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Fluid flow in closed conduits — Connections for pressure signal transmissions between primary and secondary elements

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FOREWORD

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Austria	Hungary	Portugal
Belgium	India	South Africa, Rep. of
Chile	Italy	Spain
Czechoslovakia	Japan	Switzerland
France	Korea, Rep. of	United Kingdom
Germany	Netherlands	U.S.A.
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Fluid flow in closed conduits – Connections for pressure signal transmissions between primary and secondary elements

0 INTRODUCTION

This International Standard relates to the types of pressure difference primary elements for flow measurement, described in ISO/R 541 and ISO/R 781.

The chosen order of presentation follows a logical progression away from the origin of the pressure signal obtained from the primary element, through to the inlet of the secondary device.

It should be noted that in this context a secondary device is defined as a device receiving a differential pressure signal from a primary element and converting it, when necessary with the assistance of auxiliary power, into a signal of a different nature.

Methods of grouping the individual units are presented in a section that shows various types of installation layouts.

1 SCOPE

This International Standard describes means whereby a pressure signal from a primary element can be transmitted by known techniques to a secondary device in such a way that the value of the signal is not distorted or modified even though it may be changed into a signal of a different nature.

2 FIELD OF APPLICATION

This International Standard is concerned only with the pressure difference techniques of flow measurement. It does not consider the characteristics of the secondary devices, and it does not include transducers or other similar instruments. Electrical transmission techniques are not dealt with in this International Standard. Pressure transducers and microdisplacement secondary devices will be the subject of a separate International Standard.

3 REFERENCES

ISO/R 541, *Measurement of fluid flow by means of orifice plates and nozzles.*

ISO/R 781, *Measurement of fluid flow by means of Venturi tubes.*

4 PRESSURE TAPS

4.1 Location of pressure taps in horizontal pipes

The following positions of the wall pressure taps on the straight cylindrical pipe are recommended:

1) Gas : in the vertical meridian plane, upwards (see Notes 1 and 2).

2) Liquids : in a meridian plane with which the horizontal meridian plane is forming an angle not greater than 45° above or below according with the position of the secondary device (see Note 4).

3) Steam : in the horizontal meridian plane.

NOTES

1 The position of dry gas taps may be varied without risk from the position indicated in 4.1.

2 The position of wet gas taps should be vertical if possible to allow draining to occur. They should therefore be less than 45° off the vertical meridian plane.

3 In the case of gently sloping pipelines, i.e. the slope of which can be considered as negligible, it is often possible to maintain the taps on a horizontal plane by varying their individual positions relative to the pipe centre-line. It is particularly desirable that the taps are on a horizontal plane when hot liquid flow is to be measured with a view to avoiding corrections for altitude.

4 Care should be taken when using for liquids, a position in the horizontal meridian plane. If the liquid is clean it is advisable to avoid the risk of gas in the pressure lines by using a tap location below the pipe horizontal meridian plane. If, on the other hand, the liquid has a significant solid content, then a position above the horizontal centre-line is recommended. In neither case should the taps be more than 45° from the horizontal. The case where there is a considerable volume of gas in a liquid line is exceptional, and needs special consideration : a horizontal tap position should be used in conjunction with pipe gas vents and gas collecting chambers in the pressure lines (see section 11).

4.2 Location of pressure taps in vertical pipes

In the case of vertical pipes there are generally no problems as far as the radial position of pressure taps is concerned.

4.3 Pressure taps and connections

Shape, diameter, length and location of pressure taps should be in accordance with ISO/R 541, clause 6.2; note should be taken in particular of sub-clauses 6.2.1.2 and 6.2.1.6.

There should be no burrs of other irregularities on the inside of the pipe at the connections or along the edge of the hole through the pipe wall. In no case shall any fittings project beyond the inner surface of the pipe wall. Clearly where there is risk of solid or liquid blockage it is advisable to use a large tapping size within the limits given.

4.4 Practical requirements

Some typical arrangements for pressure taps are given in Figure 1, but it should be noted that the information is included for general guidance only.

5 ISOLATING VALVES

5.1 Isolating valves are needed to separate the entire measurement system from the main pipeline when necessary, but they should not affect the pressure signal.

It is recommended that isolating valves should be located immediately following the primary element. If condensation chambers are installed the isolating valves may be fitted immediately following the condensation chambers (see Figure 18).

The final choice both of the valve specification and its location is left to the instrument engineer and/or user. The recommendations given here are therefore subject to alterations which may be necessary in view of the operating conditions and the nature of the fluid.

Practical considerations include :

1) the installations of valves suited to the pipe pressure;

2) careful choice of both valve and packing, particularly in the case of corrosive or dangerous fluids, and with such gases as oxygen;

3) the need to use valves whose design does not affect the transmission of a pressure signal, particularly when that signal is subject to any degree of fluctuation or pulsation.

5.2 Valve passages

It is recommended that the general remarks about constancy of diameter given in section 10 should be used as a guide in this section as well. Thus, every attempt should be made to ensure in the case where the valve is immediately adjacent to the pressure tap that the internal diameter of valve connections and the minimum passage diameter inside the valve should keep a constant value and preferably not be less than the internal diameter of the pressure piping between the pressure taps and the valve, this latter diameter remaining unchanged as well over its whole length.

The valve should be of full bore valve type in order :

1) in the case of liquid flow, to avoid trapping gas bubbles in the valve structure;

2) in the case of gas flow, to avoid trapping liquid in the valve structure.

6 CONDENSATION CHAMBERS

The modern trend in secondary device design is toward the micro-displacement type of differential pressure unit. There are, however, still a range of instruments widely used throughout the world that have a capacity comparable to, but smaller than, the popular mercury U-tube type of device.

It is therefore necessary to consider variations in the capacity of condensation chambers, but it is not recommended that they should be entirely omitted, even when micro-displacement secondary devices are used.

It is suggested that except when used with micro-displacement devices, the shape of the condensation chamber should be as shown in Figure 2. For micro-displacement devices, the condensation chambers may take the form of short lengths of unlagged pipe between the pressure taps and the isolating valves.

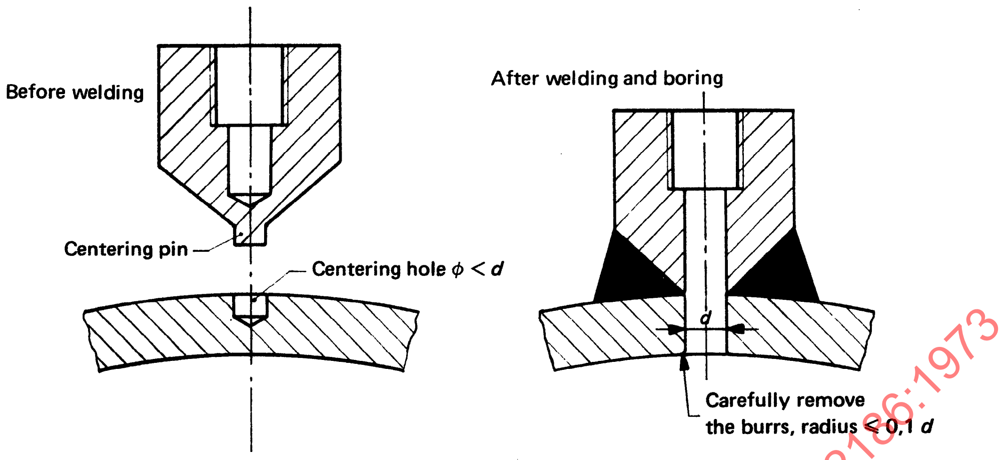
The capacities of the condensation chambers shown in Table 1 can be related both to secondary device maximum displacement at maximum head as well as to steam conditions, as shown in Figure 3. Generally, it is advisable to use condensation chambers that have a capacity two to three times that of the secondary device displacement, particularly when it is known or suspected that large and sudden variations in the flow rate may occur.

In the case of very high pressure/temperature steam, it is advisable to use a catchpot of approximately the same volume as the condensation chamber, to protect the primary element from damage caused by cool liquid from the pressure piping returning through the primary element as a result of a large and sudden change in flow rate. An example of arrangement is given on Figure 26.

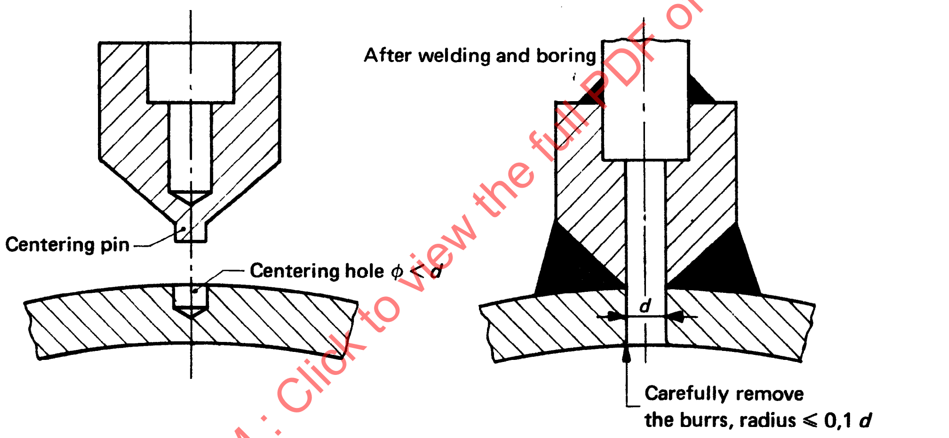
The connecting pipe between the primary element and condensation chamber/catchpot should be either of the same material as the pipeline, or of equivalent specification.

In the case of primary elements and condensation chambers installed in vertical mains, it is necessary to have both condensation chambers installed on the same level, preferably that of the higher tap, and lagged as shown in Figure 20 for example. The bore of the connecting pipe should be large enough to avoid any risk of blockage and secondary device response lag, and the pipe itself should be lagged.

For threaded connection



For welded connection



Flanged adaptor for low to medium pressure/temperature steam installation

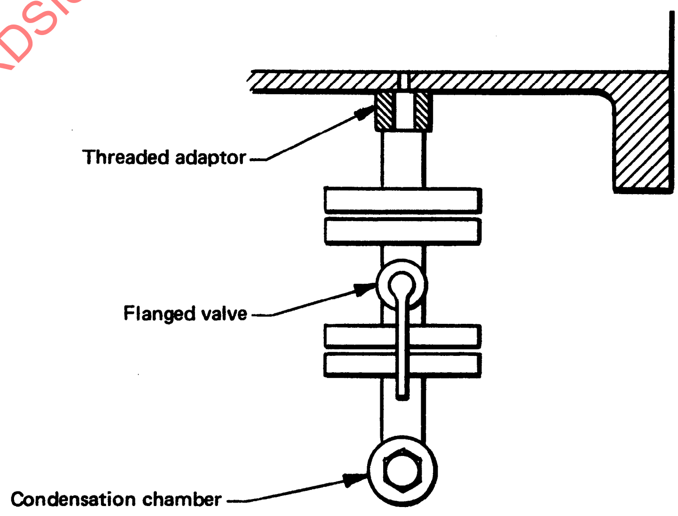
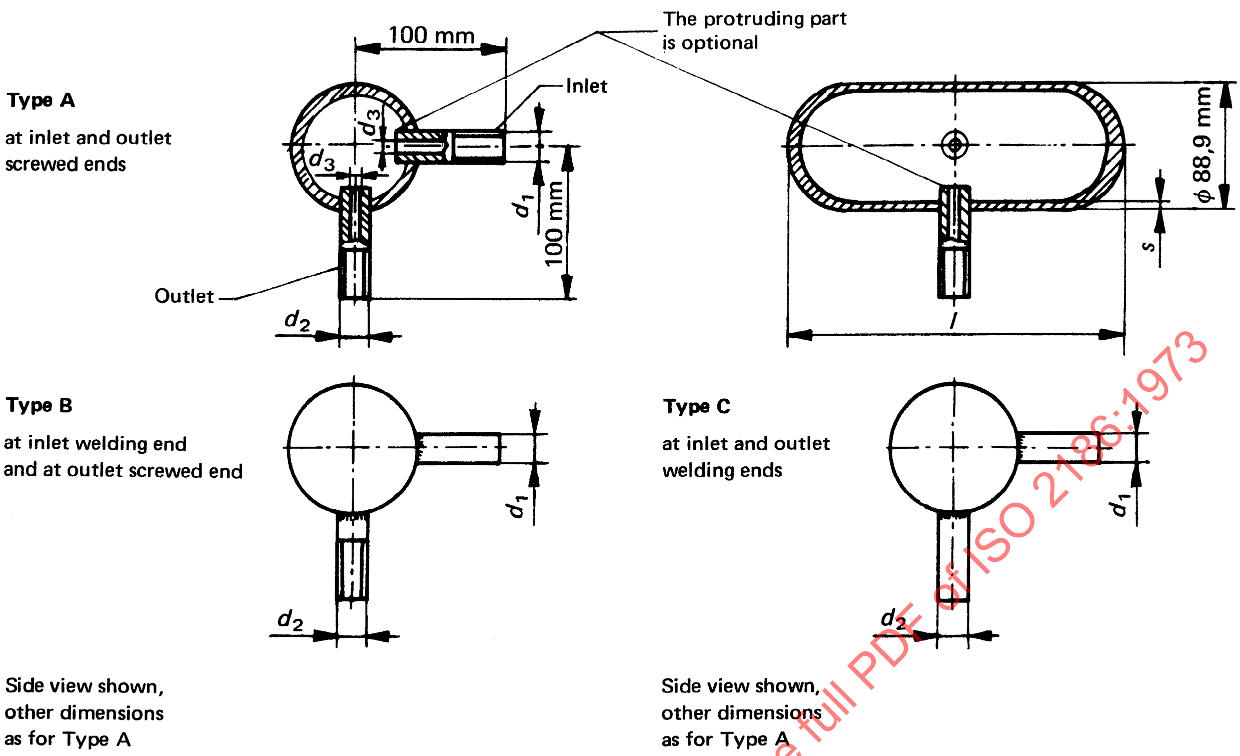


FIGURE 1 — **Typical arrangements for pressure taps**



NOTE — The pipe ends can also be fitted with flanges.

FIGURE 2 — **Condensation chamber characteristics, types A, B and C**

TABLE 1 — **Condensation chamber dimensions**

Size	**Type**	**Inlet d_1** Threaded end	**Inlet d_1** Welded end	**Outlet d_2** Threaded end	**Outlet d_2** Welded end	d_3	l	s	**Capacity**	**Test pressure**
		in	mm	in	mm	mm	mm	mm	cm3 ≈	bar *
1	A	1/2	–	1/2	–	8,7	230	5	800	190
	B	–	21,3	1/2	–					
	C	–	21,3	–	21,3					
2	A	1/2	–	1/2	–	8,7	100	5	250	
	B	–	21,3	1/2	–					
	C	–	21,3	–	21,3					
3	A	5/8	–	5/8	–	8	230	7,1	700	320
	B	–	24	5/8	–					
	C	–	24	–	24					
4	A	5/8	–	5/8	–	8	100	7,1	220	
	B	–	24	5/8	–					
	C	–	24	–	24					
5	C	–	24	–	24	8	230	12,5	600	540
6	C		24	–	24	8	100	12,5	170	

* 1 bar = 10^5 Pa

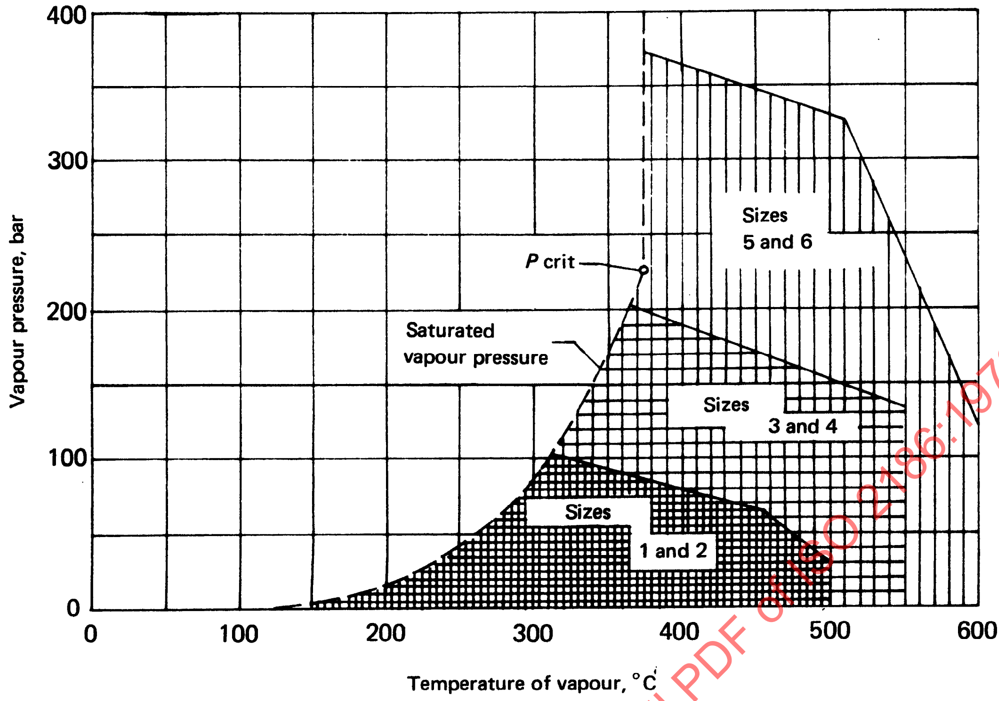


FIGURE 3 – **Range of application of condensation chambers**

NOTE – A vapour pressure-vapour temperature graph gives the limits within which the condensation chambers can be used. For the calculation of the wall thicknesses the vapour temperature was assumed to be 50 °C lower than the vapour temperature in the mains, since under operating conditions, the temperature in the condensation chambers never exceeds the temperature of the saturated vapour. Only when the pressure lines are blown down, i.e. in the non-pressurised condition, can the temperature in the condensation chambers approach the vapour temperature in the mains. Experiments have shown that the actual difference between the vapour temperature in the mains and temperature in the condensation chambers is greater than 50 °C.

7 GAS COLLECTING CHAMBERS AND SETTLING CHAMBERS

7.1 Gas collecting chambers

7.1.1 *Reasons for use*

In cases where it is thought that gas is present in a liquid that is to be measured, it is necessary to ensure that no gas can collect in the pressure piping between primary and secondary device, particularly when the latter is above the pipeline. Very often this can be avoided by laying the pressure pipes so that there is a continual slope between primary and secondary devices.

However, it is often necessary to arrange the pipe run so that there is a high point at which a gas collecting chamber or a vent valve can be installed as shown on Figure 11. Gas collecting chambers can be provided with either automatic or manual vent valves. The capacity of the chambers tends to vary with characteristics of the installation.

7.1.2 *Description of the technique*

A gas collecting chamber should be provided for each pressure pipe and, conveniently, should be mounted at the highest point of the pipe run, near to the secondary device and at an accessible location.

If the chambers are not provided with automatic vent valves, then a regular maintenance routine should be established for venting at intervals found necessary by experience.

7.1.3 *Drawings and dimensional data*

An example of construction of gas collecting chambers is shown in Figure 4. Although the capacity can be chosen according to requirements, it is recommended that the shape shown on the drawing be retained as well as the position of the inlet, outlet and release connections.

7.2 Settling chambers

7.2.1 *Reasons for use*

Settling chambers are often needed for liquid and gas installations.

In the case of liquid flow, they are necessary where there is a considerable amount of entrained solid that can block pressure pipes even if these are laid in accordance with general recommendations.

Settling chambers are most often necessary when the secondary device is below the pipeline.

In the case of gases, settling chambers are advisable when the measured fluid is both dirty and/or wet.

Settling chambers may be found useful for steam installations where pressure pipe scaling can develop.

7.2.2 *Description of the technique*

In all cases the settling chambers should be located at the lowest point of the pipe run.

If the secondary device is above the primary element it is advisable to include gas collecting chambers in the pressure piping system as well as settling chambers in the case of liquid flow.

7.2.3 *Drawings and dimensional data*

A typical design of settling chamber is shown in Figure 5. It is important that sufficient clearance should be available beneath the vessel to allow access to the drain valve.

The valve should preferably be a full bore type so that it can be cleaned and probed if blockage is suspected, or if the chamber is heavily encrusted with deposits.

It should also be noted that pressure holes, pressure pipe bores, and the connections to the settling chambers should be larger for very dirty liquids and gases.

The capacity of the settling chambers should be as large as practically possible or as large as the needs of the installation demand. The proportions given in Figure 5 are typical and should be sufficient for most purposes. However, the frequency of maintenance and the degree of solid and/or condensation entrainment are matters that should decide the size of settling chamber to use.

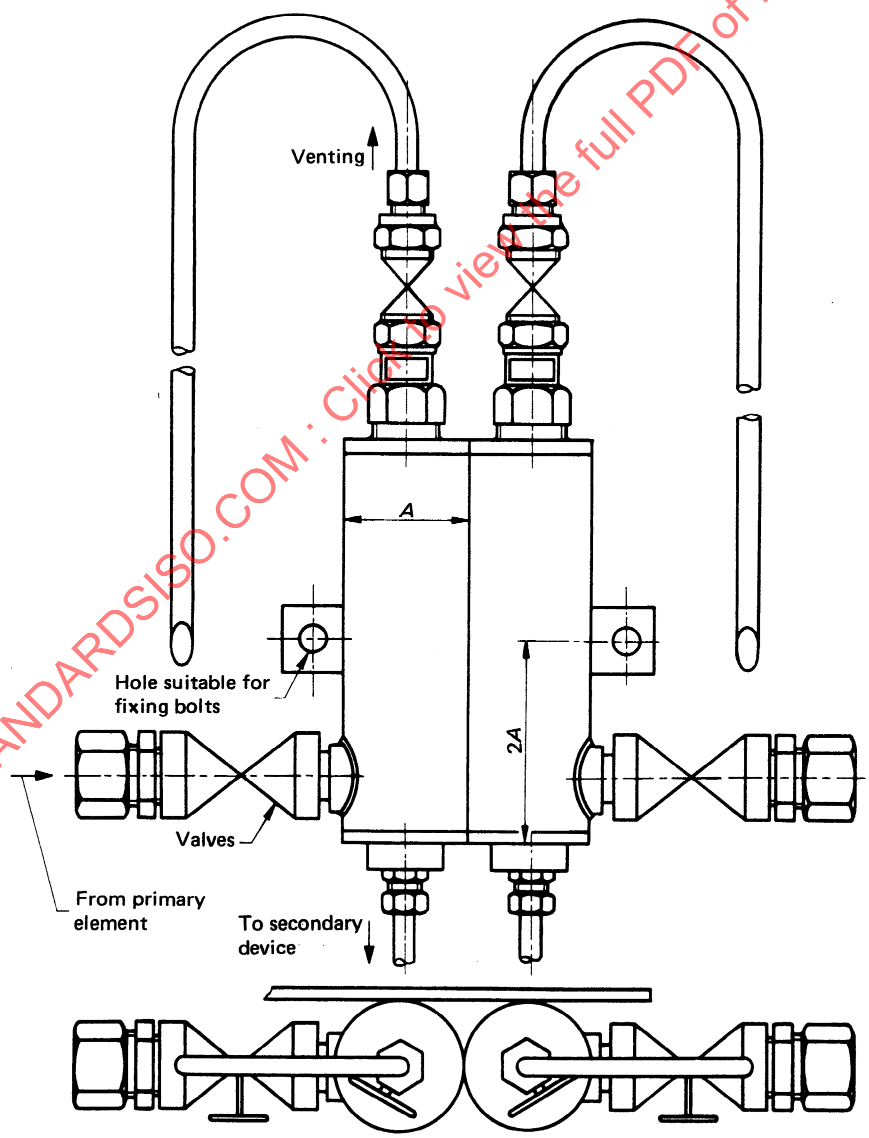


FIGURE 4 — **Arrangement of wall mounted gas collecting chambers and valves**

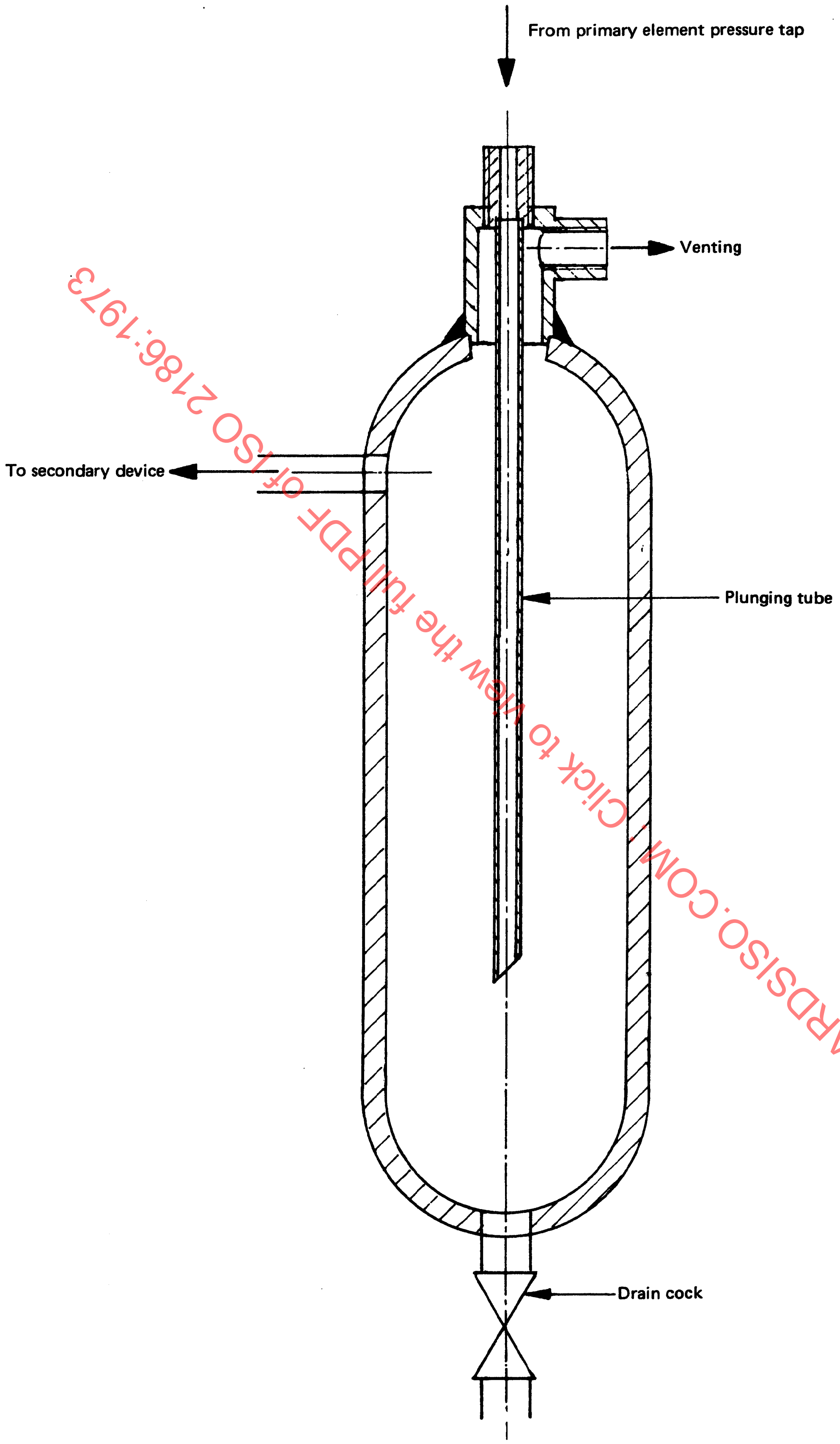


FIGURE 5 — **Settling chamber**

8 SPECIAL TECHNIQUES USED AS PROTECTION AGAINST VERY COLD AMBIENT CONDITIONS

In the cases where pressure pipes contain water it is possible to protect them against frost by the use of heating elements such as electrical tapes or steam coils.

The exact use of these techniques depends on the particular location, and advice cannot be generalized. It is important to ensure that the heating is controlled, uniform, and of equal amount to each pressure pipe and any auxiliary unit included in the pipe run. Where possible the pressure pipes should be run and lagged together, but care should be taken not to overheat liquids in the pipes since this may cause vaporization.

It may be noted that the same techniques are useful when warm or hot viscous fluids are metered, to prevent coagulation or blockage in cold pressure pipes and any other narrow passages.

9 SEALING CHAMBERS AND PURGE SYSTEMS

9.1 Sealing chambers

9.1.1 *Sealing chambers without partition*

Sealing chambers containing a liquid which separates the metered fluid from the fluid in the meter may be employed where :

- the metered fluid is corrosive;
- the metered fluid is likely to congeal, freeze or condense in the connecting pipes;
- the metered fluid is very viscous;
- deposits are likely to occur in the connecting pipes or in the meter, etc.

It must, however, not be forgotten that the pipes connecting pressure taps and sealing chambers will not be protected by the use of a sealing fluid.

The sealing fluid should not mix or react with the metered fluid or the manometric fluid and should differ in density from both fluids by an amount sufficient to ensure a stable interface.

Sealing chambers should be installed at the same level and as close as possible to the pressure taps. When there is a risk of congealing, freezing or condensation of the metered fluid, the connections from the pressure taps should be included in a pocket with the pipe lagging or be provided with supplementary heating. This might be provided as well for sealing chambers, if they are employed for liquefiable fluid flow measurements.

The general arrangements of sealing chambers are shown in Figures 6 and 7.

The interface between the metered and the sealing fluids should be at exactly the same level in both sealing chambers when there is no flow.

The filling level is determined by means of purge valves and where possible it is desirable to install visual means which allow constant control of the interface.

The sealing fluid fills the pressure pipes between the sealing chamber and the meter.

For guidance, suitable sealing chamber dimensions for industrial meters are about 100 mm diameter and 250 to 300 mm long.

Where micro-displacement devices are used the sealing chamber can be eliminated or replaced by a pipe.

In all cases, the sealing chamber capacity should be larger than the maximum volume of measuring liquid displaced in the meter. When designing sealing chambers it should be carefully checked that their inside diameters remain constant over the effective working area.

The meter reading should be corrected to take account of the displacement of the (sealing fluid/metered fluid) interface in the sealing chamber.

This correction will be of greatest importance when the difference in density is greatest between the sealing and metered fluids. When micro-displacement devices are used this correction is negligible.

Method by which differential pressure may be calculated when sealing chambers are used with a U-tube type of meter is given in Annex A.

9.1.2 *Sealing chambers with partitions*

When the physical and chemical characteristics of the metered fluid are such that a suitable sealing fluid cannot be found, sealing chambers with partitions may be used.

Diaphragm and bellows units are the simplest form of partition generally used.

It is necessary to ensure that both sealing chambers have the same stress/displacement characteristic.

The volumetric displacement of the sealing fluid over the full scale range of the meter should be greater than the maximum volume displaced by the meter itself.

Gas venting systems should be used on both sides of the partition.

In general the remarks in 9.1.1 apply equally to sealing chambers with partition.

In the cases where sealing chambers with partition are used it is normal for the manufacturer of such units to provide the relationship between input and output signals.

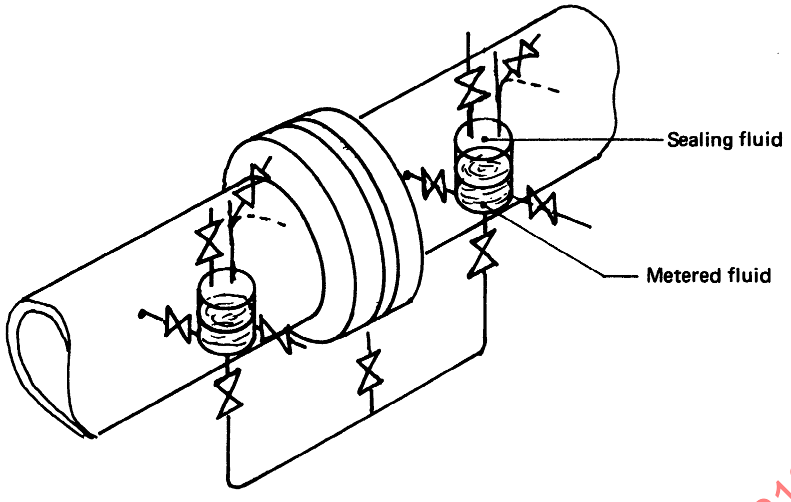


FIGURE 6 — **Sealing chambers — Metered fluid heavier than sealing fluid**

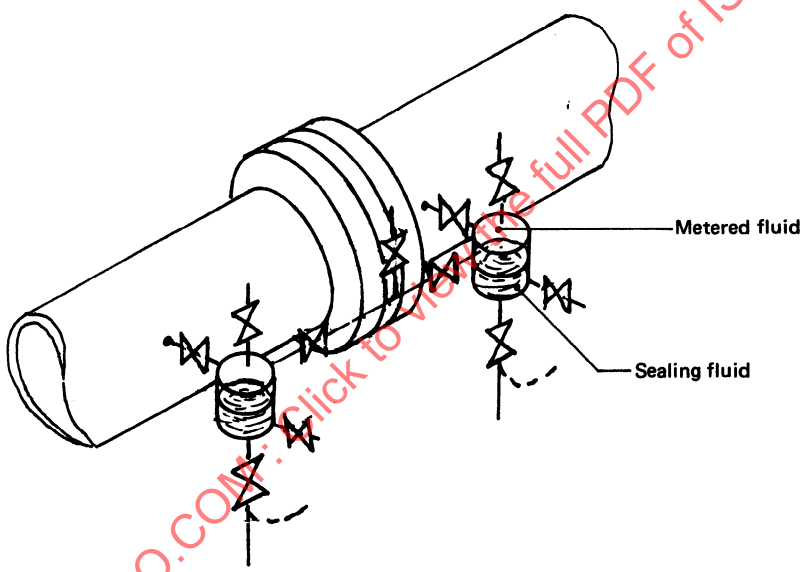


FIGURE 7 — **Sealing chambers — Metered fluid lighter than sealing fluid**

9.1.3 *Sealing liquids*

Some typical sealing liquids are given in Table 2.

TABLE 2 — **Properties of sealing liquids**

Kind of liquid	Density at the temperature 20 °C kg/m^3	Freezing temperature °C	Boiling temperature °C
Glycerine	1 262	− 17	290
Mixture of water and glycerine (Volume 1 : 1)	1 130	− 22,5	106
Dibutyl phthalate	1 047	− 35	340
Ethyl alcohol	789	−112	78
Ethylene glycol	1 113	− 12	197
Mixture of water and ethylene glycol (Volume 1 : 1)	1 070	− 36	110

9.2 Purge system

9.2.1 *General*

These techniques are intended to prevent dirty or dangerous fluids from entering the pressure pipes and the secondary devices, and they are, to some extent, an alternative to both settling chambers and sealing chambers. Generally, there are three ways in which purges may be used :

1) the introduction of gas into pressure pipes containing gases;

2) the introduction of gas into pressure pipes containing liquids;

3) the introduction of liquid into pressure pipes containing liquids;

The rate of purge will depend on :

- whether the measured flow is steady;
- the type of secondary device used;
- the total capacity of the pressure pipe runs.

It should be emphasized that in practice care should be taken to ensure that the purge does not influ^nce the performance of the secondary device nor the fluid temperature equilibrium between the two pressure pipes. Individual details are given in the following clauses.

9.2.2 *Introduction of gas into pressure pipes containing gas*

If the flow rate varies with time to a considerable extent, and the magnitude of variation is large, then it is best to use a purge flow rate equivalent to the meter total capacity between zero and maximum displacement in one minute. Steady flows do not need such a high purge flow, but very small purge rates should be avoided because they are difficult to control.

Equally, the use of larger purge flows will mean that special care will have to be taken to avoid an out-of-balance of pressure in the pressure piping. It would, for example, mean that pressure taps and pressure bores should be large enough to avoid pressure losses created by a large purge flow. For the same reasons it is always necessary to avoid changes of cross-sectional area at any point in the pressure pipe system when purge techniques are used. Furthermore, both the high and low pressure meter connections should be of the same length and have the same number of fittings.

In the case of long pressure piping, it may be necessary to place a pipe in which the purge fluid would flow up to the pressure tap and a second pipe, transmitting the pressure, to the secondary device, without pressure drop effect.

In order to keep the purge flow rates equal in both pressure pipes it is recommended that small variable-area meters or sight glasses be included in the purge system. They should be located at a point between the purge control valve and the point at which the purge flow enters the pressure pipes.

It is of course necessary to use gas purge pressures that are well above the pipeline pressure. Control of purge rate is usually obtained by means of some type of needle valve or a simple purge flow regulator.

Figures 8 and 9 show two examples of purge system installations.

9.2.3 *Introduction of gas into pressure pipes containing liquids*

The same general comments apply as given in 9.2.2, but there are important facts to note.

Gas purge into liquid filled pressure pipes can cause difficulty and error if the metered flow is unsteady, if small differential pressures are used, and if gas vessels are included in the pressure pipe system.

Furthermore, the considerable difference between the kinematic viscosities of the gas and the liquid, as well as surface tension effects, make abrupt variations in flow rate or pressure more difficult to counter and there is a real chance that, temporarily, the metered fluid will enter the pressure pipes and cause spurious differential pressure signals.

This technique is advantageous in cases where there is a low pipeline pressure, and the secondary device is located above the pipeline.

It is also important to note that with this system the secondary device is operating with gas although it is concerned with liquid flow, and therefore, that the secondary device has a dry calibration relationship between differential head and flow. It also is important that liquid/gas discontinuities in the pipe system should occur at the same levels.

9.2.4 *Introduction of liquid into pressure pipes containing liquids*

A liquid purge is useful when measuring effluents or sewage : in these cases a supply of clean water at the appropriate pressure will be sufficient. The previous remarks in this section still apply, except that there are no density/surface-tension problems. The purge flow rate can be decided on the same basis as before, but it will be necessary to reduce the pressure losses by using larger bore pressure pipes than those suitable for gases.

If the liquids are viscous or have other chemical properties that prevent the use of clean water, then care should be taken to choose a suitable purge fluid.

If a source of potable water is being used to supply a liquid purge, positive provision must be made to avoid back flow into the potable system.

9.3 Probe units

Often the purge systems described in this International Standard cannot entirely prevent blockage of the pressure taps themselves. In cases where measurements of fluids with entrained solids are required, it is recommended that probe units should be supplied as part of the purge installation. Descriptions of typical probe units are given in Annex B.

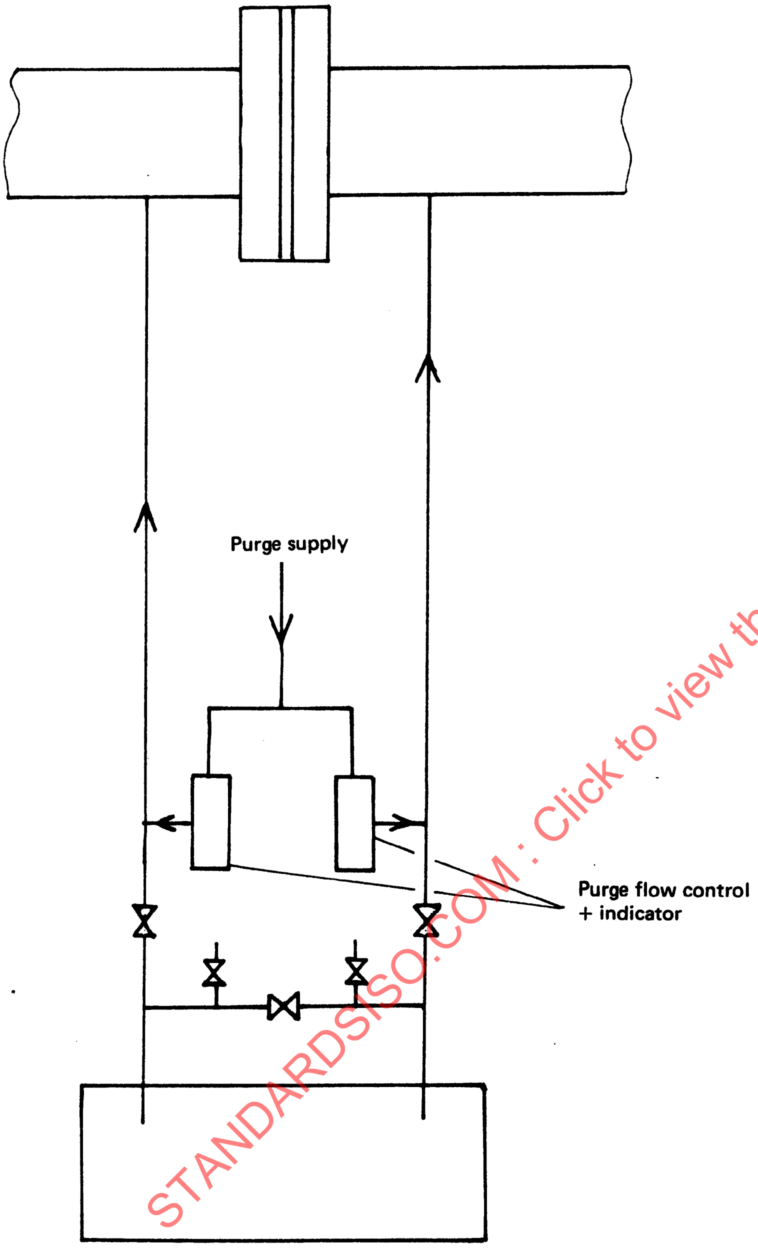


FIGURE 8 – **Example of purge system installation**

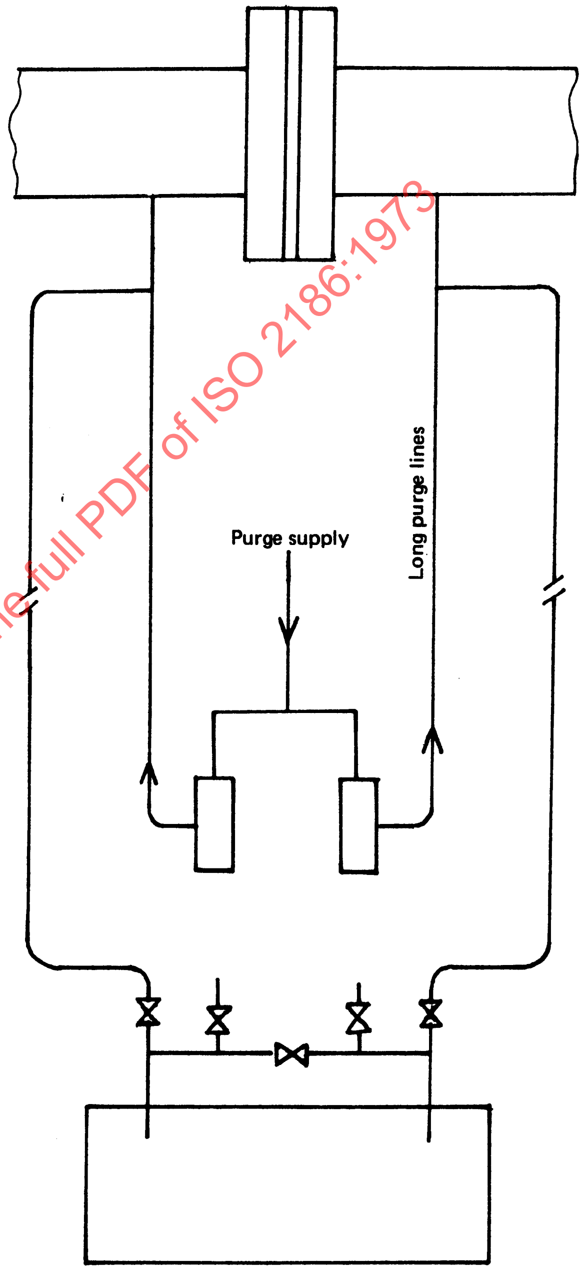


FIGURE 9 – **Example of purge system installation in the case of long pressure piping**

10 PRESSURE PIPING

The meter should be located close to the primary element; the speed of reponse is reduced if there is a long run. If possible the distance of transmission by pressure piping should not be greater than 16 m beyond which limit electrical/pneumatic transmission should be used. The two pressure pipes should be kept close together to avoid a false pressure difference arising from a difference in temperature. Where there is any risk of heating or cooling of the pressure pipes they should be lagged together. The bores of the pressure pipes should be the same and not smaller than 6 mm even with "clean" fluids and non-corrodible piping, owing to the chance of blockage after long service. If condensation is likely to occur or if gas bubbles are likely to be liberated, the bore should be not smaller than 10 mm.

The run of pressure pipes should be arranged so that their slope is always greater than 1 in 12 in order that any gas bubbles may rise to the vents and so that condensed liquids or solid deposits may drain into the catchpots or water seals. The slope should be increased if the liquid in the pressure pipes is more viscous than water. In the case of long runs (for example 30 m) or where obstructions have to be avoided, the pressure pipes may be run in a series of slopes provided that gas vents are fitted at all high points, or sealing chambers at all low points, as appropriate.

When long runs cannot be avoided, experience has shown that the data given in Table 3 are satisfactory and other recommendations given by various national bodies and organizations vary only marginally.

Further details about pressure piping can be noted from the various installation diagrams appearing in section 11, and also in Figures 27 and 28.

11 INSTALLATION

The arrangement of piping and units comprising transmission systems between primary and secondary elements, is given in this section.

11.1 Arrangement of valves

The arrangement of valves associated with the secondary device tends to vary with individual organizations and with applications.

The installation should include

a) valves in the high and low pressure piping adjacent to the inlet connections of the secondary device;

b) a valve (often called an equalizing valve) that enables any pressure difference that may exist between the high and low pressure branches of the system to be resolved.

Sometimes, the isolating valves at the primary element serve as those generally placed at the inlet connection to the secondary device.

Normally, there are also valves that control the venting of the meter system.

One commonly used arrangement of these various valves is that shown in Figures 10 to 25. However, it should be noted that, in certain cases, an arrangement as shown on the inset of page 14 is used; this arrangement presents the advantage of making possible the immediate detection of any leak.

11.2 Arrangement of pressure piping

Examples of arrangement of pressure piping (with their accessories) and pressure taps, up to the secondary device, are shown in Figures 10 to 27.

TABLE 3 — **Internal diameter of pressure pipe**

Values in millimetres

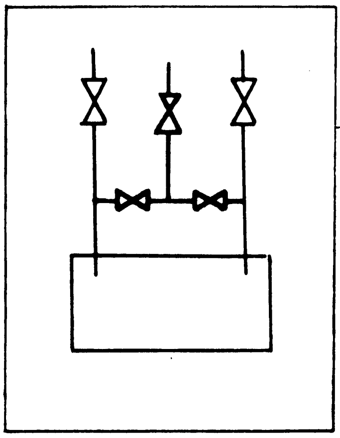
Type of metered fluid	Pressure signal transmission distance		
	0 to 16 m	16 to 45 m	45 to 90 m
Water/steam Dry air/gas	7 to 9	10	13
Wet air or gas (i.e. risk of condensation in pipes)	13	13	13
Oils of low to medium viscosity	13	19	25
Very dirty liquids or gases	25	25	38

TABLE 4 — **Applications**[1)]

Application	Figure No.	Description
Clean liquids	10	Meter below pipe line
	11	Meter above pipeline; cold liquids
	12	Vertical main; hot liquids
Dry clean gas	13	Meter above pipe line
	14	Meter below pipe line
	15	Meter above pressure taps; vertical main
	16	Meter below pressure taps; vertical main
Steam and dry condensable gas	17	Meter below pipe line
	18	Meter below pipe line, (alternative arrangement)
	19	Meter above pipe line
	20	Meter below pressure taps; vertical main
Clean wet gas	21	Meter below pipe line
	22	Meter below pipe line (alternative arrangement)
	23	Meter above pipe line
	24	Meter below pressure taps; vertical main
	25 a) and b)	Meter above pressure taps; vertical main (alternative arrangements)
High temperature, high pressure steam	26	Typical arrangement for either horizontal or vertical main
	27	Alternative arrangement for either horizontal or vertical main

1) These arrangements are typical; the principles underlying them may be used for any arrangement of pressure taps, for both horizontal and vertical pipe lines and for meters above or below the primary element.

Clean liquid



Alternative arrangement of manifold, applicable to Figures 10 to 25 as well as 28 and 29

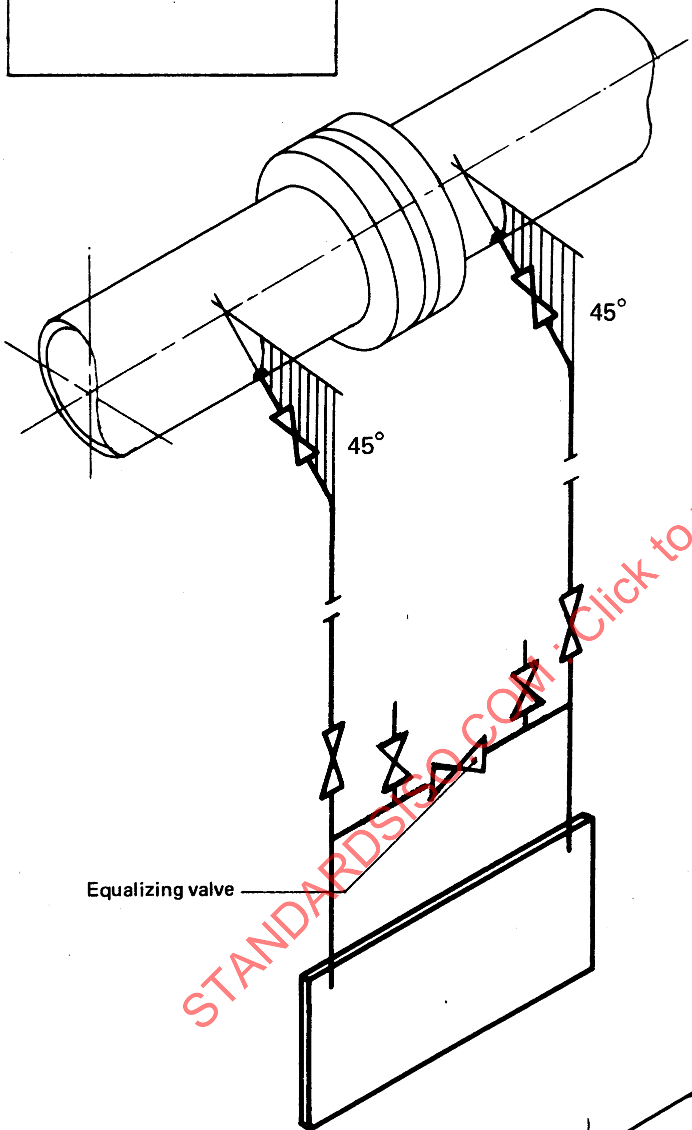


FIGURE 10 – **Meter below pipe line**

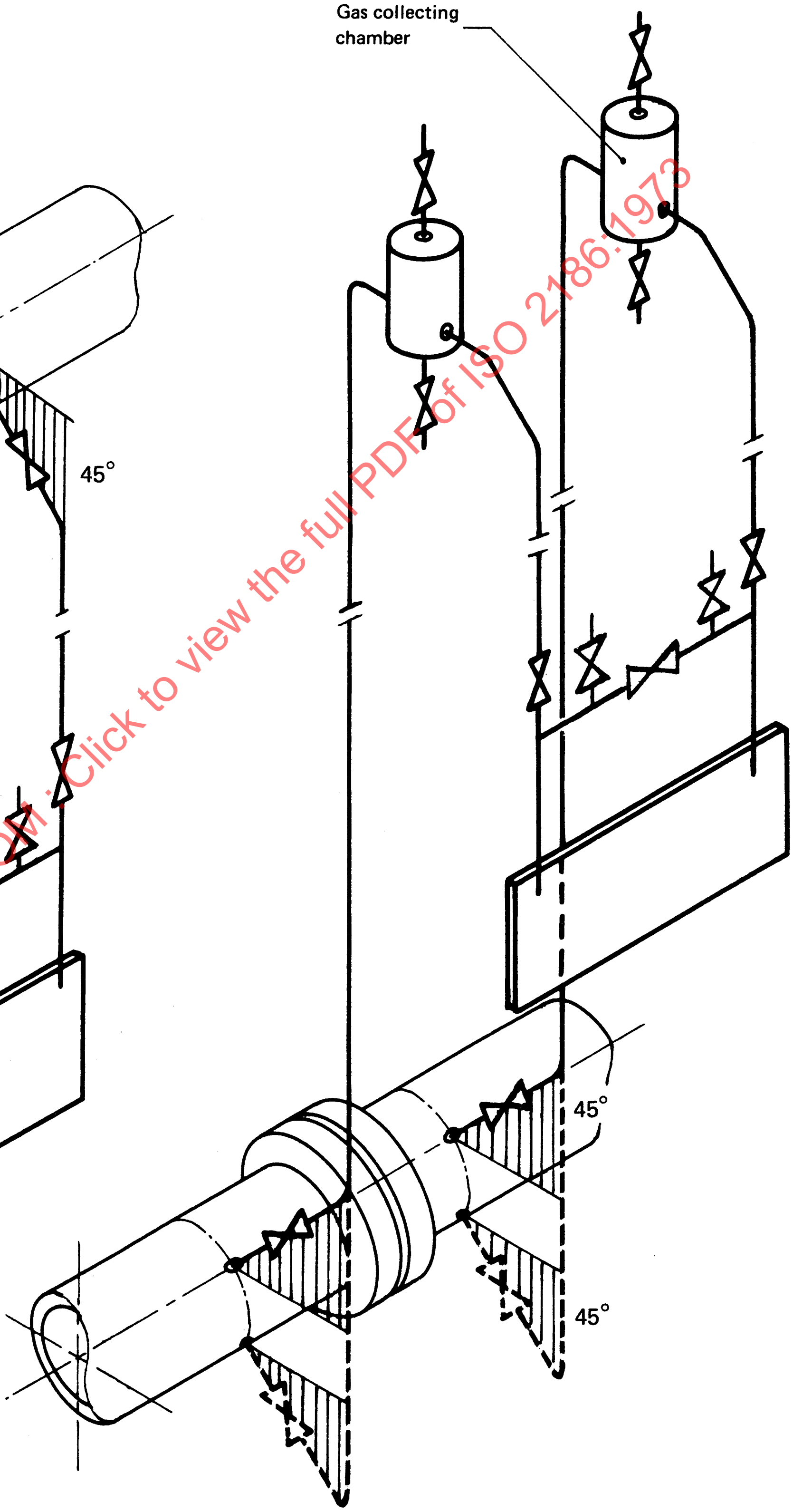


FIGURE 11 – **Meter above pipe line; cold liquids**

Clean liquid

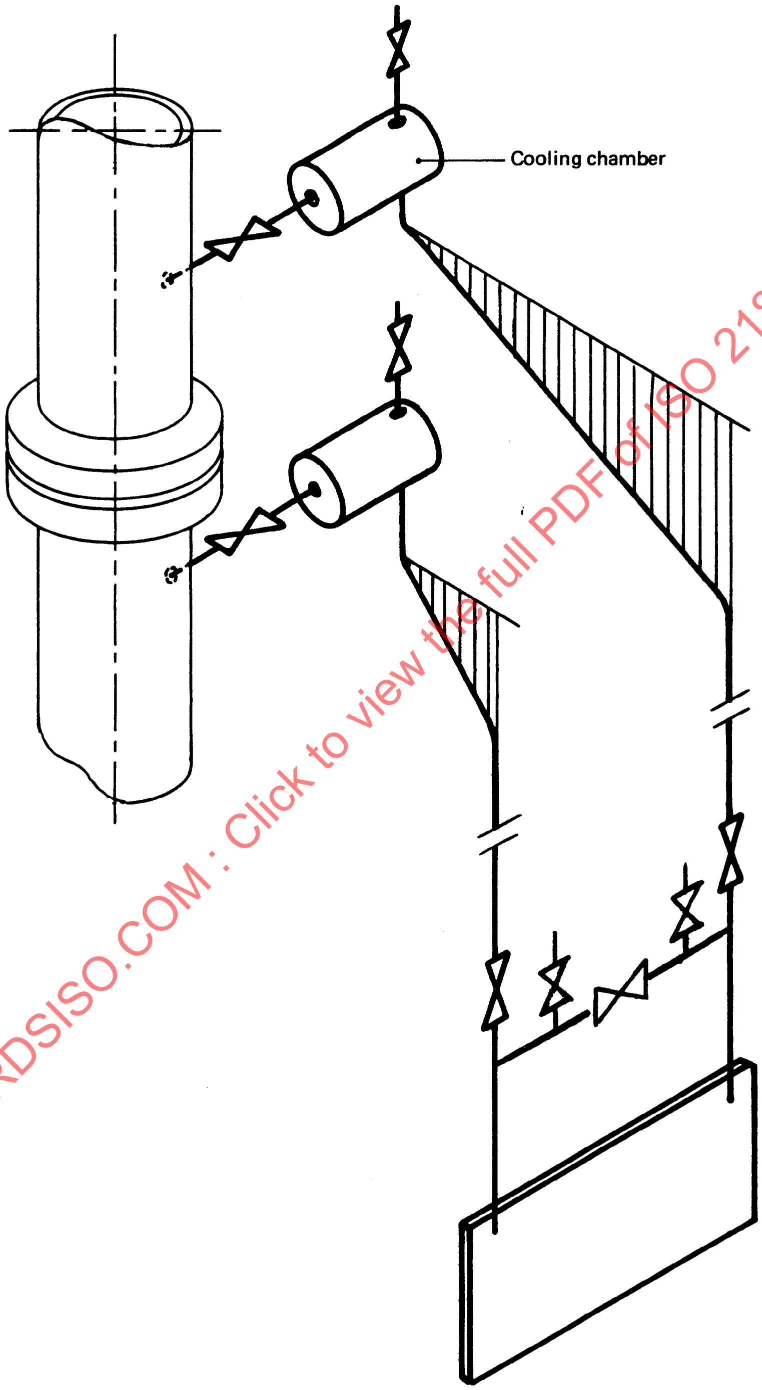


FIGURE 12 – **Vertical main; hot liquids**

Clean dry gas

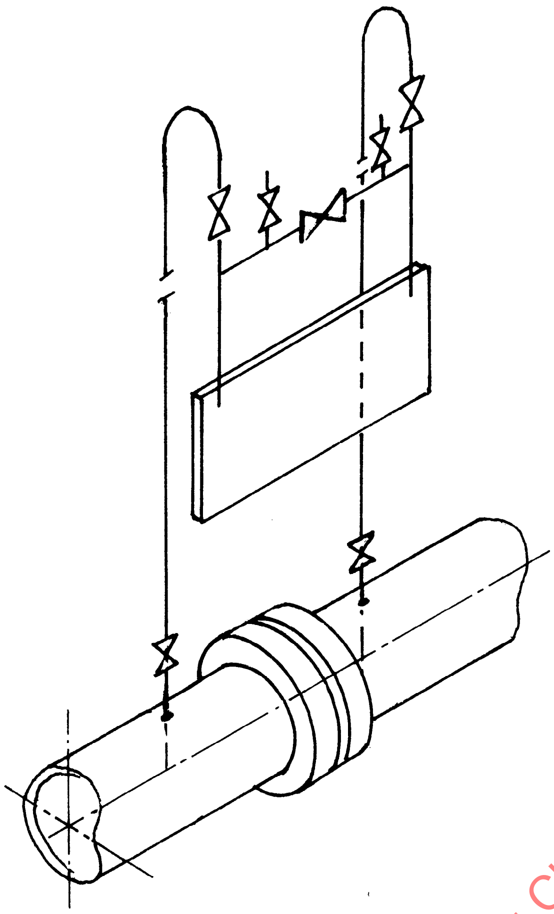


FIGURE 13 — **Meter above pipe line**

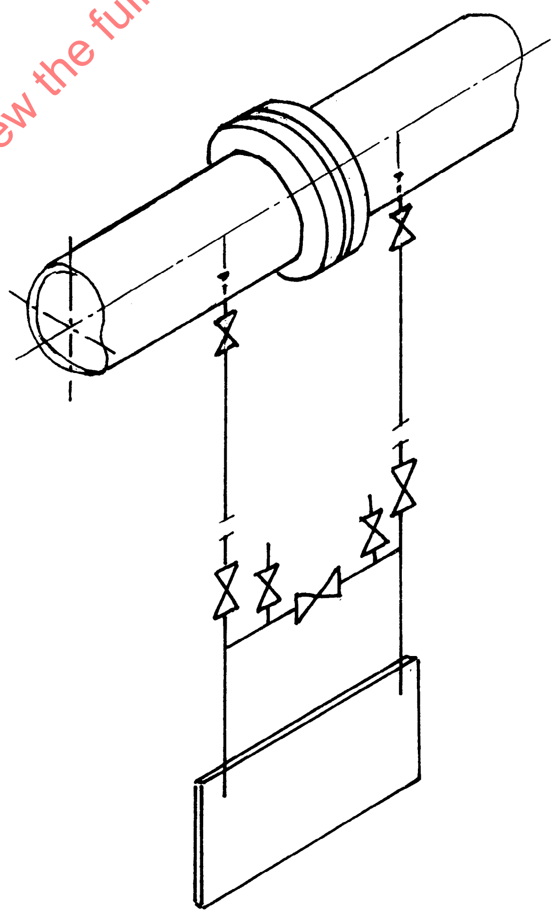


FIGURE 14 — **Meter below pipe line**

Clean dry gas

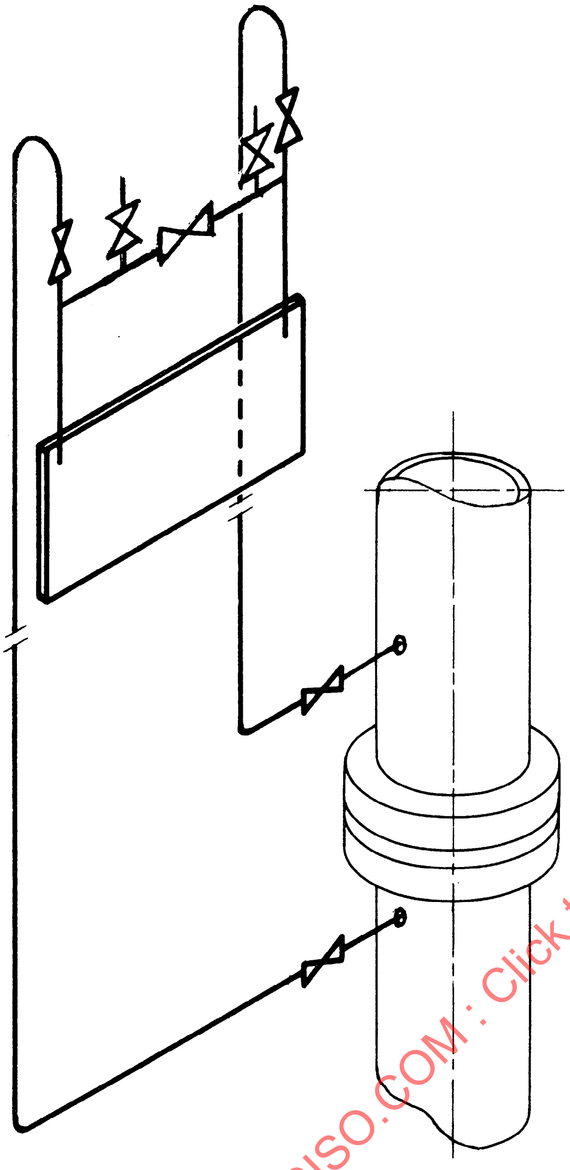


FIGURE 15 – **Meter above pressure taps; vertical main**

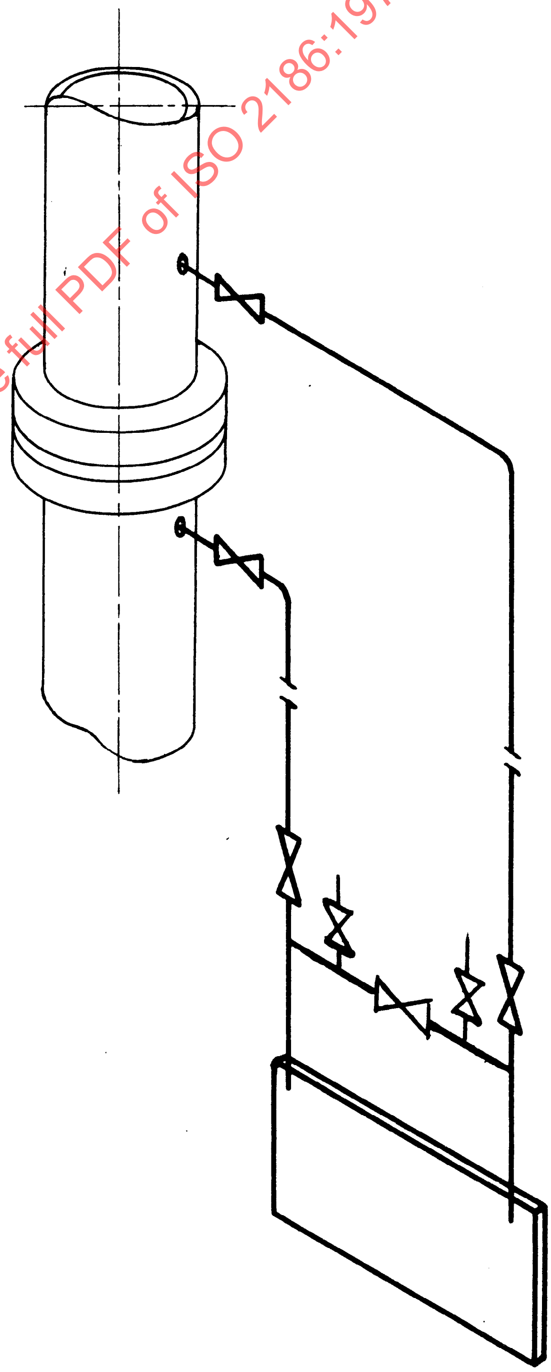


FIGURE 16 – **Meter below pressure taps; vertical main**

Steam and dry condensable gas

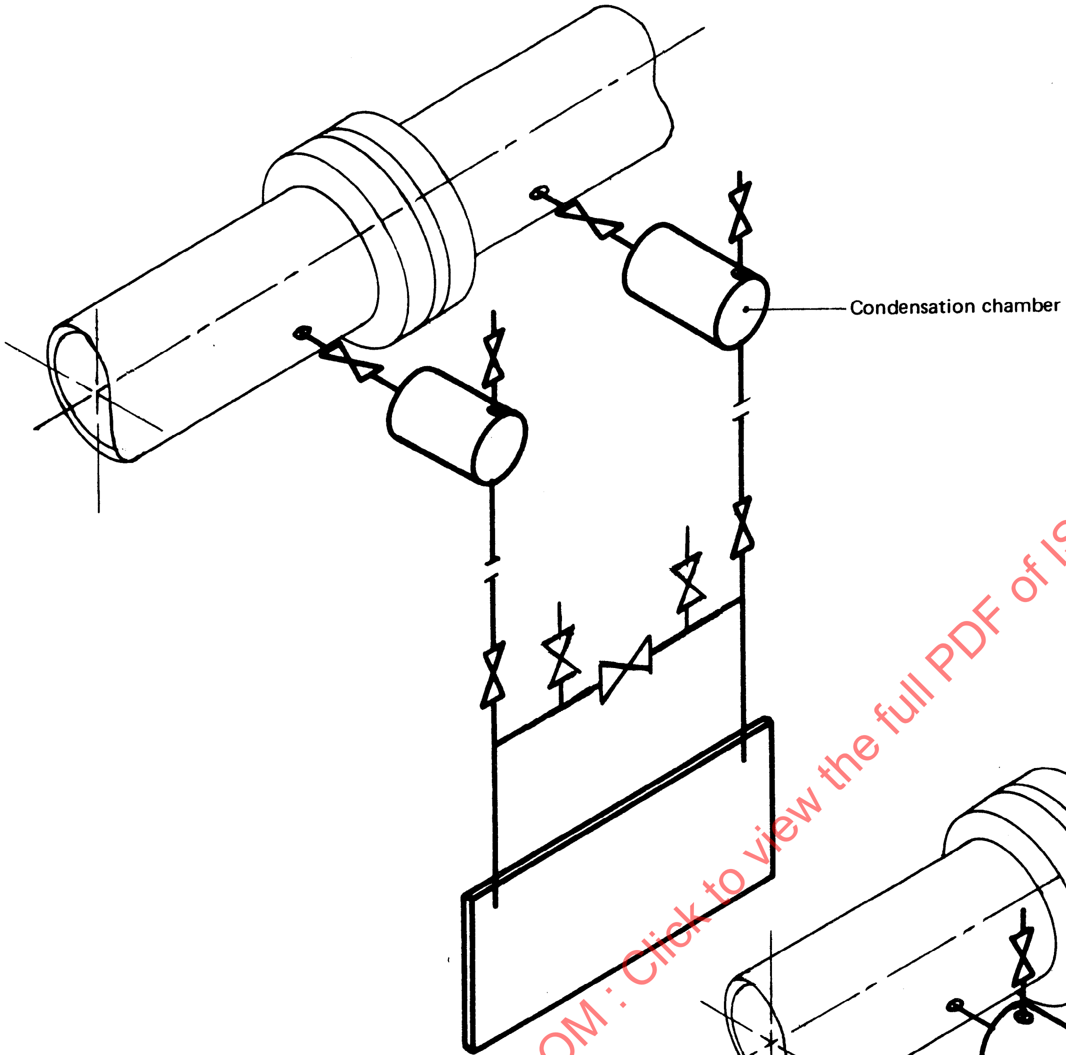


FIGURE 17 – **Meter below pipe line**

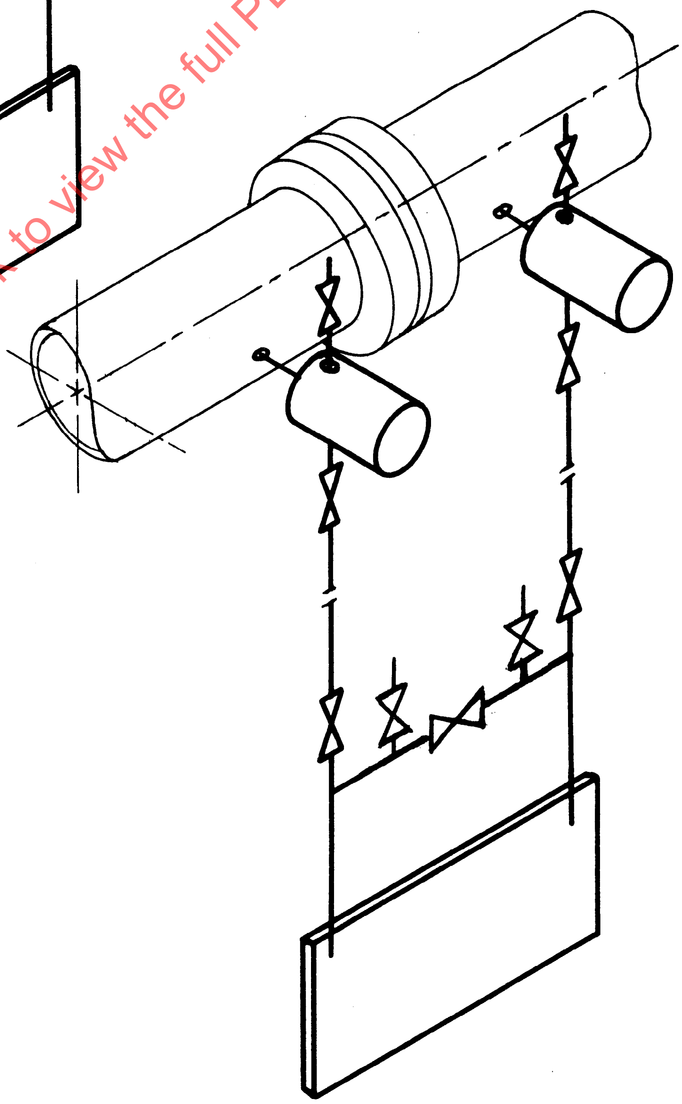
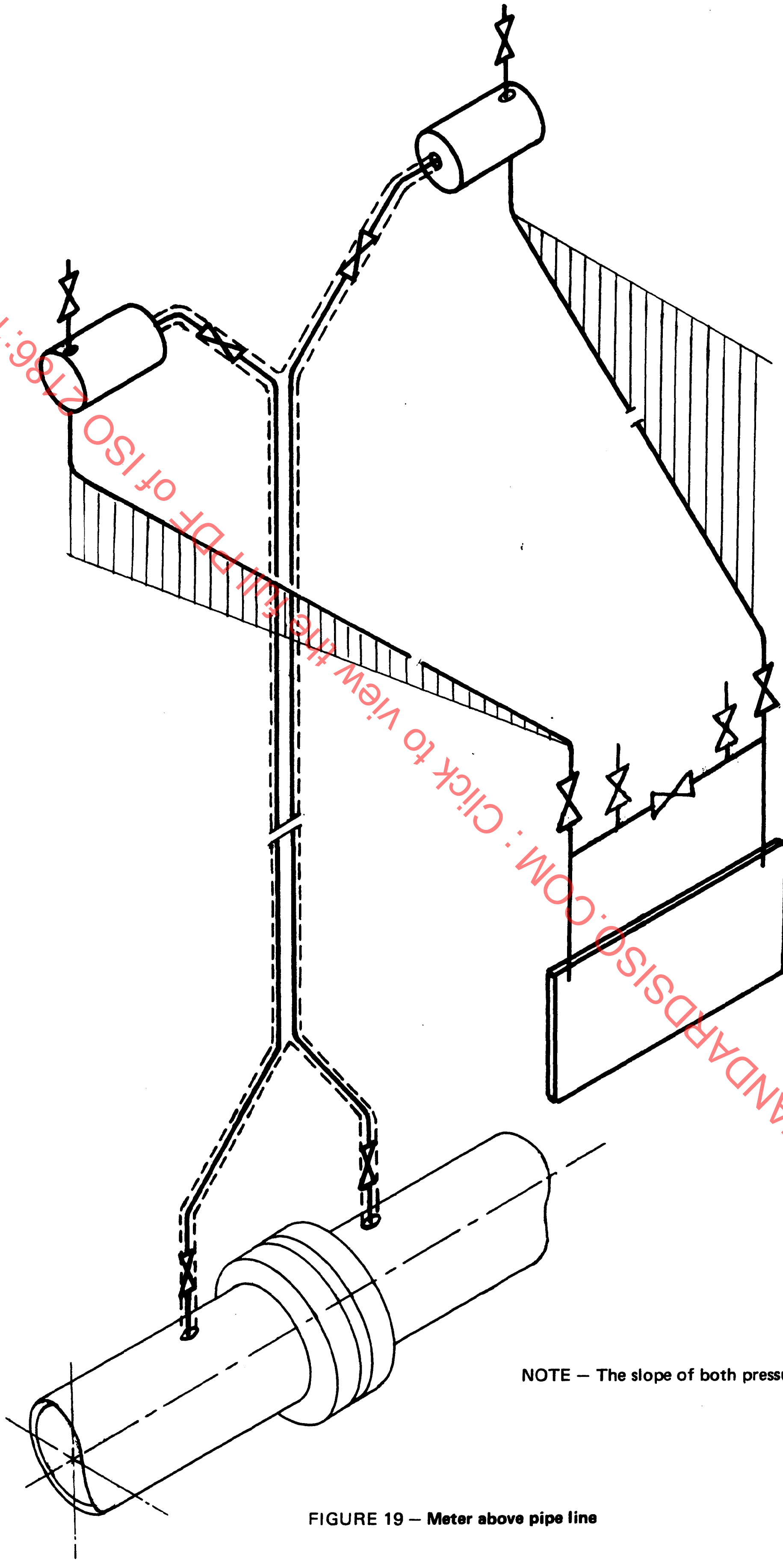


FIGURE 18 – **Meter below pipe line (alternative arrangement)**

Steam and dry condensable gas



NOTE – The slope of both pressure piping is the same.

FIGURE 19 – **Meter above pipe line**

Steam and dry condensable gas

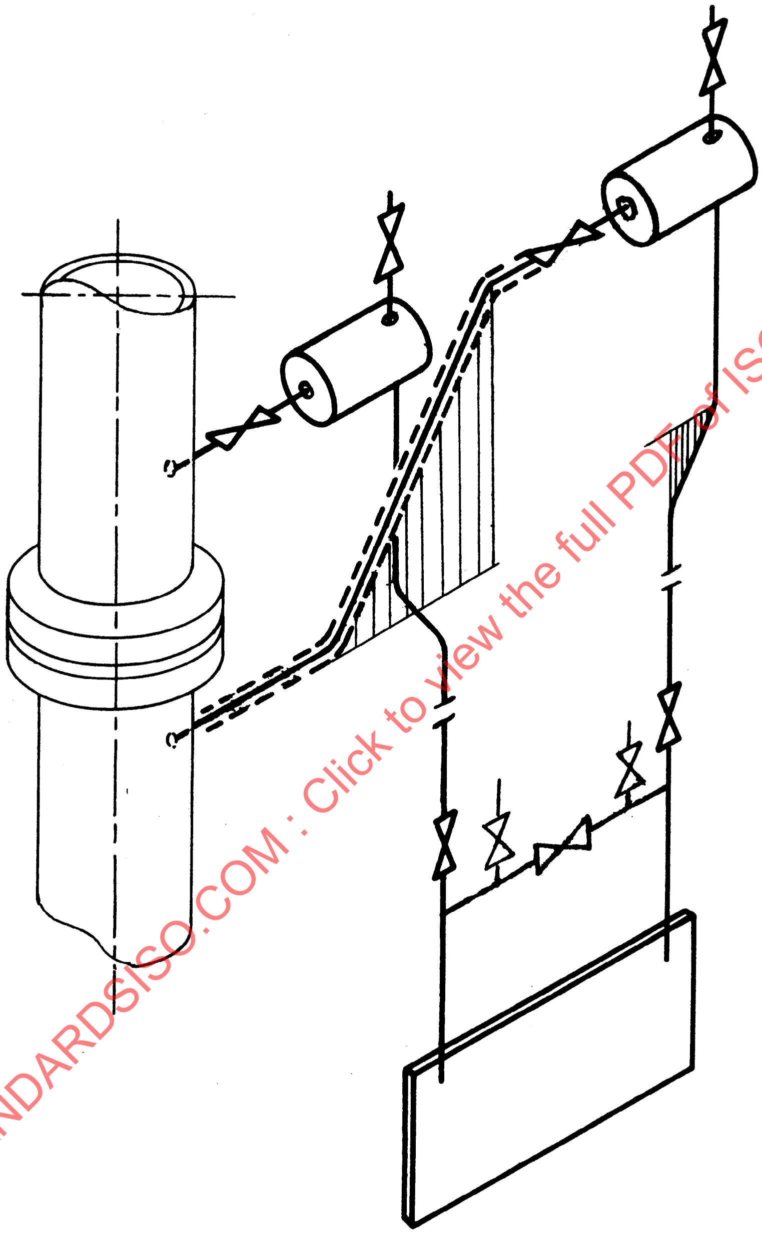


FIGURE 20 — **Meter below pressure taps; vertical main**

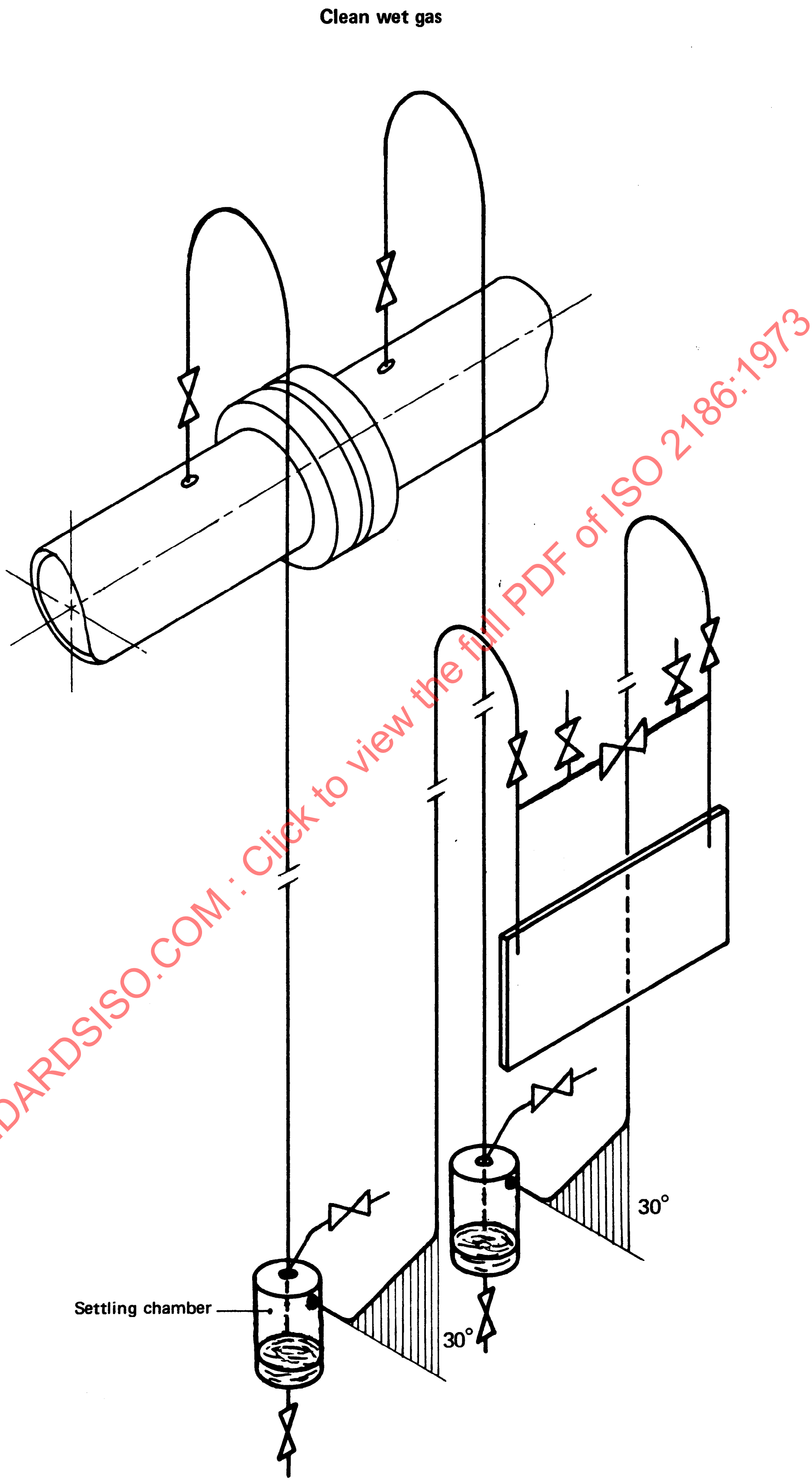


FIGURE 21 – **Meter below pipe line**

Clean wet gas

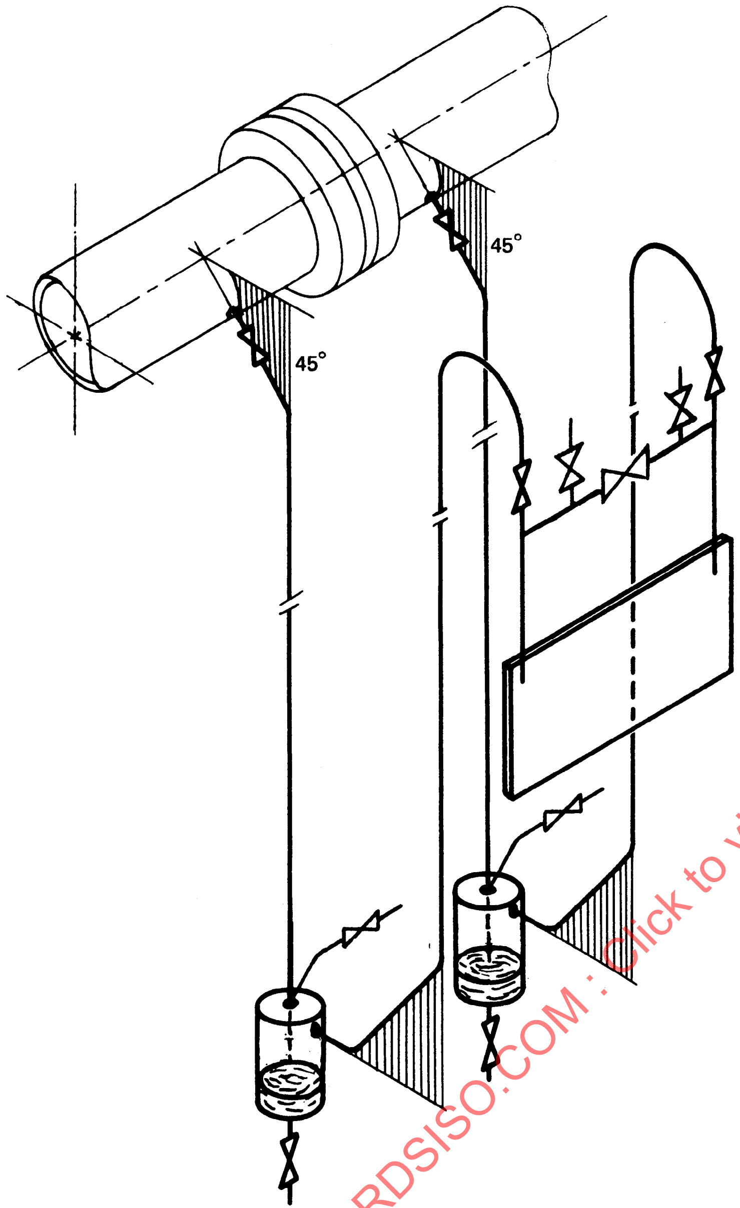


FIGURE 22 — **Meter below pipe line (alternative arrangement)**

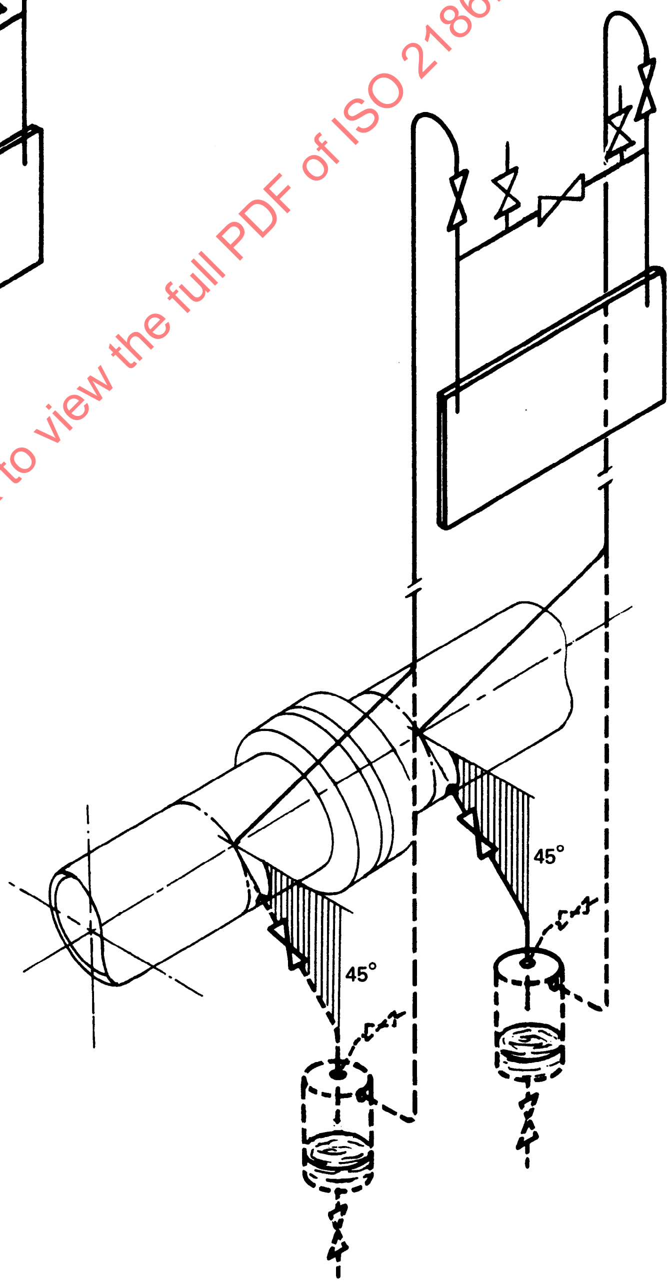
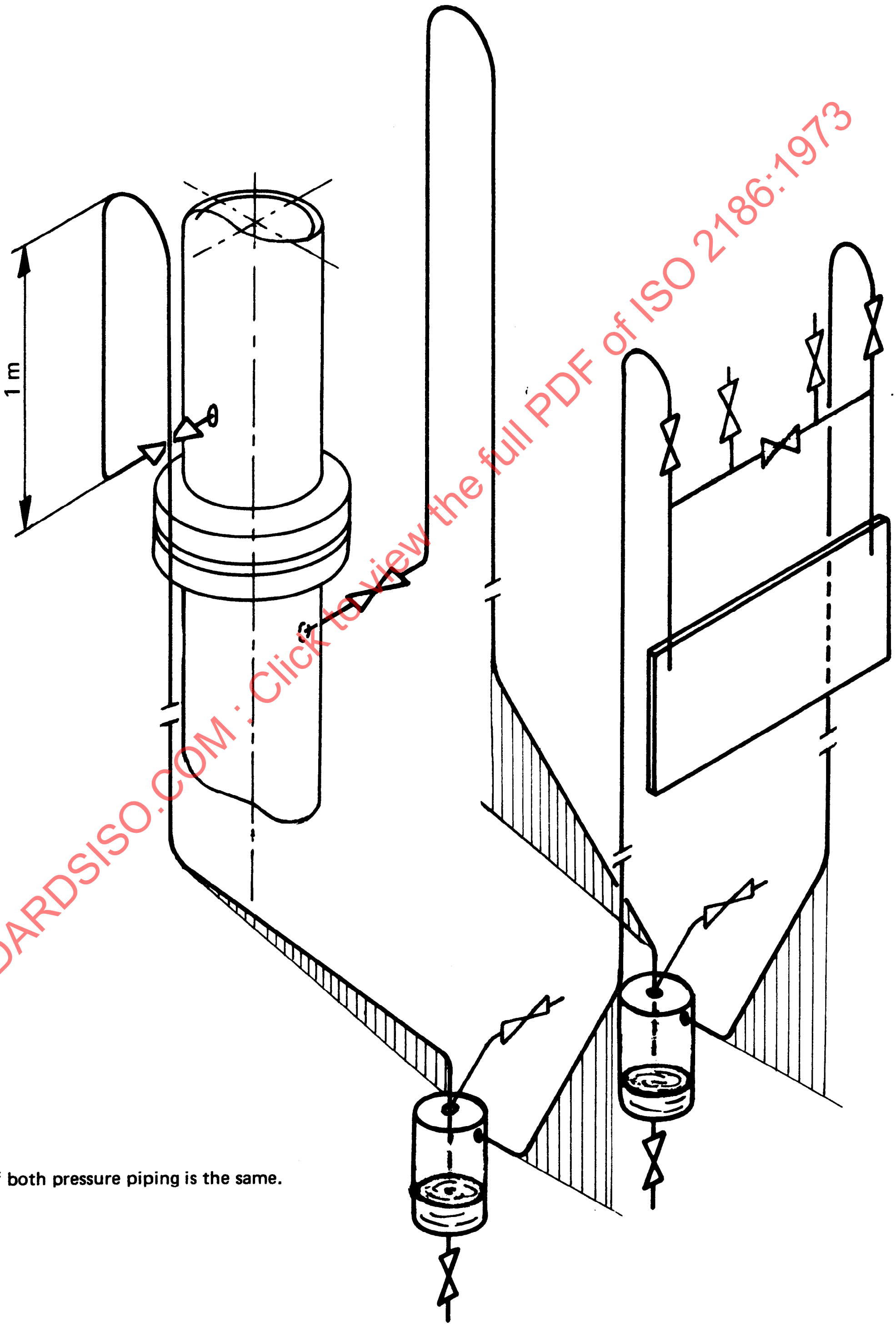


FIGURE 23 — **Meter above pipe line**
(Figure showing two alternatives)

Clean wet gas

NOTE — The measurement of wet gas in vertical pipes should be discouraged owing to the risk of blockage of pressure taps.



NOTE — The slope of both pressure piping is the same.

FIGURE 24 — **Meter below pressure taps; vertical main**

Clean wet gas

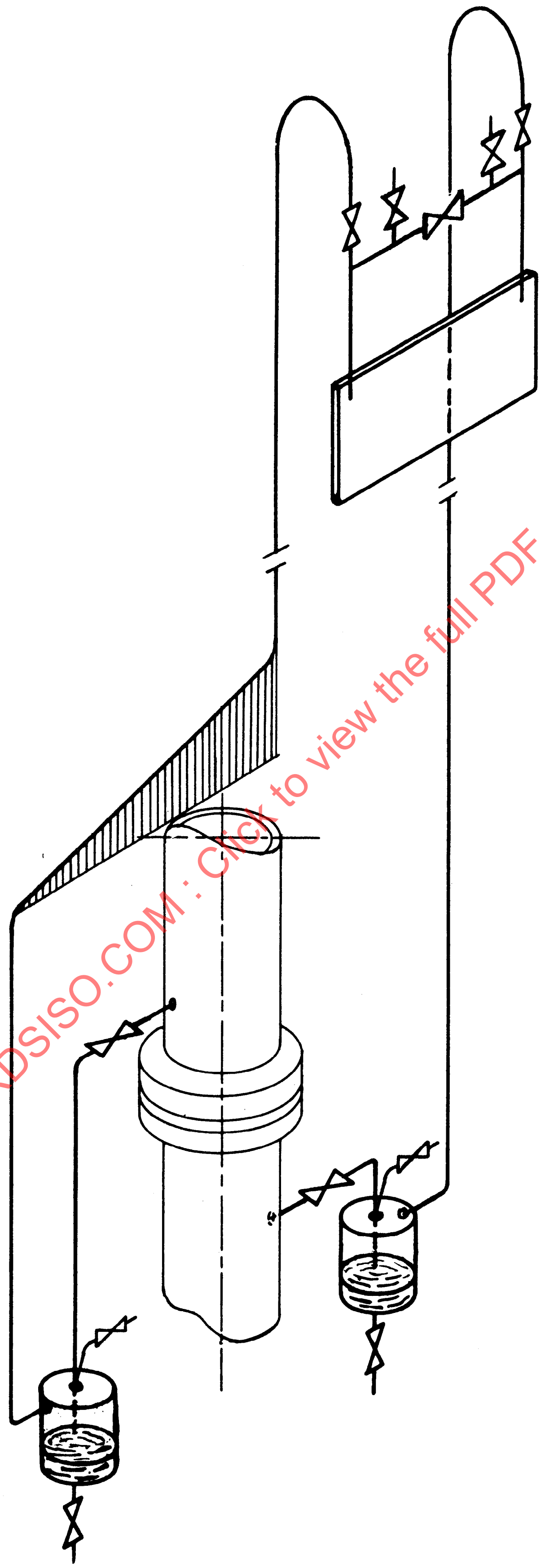
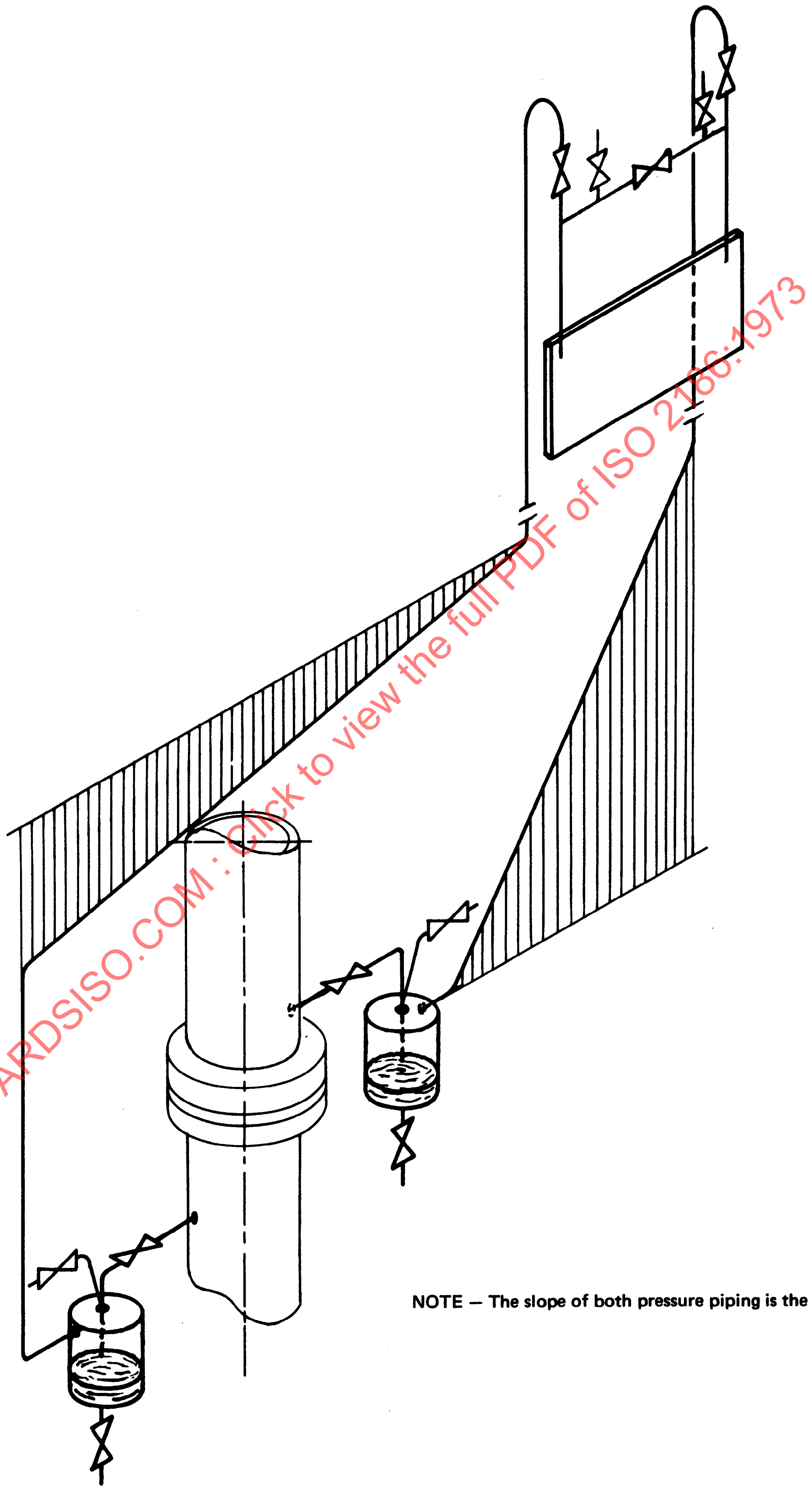


FIGURE 25 a) — **Meter above pressure taps, vertical main** (alternative arrangement)

Clean wet gas



NOTE – The slope of both pressure piping is the same.

FIGURE 25 b) – **Meter above pressure taps, vertical main** (alternative arrangement)

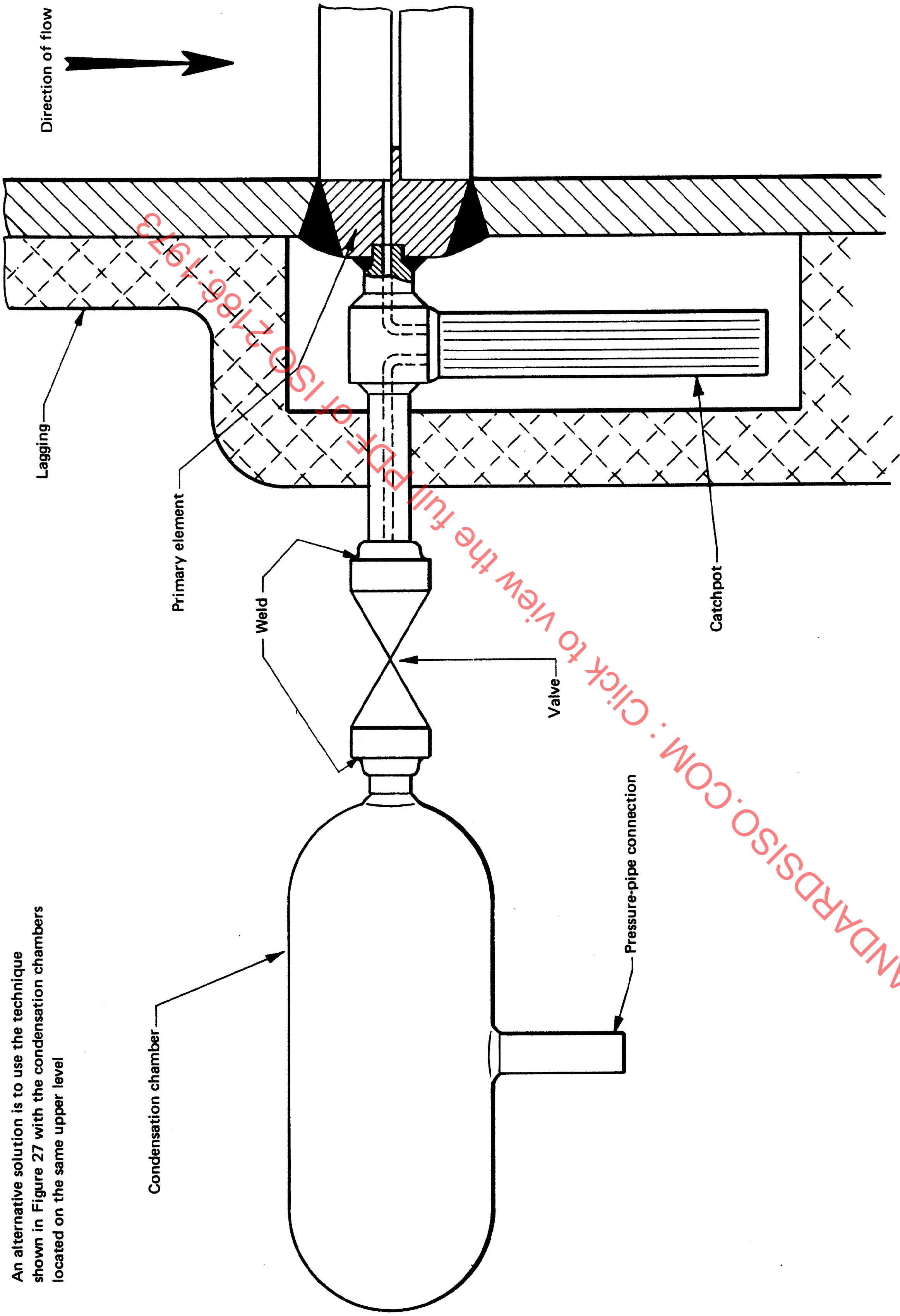


FIGURE 26 — Arrangement of high-pressure/temperature steam fitting for vertical main

An alternative solution is to use the technique shown in Figure 27 with the condensation chambers located on the same upper level