Flow Rate*																	

*Include all data necessary to compute mass flow rate.

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temperature T_1, and weight of water plus calorimeter tank, W_1.

(f) Rapidly close valve 3 and open valve 4. Start timing interval when valve 4 is open. Use of a 3-way valve is recommended to facilitate rapid closing and opening.

(g) Agitate the water in the calorimeter tank as necessary to insure 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 4 and open valve 3, simultaneously recording the elapsed time, then the final water temperature T_2, and weight of water plus calorimeter tank, W_2.

(i) When testing condensate removal devices, average results from three consecutive tests must agree within 10 percent or one pound per hour, which ever is greater. If this cannot be obtained check system for integrity and increase condensate tank capacity.

(j) See steam loss calculation procedure (paragraph 5.03.1).

4.08 Discharge Capacity Tests – Saturated Condensate

4.08.1 Test Arrangement. The recommended test arrangement for saturated condensate capacity determination is shown in Figs. 7.1.2, 7.1.3, and 7.1.4. All piping and equipment shown in Fig. 7.1.2 shall be insulated to a minimum R value of:

$$15\ \frac{\text{ft}^2 - {}^\circ\text{F} - hr}{\text{Btu}} \left(0.75\ \frac{\text{m}^2 - {}^\circ\text{C} - h}{kJ}\right)$$

to minimize heat loss effects. All instrumentation shall comply with Sections 4.02, 4.03, 4.04, 4.05, and 4.06 of this code. The condensate removal device must not be modified in any way from its commercial form.

4.08.2 Code Test Procedure – Continuous Flow "A" (Fig. 7.1.2)

Starting with all valves closed:

(a) Warm up system by gradually opening valves 1, 2, 3, 4 and 5.

(b) Adjust valves 1, 2, 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 on the temperature differential indicator of 5°F (3°C) or less.

(c) Observe and record the following data:

1. Steam supply pressure, P_1 psig (kPa gage)
2. Accumulator steam pressure, P_2 psig (kPa gage)
3. Trap inlet pressure, P_3 psig (kPa gage)
4. Trap outlet pressure, P_4 psig (kPa gage)
5. Steam supply temperature, T_1 °F (°C)
6. Water supply temperature, T_2 °F (°C)
7. Temperature differential (subcooling) between steam in accumulator and fluid entering trap, ΔT °F (°C)
8. Steam supply quality, χ %
9. Accumulator water level, z ft (m)
10. Time, hr, min, sec (h, min, s)
11. Water supply flow rate, W_1 lbm/hr (kg/h)
12. Steam supply flow rate, W_2 lbm/hr (kg/h)

(d) Record data in (c) at five minute intervals for a minimum total of five sets of observations.

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

1. The difference between the maximum and minimum tank level (z) shall not exceed 2 in. (50mm).
2. The maximum value of tank level (z) shall not exceed 18 in. (450 mm) at any time during the test.
3. The maximum temperature differential (ΔT) shall not exceed 5°F (3°C) during the test.
4. No individual trap inlet pressure (P_3) observation shall vary more than one percent of the average of all observations.
5. The calculated vent steam (W_6) shall not exceed a maximum value equal to a leaving velocity of 1 ft/sec (0.31 m/s) in the tank.

4.08.3 Flow Calculations

$$W_f = (W_1 + W_3 - W_4) \pm W_8 \quad (4.07.3\text{-}1)$$

where: W_f = discharge flow lbm/hr (kg/h)

W_1 = water flow lbm/hr (kg/h)

W_3 = steam flow to heat W_1 lbm/hr (kg/h)

$$= W_1\ \frac{(h_3 - h_1)}{(h_2 - h_3)}$$

W_4 = flash steam in accumulator lbm/hr (kg/h)

$$= (W_1 + W_3)\ \frac{(h_3 - h_5)}{(h_4 - h_5)}$$

W_8 = accumulator storage rate lbm/hr (kg/h)

$$= \frac{\pi}{4}\ D^2\ \frac{(z_1 - z_2)}{\Delta t}\ \left(\frac{3600}{V_2}\right)$$

h_1 = enthalpy of supply water Btu/lbm (kJ/kg)

h_2 = enthalpy of supply steam Btu/lbm (kJ/kg)

h_3 = enthalpy of saturated water at supply pressure Btu/lbm (kJ/kg)

h_4 = enthalpy of saturated steam in accumulator Btu/lbm (kJ/kg)

h_5 = enthalpy of saturated water in accumulator Btu/lbm (kJ/kg)

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V_1 = specific vol of saturated steam in accumulator ft³/lbm (m^3/kg)

V_2 = specific vol of saturated water in accumulator ft³/lbm (m^3/kg)

Δt = time interval sec (s)

4.08.4 Reporting of Results

Method A — Test results may be reported in lbm/hr (kg/h) only if the following additional data is reported: trap inlet pressure (P_3), trap outlet pressure (P_4), and subcooling (ΔT). A minimum of five tests shall be used to plot any graph. The extrapolation of any graph outside of the initial pressure range (P_3) covered by the tests shall be clearly marked and the maximum subcooling (ΔT) and minimum outlet pressure of the tests noted on the graph.

4.09 Code Test Procedure — "B" — Intermittent Flow (Fig. 7.1.3)

Starting with all valves closed:

(a) Open valves 1 and 2 and fill accumulator tank to desired level. Close valve 1.

(b) Open valve 3 and heat water in accumulator tank to desired temperature. Close valves 2 and 3 and open valve 4.

(c) Open valves 5 and 6 to heat test pipe and condensate removal device. Monitor and adjust system to produce desired pressure at test condensate removal device.

(d) When thermal equilibrium is reached with ($T_s - T_c$) at 5°F (3°C) or less, begin test. Observe accumulator tank level and start timing device. A circulation device may be necessary to assume uniform temperature within the tank.

(e) When desired lower accumulator tank level is reached, stop timing device.

(f) Observe and record the following data:

1. Elapsed time (h,min,s)
2. Ambient temperature, T_a °F (°C)
3. Barometric pressure, P_a psia (kPa)
4. Steam pressure and temperatures, P_s and T_s psig (kPa gage), °F (°C)
5. Initial and final values of the following:
   (i) Accumulator tank level, F_1 and F_2 ft (m)
   (ii) Temperature differential, ($T_s - T_c$) °F (°C)
   (iii) Inlet pressure, P_1 psig (kPa gage)
   (iv) Back pressure, P_2 psig (kPa gage)

(g) Repeat (a) through (f) as necessary to produce three sets of observations which result in three calculated capacity ratings, none of which vary from the average by more than 5 percent.

(h) Alternate methods of heating the water in accumulator tank (such as by steam injector or direct firing) are acceptable if $T_s - T_c$ does not exceed 5°F (3°C) throughout the test run.

4.10 Code Test Procedure "C" — Intermittent Flow Alternate Method (Fig. 7.1.4)

Starting with all valves closed:

(a) Open valves 1 and 2 and fill accumulator tank to desired level. Close valve 1.

(b) Open valve 3 and heat water in accumulator tank to desired temperature. Close valves 2 and 3 and open valve 4.

(c) Fill barrel approximately half full of cold water and so that the end of the discharge pipe is under water in the weigh tank. Balance scale lever arm, then add an appropriate weight to allow time for opening and closing valves.

(d) Open valves 5 and 6 to heat test pipe and condensate removal device.

(e) When thermal equilibrium is reached with ($T_s - T_c$) at 5°F (3°C) or less, close valve 6 and open valve 7. A circulation device may be necessary to assure uniform temperature within the tank.

(f) When scale lever arm is balanced, start timing and add an appropriate weight to the yoke corresponding to the number of pounds of condensate to be collected. This may be less than the amount necessary to cause boiling of the water in the weigh tank.

(g) When scale lever arm is again balanced, stop timing and close valve 5.

(h) Observe and record the following data:

1. Elapsed time (h,min,s)
2. Ambient temperature, T_a °F (°C)
3. Barometric pressure, P_a psia (kPa)
4. Steam pressure and temperatures, P_s and T_s psig (kPa gage), °F (°C)
5. Weight of condensate plus barrel at start and finish W_c lbm (kg)
6. Initial and final values of the following:
   (i) Temperature differential ($T_s - T_c$) °F (°C)
   (ii) Inlet pressure, P_1 psig (kPa gage)
   (iii) Back pressure, P_2 psig (kPa gage)

(i) Repeat (a) through (h) as necessary to produce three sets of observations which result in three calculated capacity ratings none of which vary from the average by more than 5 percent.

(j) Alternate methods of heating the water in the accumulator tank, (such as by steam injector or direct firing) are acceptable if ($T_s - T_c$) does not exceed 5°F (3°C) throughout the test run.

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DATA LOG FORM 4.09

CAPACITY TEST – SATURATED CONDENSATE – PROCEDURE "B"

Test No. _____ Date of Test _____ Data Taken By _____ Ambient Temperature (T_a) _____ Manuf. Name _____

Serial No. _____ Size _____ Barometric Press. (P_a) _____ Description & Type of Device _____

DATA		RUN NUMBER											
ITEM	UNITS	1		2		3		4		5		6	
		S	F	S	F	S	F	S	F	S	F	S	F
Time													
P_S – Steam Pressure													
P_1 – Inlet Pressure													
P_2 – Outlet Pressure													
T_S – Steam Temperature													
T_C – Condensate Temp.													
F_1 – Accumulator Level													
F_2 – Accumulator Level													

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DATA LOG FORM 4.10

INTERMITTENT FLOW CAPACITY TEST — SATURATED CONDENSATE — PROCEDURE "C"

Test No. _____ Date of Test _____ Data Taken by _____ Ambient Temp. (T_a) _____ Manuf. Name _____

Serial No. _____ Size _____ Barometric Press. (P_a) _____ Description & Type of Device _____

DATA		RUN NUMBER											
ITEM	UNITS	1		2		3		4		5		6	
		S	F	S	F	S	F	S	F	S	F	S	F
Time													
P_S — Steam Pressure													
P_1 — Inlet Pressure													
P_2 — Outlet Pressure													
T_S — Steam Temp.													
T_C — Condensate Temp.													
W_C — Condensate + Barrel Weight													

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DATA LOG FORM 4.11

INTERMITTENT FLOW CAPACITY TEST – SATURATED CONDENSATE – PROCEDURE "D"

Test No._____ Date of Test _____ Data Taken by _____ Ambient Temp. (T_a) _____ Manuf. Name _____

Serial No. _____ Size _____ Barometric Pressure (P_a) _____ Description & Type of Device _____

DATA		RUN NUMBER											
		1		2		3		4		5		6	
ITEM	UNITS	S	F	S	F	S	F	S	F	S	F	S	F
Time													
P_S – Steam Pressure													
P_1 – Inlet Pressure													
P_2 – Outlet Pressure													
T_S – Steam Temp.													
T_C – Condensate Temp.													
T_W – Water Temp.													
Z_1 – Accumulator Level													
Z_2 – Accumulator Level													
F_1 – Flow													

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4.11 Code Test Procedure "D" – Intermittent Flow Alternate Method for Pressures Exceeding 45 psig (Fig. 7.1.5)

Starting with all valves closed:

(a) Open valves 1 and 2 to full accumulator tank approximately ¾ full. Close valve 1.

(b) Set temperature controller to saturated temperature corresponding to condensate removal device testing pressure.

(c) Open valve 3 allowing steam into the accumulator tank simultaneously circulating the water in the tank.

(d) Start circulator.

(e) As T_w temperature begins to rise, throttle vent valve 2 to minimize steam loss.

(f) When water temperature is within 1°F (½°C), close valve 3. Set pressure regulating valve to the desired pressure at which the condensate removal device shall be tested.

(g) Open valve 4. Close valve 2.

(h) Completely open valve 5. Partially open valve 6. Flow is now warming the condensate removal device. When thermometer T_c indicates within 5°F (3°C) of saturation, fully open as rapidly as possible.

(i) Begin timing when the water level falls to some pre-established height. Stop timing when the water level falls to the lower pre-determined height.

(j) If an area flowmeter is used, observe the flow rate through the meter during the test.

(k) Observe and record the following data:

1. Ambient temperature, T_a °F (°C)
2. Ambient barometric pressure, P_a psia (kPa)
3. Start and finish times (h,min,s)
4. Steam pressure, P_s psig (kPa gage)
5. Inlet and Outlet device pressures, P_1 and P_2 start and finish psig (kPa gage)
6. Steam temperature, T_s — start and finish °F (°C)
7. Condensate temperature, T_c — start and finish °F (°C)
8. Accumulator tank levels, Z_1 and Z_2. ft (m)

(l) Repeat (a) through (k) as necessary to produce three sets of observations which result in three calculated capacity ratings, none of which vary from the average more than 5 percent.

(m) Alternate methods of heating the water in the accumulator tank (such as by steam injection or direct firing) are acceptable if $T_s - T_c$ does not exceed 5°F (3°C) throughout the test run.

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SECTION 5 — COMPUTATION OF RESULTS

5.01 Correction of Measured Variables. The values of observed variables shall be corrected in accordance with instrument calibrations and as necessary converted to the proper units required for calculations.

5.02 Use of Formula Symbols. The symbols used in this Code are the ones normally associated with engineering practice in this field. In a few cases, the same symbol has different meanings in different parts of the Code according to its application. In order to avoid confusion, each formula has been provided with its own list of definitions of symbols and units.

5.03 Steam Loss Calculations

(a) For saturated steam supplied:

$$W_L = \left[\frac{W_s (h_{fs} - h_{f_1}) - W_f (h_{fs} - h_{f_2}) + c_p W_t (T_2 - T_1)}{h_{fgs}}\right]\left[\frac{3600}{\Delta t}\right] \quad (5.03\text{-}1)$$

Where:

W_L = steam loss, lbm/hr (kg/hr)
W_s = initial mass of water in calorimeter, lbm (kg)
W_f = final mass of water in calorimeter, lbm (kg)
W_1 = weight of calorimeter plus water, start, lbm (kg)
W_2 = weight of calorimeter plus water, finish, lbm (kg)
W_t = mass of tank calorimeter, lbm (kg)
h_{f_1} = initial enthalpy of water in calorimeter, Btu/lbm (J/kg)
h_{f_2} = final enthalpy of condensate in calorimeter, Btu/lbm (J/kg)
h_{fs} = enthalpy of liquid at steam inlet, Btu/lbm (J/kg)
h_{fgs} = enthalpy of evaporation at steam inlet, Btu/lbm (J/kg)
c_p = specific heat of barrel calorimeter, Btu/lbm — °F J/(kg • K)
T_1 = initial water temperature, °F (°C)
T_2 = final water temperature, °F (°C)
Δt = time interval, sec (s)

(b) For superheated steam supplied:

W_L = steam loss, lbm/hr (kg/hr) = $\frac{\Delta W}{\Delta t}$
ΔW = increase in weight of water in calorimeter, lbm (kg) = $W_2 - W_1$
Δt = time interval sec (s)

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CALCULATION FORM 5.03.1
STEAM LOSS TEST
General Information

1. Test No. _____ 2. Test Date _____ 3. Location _____
4. Manufacturer's Name _____ 5. Serial No. _____
6. Type of Device _____ 7. Size _____
8. Calorimeter Material _____
9. Weight of Empty Calorimeter, W_t _____

Averaged and Corrected Test Data

10. Weight of calorimeter plus water, start, W_1 . . . . . lbm (kg) _____
11. Weight of calorimeter plus water, finish, W_2 . . . . . lbm (kg) _____
12. Weight added to scale, ΔW . . . . . lbm (kg) _____
13. Time interval, Δt . . . . . (sec) _____
14. Ambient temperature, T_a . . . . . °F (°C) _____
15. Steam temperature at trap inlet, T_s . . . . . °F (°C) _____
16. Initial water temperature, T_1 . . . . . °F (°C) _____
17. Final temperature of water and condensate, T_2 . . . . . °F (°C) _____
18. Barometric pressure, P_a . . . . . psia (kPa) _____
19. Steam pressure at trap inlet, P_s . . . . . psia (kPa) _____

Thermodynamic Properties

20. Reference used for specific heat data _____
21. Reference used for steam/water data _____
22. Specific heat of calorimeter material c_p . . . . . Btu/lbm – °F (J/kg • K) _____
    (From Item 20 for Item 8 at average of Items 16 and 17)
23. Initial enthalpy of water in calorimeter h_{f_1} . . . . . Btu/lbm (J/kg) _____
    (From Item 21 at Item 16)
24. Final enthalpy of water in calorimeter h_{f_2} . . . . . Btu/lbm (J/kg) _____
    (From Item 21 at Item 17)
25. Enthalpy of saturated liquid at trap inlet temperature h_{fs} . . . . . Btu/lbm (J/kg) _____
    (From Item 21 at Item 15)
26. Enthalpy of evaporation at trap inlet temperature h_{fgs} . . . . . Btu/lbm (J/kg) _____
    (From Item 21 at Item 15)

Calculations

27. Initial mass of water in calorimeter W_s . . . . . lbm (kg) _____
    Item 10 – Item 9

    _____ – _____

28. Final mass of water and condensate in calorimeter W_f . . . . . lbm (kg) _____
    Item 11 – Item 9

    _____ – _____

29. Term $W_s (h_{fs} - h_{f_1})$ . . . . . Btu (J) _____
    Item 27 X (Item 25 – Item 23)

    _____ X (_____ – _____)

30. Term $W_f (h_{fs} - h_{f_2})$ . . . . . Btu (J) _____
    Item 28 X (Item 25 – Item 24)

    _____ X (_____ – _____)

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CALCULATION FORM 5.03.1 (Cont'd)

Calculations

31. Term $c_p\ W_t\ (T_2 - T_1)$ ..... Btu (J) _____
Item 22 X Item 9 X (Item 17 - Item 16)

_____ X _____ X (_____ - _____)

32. Steam loss W_L ..... lbm/hr (kg/h) _____
3600 X (Item 29 - Item 30 + Item 31) / (Item 26 X Item 13)

3600 X (_____ - _____ + _____) / (_____ X _____)

33. Water discharged with steam W_w ..... lbm/hr (kg/h) _____

$$\frac{(\text{Item 12} \times 3600)}{\text{Item 13}} - (\text{Item 32})$$

34. *Condensate load ..... lbm/hr (kg/h) _____

$$\frac{(T_L - T_E)\ (W_4 - W_3) \times 3600}{t\ (h_{fgs})}$$

*Values for variables T_L, T_F, W_3, and W_4 from Data Log Form 4.07.

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CALCULATION FORM 5.04
CAPACITY TEST – SATURATED CONDENSATE – PROCEDURE A

General Information

1. Test No. _____ 2. Date of Test _____ 3. Calculation by _____
4. Manufacturer's Name _____
5. Serial No. _____ 6. Size _____
7. Description & Type of Device _____
8. Inside Diameter of Accumulator ft(m) _____

Averaged and Corrected Test Data

9. Steam supply pressure, P_1 . . . . . psia (kPa) _____
10. Accumulator stm. press., P_2 . . . . . psia (kPa) _____
11. Trap inlet press., P_3 . . . . . psia (kPa) _____
12. Trap outlet press., P_4 . . . . . psia (kPa) _____
13. Steam supply temp., T_1 . . . . . °F (°C) _____
14. Water supply temp., T_2 . . . . . °F (°C) _____
15. Subcooled temp., ΔT . . . . . °F (°C) _____
16. Steam supply quality, χ . . . . . % _____
17. Change in accumulator level, $\Delta z = Z_1 - Z_2$ . . . . . ft (m) _____
18. Water supply flow rate, W_1 . . . . . lbm/hr (kg/h) _____
19. Steam supply flow rate, W_2 . . . . . lbm/hr (kg/h) _____
20. Elapsed time, Δt . . . . . sec (s) _____

Thermodynamic Properties

21. Reference used for steam/water data _____
22. Enthalpy of water supply, h_1 . . . . . Btu/lbm (kJ/kg) _____
23. Enthalpy of steam supply, h_2 . . . . . Btu/lbm (kJ/kg) _____
24. Enthalpy of saturated liquid at steam supply pressure, h_3 . . . . . Btu/lbm (kJ/kg) _____
25. Enthalpy of saturated vapor at accumulator press (h_4) . . . . . Btu/lbm (kJ/kg) _____
26. Enthalpy of saturated liquid at accumulator press (h_5) . . . . . Btu/lbm (kJ/kg) _____
27. Specific volume of saturated vapor at accumulator press (V_1) . . . . . ft^3/lbm (m^3/kg) _____
28. Specific volume of saturated liquid at accumulator press (V_2) . . . . . ft^3/lbm (m^3/kg) _____

Calculations

29. Steam to heat water supply (W_3) . . . . . lbm/hr (kg/h) _____

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

$$(_____) \times \frac{(_____ - _____)}{(_____ - _____)}$$

30. Flash steam in accumulator (W_4) . . . . . lbm/hr (kg/h) _____

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

$$\frac{(_____ + _____)\ (_____ - _____)}{(_____ - _____)}$$

31. Water rate to accumulator (W_5) . . . . . lbm/hr (kg/h) _____

(Item 18 + Item 29 – Item 30)

_____ + _____ – _____

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CALCULATION FORM 5.04 (Cont'd)

Calculations

32. Steam flow to vent (W_6) . . . . . lbm/hr (kg/h) _____
Item 19 - Item 29 + Item 30

_____ - _____ + _____

33. Maximum uncorrected steam flow to vent (W_7) . . . . . lbm/hr (kg/h) _____

$$\frac{2827 \times (\text{Item 8})^2}{\text{Item 27}}$$

$$\frac{2827 \times (_____)^2}{_____}$$

34. Vent Fraction of Maximum (R) . . . . . _____

$$R = \frac{(\text{Item 32})}{(\text{Item 33})} = _____$$ (must be equal to or less than 1.0 for test to be valid)

35. Accumulator storage rate (W_8) . . . . . lbm/hr (kg/h) _____

$$\frac{2827 \times (\text{Item 8})^2 \times (\text{Item 17})}{(\text{Item 20}) \times (\text{Item 28})}$$

$$\frac{2827 \times (_____)^2 \times (_____)}{(_____) \times (_____)}$$

36. Discharge flow (W_f) . . . . . lbm/hr (kg/h) _____
(Item 34) (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).

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Sample Problem

Data:

D = 2 ft
W_1 = 3600 lbm/hr
W_2 = 1800 lbm/hr
z_1 = 12 in.
z_2 = 14 in.
Δt = 1500 sec
χ = 100%

P_1 = 100 psia
P_2 = 80 psia
P_3 = 80 psia
P_4 = 14.7 psia
T_2 = 70°F
Δt = 4°F

Properties:

h_1 = 38.04 Btu/lbm
h_2 = 1187.2 Btu/lbm
h_3 = 298.4 Btu/lbm
h_4 = 1183.1 Btu/lbm
h_5 = 282.02 Btu/lbm

$\bar{V}_1$ = 5.472 ft³/lbm
$\bar{V}_2$ = 0.01757 ft³/lbm

Calculations

$$W_3 = 3600\left(\frac{298.40 - 38.04}{1187.2 - 298.4}\right) = 1054.56 \text{ lbm/hr}$$

$$W_4 = (3600 + 1054.56)\left(\frac{298.4 - 282.02}{1183.1 - 282.05}\right) = 84.61 \text{ lbm/hr}$$

$$W_8 = \frac{\pi}{4}(2)^2\left(-\frac{2}{12}\right)\left(\frac{3600}{1500}\right)\left(\frac{1}{0.01757}\right) = -71.5 \text{ lbm/hr}$$

$$W_6 = 1800 + 84.61 - 1054.56 = 830.05 \text{ lbm/hr}$$

$$W_7 = \frac{\pi}{4}(2)^2\left(\frac{3600}{5.472}\right) = 2066.8 \text{ lbm/hr}$$

Since: $R = \frac{830.05}{2066.8} = 0.40$, test is valid

$$W_f = 0.4\,(3600 + 1054.56 - 84.61) - 71.5$$
$$= 1756.5 \text{ lbm/hr}$$

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CALCULATION FORM 5.05

SATURATED CONDENSATE CAPACITY – PROCEDURE B

General Information

1. Test No. _____ 2. Test Date _____
3. Manufacturer Name _____
4. Type of Device/Model No. _____
5. Serial No. _____ 6. Size _____
7. Tested by _____ 8. Calculation by _____
9. Capacity of Accumulator Tank _____
10. Accumulator Tank Calibration Data (Reference) _____

Test Data

11. Temperature of steam in accumulator tank, T_s, start . . . . . °F (°C) _____
12. Temperature of steam in accumulator tank, T_s, finish . . . . . °F (°C) _____
13. Temperature of condensate to device, T_c, start . . . . . °F (°C) _____
14. Temperature of condensate to device, T_c, finish . . . . . °F (°C) _____
15. Temperature difference, $T_s - T_c$, start . . . . . °F (°C) _____
16. Temperature difference, $T_s - T_c$, finish . . . . . °F (°C) _____
17. Initial level of water in accumulator tank, F_1 . . . . . ft (m) _____
18. Final level of water in accumulator tank, F_2 . . . . . ft (m) _____
19. Quantity of water discharged (reference, Item 10) . . . . . lbm (kg) _____
20. Time interval . . . . . sec (s) _____
21. Steam pressure in accumulator tank, P_s, start . . . . . psig (kPa gage) _____
22. Steam pressure in accumulator tank, P_s, finish . . . . . psig (kPa gage) _____
23. Steam pressure at device inlet, P_1, start . . . . . psig (kPa gage) _____
24. Steam pressure at device inlet, P_1, finish . . . . . psig (kPa gage) _____
25. Steam pressure at device outlet, P_2, start . . . . . psig (kPa gage) _____
26. Steam pressure at device outlet, P_2, finish . . . . . psig (kPa gage) _____

Calculations

27. Differential pressure at start of test . . . . . psi (kPa) _____
    (Item 23) – (Item 25)
28. Differential pressure at finish of test . . . . . psi (kPa) _____
    (Item 24) – (Item 26)
29. Average differential pressure . . . . . psi (kPa) _____
    $$\frac{(\text{Item 27}) + (\text{Item 28})}{2}$$
30. Capacity . . . . . lbm/hr (kg/hr) _____
    $$\frac{(\text{Item 19}) \times 3600}{(\text{Item 20})}$$

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CALCULATION FORM 5.06

SATURATED CONDENSATE CAPACITY – PROCEDURE C

General Information

1. Test No. _____ 2. Test Date _____
3. Manufacturer's Name _____
4. Type of Device/Model No. _____
5. Serial No. _____ 6. Size _____
7. Tested by _____ 8. Calculation by _____
9. Capacity of Accumulator Tank _____
10. Scales: Description _____

Test Data

11. Weight of condensate plus barrel at start . . . . . lbm (kg) _____
12. Weight of condensate plus barrel at finish . . . . . lbm (kg) _____
13. Temperature of steam in accumulator tank, T_s, start . . . . . °F (°C) _____
14. Temperature of steam in accumulator tank, T_s, finish . . . . . °F (°C) _____
15. Temperature differential, $T_s - T_c$, start . . . . . °F (°C) _____
16. Temperature differential, $T_s - T_c$, finish . . . . . °F (°C) _____
17. Temperature of water in barrel, start . . . . . °F (°C) _____
18. Temperature of water in barrel, finish . . . . . °F (°C) _____
19. Steam pressure in accumulator tank, start . . . . . psig (kPa gage) _____
20. Steam pressure in accumulator tank, finish . . . . . psig (kPa gage) _____
21. Steam pressure at device inlet, P_1, start . . . . . psig (kPa gage) _____
22. Steam pressure at device outlet, P_2, start . . . . . psig (kPa gage) _____
23. Steam pressure at device inlet, P_1, finish . . . . . psig (kPa gage) _____
24. Steam pressure at device outlet, P_2, finish . . . . . psig (kPa gage) _____
25. Time interval . . . . . sec (s) _____

Calculations

26. Differential pressure at start of test . . . . . psi (kPa) _____
    (Item 21) – (Item 22)
27. Differential pressure at finish of test . . . . . psi (kPa) _____
    (Item 23) – (Item 24)
28. Average differential pressure . . . . . psi (kPa) _____

$$\frac{\text{(Item 26)} + \text{(Item 27)}}{2}$$

29. Amount of condensate collected . . . . . lbm (kg) _____
    (Item 12) – (Item 11)
30. Capacity . . . . . lbm/hr (kg/hr) _____

$$\frac{\text{(Item 29)} \times 3600}{\text{(Item 25)}}$$

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CALCULATION FORM 5.07
SATURATED CONDENSATE CAPACITY – PROCEDURE D

General Information

1. Test Number _____ 2. Test Date _____
3. Manufacturer's Name _____
4. Type of Device/Model No. _____
5. Serial No. _____ 6. Size _____
7. Tested by _____ 8. Calculation by _____
9. Diameter of Accumulator Tank _____ m
10. Accumulator Tank Calibration Data (Reference) _____
11. Area Flowmeter – Mfr./Model/Serial No./Calibration Data _____

Test Data

12. Temperature of steam in accumulator tank, T_s, start . . . . . °F (°C) _____
13. Temperature of steam in accumulator tank, T_s, finish . . . . . °F (°C) _____
14. Temperature of condensate to device, T_c, start . . . . . °F (°C) _____
15. Temperature of condensate to device, T_c, finish . . . . . °F (°C) _____
16. Temperature difference, $T_s - T_c$, start . . . . . °F (°C) _____
17. Temperature difference, $T_s - T_c$, finish . . . . . °F (°C) _____
18. Initial level of water in accumulator tank, Z_1 . . . . . in. (m) _____
19. Final level of water in accumulator tank, Z_2 . . . . . in. (m) _____
20. Specific volume of liquid, V_f . . . . . ft^3/lbm (m^3/kg) _____
21. Time interval . . . . . sec (s) _____
22. Steam pressure in accumulator tank, P_s, start . . . . . psig (kPa gage) _____
23. Steam pressure in accumulator tank, P_s, finish . . . . . psig (kPa gage) _____
24. Steam pressure at device inlet, P_1, start . . . . . psig (kPa gage) _____
25. Steam pressure at device inlet, P_1, finish . . . . . psig (kPa gage) _____
26. Steam pressure at device outlet, P_2, start . . . . . psig (kPa gage) _____
27. Steam pressure at device outlet, P_2, finish . . . . . psig (kPa gage) _____

Calculations

28. Differential pressure at start of test . . . . . psi (kPa) _____
    (Item 24) – (Item 26)
29. Differential pressure at finish of test . . . . . psi (kPa) _____
    (Item 25) – (Item 27)
30. Average differential pressure . . . . . psi (kPa) _____
    $$\frac{(\text{Item 28}) + (\text{Item 29})}{2}$$
31. Quantity of water discharged . . . . . lbm (kg) _____
    $$\frac{\pi}{4}\frac{(\text{Item 9})^2}{(\text{Item 20})}\frac{(\text{Item 18} - \text{Item 19})}{1728}, \left(\frac{\pi}{4}\frac{(\text{Item 9})^2}{(\text{Item 20})}\right)$$
32. Capacity . . . . . lbm/hr (kg/hr) _____
    $$\frac{(\text{Item 31}) \times 3600}{(\text{Item 21})}$$
33. Average flow (area flowmeter) . . . . . lbm/hr (kg/hr) _____

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SECTION 6 — REPORT OF TEST

6.01 General Information

6.01.1 The Report of Test shall be prepared to formally document the observed data and computed results. It shall contain sufficient information to prove that all Code test objectives were attained.

6.01.2 The procedures described in Section 5 are to be used in computing the test results.

6.01.3 The Report of Test shall include Parts I to VI as listed below:

I. General Information
II. Summary of Test Results
III. Description of Condensate Removal Device Tested
IV. Observed Data and Computed Results
V. Test Methods and Procedures
VI. Supporting Data

6.02 Detailed Information. The following is a discussion of each part of the test report.

6.02.1 Part I — General Information. This part shall include the following items:

(a) Date of test
(b) Location of test facilities
(c) Manufacturer's name
(d) Manufacturer's serial number and complete identification of the condensate removal device
(e) Inlet and outlet connections (stating size, pressure ratings and type such as threaded flanges, etc.)
(f) Test conducted by
(g) Representatives of parties to the test
(h) Object of test
(i) Fluid at device inlet (saturated steam, superheated steam, wet steam, saturated water, subcooled water, air, etc.)

6.02.2 Part II — Summary of Results. This part shall include those quantities and characteristics which describe the performance of the condensate removal device at test conditions. The Test Report Form for the particular test shall list the quantities, characteristics and units of measurement required for the report.

6.02.3 Part III — Description of Condensate Removal Device Tested. This part may include assembly drawings, manufacturing drawings, and measured dimensions if agreed to by the Parties to the test. If no agreement is made, then it shall contain such descriptive information as may be furnished by the manufacturer or from his catalogs.

6.02.4 Part IV — Observed Data and Computed Results. This part shall include a record of data and calculations required to determine the results of the tests. The data shall have been corrected for instrument calibrations and conditions prevailing for each test run. The computation forms included in Section 5 shall be used for computing test results.

6.02.5 Part V — Test Methods and Procedures. This part shall include a detailed description of the instruments and apparatus used to measure the various quantities, and procedures for observing the characteristics of the condensate removal device during test.

6.02.6 Part VI — Supporting Data. This part shall include pertinent material supplementing data presented elsewhere in the Report of Test, whereby an independent verification of the report results can be made. This material may include, but not necessarily be limited to the following:

(a) Instrument calibration records
(b) Detailed log sheets
(c) Sample calculations

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SECTION 7 — APPENDIX

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7.1 Figures and Diagrams

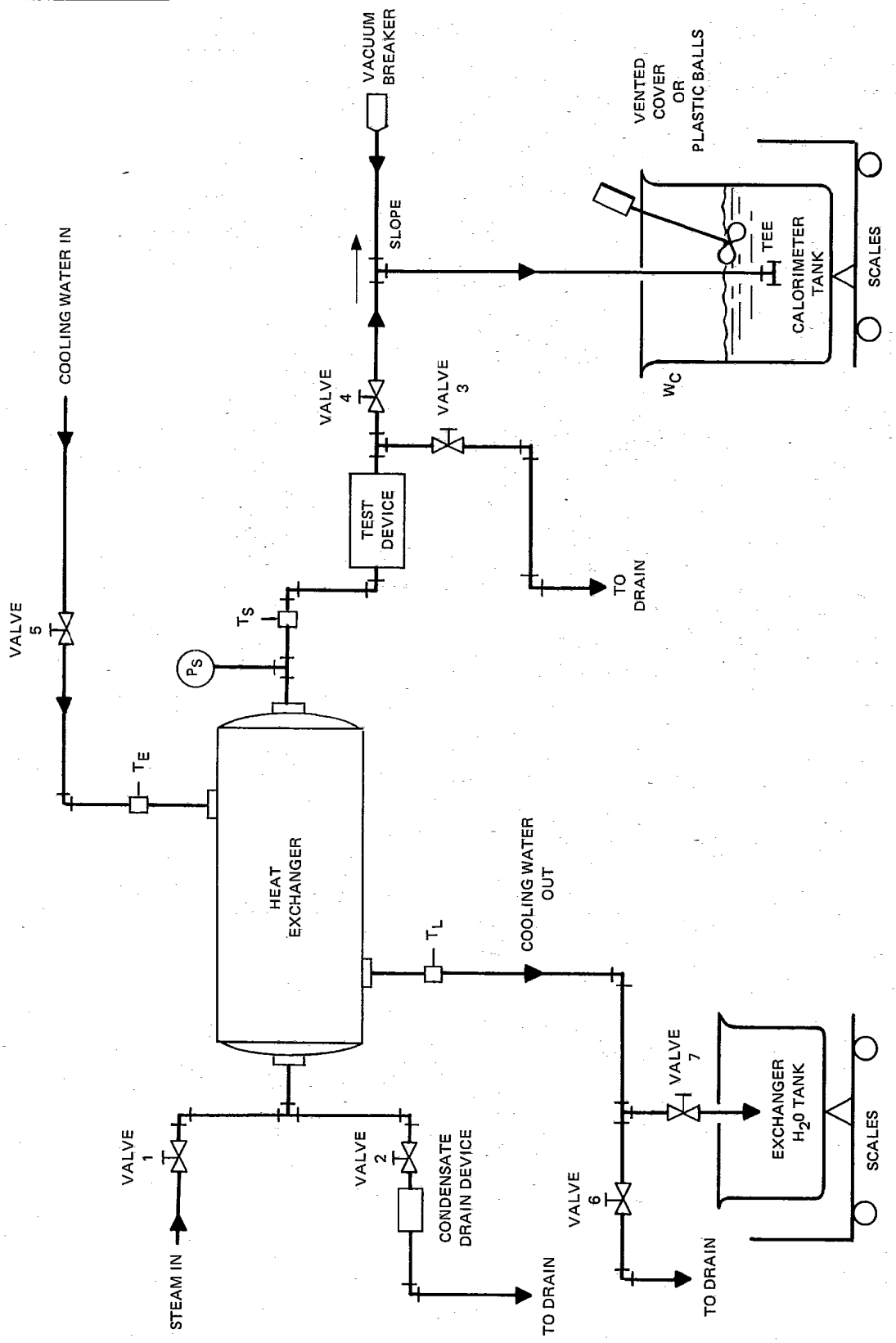
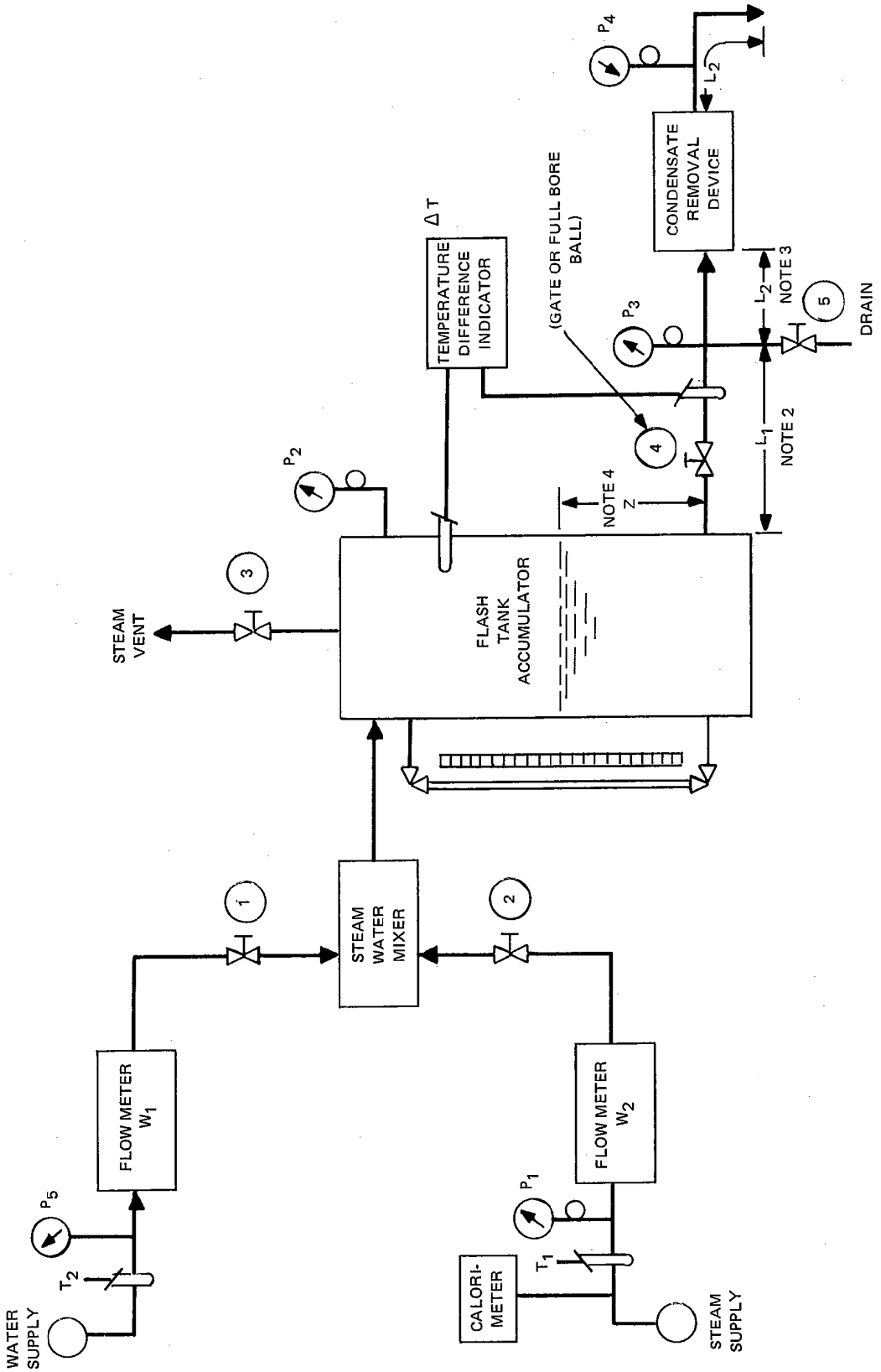


FIG. 7.1.1 TEST ARRANGEMENT FOR STEAM LOSS TESTS

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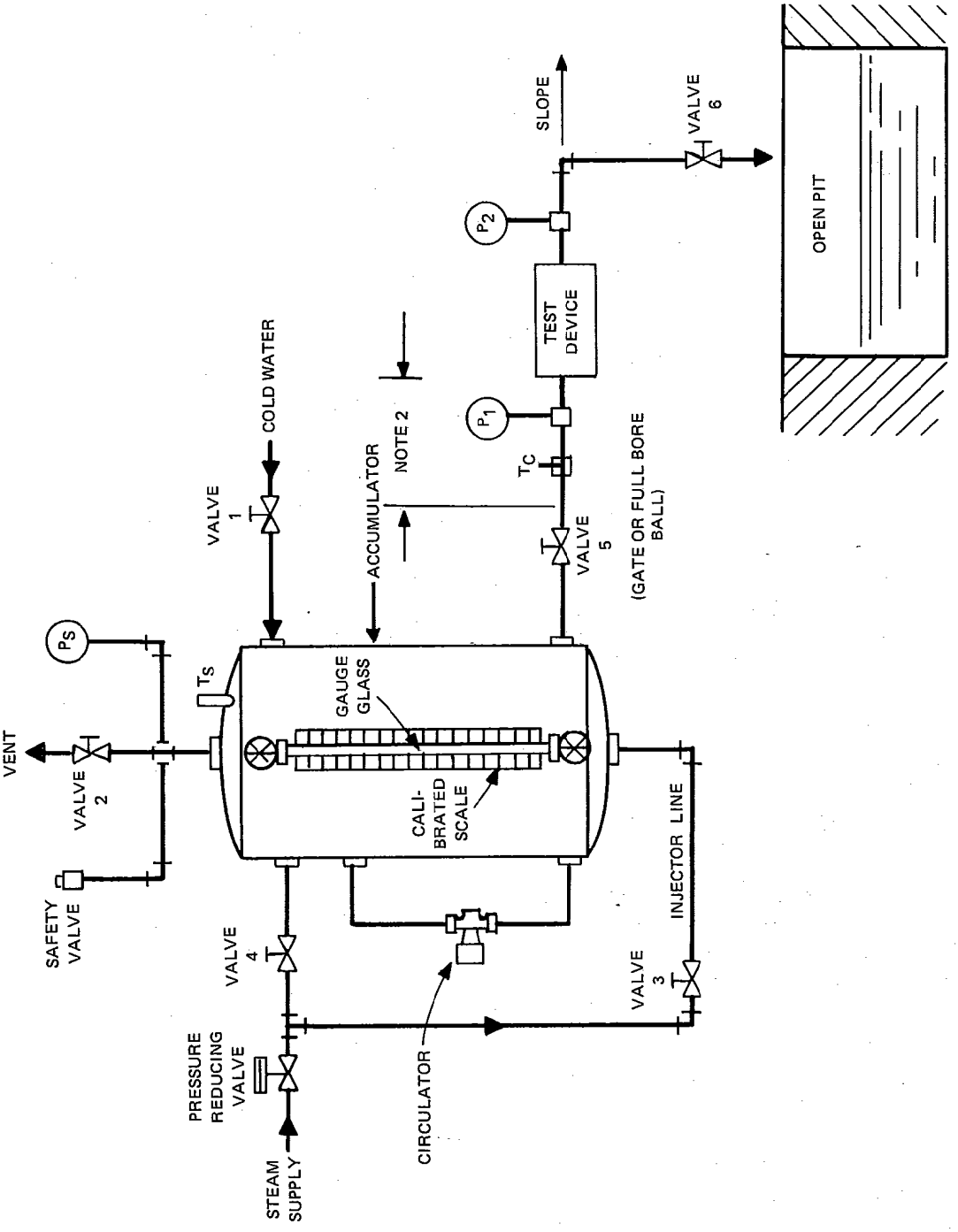


Notes:

1. The piping from the accumulator to the condensate removal device shall be of the same diameter as the inlet connection on the device. The inlet to the piping from the accumulator shall be in the form of a well rounded entrance.
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 center of the inlet connection of the condensate removal device.

FIG. 7.1.2 TEST ARRANGEMENT FOR CAPACITY TEST – SATURATED CONDENSATE PROCEDURE A – CONTINUOUS FLOW

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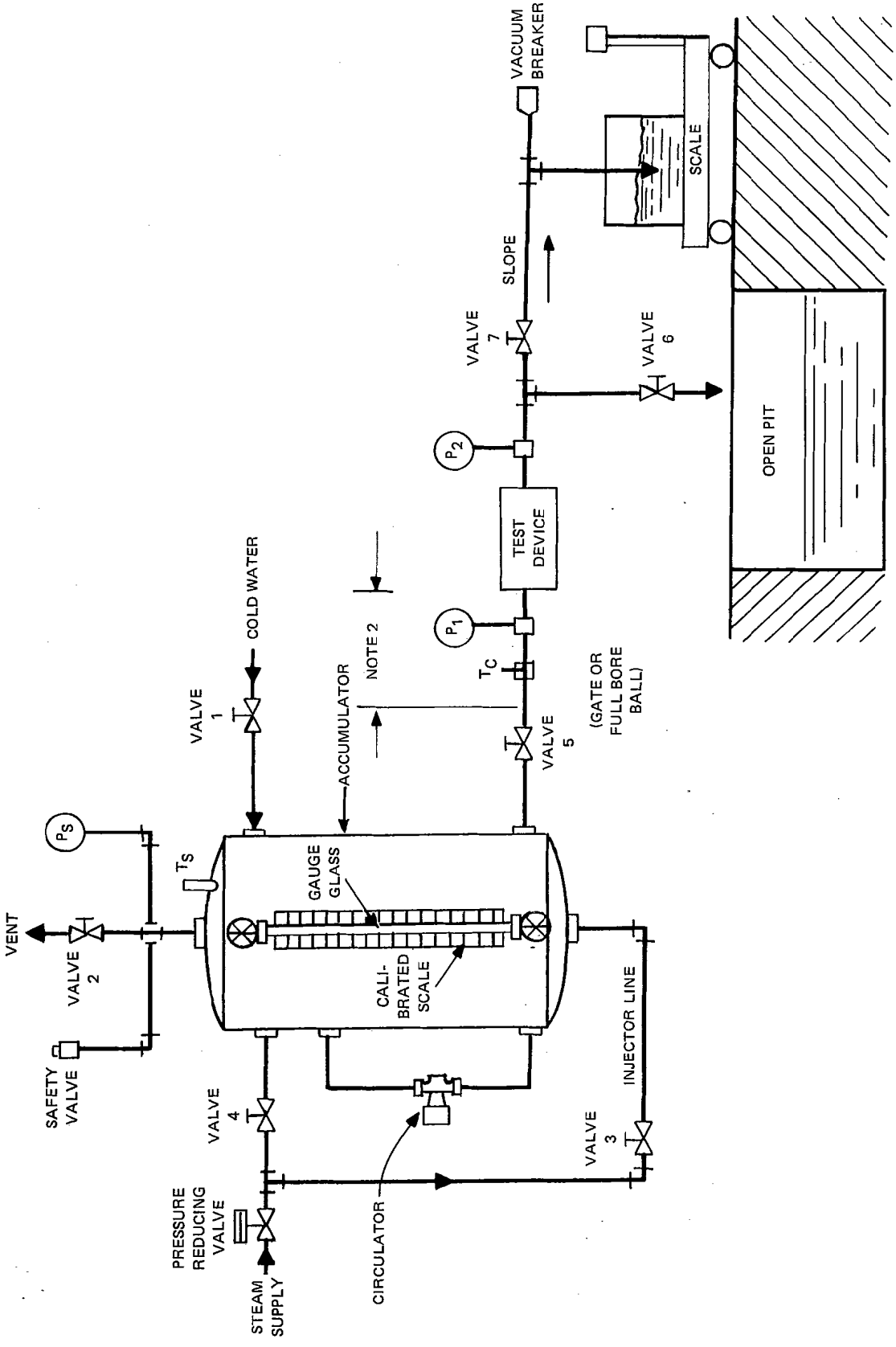


Notes:

1. The piping from the accumulator to the test device shall be of the same diameter as the inlet connection on the test device. The inlet to the piping from the accumulator shall be in the form of a well rounded entrance.
2. The distance between the sensors and the test device shall not exceed 20 internal pipe diameters.

FIG. 7.1.3 TEST ARRANGEMENT FOR CAPACITY TEST – SATURATED CONDENSATE PROCEDURE B – INTERMITTENT FLOW

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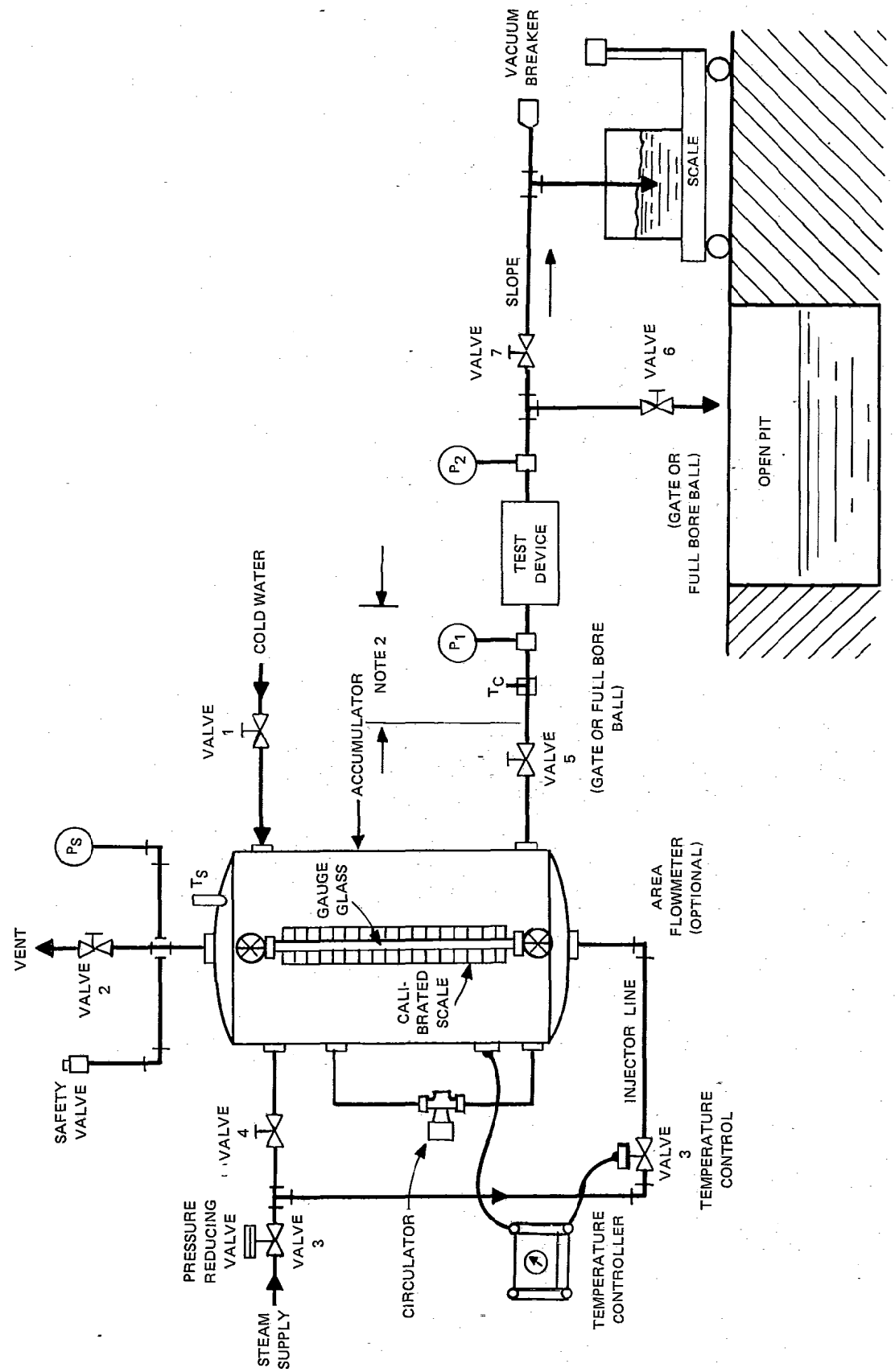
Notes:

1. The piping from the accumulator to the test device shall be of the same diameter as the inlet connection on the test device. The inlet to the piping from the accumulator shall be in the form of a well rounded entrance.
2. The distance between the sensors and the test device shall not exceed 20 internal pipe diameters.

FIG. 7.1.4 TEST ARRANGEMENT FOR CAPACITY TEST – SATURATED CONDENSATE PROCEDURE C – INTERMITTENT FLOW

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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. The inlet to the piping from the accumulator shall be in the form of a well rounded entrance.
2. The distance between the sensors and the test device shall not exceed 20 internal pipe diameters.

FIG. 7.1.5 TEST ARRANGEMENT FOR CAPACITY TEST – SATURATED CONDENSATE PROCEDURE D – INTERMITTENT FLOW

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7.2 Conversion Tables

7.2.1 SI (Metric) Conversion Table

Quantity	Conversion		Multiplication Factor
Acceleration-Linear	ft/sec^2	to m/s^2	3.048* E-01
	standard gravity	to m/s^2	9.806 65* E+00
Area	in^2	to m^2	6.451 6 E-04
	ft^2	to m^2	9.290 304* E-02
Coefficient of thermal expansion	$°R^{-1}$	to K^{-1}	1.8* E+00
Density	lbm/ft^3	to kg/m^3	1.601 846 E+01
	$slugs/ft^3$	to kg/m^3	5.153 788 E+02
Energy, work, heat	Btu (IT)	to J	1.055 056 E+03
	ft-lbf	to J	1.355 818 E+00
Flow rate, mass	lbm/sec	to kg/s	4.535 924 E-01
	lbm/min	to kg/s	7.559 873 E-03
	lbm/hr	to kg/s	1.259 979 E-04
	slugs/sec	to kg/s	1.459 390 E+01
Flow rate, volume	ft^3/min	to m^3/s	4.719 474 E-04
	ft^3/sec	to m^3/s	2.831 685 E-02
	gallon (US liquid)/min	to m^3/s	6.309 020 E-05
Gas constant	Btu/lbm-°R	to J/(kg • K)	4.186 8* E+03
	ft-lbf/lbm-°R	to J/(kg • K)	5.380 320 E+00
Heat transfer coefficient	Btu/hr-ft^2-°R	to $W/(m^2 • K)$	5.678 263 E+00
Length	in.	to m	2.54* E-02
	ft	to m	3.048* E-01
Mass	lbm (avoirdupois)	to kg	4.535 924 E-01
	slug	to kg	1.459 390 E+01
Pressure	standard atmosphere	to Pa	1.013 25* E+05
	bar	to Pa	1* E+05
	lbf/ft^2	to Pa	4.788 026 E+01
	lbf/in^2	to Pa	6.894 757 E+03
Rotational frequency	min^{-1}	to s^{-1}	1.666 667 E-02
Specific enthalpy	Btu/lbm	to J/kg	2.326 E+03
Specific entropy	Btu/lbm-°R	to J/(kg • K)	4.186 8* E+03
Specific heat	Btu/lbm-°R	to J/(kg • K)	4.186 8* E+03
Specific volume	ft^3/lbm	to m^3/kg	6.242 797 E-02
Temperature interval	°F	to °C	5.555 556 E-01
Temperature, measured	°F	to °C	$t_C = (t_F - 32)/1.8$
Temperature, thermodynamic	°C	to K	$T_K = t_C + 273.15$
	°F	to K	$T_K = (t_F + 459.67)/1.8$
	°R	to K	$T_K = T_R/1.8$
Thermal conductivity	Btu-ft/hr-ft^2-°R	to W/(m • K)	1.730 735 E+00
Time	hr	to s	3.6* E+03
	min	to s	6* E+01

The factors are written as a number greater than one and less than ten with six decimal places. The number is followed by the letter E (for exponent), a plus or minus symbol, and two digits which indicate the power of 10 by which the number must be multiplied to obtain the correct value.

For example: 3.785 412 E-03 is 3.785 412 X 10^{-3} or 0.003 785 412

*Exact relationship in terms of the base units.

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SI (Metric) Conversion Table (Cont'd)

Quantity	Conversion		Multiplication Factor
Velocity	ft/hr	to m/s	8.466 667 E-05
	ft/min	to m/s	5.08* E-03
	ft/sec	to m/s	3.048* E-01
Volume	gallon (US liquid)	to m^3	3.785 412 E-03
	ft^3	to m^3	2.831 685 E-02
	$in.^3$	to m^3	1.638 706 E-05
	liter	to m^3	1* E-03

The factors are written as a number greater than one and less than ten with six decimal places. The number is followed by the letter E (for exponent), a plus or minus symbol, and two digits which indicate the power of 10 by which the number must be multiplied to obtain the correct value.

For example:

3.785 412 E-03 is 3.785 412 X 10^{-3} or 0.003 785 412

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7.2.2 Conversion Factors for Pressure, (Force/Area)

To obtain / Multiply, by	atm	bar	$\frac{lbf}{in.^2}$	in. Hg (0°C)	ft H_2O (20°C)	mm Hg (0°C)	kPa (SI Units)
atm	1	1.013 25	$\frac{1\ 013\ 250 \times 2.54^2}{980.665 \times 453.592\ 37} = 14.695\ 948\ 8$	$\frac{1\ 013\ 250/980.665}{13.595\ 088\ 9 \times 2.54} = 29.921\ 280\ 0$	$\frac{1\ 013\ 250/980.665}{0.998\ 278\ 282 \times 30.48} = 33.957\ 002\ 9$	$\frac{10\ 132\ 500/980.665}{13.595\ 088\ 9} = 760.000\ 512$	101.325
bar	$\frac{1.0}{1.013\ 25} = 0.986\ 923\ 267$	1	$\frac{2.54^2 \times 10^6}{980.665 \times 453.592\ 37} = 14.503\ 773\ 8$	$\frac{10^6/980.665}{13.595\ 088\ 9 \times 2.54} = 29.530\ 007\ 4$	$\frac{10^6/980.665}{0.998\ 278\ 282 \times 30.48} = 33.512\ 956\ 2$	$\frac{10^7/980.665}{13.595\ 088\ 9} = 750.062\ 188$	100
$\frac{lbf}{in.^2}$	$\frac{980.665 \times 453.592\ 37}{1\ 013\ 250 \times 2.54^2} = 0.068\ 045\ 963\ 9$	$\frac{980.665 \times 453.592\ 37}{2.54^2 \times 10^6} = 0.068\ 947\ 572\ 9$	1	$\frac{453.592\ 37/2.54^3}{13.595\ 088\ 9} = 2.036\ 022\ 34$	$\frac{453.592\ 37/2.54^3}{0.998\ 278\ 282 \times 12} = 2.310\ 636\ 99$	$\frac{453.592\ 37 \times 10}{13.595\ 088\ 9 \times 2.54^2} = 51.714\ 967\ 4$	$\frac{980.665 \times 453.592\ 3}{2.54^2 \times 10^4} = 6.894\ 757\ 29$
in. Hg (0°C)	$\frac{13.595\ 088\ 9 \times 2.54}{1\ 013\ 250/980.665} = 0.033\ 421\ 030\ 1$	$\frac{13.595\ 088\ 9 \times 2.54}{10^6/980.665} = 0.033\ 863\ 858\ 8$	$\frac{13.595\ 088\ 9 \times 2.54^3}{453.592\ 37} = 0.491\ 153\ 746$	1	$\frac{13.595\ 088\ 9}{0.998\ 278\ 282 \times 12} = 1.134\ 878\ 01$	25.4	$\frac{13.595\ 088\ 9 \times 2.54}{10^4/980.665} = 3.386\ 385\ 88$
ft H_2O (20°C)	$\frac{0.998\ 278\ 282 \times 30.48}{1\ 013\ 250/980.665} = 0.029\ 449\ 006\ 6$	$\frac{0.998\ 278\ 282 \times 30.48}{10^6/980.665} = 0.029\ 839\ 205\ 9$	$\frac{0.998\ 278\ 282 \times 12}{453.592\ 37/2.54^3} = 0.432\ 781\ 092$	$\frac{0.998\ 278\ 282 \times 12}{13.595\ 088\ 9} = 0.881\ 151\ 971$	1	$\frac{9.982\ 782\ 82 \times 30.48}{13.595\ 088\ 9} = 22.381\ 260\ 1$	$\frac{0.998\ 278\ 282 \times 30.4}{10^4/980.665} = 2.983\ 920\ 59$
mm Hg (0°C)	$\frac{13.595\ 088\ 9}{10\ 132\ 500/980.665} = 0.001\ 315\ 788\ 59$	$\frac{13.595\ 088\ 9}{10^7/980.665} = 0.001\ 333\ 222\ 79$	$\frac{13.595\ 088\ 9 \times 2.54^2}{453.592\ 37 \times 10} = 0.019\ 336\ 761\ 7$	$\frac{1.0}{25.4} = 0.039\ 370\ 078\ 7$	$\frac{13.595\ 088\ 9}{9.982\ 782\ 82 \times 30.48} = 0.044\ 680\ 236\ 8$	1	$\frac{13.595\ 088\ 9}{10^5/980.665} = 0.133\ 322\ 279$
kPa (SI Units)	$\frac{1.0}{101.325} = 0.009\ 869\ 232\ 67$	0.01	$\frac{2.54^2 \times 10^4}{980.665 \times 453.592\ 37} = 0.145\ 037\ 738$	$\frac{10^4/980.665}{13.595\ 0889 \times 2.54} = 0.295\ 300\ 074$	$\frac{10^4/980.665}{0.998\ 278\ 282 \times 30.48} = 0.335\ 129\ 562$	$\frac{10^5/980.665}{13.595\ 088\ 9} = 7.500\ 621\ 88$	1

All values given in the rational fractions are exact except the densities of water and mercury. The density of water (0.998 278 282 g/cm³ at 20°C) is computed from the IFC Formulation. The density of mercury (13.595 0889 g/cm³ at 0°C) is taken from NBS Monograph 8, P3-4.

Example: 1 bar = 1 bar × 0.986 923 267 atm/bar = 0.986 923 267 atm = (1/1.013 25) atm.

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7.3 References*

PTC 1 General Instructions

PTC 2 Definitions and Values

PTC 19.2 Pressure Measurement

PTC 19.3 Temperature Measurement

PTC 19.5 Application, Part II of Fluid Meters; Interim Supplement on Instruments & Apparatus

PTC 19.5, 1 Weighing Scales

PTC 19.12 Measurement of Time

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PTC 4.2 — Coal Pulverizers . . . . . (1969)
PTC 10 — Compressor and Exhausters . . . . . (1965)
PTC 39.1 — Condensate Removal Devices for Steam Systems . . . . . (1980)
PTC 2 — Definitions and Values . . . . . (1971)
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PTC 16 — Gas Producers and Continuous Gas Generators . . . . . (1958)
PTC 22 — Gas Turbine Power Plants . . . . . (1966)
PTC 3.3 — Gaseous Fuels . . . . . (1969)
PTC 1 — General Instructions . . . . . (1980)
PTC 18 — Hydraulic Prime Movers . . . . . (1949)
PTC 31 — Ion Exchange Equipment . . . . . (1973)
PTC 33 — Large Incinerators . . . . . (1978)
PTC 32.1 — Nuclear Steam Supply Systems . . . . . (1969)
PTC 20.2 — Overspeed Trip Systems for Steam Turbine-Generator Units . . . . . (1965)
PTC 20.3 — Pressure Control Systems Used on Steam Turbine-Generator Units . . . . . (1970)
PTC 18.1 — Pumping Mode of Pump/Turbines . . . . . (1978)
PTC 17 — Reciprocating Internal-Combustion Engines . . . . . (1973)
PTC 7 — Reciprocating Steam-Driven Displacement Pumps . . . . . (1949)
PTC 5 — Reciprocating Steam Engines . . . . . (1949)
PTC 25.3 — Safety and Relief Valves . . . . . (1976)
PTC 3.2 — Solid Fuels . . . . . (1954)
PTC 20.1 — Speed and Load Governing Systems for Steam Turbine-Generator Units . . . . . (1977)
PTC 29 — Speed-Governing Systems for Hydraulic Turbine-Generator Units . . . . . (1965)
PTC 26 — Speed-Governing Systems for Internal Combustion Engine-Generator Units . . . . . (1962)
PTC 12.2 — Steam Condensing Apparatus . . . . . (1955)
PTC 4.1 — Steam-Generating Units . . . . . (1964)
PTC 6 — Steam Turbines . . . . . (1976)
PTC 6A — Appendix A to Test Code for Steam Turbines . . . . . (1964)

PTC 6 Report — Guidance for Evaluation of Measurement Uncertainty in Performance Tests of Steam Turbines . . . . (1969)
PTC 6S Report — Simplified Procedures for Routine Performance Tests of Steam Turbines . . . . . (1970)
PTC 32.2 Report — Methods of Measuring the Performance of Nuclear Reactor Fuel in Light Water Reactors . . . . . (1978)

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