Special Addenda
to
ASME PTC 25-1994
Pressure Relief Devices

This 1998 Special Addenda to ASME PTC 25-1994, Pressure Relief Devices, is issued to revise portions of this Code as it pertains to the performance testing of rupture disk devices. It reflects the current industry-accepted terms and performance characteristics of these devices as used in ASME accreditation programs. The American National Standards Institute approved this document on March 19, 1998.

Replace the pages listed. The pages not listed are the reverse sides of the listed pages and contain no changes.

Page	*Location*	*Change*
vii, viii	Contents	Updated to reflect Addenda
7–10	2.7	Definition for *flow resistance* added
	2.8	(1) Definitions for f and G revised (2) Definitions for $H_{L\ B\text{-}C}$ and L_{ex} deleted (3) Definitions for $K_{C\text{-}D}$ and $K_{E\text{-}F}$ redesignated as $K_{B\text{-}C}$ and $K_{C\text{-}D}$, respectively (4) Definitions for $K_{pipe\ B\text{-}C}$, $K_{pipe\ B\text{-}D}$, K_{Ri}, $K_{B\text{-}D}$, $L_{B\text{-}D}$, $\Delta P_{A\text{-}B}$, $\Delta P_{B\text{-}C}$, and $\Delta P_{C\text{-}D}$ added
18	Fig. 4	Revised
19	Fig. 5	Revised
	Fig 6	Revised
32	4.9	Title revised
	4.9.1	First paragraph revised
33	Fig. 9	Revised
34	4.9.4	(1) Title revised (2) Subparagraphs (a) and (b) revised (3) Subsubparagraphs (d)(1), (d)(2), and (d)(6) through (d)(9) revised
	4.9.5	(1) Title revised (2) Subparagraphs (a) and (b) revised (3) Subsubparagraphs (d)(1), (d)(2), and (d)(5) through (d)(8) revised
37	5.5.7	(1) Title revised (2) Revised in its entirety
47, 48	Form 5.5.7	(1) Subtitle revised (2) Step (6) revised (3) Steps (13) through (17) revised (4) Steps (34) and (35) revised (5) Step (37) deleted

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Tables

built-up back pressure — pressure existing at the outlet of a pressure relief device caused by the flow through that particular device into a discharge system

burst pressure — the value of inlet static pressure at which a rupture disk device functions

chatter — abnormal rapid reciprocating motion of the movable parts of a pressure relief valve in which the disk contacts the seat

closing pressure — the value of decreasing inlet static pressure at which the valve disk reestablishes contact with the seat or at which lift becomes zero

coefficient of discharge — the ratio of the measured relieving capacity to the theoretical relieving capacity

cold differential test pressure — the inlet static pressure at which a pressure relief valve is adjusted to open on the test stand. This test pressure includes corrections for service conditions of superimposed back pressure and/or temperature

constant back pressure — a superimposed back pressure which is constant with time

cracking pressure — see *opening pressure*

flow capacity — see *measured relieving capacity*

flow-rating pressure — the inlet static pressure at which the relieving capacity of a pressure relief device is measured

flow resistance — a dimensionless term (such as used in para. 5.5.7) which expresses the number of velocity heads lost due to flow through a rupture disk device (where velocity head is one-half the velocity squared divided by the acceleration of gravity)

flutter — abnormal, rapid reciprocating motion of the movable parts of a pressure relief valve in which the disk does not contact the seat

leak pressure — see *start-to-leak pressure*

leak test pressure — the specified inlet static pressure at which a quantitative seat leakage test is performed in accordance with a standard procedure

marked breaking pressure — the value of pressure marked on a breaking pin or a shear pin device or its nameplate

marked burst pressure — the value of pressure marked on the rupture disk device or its nameplate or on the tag of the rupture disk and indicates the burst pressure at the coincident disk temperature

marked set pressure — the value or values of pressure marked on a pressure relief device

marked relieving capacity — see *rated relieving capacity*

measured relieving capacity — the relieving capacity of a pressure relief device measured at the flow-rating pressure, expressed in gravimetric or volumetric units

opening pressure — the value of increasing inlet static pressure of a pressure relief valve at which there is a measurable lift, or at which the discharge becomes continuous as determined by seeing, feeling, or hearing

overpressure — a pressure increase over the set pressure of a pressure relief valve, usually expressed as a percentage of set pressure

popping pressure — the value of increasing inlet static pressure at which the disk moves in the opening direction at a faster rate as compared with corresponding movement at higher or lower pressures

primary pressure — the pressure at the inlet in a pressure relief device

rated relieving capacity — that portion of the measured relieving capacity permitted by the applicable code or regulation to be used as a basis for the application of a pressure relief device

reference conditions — those conditions of a test medium which are specified by either an applicable standard or an agreement between the parties to the test, which may be used for uniform reporting of measured flow test results

relieving pressure — set pressure plus overpressure

resealing pressure — the value of decreasing inlet static pressure at which no further leakage is detected after closing. The method of detection may be a specified water seal on the outlet or other means appropriate for this application.

reseating pressure — see *closing pressure*

seal-off pressure — see *resealing pressure*

secondary pressure — the pressure existing in the passage between the actual discharge area and the valve outlet in a safety, safety relief, or relief valve

set pressure — the value of increasing inlet static pressure at which a pressure relief device displays one of the operational characteristics as defined under opening pressure, popping pressure, start-to-leak pressure, burst pressure, or breaking pressure. (The applicable operating characteristic for a specific device design is specified by the device manufacturer.)

simmer — the audible or visible escape of fluid between the seat and disk at an inlet static pressure below the popping pressure and at no measurable capacity. It applies to safety or safety relief valves on compressible-fluid service.

specified burst pressure (of a rupture disk device) — the value of increasing inlet static pressure, at a specified temperature, at which a rupture disk is designed to function

start-to-discharge pressure — see *opening pressure*

start-to-leak pressure — the value of increasing inlet static pressure at which the first bubble occurs when a pressure relief valve is tested by means of air under a specified water seal on the outlet

superimposed back pressure — the static pressure existing at the outlet of a pressure relief device at the time the device is required to operate. It is the result of pressure in the discharge system from other sources.

test pressure — see *relieving pressure*

theoretical relieving capacity — the computed capacity expressed in gravimetric or volumetric units of a theoretically perfect nozzle having a minimum cross-sectional flow area equal to the actual discharge area of a pressure relief valve or relief area of a non-reclosing pressure relief device

vapor-tight pressure — see *resealing pressure*

variable back pressure — a superimposed back pressure that will vary with time

warn — see *simmer*

yield (melt) temperature — the temperature at which the fusible material of a fusible plug device becomes sufficiently soft to extrude from its holder and relieve pressure

2.8 DESCRIPTION OF TERMS

a = Actual discharge area, in.^{2}
a = Minimum net flow area in.^{2}
a_m = Meter-bore area, in.^{2}
ρ = Water density, lbm per cu ft
d = Meter-bore diameter, in.
d^2 = Meter-bore diameter squared, in.^{2}
d_b = Minimum holder bore diameter, in.
d_b = Bore diameter, in.
d_o = Diameter of orifice plate, in.
d_s = Seat diameter, in.
f = Fanning friction factor, dimensionless
h_w = Differential pressure at the meter, inches of water
k = Ratio of specific heats
l = Valve-disk lift, in.
m = Mass flow rate, lbm/hr
q_b = Volumetric rate at base condition at the meter, cfm
q_r = Valve capacity at reference inlet temperature, cfm
t = Length of test, min
v = Specific volume, ft^3/lbm
w = Mass of water or condensate, lbm (w)
w_{vl} = Valve-steam leakage, lbm/hr
w_{cl} = Condenser leakage, lbm/hr
w_{dr} = Test-drum drainage, lbm/hr

C = Valve inlet temperature correction
C = Discharge coefficient, dimensionless
C_{tap} = Sonic velocity at pressure tap, ft/sec
D = Internal diameter of meter run pipe, in.
D = Test rig inside diameter, ft
D = Internal diameter of meter run pipe, in.
E = Pipe roughness, in.
F_a = Thermal expansion number, dimensionless
F_a = Area factor for thermal expansion, F_a
G = Mass velocity, lbm/ft^2-sec
G = Specific gravity with respect to dry air, $\frac{M}{M_a}$
K = Flow coefficient
K_o = Trial flow coefficient
$K_{pipe\ B\text{-}C}$ = Pipe resistance factor between pressure taps B and C without the rupture disk device
$K_{pipe\ B\text{-}D}$ = Pipe resistance factor between pressure taps B and D without the rupture disk device
K_{Ri} = Individual flow resistance
K_{tap} = Total resistance factor to pressure tap
$K_{A\text{-}B}$ = Resistance factor between pressure taps A and B
$K_{B\text{-}C}$ = Resistance factor between pressure taps B and C
$K_{B\text{-}D}$ = Resistance factor between pressure taps B and D
$K_{C\text{-}D}$ = Resistance factor between pressure taps C and D
$L_{A\text{-}B}$ = Length between tap A and B, ft

$L_{B\text{-}C}$ = Length between tap B and C, ft
$L_{B\text{-}D}$ = Length between tap B and D, ft
$L_{C\text{-}D}$ = Length between tap C and D, ft
M = Molecular weight of gas
M_1 = Mach number at pipe entrance
M_a = Molecular weight of air
M_w = Molecular weight, MW
M_{tap} = Mach number at pressure tap
N_{Re} = Reynolds number
P = Static pressure, psia
P_1 = Pressure at pipe entrance
P_b = Barometric pressure, psia
P_m = Static pressure at the meter calorimeter, psia
P_{set} = Set pressure, psig
P_f = Flow rating pressure, psia
P_o = Back pressure, psig
P_B = Base pressure, psia
P_s = Meter inlet stagnation pressure, psia
P_{tapA} = Pressure @ tap A, psia
P_{tapB} = Pressure @ tap B, psia
P_{tapC} = Pressure @ tap C, psia
P_{tapD} = Pressure @ tap D, psia
Q = Relieving capacity in gpm of water at reference condition, (US. gallons) (gpm)
R = Gas constant, 1545.4/M, ft-lbf/lbm-°R
R_d = Throat Reynolds number
S_g = Specific gravity (ideal)
T = Temperature, °R
T = Fluid temperature, °F
T_1 = Temperature at pipe entrance
T_b = Base temperature, absolute, °R
T_m = Fluid temperature at the meter, °F
T_m = Temperature upstream of the meter, °F
T_o = Base temperature, °R
T_v = Fluid temperature, °F
T_s = Meter inlet stagnation temperature, absolute, °R
T_v = Temperature at the valve inlet, absolute, °R
T_r = Reference temperature at the valve inlet, absolute °R
T_{cal} = Fluid temperature at the calorimeter, °F
$T_{cal'\,Drum}$ = Fluid temperature at the test drum calorimeter, °F
$T_{cal,\,meter}$ = Fluid temperature at the meter calorimeter, °F
T_{tap} = Temperature at pressure tap, °R
T_B = Base temperature, °F
V_{act} = Specific volume at inlet conditions, ft^3/lbm
$V_{act'\,Drum}$ = Specific volume at inlet conditions, ft^3/lbm
$V_{act,\,meter}$ = Specific volume at flowing conditions at the meter, ft^3/lbm
V_{ref} = Specific volume at reference condition, ft^3/lbm
$V_{ref,\,Drum}$ = Specific volume at reference condition, ft^3/lbm
$V_{ref,\,meter}$ = Specific volume at reference conditions at the meter, ft^3/lbm
V_{tap} = Specific volume at pressure tap, ft^3/lbm
W = Measured relieving capacity, lbm/sec
W_c = Measured relieving capacity adjusted to the reference condition, lbm/hr
$W_{cal,\,drum}$ = Test-drum calorimeter flow adjusted to the reference condition, lbm/hr
$W_{cal,\,meter}$ = Meter calorimeter flow adjusted to the reference condition, lbm/hr
W_{dc} = Test-drum calorimeter flow, lbm/hr
W_h = Flow rate, lbm/hr
W_h = Measured relieving capacity adjusted to the reference condition, lbm/hr
W_{mc} = Meter calorimeter flow, lbm/hr
W_r = Relieving capacity adjusted to water at reference condition, lbm/hr
W_t = Trial flow rate, lbm/hr
Y = Expansion factor
Y_{tap} = Expansion factor at pressure tap
Z = Compressibility factor as defined in the equation of state, $PV = ZRT$.
Z_b = Base compressibility factor

β = Beta ratio ($\beta = d/D$)
ρ = Water density, lbm per cu ft
ρ_{act} = Density of water at inlet conditions, lbm/ft^3
ρ_m = Fluid density at meter inlet, lbm/ft^3
ρ_m = Density, lbm/ft^3

ρ_{ref} = Density of water at reference condition, lbm/ft^3

ρ_s = Density of dry air at 14.696 psia and at the base temperature, lbm/ft^3

ρ_{std} = Density of dry air at 14.696 psia and reference temperature, lbm/ft^3, (ρ_{std})

ρ_B = Density at base temperature and pressure

μ = Viscosity, lbm/ft-sec

μ = Viscosity of air at T_B and T_B, (centipoise)

ΔP = Differential pressure head across meter, inches water

$\Delta P_{A\text{-}B}$ = Differential pressure between taps A and B, psia

$\Delta P_{B\text{-}C}$ = Differential pressure between taps B and C, psia

$\Delta P_{C\text{-}D}$ = Differential pressure between taps C and D, psia

ϕ_i = Ideal gas sonic-flow functions

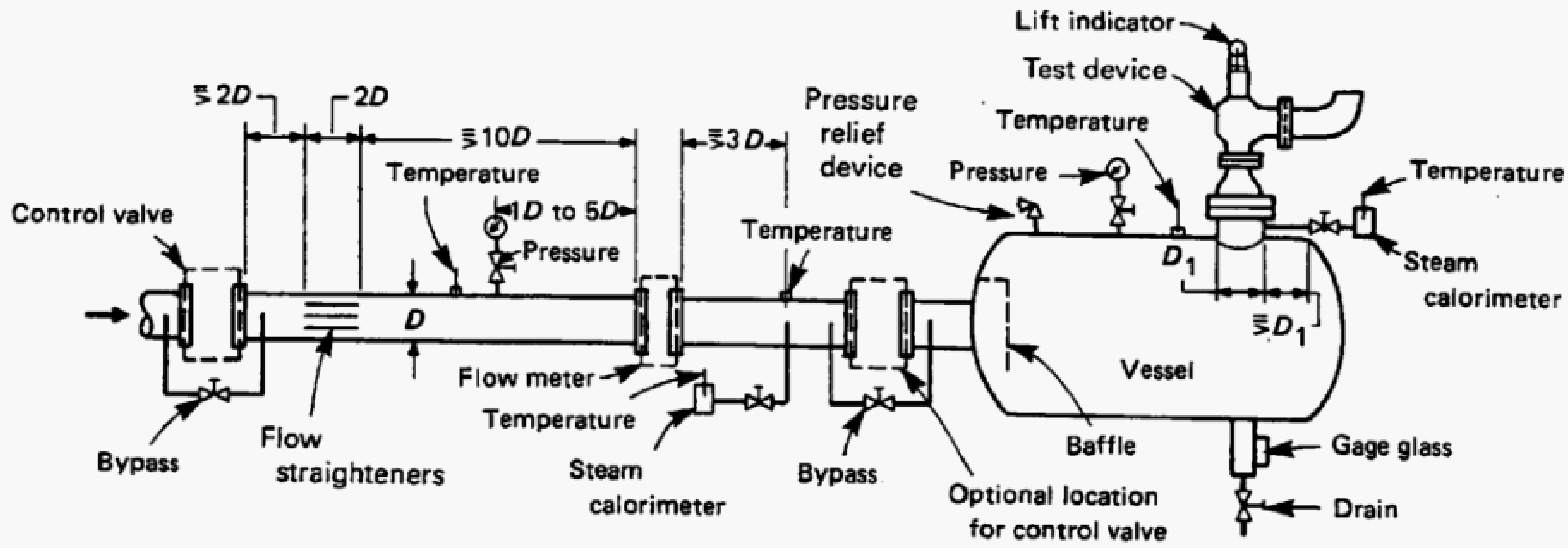


FIG. 2 RECOMMENDED ARRANGEMENTS FOR TESTING DEVICES WITH ATMOSPHERIC BACK PRESSURE—FLOW-METER TEST ARRANGEMENT

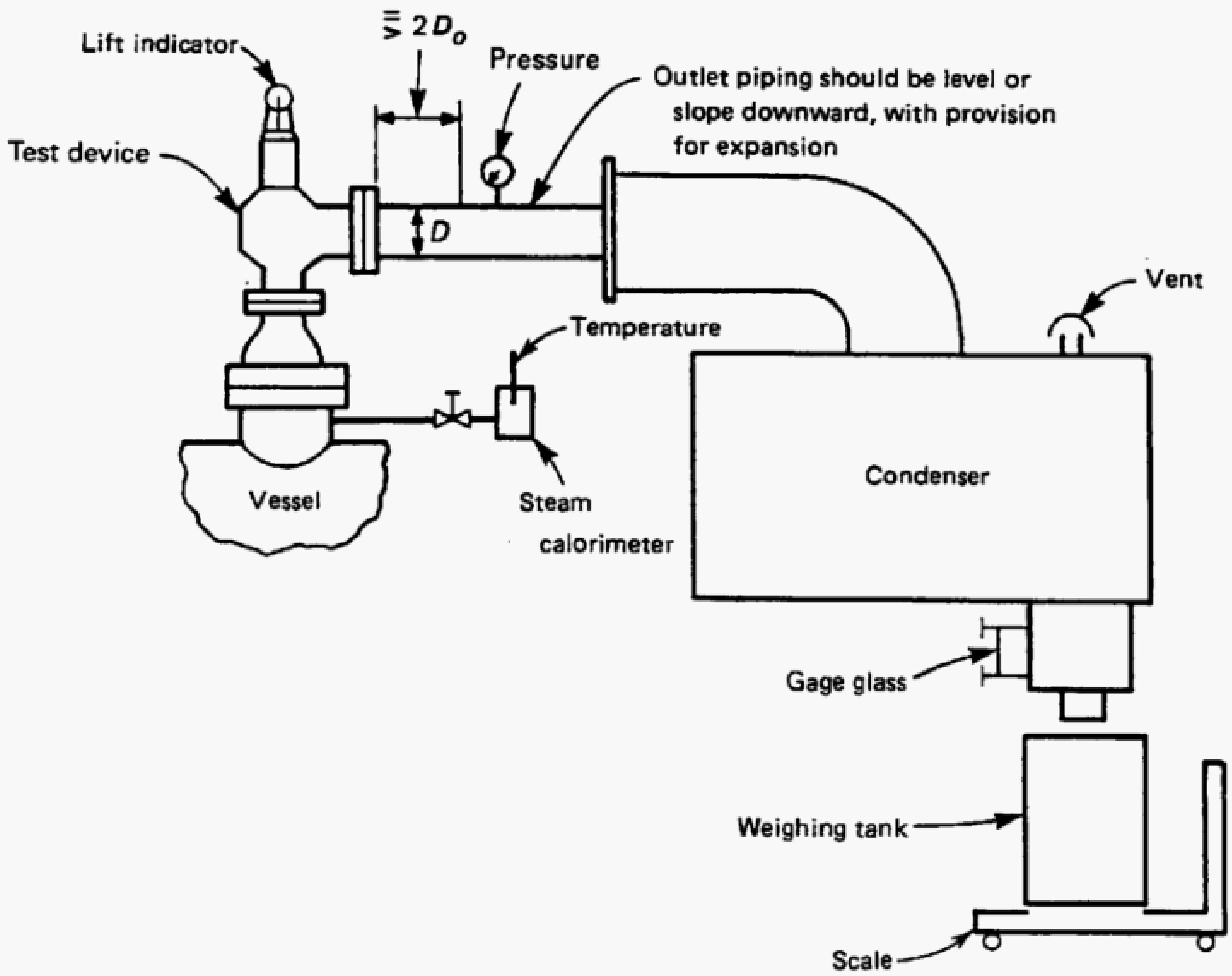


FIG. 3 RECOMMENDED ARRANGEMENTS FOR TESTING DEVICES WITH ATMOSPHERIC BACK PRESSURE—WEIGHED-CONDENSATE TEST ARRANGEMENT

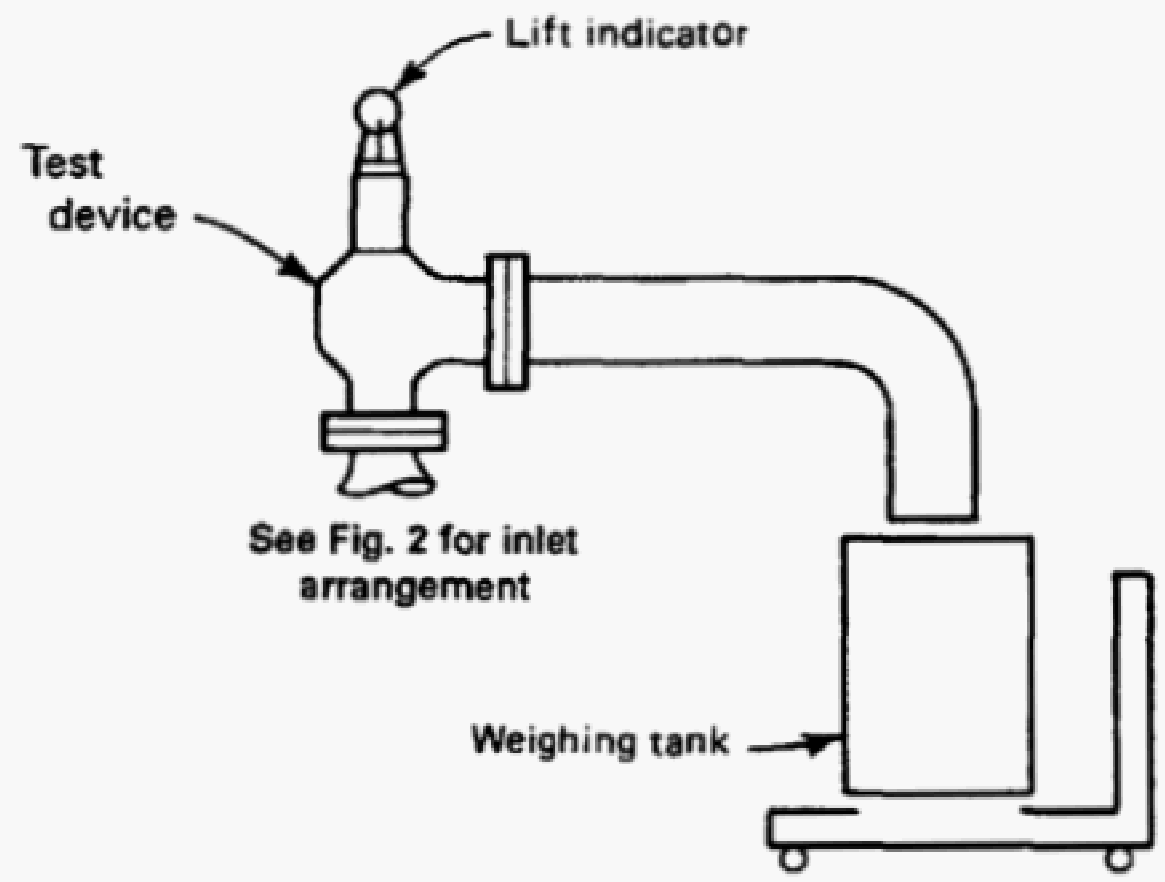


FIG. 4 RECOMMENDED ARRANGEMENTS FOR TESTING DEVICES WITH ATMOSPHERIC BACK PRESSURE—WEIGHED-WATER TEST ARRANGEMENT

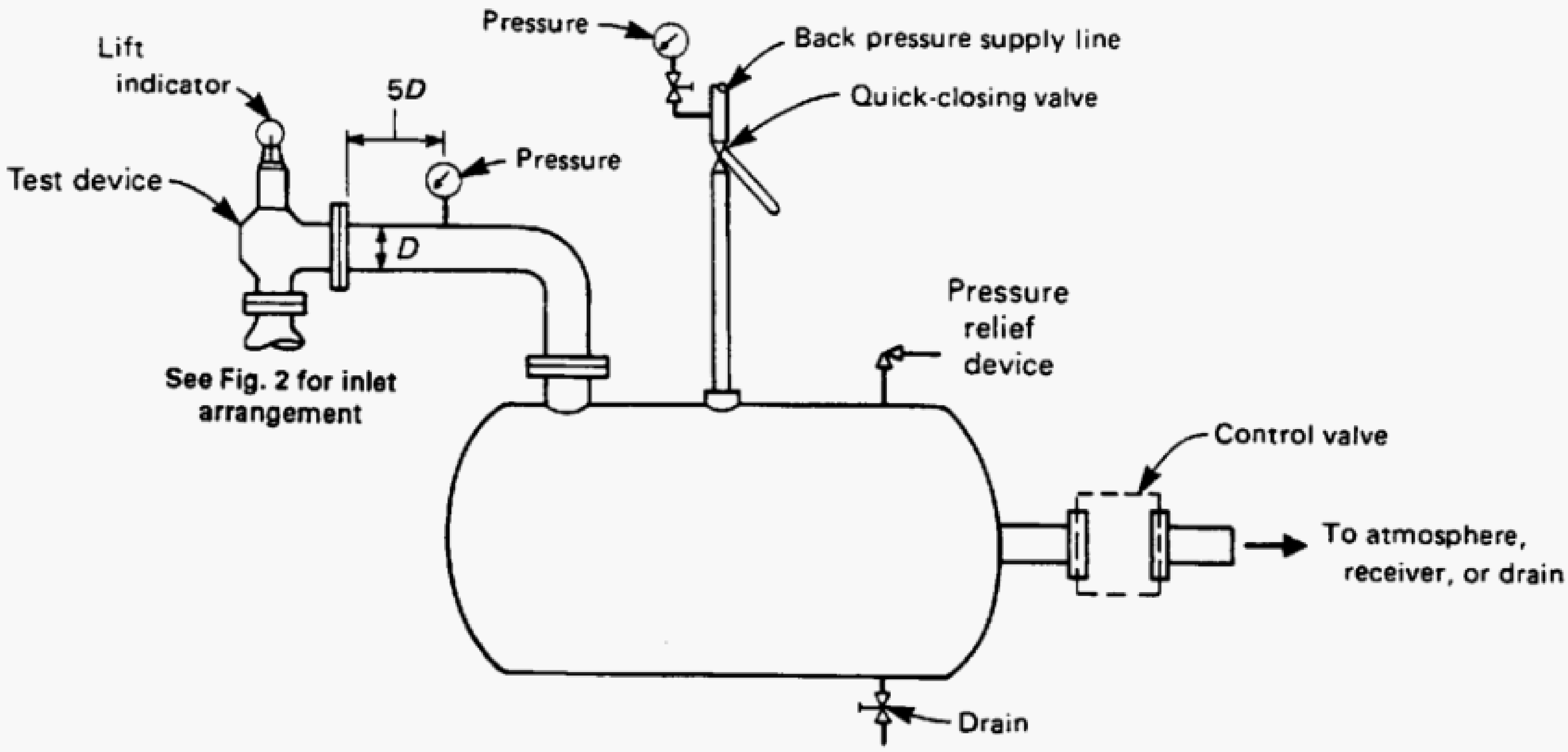


FIG. 5 RECOMMENDED DISCHARGE ARRANGEMENTS FOR TESTING DEVICES WITH SUPERIMPOSED BACK PRESSURE

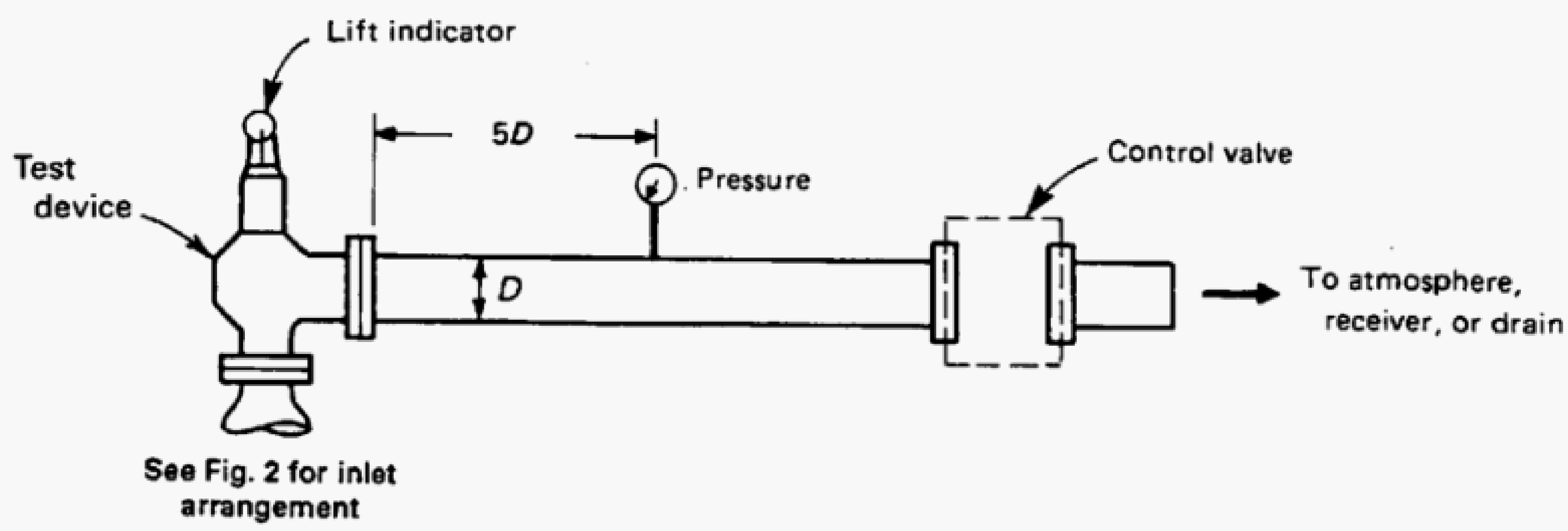
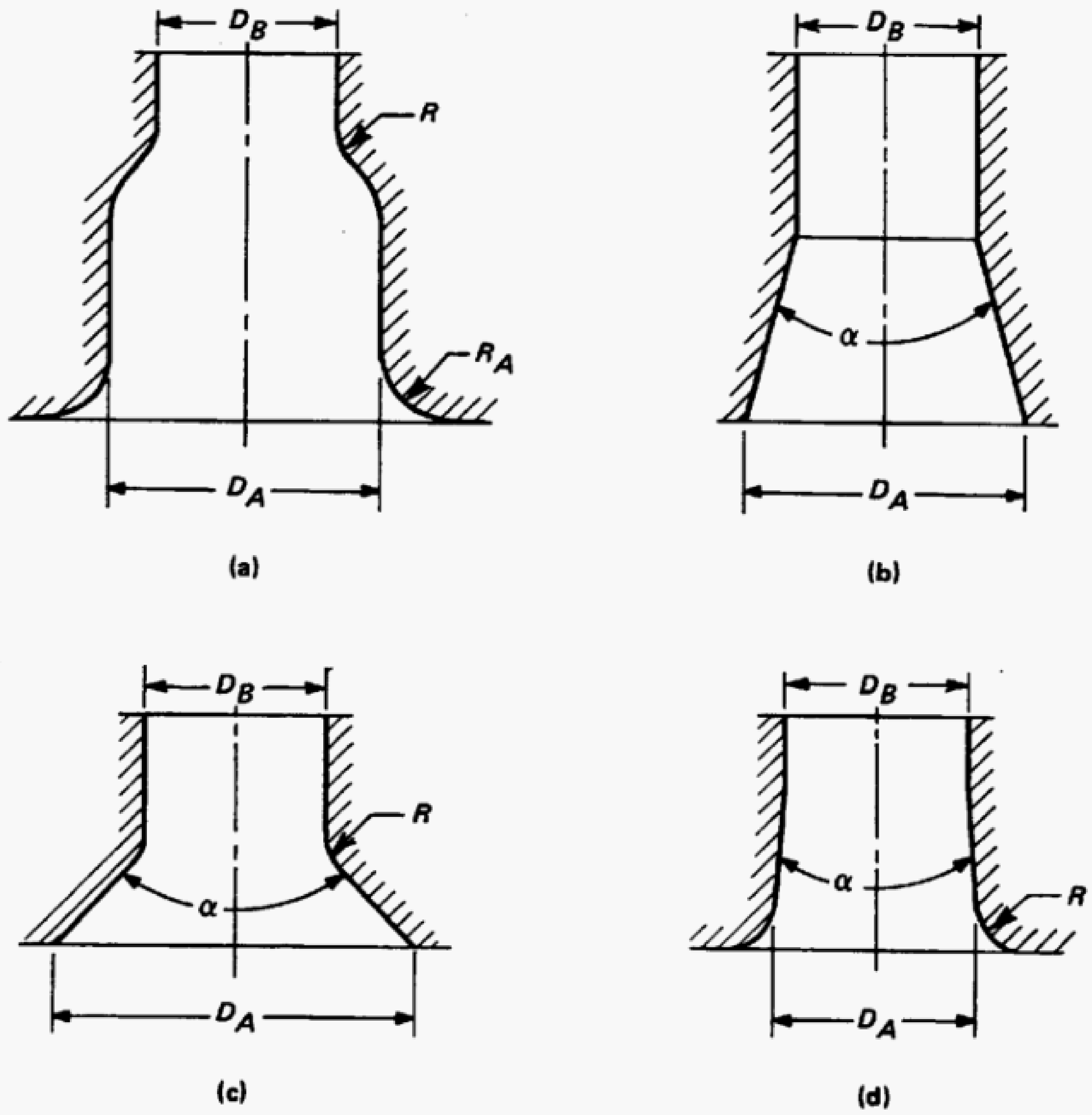


FIG. 6 RECOMMENDED DISCHARGE ARRANGEMENTS FOR TESTING DEVICES WITH BUILT-UP BACK PRESSURE



For sketch (a) — If $D_B \geqslant 0.75\ D_A$, then $R_A \geqslant 0.25\ D_A$
If $D_B < 0.75\ D_A$, then $R \geqslant 0.25\ D_B$

For sketch (b) — If $\alpha \leqslant 30$ deg. and $D_B < 0.75\ D_A$, break all edges

For sketch (c) — If $\alpha > 30$ deg. and $D_B < 0.75\ D_A$, then $R \geqslant 0.25\ D_B$

For sketch (d) — If $\alpha \leqslant 30$ deg. and $D_B \geqslant 0.75\ D_A$, then $R_A \geqslant 0.25\ D_A$

GENERAL NOTE: In no case shall the size of the fitting exceed the size of the connection on the test vessel.

FIG. 7 RECOMMENDED INTERNAL CONTOURS OF FITTINGS, ADAPTER, AND REDUCERS BETWEEN TEST VESSEL AND TEST DEVICE

4.7.7 Observation of Mechanical Characteristics. During the tests with superimposed or built-up back pressure, mechanical characteristics shall be observed by hearing, feeling, or seeing, and recorded during the flow test. If the valve chatters, flutters, or does not reseat satisfactorily, such action shall be recorded. Upon agreement of all interested parties, the valve may be readjusted or repaired and retested. When testing valves against back pressure, any range in which the valve does not reach rated lift at the flow-rating pressure shall be recorded.

4.7.8 Recording Additional Data. It may be desirable or a requirement to record pressures other than, or in addition to, those listed in para. 4.3.4. Where possible, such recorded pressures shall be identified in accordance with Appendix I. With closed discharge systems, it is not possible to observe or record some characteristic pressures.

4.8 TESTING WITH LIQUIDS, WITH BACK PRESSURE ABOVE ATMOSPHERIC

4.8.1 Test Arrangements. Pressure sources can be a pump or an accumulator of liquid, in combination with high-pressure compressed gas. Precautions shall be taken to ensure that pressure pulsations are reduced to a minimum. Figure 2 shows a recommended test arrangement, up to and including the test valve. Figures 5 and 6 show discharge arrangements, for testing with superimposed and built-up back pressure, respectively. A flow meter [para. 4.2.4(b)(1)] shall be used in either case. Instrumentation shall be suitably installed to indicate or record the following:

(*a*) liquid temperature;
(*b*) flow-meter differential pressure;
(*c*) valve-inlet pressure;
(*d*) back pressure.

4.8.2 Preliminary Tests. Preliminary tests may be permitted for testing and adjusting operation of the test apparatus and/or valve being tested (see para. 3.5). Such tests may be necessary to ensure the absence of leaks in the test apparatus and to ensure that all gas or air has been vented from the component parts of the system.

4.8.3 Details of Procedure for Flow Measurement

(*a*) *Atmospheric Back-Pressure Test.* Tests may be conducted to determine the performance of the valve when discharging at atmospheric back pressure. The valve shall be equipped with an atmospheric discharge, as shown in Fig. 2. Test procedure shall be in accordance with paras. 4.5.3 (a) through (n), performing such portions of the procedure and recording such data as has been agreed upon.

NOTE: The objectives of this portion of the test may be only to determine and record the set pressure and closing pressure of the valve; and the lift of the valve at the flow-rating pressure, when the valve is discharging to atmosphere. In this case, the portions of paras. 4.5.3 (a) through (h) relating to capacity determination may be eliminated.

(*b*) *Back-Pressure Test.* Following the atmospheric back-pressure test, if performed, install the discharge arrangement required by Fig. 5 or 6, depending on type of back pressure desired.

4.8.4 Testing With Superimposed Back Pressure (Fig. 5)

(*a*) Adjust the back pressure on the valve and discharge piping to the required value. Increase the pressure at the valve inlet. During the pressure interval starting at 90% of the expected set pressure, the rate of pressure increase shall not exceed 2.0 psi/sec, or whatever lesser rate of increase is necessary for the accurate reading of the pressure. Observe and record the set pressure of the valve, the back pressure, and any other desired or pertinent characteristics.

(*b*) Continue increasing the pressure at the valve inlet until the valve remains open. Observe the action of the valve. Gradually decrease the inlet pressure until the valve closes. Record the reseating pressure of the valve and the back pressure. Observe the action of the valve.

NOTE: During (a) and (b) above, care shall be exercised to maintain the back pressure at as uniform a value as possible.

(*c*) Repeat (a) and (b), recording set and reseating pressures, and back pressure, until all are established and stabilized.

(*d*) Establish and maintain flow-rating pressure until flow instruments and back pressure gage indicate a steady-state condition.

(*e*) Record the following:

(*1*) valve-inlet pressure;
(*2*) valve-disk lift;
(*3*) liquid-inlet temperature;
(*4*) flow-meter differential pressure;
(*5*) back pressure.

(*f*) Decrease inlet pressure slowly and again record reseating pressure of valve and back pressure.

(*g*) In most instances, it is desirable, or a requirement, that the valve be tested over a given range of back pressure. In such cases, it is convenient if the value of back pressure chosen in (a) above be either the lowest or highest of this range. Back pressure may then be increased or decreased in increments, repeating (a) through (h) above at each incremental value.

4.8.5 Testing With Built-Up Back Pressure (Fig. 6)

(*a*) Increase the pressure at the valve inlet. During the pressure interval starting at 90% of the expected set pressure, the rate of pressure increase shall not exceed 2.0 psi/sec, or whatever lesser rate of increase is necessary for the accurate reading of the pressure. Observe and record the set pressure of the valve and any other desired or pertinent characteristics.

(*b*) Continue increasing the pressure at the valve inlet until the valve remains open. Adjust built-up back pressure to desired value. Observe the action of the valve. Gradually decrease the inlet pressure until the valve closes. Record the reseating pressure of the valve and back pressure. Observe the action of the valve.

(*c*) Repeat paras. (a) and (b), recording set and reseating pressures, and back pressure, until all are established and stabilized.

(*d*) Establish and maintain flow-rating pressure until flow instruments and back-pressure gage indicate a steady-state condition.

(*e*) Record the following:

(*1*) valve-inlet pressure;
(*2*) valve-disk lift;
(*3*) liquid-inlet temperature;
(*4*) flow-meter differential pressure;
(*5*) back pressure.

(*g*) Decrease inlet pressure slowly and again record reseating pressure of valve and back pressure.

(*h*) In most instances, it is desirable, or a requirement, that the valve be tested over a given range of back pressure. In such cases, it is convenient if the value of back pressure chosen in para. 4.8.4(a) be either the lowest or highest of this range. Back pressure may then be increased or decreased in increments, repeating (a) through (h) above at each incremental value.

4.8.6 Tests With Built-Up Back Pressure With Measuring Tank. The use of volumetric or gravimetric determination of valve discharge when testing with built-up back pressure is permissible. In such cases, the interested parties shall agree on a test procedure prior to conducting the tests.

4.8.7 Observation of Mechanical Characteristics. During the tests with superimposed or built-up back pressure, mechanical characteristics shall be observed by hearing, feeling, or seeing, and recorded during the flow test. If the valve chatters, flutters, or does not reseat satisfactorily, such action shall be recorded. Upon agreement of all interested parties, the valve may be readjusted and repaired and retested. When testing valves against back pressure, any range in which the valve does not reach rated lift at the flow-rating pressure shall be recorded.

4.8.8 Recording Additional Data. During the tests with superimposed or built-up back pressure, it may be desirable, or a requirement, to record pressures other than, or in addition to, those listed in para. 4.8.4 or 4.8.5. Where possible, such recorded pressure shall be identified in accordance with Appendix I. With closed discharge systems, it is not possible to observe or record some characteristic pressures.

4.9 TESTING WITH GAS OR AIR, RUPTURE DISK DEVICE FLOW RESISTANCE METHOD

4.9.1 Test Arrangement. A recommended test arrangement is shown in the flow resistance test rig arrangement, Fig. 9, which represents the test vessel and test device of Fig. 2. Rupture disk device shall have same nominal pipe size dimension as the test rig. Differential pressure measurement instruments or transducers shall be used between pressure taps A&B, B&C, C&D. The primary element shall be either a subsonic-inferential meter or sonic-inferential meter as shown in Fig. 2 and described in para. 4.2.4(a).

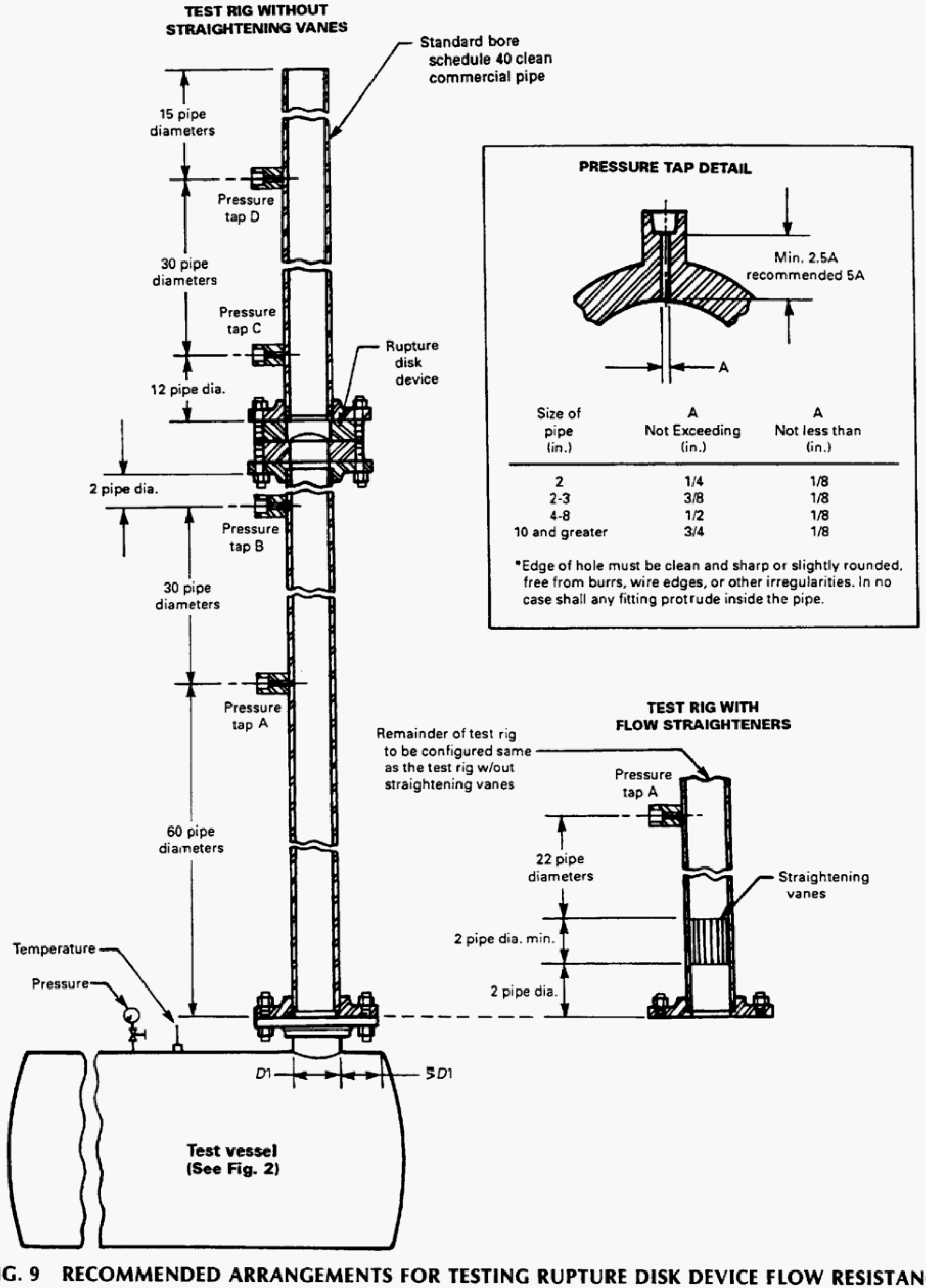
Instrumentation for each type of meter is listed in the following subparagraphs.

(*a*) *Subsonic-Inferential Meters.* Measurements associated with subsonic-inferential meters are:

(*1*) inlet static pressure;
(*2*) inlet temperature;
(*3*) differential pressure.

(*b*) *Sonic-Inferential Meters.* Measurements associated with sonic-inferential meters are:

(*1*) inlet total (stagnation) pressure;
(*2*) inlet total (stagnation) temperature.



Size of pipe (in.)	A Not Exceeding (in.)	A Not less than (in.)
2	1/4	1/8
2-3	3/8	1/8
4-8	1/2	1/8
10 and greater	3/4	1/8

FIG. 9 RECOMMENDED ARRANGEMENTS FOR TESTING RUPTURE DISK DEVICE FLOW RESISTANCE

4.9.2 Preliminary Tests. Preliminary tests may be permitted for testing the test apparatus. Such tests may be necessary to ensure the absence of leaks in the test apparatus and that all differential pressure measurement devices are functioning properly and within their pressure measurement range.

4.9.3 Barometric Pressure. Record the barometric pressure (see para. 4.2.1).

4.9.4 Details of Procedure for Flow Resistance Measurement Using Subsonic-Inferential-Meter Method

(*a*) Install rupture disk device into the flow resistance test rig.

(*b*) Increase the pressure at pressure tap B. During the interval starting at 90% of the expected set pressure, the rate of pressure increase shall not exceed 2.0 psi/sec, or whatever lesser rate of increase is necessary for the accurate reading of the pressure. Observe and record the set pressure of the device and any other desired or pertinent characteristics.

(*c*) Establish and maintain flow-rating pressure until flow instruments indicate a steady-state condition.

(*d*) Simultaneously record the following measurements (it is preferable to use a data acquisition system for these measurements)

(*1*) test rig inlet pressure
(*2*) test rig inlet temperature
(*3*) flow meter inlet static pressure
(*4*) flow meter inlet total temperature
(*5*) flow meter differential pressure
(*6*) tap B pressure
(*7*) differential pressure tap A-B
(*8*) differential pressure tap B-C
(*9*) differential pressure tap C-D

4.9.5 Details of Procedure for Flow Resistance Measurement Using Sonic-Inferential-Meter Method

(*a*) Install rupture disk device into the flow resistance test rig.

(*b*) Increase the pressure at pressure tap B. During the interval starting at 90% of the expected set pressure, the rate of pressure increase shall not exceed 2.0 psi/sec, or whatever lesser rate of increase is necessary for the accurate reading of the pressure. Observe and record the set pressure of the device and any other desired or pertinent characteristics.

(*c*) Establish and maintain flow-rating pressure until flow instruments indicate a steady-state condition.

(*d*) Simultaneously record the following measurements (it is preferable to use a data acquisition system for these measurements)

(*1*) test rig inlet pressure
(*2*) test rig inlet temperature
(*3*) flow meter inlet total pressure
(*4*) flow meter inlet total temperature
(*5*) tap B pressure
(*6*) differential pressure tap A-B
(*7*) differential pressure tap B-C
(*8*) differential pressure tap C-D

4.9.6 Recording Additional Data. During the subsonic or sonic-inferential-meter method of test, it may be desirable, or a requirement, to record pressures other than, or in addition to, those listed in para. 4.9.4 or 4.9.5. Where possible, such recorded pressures shall be identified in accordance with Appendix I.

lation to be able to evaluate the proper factors for refinement, through the measured capacity in pounds per hour (Item 25), and on to the flow rate through the meter in cubic feet per minute at some prespecified base condition.

Items 35 through 40 then provide for the calculation of the flow through the valve in cubic feet per minute at a reference inlet condition.

5.5.5 Air or Gas — Sonic-Flow Method. This technique meters the gas flow upstream of the valve under test. Care must be taken that all the metered gas passes through the valve or is accounted for in the calculations.

The flow equations, flow functions, correction factors, and procedures for calculation incorporated in Form 5.5.5 are in accordance with PTC 19.5.

The use of Form 5.5.5 is recommended for either air or gas and, with the addition of basic data and valve identification, the form follows the procedure of PTC 19.5.

This calculation follows through to evaluate the flow through the meter (Item 23) in pounds per hour.

Items 24 through 30 are then used to determine the flow through the valve in cubic feet per minute at a reference condition.

5.5.6 Fuel-Gas Flow — Flow-Meter Method. This technique meters the gas flow upstream of the valve under test. Care must be taken that all of the metered gas passes through the valve or is accounted for in the calculations.

The flow equations, correction factors, and procedures for calculation incorporated in Form 5.5.6 are in accordance with PTC 19.5.

Form 5.5.6 should be used for recording the data and computing the results. The first twelve items on this form are primarily for identification purposes.

Form 5.5.6 proceeds through the trial-flow calculation to be able to evaluate the proper factors for refinement, through the measured capacity in cubic feet per hour at some prespecified base condition converted from the required pounds per hour (Item 32).

Items 35 through 40 provide for the calculation of the flow through the valve in cubic feet per minute at a reference inlet condition.

5.5.7 Air or Gas Rupture Disk Device Flow Resistance Method. This technique measures the resistance due to the presence of a rupture disk device in a piping system. It is used in conjunction with either the flow-meter or sonic-flow meter methods described in paras. 5.5.4 or 5.5.5, respectively.

Form 5.5.7 should be used for recording the data and computing the results. The first seventeen (17) items on this form are for identification purposes and listing of the measured variables. Item 6, Measured Relieving Capacity, is obtained from either Form 5.5.4 or 5.5.5. Care must be taken that all of the metered gas passes through the test arrangement (see Fig. 9) or is accounted for in the calculations.

The remaining items on Form 5.5.7 are used to determine the resistance factor between each of the established pressure taps. An individual flow resistance associated with the rupture disk device is then calculated from these results.

Two test checks must be done to verify the test results.

First, verify that the value $K_{C\text{-}D}$ is within 3% of the value $K_{A\text{-}B}$. If not, verify that the test arrangement is properly set up. Next, run a calibration test with no rupture disk device installed to verify that the value $K_{C\text{-}D}$ is within 3% of the value $K_{A\text{-}B}$. If so, calculate the resistance factor $K_{B\text{-}D} = K_D - K_B$ and the pipe length $L_{B\text{-}D} = L_D - L_B$. Complete the rupture disk device individual flow resistance calculation, replacing $K_{B\text{-}C}$, $K_{\text{pipe B-C}}$, and $L_{B\text{-}C}$ with $K_{B\text{-}D}$, $K_{\text{pipe B-D}}$, and $L_{B\text{-}D}$, respectively, in equations 34 and 35. This is done since the air turbulence caused by the rupture disk device is affecting the true pressure reading of tap C.

Second, verify that the calculated pipe roughness from equation 33 is within the range 0.0018 to 0.00006. This is the range for schedule 40 clean commercial pipe.

TEST REPORT FORM 5.5.1 PRESSURE RELIEF DEVICE TESTED WITH STEAM AND WATER
Observed Data and Computed Results — Weighed-Water Method

(1) Test number
(2) Test date
(3) Manufacturer's name

Measured Device Dimensions

Valve
(4) Bore diameter, in. (d_b)
(5) Seat diameter, in. (d_s)
(6) Seat angle, deg.
(7) Valve-disk lift, in. (l)
(8) Actual discharge area, in.^{2} (a)

Non-reclosing Devices
(4) Minimum holder bore diameter, in. (d_b)
(5) Minimum net flow area in.^{2} (a)

Observed Data

(9) Length of test, min (t)
(10) Mass of water or condensate, lbm (w)
(11) Valve-steam leakage, lbm/hr (w_{v1})
(12) Condenser leakage, lbm/hr (w_{c1})

STEAM
Observed Data and Computed Results at the Device Inlet

(13) Set pressure, psig (P_{set})
(14) Flow rating pressure, psia (P_f)
(15) Back pressure, psig (P_o)
(16) Fluid temperature at the calorimeter, °F (T_{cal})
(17) Percent quality or deg. superheat
(18) Specific volume at reference condition, ft^3/lbm, V_{ref}
(19) Specific volume at inlet conditions, ft^3/lbm, V_{act}
(20) Measured relieving capacity adjusted to the reference condition, lbm/hr

$$W_h = \frac{60 \times w}{t} \sqrt{\frac{V_{act}}{V_{ref}}} + W_{vl} - W_{cl}$$

WATER
Observed Data and Computed Results at the Device Inlet

(21) Set pressure, psig (P_{set})
(22) Flow-rating pressure, psig (P_f)
(23) Back pressure, psig (P_o)
(24) Fluid temperature, °F (T)
(25) Density of water at inlet conditions, lbm/ft^3 (ρ_{act})
(26) Density of water at reference condition, lbm/ft^3 (ρ_{ref})
(27) Measured relieving capacity, lbm/hr

$$W_h = \frac{60 \times w}{t} + w_{vl}$$

(28) Relieving capacity adjusted to water at reference condition, lbm/hr

$$W_r = w_h \times \sqrt{\frac{\rho_{ref}}{\rho_{act}}}$$

(29) Relieving capacity in gpm of water at reference condition, (US. gallons) Q (gpm)

$$Q = 0.1247 \frac{W_r}{\rho_{ref}}$$

TEST REPORT FORM 5.5.7 RUPTURE DISK DEVICE TESTED WITH AIR
Observed Data and Computed Results — Flow Resistance

(1) Test number
(2) Test date
(3) Manufacturer's name
(4) Ratio of specific heats, k
(5) Molecular weight, mw
(6) Measured relieving capacity, W_h (lbm/hr) (from Form 5.5.4 or 5.5.5)
(7) Base pressure, P_B (psia)
(8) Base temperature, T_o (°R)
(9) Test rig inside diameter, D (ft)
(10) Length between tap A and B, $L_{A\text{-}B}$ (ft)
(11) Length between tap B and C, $L_{B\text{-}C}$ (ft)
(12) Length between tap C and D, $L_{C\text{-}D}$ (ft)
(13) Pressure @ tap B, P_{tapB} (psia)
(14) Differential pressure between taps A and B, $\Delta P_{A\text{-}B}$ (psia)
(15) Differential pressure between taps B and C, $\Delta P_{B\text{-}C}$ (psia)
(16) Differential pressure between taps C and D, $\Delta P_{C\text{-}D}$ (psia)

Flow Resistance Factor Calculation

(17) Mass velocity, G (lb/ft²-sec)
$G = W_h/(3600 \times \pi \times D^2/4)$
(18) Mach number at pipe entrance, M_1

$$M_1 = G/144\ P_B \sqrt{\frac{Y_1^{((k+1)/(k-1))}}{32.2 \times \text{mw} \times k/(1544 \times T_o)}}$$

Solve by iteration

$$Y_1 = 1 + \frac{(k-1) \times M_1^2}{2}$$

(19) Pressure at pipe entrance

$$P_1 = P_B\left(\frac{2}{2 + (k-1) \times M_1^2}\right)^{1/2}$$

(20) Temperature at pipe entrance

$$T_1 = T_o \times (P_1/P_B)^{(k-1)/k}$$

Calculating total resistance factor at each pressure tap A, B, C & D. Repeat steps (21) thru (26) for each tap.
(21) Temperature at pressure tap, T_{tap} (°R)

$$T_{tap} = T_1\left[\frac{-1 + \sqrt{1 + 2 \times (k-1) \times M_1^2 \times (P_1/P_{tap})^2 \times (1 + (k-1) \times M_1^2/2)}}{(k-1) \times M_1^2 \times (P_1/P_{tap})^2}\right]$$

(22) Sonic Velocity at pressure tap, C_{tap} (ft/sec)

$$C_{tap} = \sqrt{(32.2 \times k \times 1544 \times T_{tap}/\text{mw}}$$

(23) Specific volume at pressure tap, V_{tap} (ft³/lbm)

$$V_{tap} = (1544 \times T_{tap})/(\text{mw} \times 144 P_{tap})$$

(24) Mach number at pressure tap, M_{tap}

$$M_{tap} = G \times V_{tap}/C_{tap}$$

(25) Expansion factor at pressure tap, Y_{tap}

$$Y_{tap} = 1 + \frac{(k-1) \times (M_{tap})^2}{2}$$

(26) Total resistance factor to pressure tap, K_{tap}

$$K_{tap} = \frac{1/M_1^2 - 1/(M_{tap})^2 - ((k + 1)/2) \times ln[(M_{tap}^2 \times Y_1)/(M_1^2 \times Y_{tap})]}{k}$$

(27) Resistance factor between pressure taps A and B, $K_{A\text{-}B}$

$$K_{A\text{-}B} = K_B - K_A$$

(28) Resistance factor between pressure taps B and C, $K_{B\text{-}C}$

$$K_{B\text{-}C} = K_C - K_B$$

(29) Resistance factor between pressure taps C and D, $K_{C\text{-}D}$

$$K_{C\text{-}D} = K_D - K_C$$

(30) Friction factor, f

$$f = K_{A\text{-}B} \times D/(4 \times L_{A\text{-}B})$$

(31) Obtain the viscosity of air at T_B and P_B μ (centipoise)

(32) Reynolds number, N_{Re}

$$N_{Re} = D \times G/(\mu/1488)$$

(33) Pipe roughness E (inch)

$$E = 44.4 \times D \times [10^{(-1/(4 \times \sqrt{f}))} - 1.256/(N_{Re} \times \sqrt{f})]$$

(34) Pipe resistance factor between pressure taps B and C, $K_{pipe\ B\text{-}C}$

$$K_{pipe\ B\text{-}C} = \frac{4fL_{B\text{-}C}}{D}$$

(35) Test object individual flow resistance, K_{Ri}

$$K_{Ri} = K_{B\text{-}C} - K_{pipe\ B\text{-}C}$$

GENERAL NOTE: Equations for calculations are in accordance with Levenspiel paper, Lapple paper, Perry Handbook and Colebrook equation.

Colebrook, "Perry's Chemical Engineer's Handbook," Sixth Ed., McGraw-Hill Book Co., NY (1984).
Green, P. W. (Ed.), "Perry's Chemical Engineer's Handbook," Sixth Ed., McGraw-Hill Book Co., NY (1984).
Lapple, C. E., "Isothermal and Adiabatic Flow of Compressible Fluids," Trans. AIChE, 39, pp. 385–432 (1943).
Levenspiel, O., "The Discharge of Gases from a Reservoir Through a Pipe," AIChE Journal 23(3), pp. 402–403 (May 1977).