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INSTALLATION MANUAL

CONE METER
HFV-SERIES

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Contents

1. General Description and Specifications

1) Introduction

The Cone Meter is a process control and multi-fluid meter that uses differential pressure to provide accurate, repeatable and cost-optimized measurement solutions.

2) Applications

The Cone Meter is designed to work in unprocessed and processed applications, and is ideal for upstream, midstream and downstream applications that present a wide range of measurement challenges. The Cone is ideal for low-pressure coal-bed methane wellhead and field applications, compressor anti-surge control, and test separator applications.

3) Meter Components

The meter comprises three primary elements, as shown in Figures 1.1

- a meter body or tube with or without flanges
- a cone assembly, either fabricated or machined from a solid piece of metal, positioned in the center of the meter tube
- a pair of pressure taps—a wall tap upstream and an integral sensing tap downstream—for reading the differential pressure in the center of the pipe

The meter can be manufactured from various materials (carbon, stainless, or duplex stainless steel) to meet the specific requirements for metering steam, air, natural gas, digester gas, nitrogen, ethanol, and a host of liquids from crude oil to waste water.

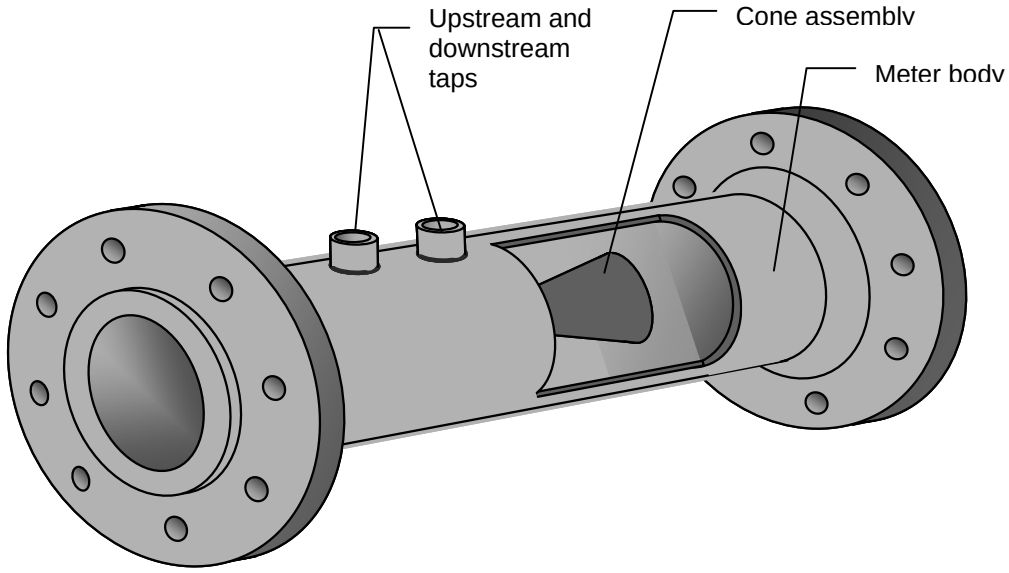

Figure 1.1—Basic components of the Cone Meter

The Cone Meter has no moving parts, and is designed such that there are no areas where debris or fluid particles can lodge, so it is virtually maintenance-free.

4) Meter Nameplate

The nameplate affixed to the Cone Meter (Figure 1.2) contains specifications for the meter, including the coefficient of discharge (Cd). The calibrated Cd, which is unique to each meter, offers traceability for the accuracy of the meter and enhances performance.

The direction of flow is also indicated on every nameplate for easy reference during installation of the meter.

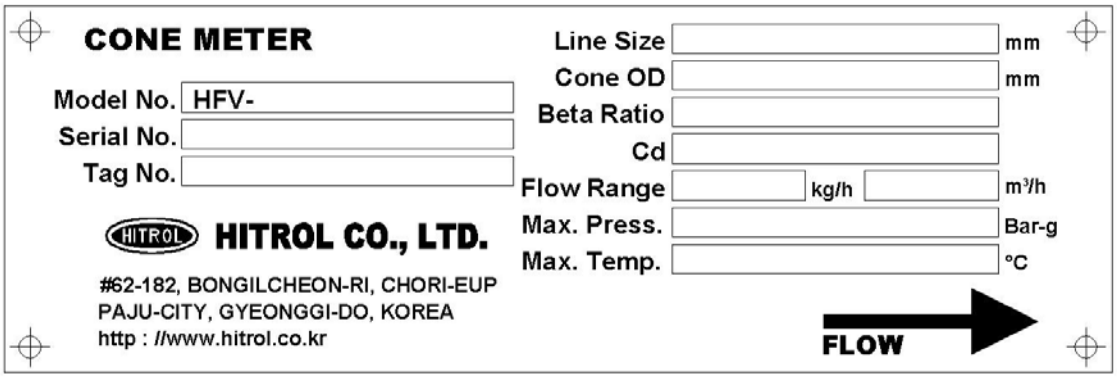

Figure 1.2—Sample nameplate

2. General Installation Guidelines

Important Safety Information
Installation, inspection, and maintenance of the Cone Meter must be performed by authorized and trained personnel who have a working knowledge of piping configurations.

WARNING

Never open a manifold valve or flange unless you have first verified that the system is completely de-pressurized.

Always use proper procedures and equipment for lifting and moving the Cone Meter to avoid risk of injury.

Secure all connections properly before starting up a system. Keep a safe distance away from the process upon startup.

Be mindful of static electricity generated by insulated footwear etc., and always ground yourself before touching pipes in the hazardous area.

Unpacking the Meter
All Cone Meters are securely packed to help prevent damage during shipment. Inspect the packing list on receipt of the device and report any discrepancies immediately.

Assembling the System
The Cone Meter alone cannot measure flow. Rather, it is intended for use with instrumentation such as a transmitter or flow computer.

The installation usually comprises a manifold system for isolating the process fluid and allowing maintenance and calibration of the transmitter. The pressure ports are purged when all three valves are opened.

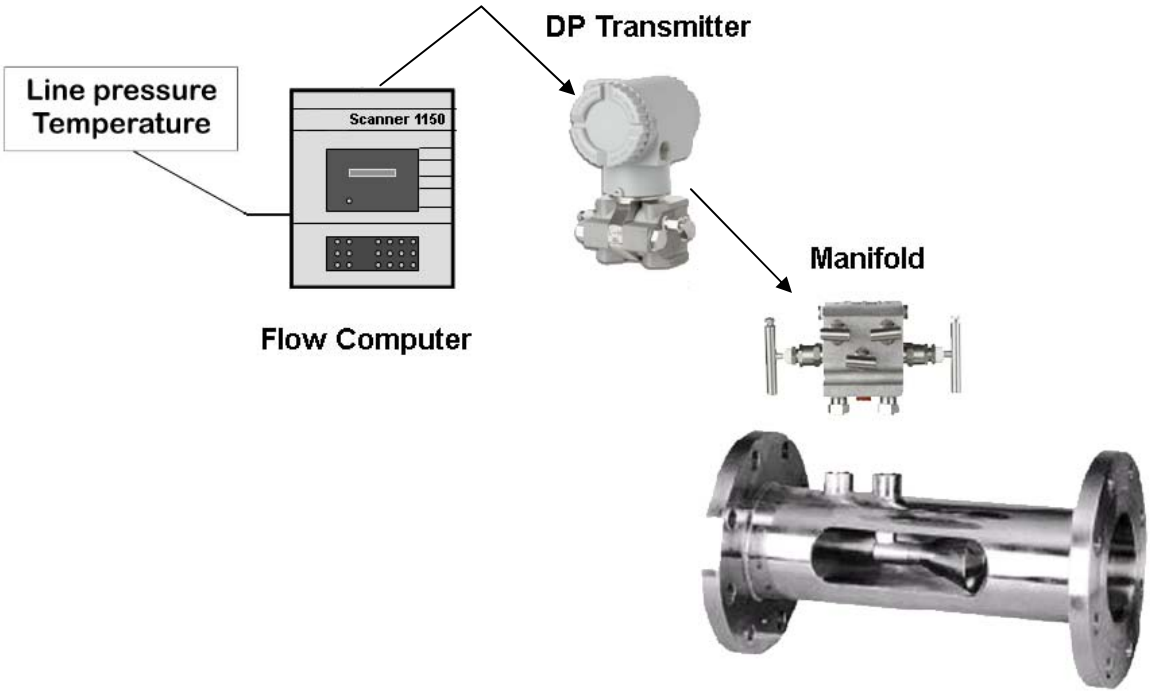

Figure 2.1—Typical components of a Cone Meter system

1) System Components

A differential pressure transmitter, shut-off valves, and a valve manifold are typically required for the operation of a Cone Meter. If the meter will be used to measure steam, a condensate chamber may also be required.

Before installing a Cone Meter, review the following installation tips:

- Make sure the piping, tubing, or manifold installed between the Cone Meter and the complies with national and local standards, regulations, and codes of practice to ensure safe containment of fluid.
- A hydrostatic or pneumatic test may be required for piping systems to prove the integrity of the pressure-containing components.
- In installations that are prone to plugging, a rod or other device may be used to remove materials blocking the process lines.

WARNING	**Never use a rod to clean out process lines in high-pressure applications or where high temperatures (e.g. steam) or dangerous fluids are being measured. The meter run should be isolated and completely depressurized before inserting a rod into an impulse tube.**

(1) Differential Pressure Transmitter

A differential pressure transmitter records the differential pressure signal generated by the cone meter and provides a 4 to 20 mA signal to a flow computer or data control system.

The DP transmitter selected for an installation must have a pressure range that is suited to the pressure range (upper and lower pressures) of the Cone Meter with which it will be used. In some cases, the pressure range of the meter is too broad to be covered with one DP transmitter. In such cases, dual DP transmitter may be used.

(2) Shut-Off Valves

Choose a block valve that is rated for the operating pressure of the pipe in which it will be installed. Where dangerous or corrosive fluids or gases like oxygen are likely, the block valve and packing must provide ample protection. The valves must not affect the transmission of the differential pressure signal.

Install block valves next to the Cone Meter pressure taps. If condensate chambers are used, install the block valve immediately after the condensate chambers. Never use a globe valve for differential pressure transmission lines.

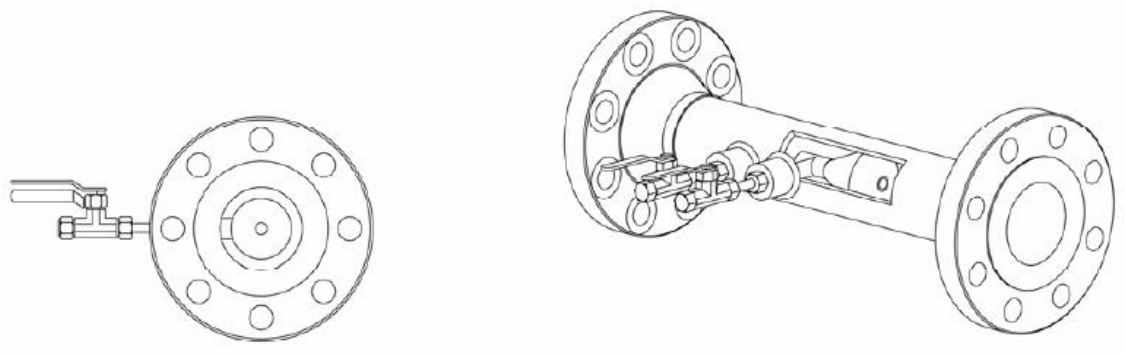

Figure 2.2—Block valves

(3) Valve Manifolds

A 3-way valve manifold isolates the DP transmitter from the process lines. It allows the operator to calibrate the transmitter without removing it from the process piping, or to drain the transmitter and piping or vent it to atmosphere. If the operator prefers to calibrate the DP transmitter without stopping the flow, a 5-way manifold can be used instead. Valve manifolds must be oriented according to the manufacturer’s instructions to prevent trapping of air or liquid.

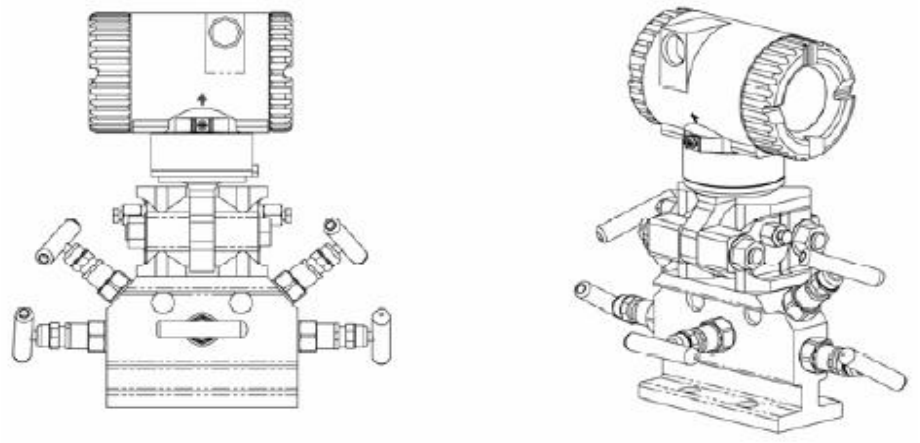

Figure 2.3—A 3-way manifold block mounted with a multi-variable transmitter

(4) Thermo well or Thermocouple

Flow measurement calculations for differential pressure devices require temperature and pressure measurement. Generally, a thermowell with an RTD installed is mounted downstream of the meter within 3 pipe diameters of the meter. Alternatively, a thermo-well can be installed inside the meter body upstream of the cone and the meter calibrated with it in position. For installations where temperatures are stable, a thermocouple or temperature probe may be attached to the outside of the upstream piping and covered with insulation.

(5) Impulse Tubing Considerations

Before connecting impulse tubing between the Cone Meter and the transmitter, consider the following tips for optimizing your system's measurement accuracy. In a well-designed installation, fluids will drain freely from the process lines and gases will vent to the atmosphere.

(6) Tubing Size Selection

Impulse tubing (that connects the DP Cone meter tap holes to the transmitter) diameters vary with service conditions. The bore should be no smaller than ¼ in. (6 mm); a minimum diameter of 3/8 in. (10 mm) is recommended. The internal diameter (ID) must not exceed 1 in. (25 mm). For steam applications, the ID should be 3/8 in. (10 mm) to 1 in. (25 mm).

In most process control applications, the primary concern is flow reliability. If the pressure taps or the impulse tubes become plugged, the reliability of the flow measurement is lost. This creates a safety risk and the cost incurred in regaining control can be substantial. High reliability is required for flow signals used in process safety management. A minimum tubing ID of 5/8 in. (16 mm) is recommended in industrial applications. For high temperatures in condensing vapor service, 1 in. (25 mm) is recommended.

(7) Tubing Material

Most instrument tubing is 316 stainless steel. However, duplex steel may be preferred for offshore applications where corrosion protection against saltwater is needed.

(8) Tubing Length and Configuration

For best performance, adhere to the following recommendations for tubing length and orientation:

- Tubing length must be short enough to ensure a high degree of accuracy, and long enough to ensure proper cooling of high-temperature fluids before they reach the transmitter.
- Make sure the installation permits access to the impulse tubes, valves, valve manifolds, and transmitters.
- Limit the number of fittings and avoid long tubing sections, which can impair measurement accuracy and increase the risk of plugging.
- Avoid changes in tubing elevation and fluid temperature. Differences in elevation will cause a difference in the hydrostatic pressure of the liquid column in the process lines. Temperature differences will cause a difference in the density of the fluids in the two lines, which will change the amount of pressure generated. Both can result in inaccurate differential pressure measurements. Fasten the process lines together, if possible.
- Install process lines so that they slope in only one direction (up or down). If piping must slope in more than one direction, do not allow more than one bend and install a liquid or gas trap, as applicable. A liquid trap should be installed at the lowest point in a gas service installation. A gas trap should be installed at the highest point in a liquid service installation.

(9) Extreme Temperature Applications

Steam temperatures can reach 1500°F (815°C), well exceeding the temperature rating of a standard DP transmitter (200°F or 93°C). A condensate chamber can be used to isolate the transmitter from the extreme temperatures. Alternatively, a long tube section can be installed to allow the fluid to cool before it reaches the transmitter.

As a general guideline when planning tubing lengths for temperature control, run tubing horizontally where possible, and allow for a temperature drop of 100°F (38°C) per foot (305 mm) of tubing. This is merely a guideline, however; the operator is still responsible for ensuring that the temperature at the transmitter does not exceed the transmitter's rating for the environmental conditions present.

In extreme cold temperature installations, thermal insulation and/or "heat tracing" of process lines may be necessary. The amount of heat used must be carefully calculated to prevent liquids from vaporizing and prevent condensable vapors from producing unwanted condensation. Fastening process lines together is recommended for keeping process lines at approximately the same temperature. Providing a temperature-controlled environment for the transmitter also helps ensure accurate metering in locations where extreme temperatures are likely (such as on offshore platforms or in desert installations).

2) Best Practices for Installing the Cone Meter System Components

Note	Read the best practice recommendations below in their entirety before installation of the Cone Meter.

The basic steps for installing a Cone Meter system are described as follows.

A. Install the meter in the meter run in accordance with the flowrun requirements below.
B. Secure the manifold to the meter taps.
C. Connect the differential pressure transmitter to the manifold, observing the recommended guidelines below for pressure measuring tubes.
D. Connect the transmitter to the flow computer according to instructions in the transmitter user manual.
E. Zero the transmitter.

(1) Flowrun Requirements

The Cone Meter should be installed with zero to five pipe diameters upstream of the meter and zero to three pipe diameters downstream of the meter. The meter can be used in pipelines that are slightly larger than the meter tube; however, if the meter tube is larger than the pipeline, operators should contact HITROL for installation requirements.

(2) Meter Orientation and Transmitter Position

The Cone Meter can be installed in a horizontal or vertical position. The location of the transmitter with respect to the meter should be based on the properties of the fluid or gas being measured (gas, steam, liquid, etc.) and the direction of flow through the pipeline.

The direction of flow is clearly labeled on nameplate affixed to the body of every Cone Meter shipped. The meter must be installed so that the static pressure tap is always upstream of the differential pressure tap.

(3) Pressure Tap Location

Location of the static pressure and differential pressure taps will vary with the product flowing through the pipeline (liquid, gas, or steam) and the orientation of the meter (vertical or horizontal).

For horizontal installations, the following installation guidelines apply:

- For measuring liquid, differential pressure taps should be located in the bottom half of the pipeline, between 4 o'clock and 5 o'clock positions, or between 7 o'clock and 8 o'clock positions.
- For measuring gas, differential pressure taps should be located in the top half of the pipeline. For wet gas, taps should be located between the 10 o'clock and 2 o'clock positions to allow proper drainage of liquids present.
- For steam, differential pressure taps should be located in the side of the pipeline.

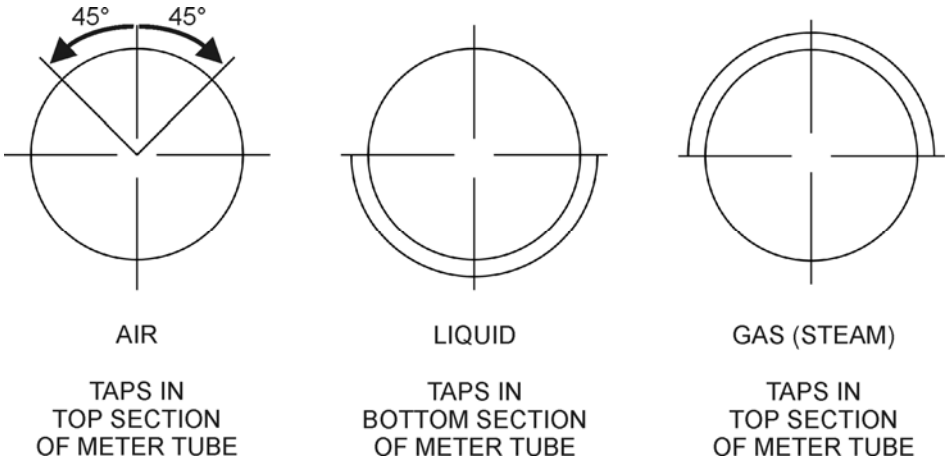

Figure 2.4—Recommended tap locations for horizontal meter installations

For vertical installations, the location of differential pressure taps is unrestricted, as long as the static pressure tap is upstream of the lower-pressure tap.

(4) Impulse Tubing

Impulse tubing is used to connect the sensing taps of the cone meter to the manifold connected to the differential pressure transmitter. One section of tubing should connect the high-pressure tap to the high-pressure (static) side of the differential pressure transmitter; another section of tubing should connect the low-pressure tap to the low-pressure side of the differential pressure transmitter.

- Impulse tubing should be installed with a gradient larger than 1/10 to help prevent undesirable fluids from being transferred to the differential pressure transmitter.
- If tubing is installed in a horizontal orientation, install a gas/liquid separator device.
- Avoid abrupt bends in impulse tubing.
- If impulse tubing sections are long, use mounting brackets to support them.

WARNING

Never use excessive pressure or force when connecting the pressure measuring tubes to a differential pressure transmitter.

CAUTION

If high-temperature fluids are likely to be encountered, make sure the measuring tube used is rated for the anticipated temperature range.

See 3, 4, and 5 for installation procedures recommended for liquid, gas, and steam applications, respectively. Both horizontal and vertical meter orientations are discussed as appropriate for each application.

3. Meter Installation for Liquid Service

1) Installation Options

(1) Meter Orientation

Cone Meters can be installed in a horizontal or vertical position. Horizontal is the standard orientation, however where space is very limited, a vertical position may prove to be the best option.

(2) Pipe Orientation

The orientation of piping is dictated by the position of the meter, the type of product being measured, and for vertical meter installations, the direction of flow. When a vertical piping system is used, the operator must give special consideration to the piping configuration to prevent gas from being trapped in liquid differential pressure.

(3) Condensate Chamber

The condensate chamber (drip pot) is a collection vessel to avoid gas bubbles in liquid instrument tubing. It should be mounted at the highest point in the impulse tubing between the cone meter and the DP transmitter.

2) Horizontal Meter Installation

For horizontal installations, pressure taps must be positioned 30° to 60° below the horizontal centerline (4 o'clock to 5 o'clock or 7 o'clock to 8 o'clock). Taps at the bottom of the pipe may become plugged with solids from the liquid; taps above the centerline can accumulate air or non-condensing gases. In liquid service, the connecting lines from the meter shall slope downward to the transmitter with no upturns or pockets. The minimum recommended lope for self-venting is 1 inch per foot.

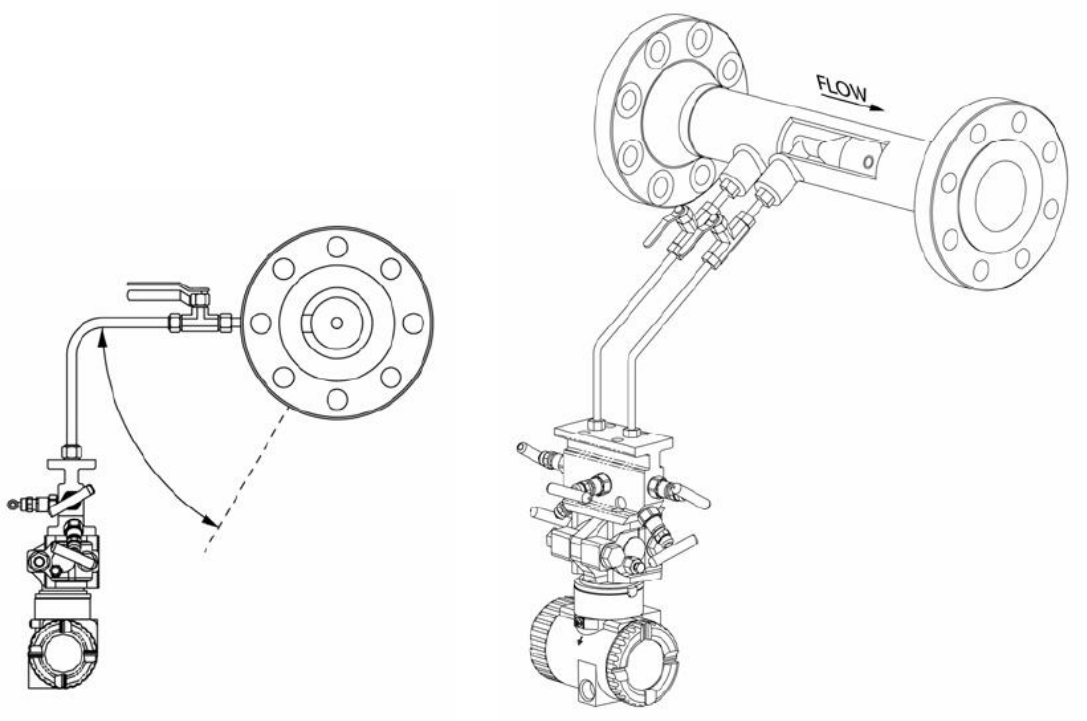

Figure 3.1—Piping installation for liquid measurement with a horizontal meter

(1) Bubble Pot Installation (Optional)

In liquid applications where the transmitter must be mounted above the metering line, gas or vapor in the liquid can collect at the highest point in the instrument tubing and give a false differential pressure reading. Bubble pots may be the only effective solution for such installations. The piping from the meter connects to the bubble pot anywhere between the 10 o'clock and 2 o'clock positions on a horizontal plane.

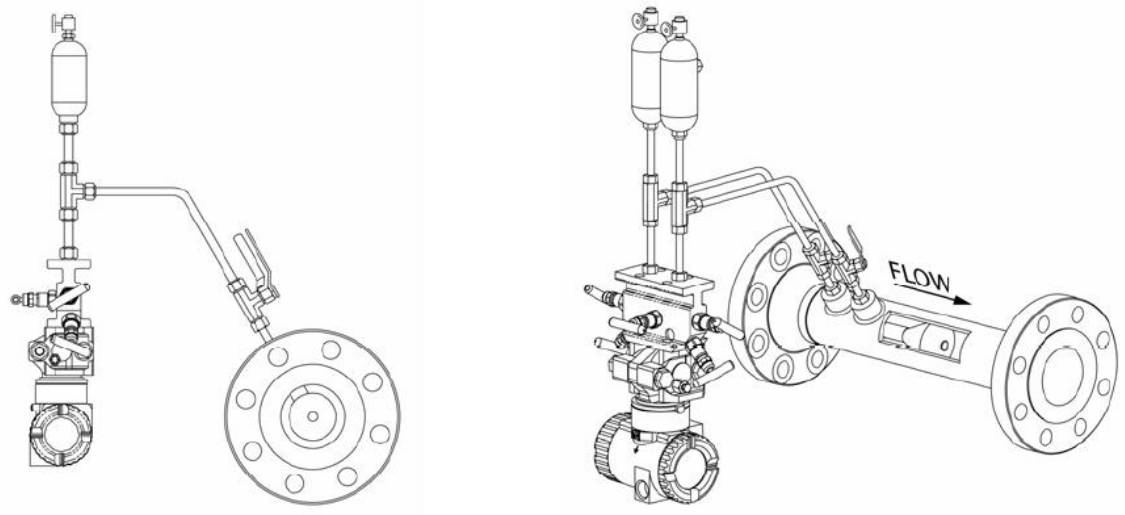

Figure 3.2—Bubble pot installation for liquid service

(2) Vertical Meter Installation

In most process applications, the operator should assume that some level of gas or vapor exists in a liquid service, even if the liquid is water. As a result, the piping configuration must be designed to allow gas to rise back into the flow stream. The process piping should be extended horizontally a very short distance from the downstream tap and then sloped at a 30° angle to the top of the manifold block. The manifold black should be mounted horizontally below the upstream tap so that piping from the upstream tap to the manifold slopes downward also.

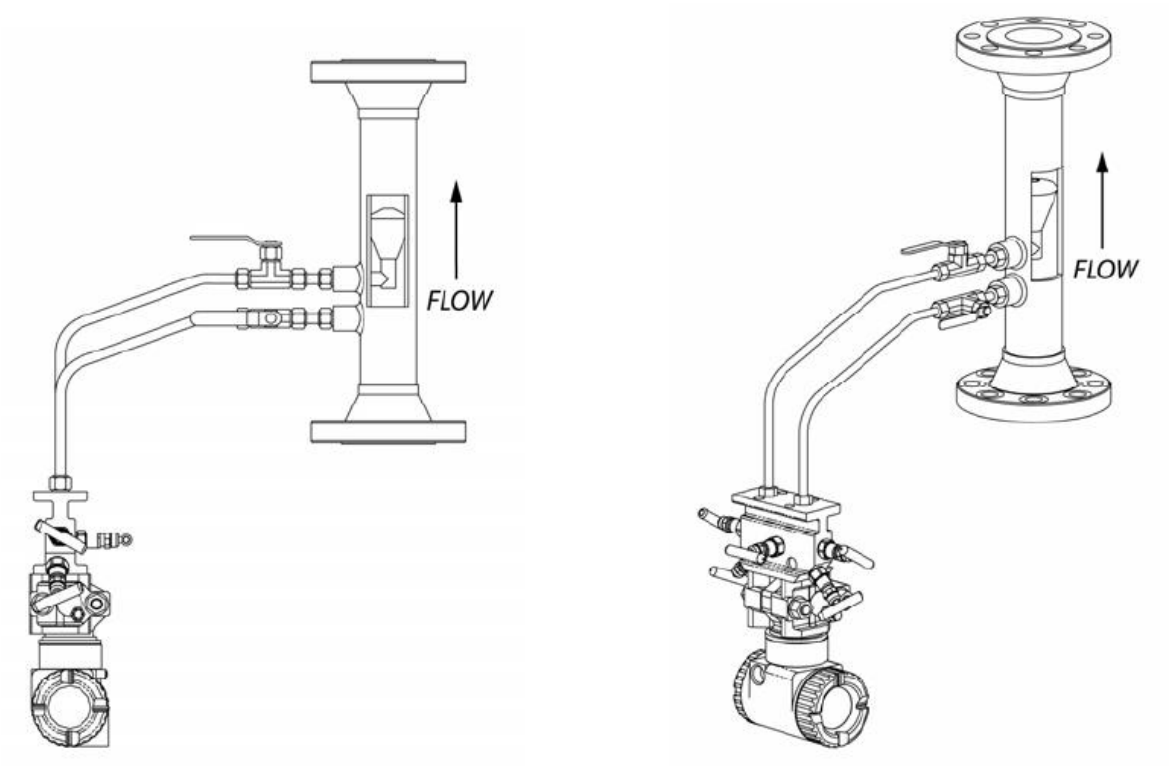

Figure 3.3—Piping installation for upward flow through a vertical meter

Note:	**While downward flow through a vertically oriented meter is suitable for a gas application, downward flow piping configurations that use the standard upstream and downstream pressure ports are not recommended for liquid applications due to the risk of trapping gas. For such applications, consider the use of a vertically oriented meter with wall taps, as described below.**

3) Vertical Meter with Wall Taps

Both process lines should be extended horizontally for a very short distance, and then piped downwards to a manifold block. The manifold block should be mounted horizontally below the bottom tap, and the DP transmitter should be mounted below the manifold block.

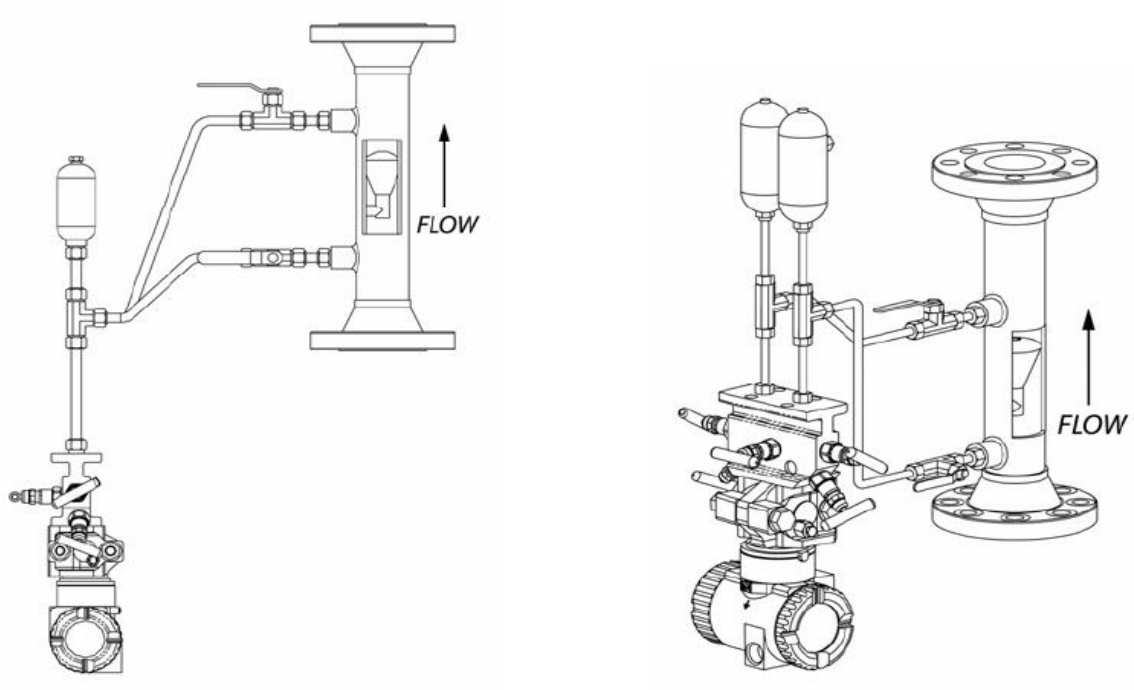

Figure 3.4—Piping installation for upward flow through a vertical meter with wall taps

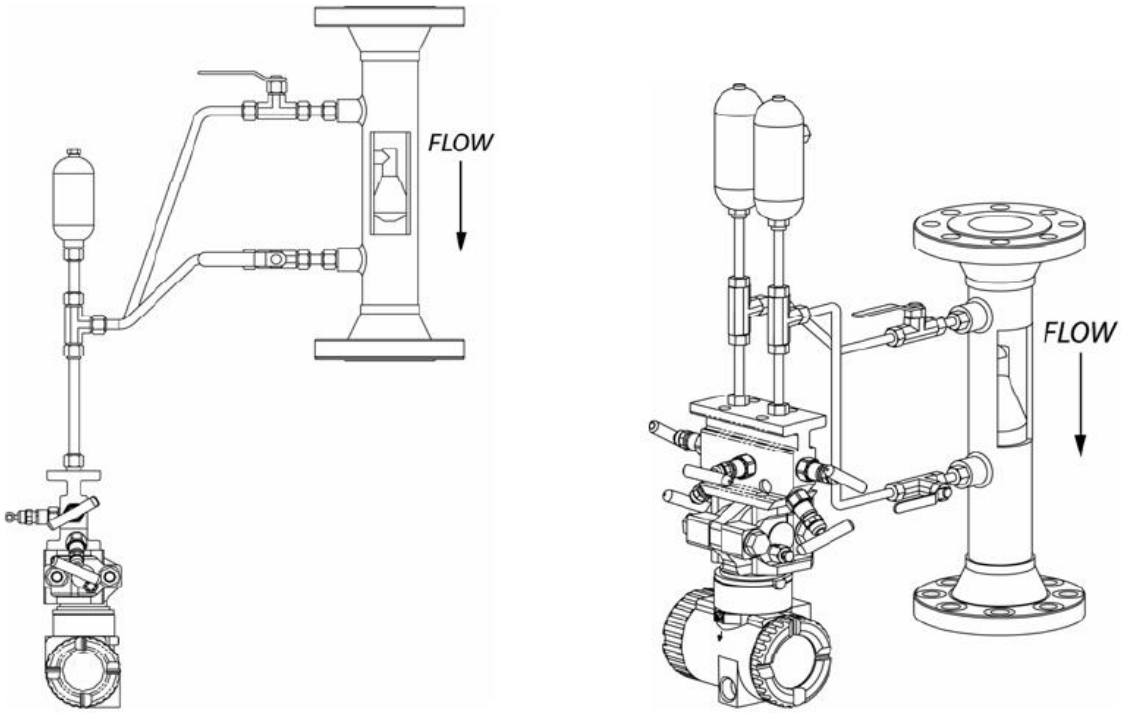

Figure 3.5—Piping installation for downward flow through a vertical meter with wall taps

4) Transmitter Calibration

Transmitters (differential pressure and/or multi-variable) should be calibrated according to the manufacturer's recommendations, appropriate national or company standards and contractually agreed methodology. Consideration should be given to the service in which the Cone Meter and transmitter are installed and operated.

4. Meter Installation for Gas Service

1) Installation Options

(1) Meter Orientation

Cone Meters can be installed in a horizontal or vertical position. Horizontal is the standard orientation, however where space is very limited, a vertical position may prove to be the best option.

(2) Pipe Orientation

The orientation of piping is dictated by the position of the meter, the type of product being measured, and for vertical meter installations, the direction of flow. When a vertical piping system is used, the operator must give special consideration to the piping configuration to prevent liquid from being trapped in gas differential pressure lines in gas service installations.

(3) Condensate Chamber

The condensate chamber is a collection vessel to avoid gas bubbles in liquid instrument tubing or conversely liquid pockets collecting in gas instrument tubing.

2) Horizontal Meter Installation

The pressure taps on the NuFlo DP Cone Meter should be between the horizontal centerline and the top of the pipe (3 o'clock to 12 o'clock or 9 o'clock to 12 o'clock). If the fluid is a "wet gas" (i.e., a gas containing small quantities of liquids), the pressure taps should be situated in a vertical position (12 o'clock) to allow all liquids to drain away from the transmitter (Figure 4.2). If the connecting tubing extending from the cone meter to the transmitter is not installed in a vertical position, it should slope upward (at least 1 inch per foot) to ensure proper drainage.

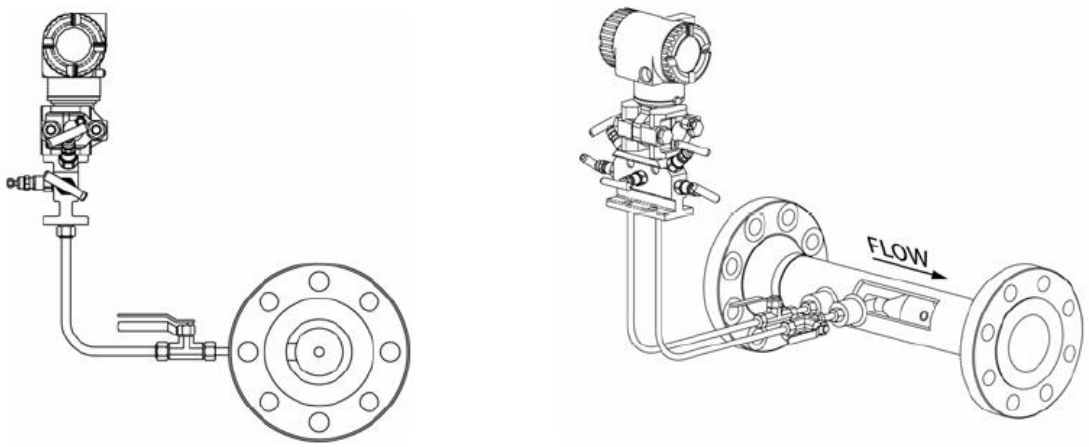

Figure 4.1—Piping installation for dry gas measurement with a horizontal meter

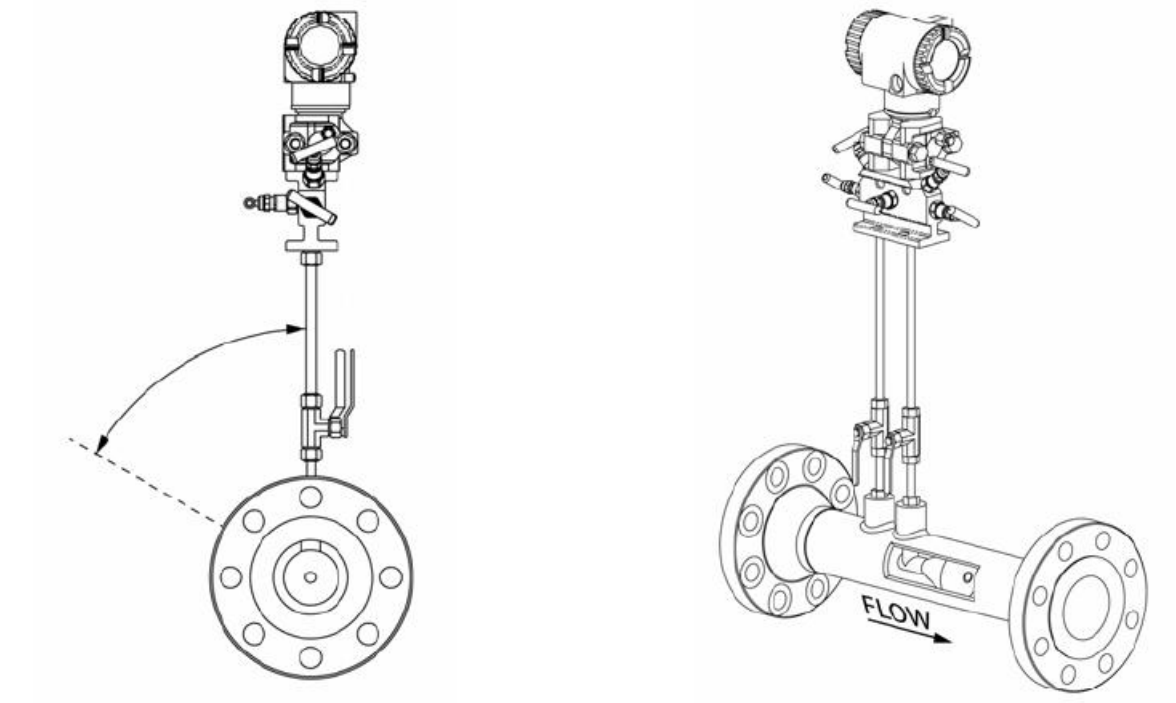

Figure 4.2—Piping installation for wet gas measurement with a horizontal meter

(1) Drip Pot Installation (Optional for Wet Gas)

If condensate chambers are used, they should be mounted immediately following the shutoff valves installed near the upstream and downstream pressure taps of the meter. For steam applications, the piping from the meter connects to the condensate chamber in a 3 o'clock or 9 o'clock position on a horizontal plane. The chambers are positioned horizontally so that the vent and fill points are at the top and drain points are at the bottom of the chambers. Both chambers must be mounted on the same level and must remain parallel at the point of connection to the shutoff valves. This is to ensure that no pressure difference results due to different liquid levels in the chambers.

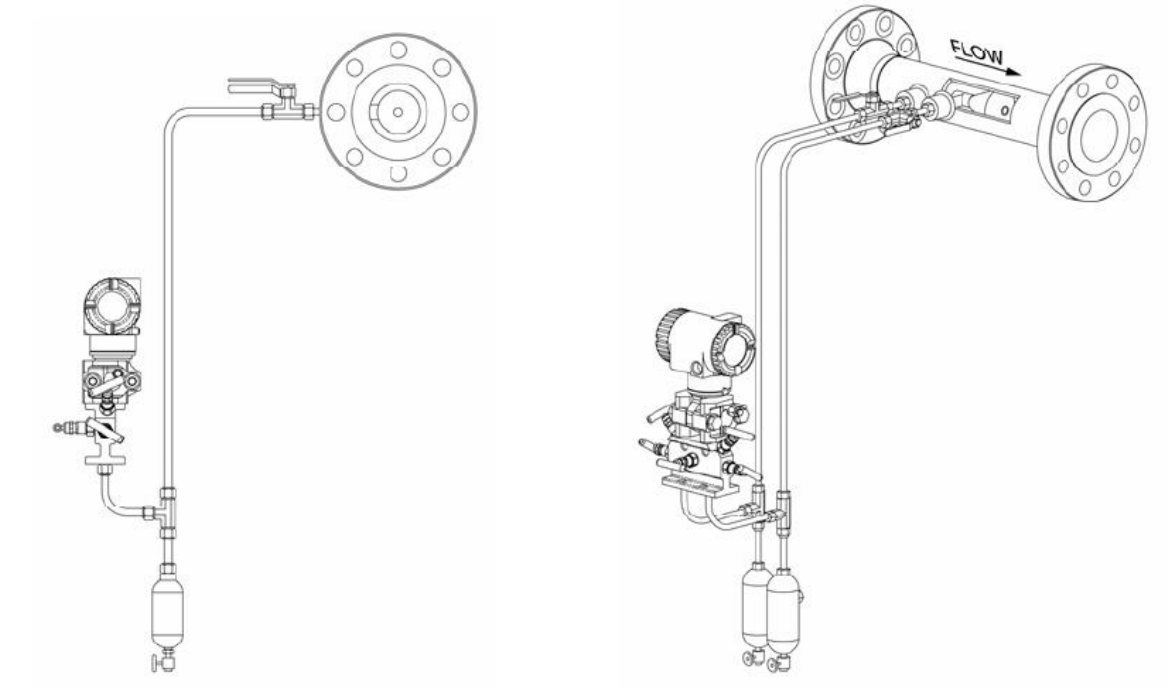

Figure 4.3—Condensation pot installation

(2) Vertical Meter Installation

When the meter is installed in a vertical position, the operator must take special care to ensure that no trap forms in the downstream tap such that gas is trapped in a liquid or liquid is trapped in a gas.

When measuring dry, non-condensing gases, where there is absolutely no risk for liquid being present, the piping from the downstream pressure tap of the cone meter can be extended horizontally and then angled upward to connect to the manifold block. The manifold block must be mounted horizontally, and the tubing from the upstream tap of the cone meter must slope at least 1 inch per foot to the same level as the downstream tap piping to connect to the manifold.

Note:	**If there is any liquid present in the gas, do not use this piping arrangement. The "U" configuration could trap liquid in the cone, changing the downstream pressure. See instead the installation diagrams for upward and downward flow using a vertical meter with wall taps (below).**

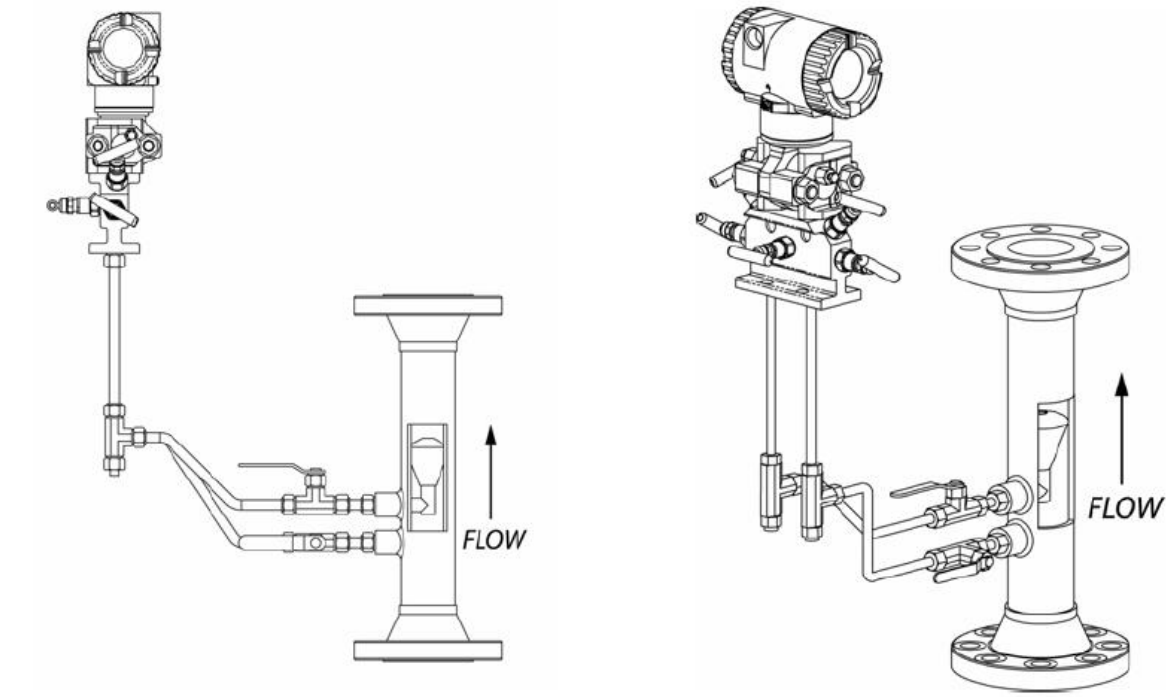

Figure 4.4—Piping installation for upward flow (dry gas) through a vertical meter

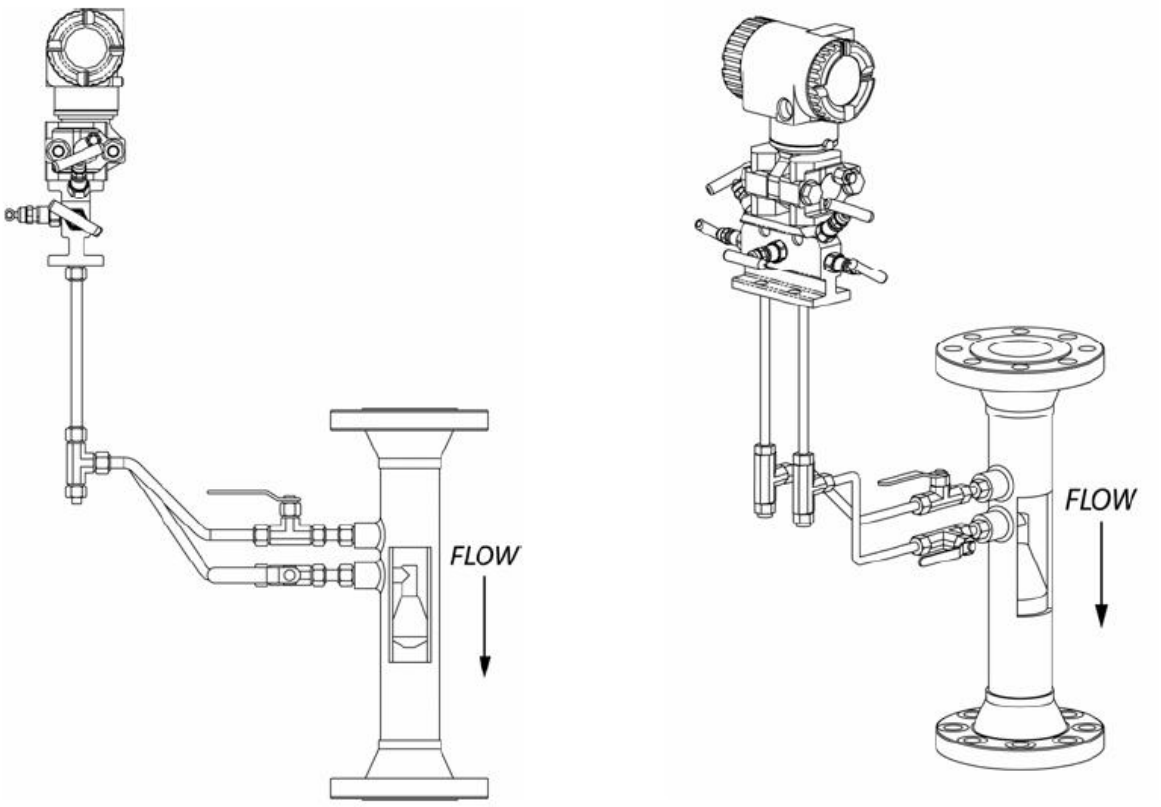

Figure 4.5—Piping installation for downward flow (dry gas) through a vertical meter

3) Transmitter Calibration

Transmitters (differential pressure and/or multi-variable) should be calibrated according to the manufacturer's recommendations, appropriate national or company standards and contractually agreed methodology. Consideration should be given to the service in which the one Meter and transmitter are installed and operated.

5. Meter Installation for Steam Service

1) Installation Options

Steam measurement is the most difficult application for differential pressure piping and requires careful consideration during installation. Steam can be at a very high temperature which can damage the transmitter and in addition it can be in the liquid or gaseous phase depending on temperature and pressure. Due to this the differential pressure pipework must be orientated in such a manner that it can operate with a gas or liquid present.

(1) Meter Orientation

Cone Meters can be installed in a horizontal or vertical position. Horizontal is the standard orientation, however where space is very limited, a vertical position may prove to be the best option.

(2) Impulse Tubing Orientation

The orientation of piping is dictated by the position of the meter, the type of product being measured, and for vertical meter installations, the direction of flow. When a vertical piping system is used, the operator must give special consideration to the piping configuration to prevent liquid from being trapped in gas differential pressure lines.

(3) Condensate Chamber

The condensate chamber is a liquid reservoir that helps prevent super-heated steam from entering the differential pressure transmitter. In most cases, a large-diameter tee is all that is required to collect the liquid (see Figure 5.1). However, if the DP measuring instrument is designed with hydraulic/pneumatic bellows (such a Barton 202E chart recorder), a larger-volume condensate chamber will be required (see Figure 5.2). Modern DP transmitters have very little diaphragm movement and do not require the large-volume condensate chamber.

2) Horizontal Meter Installation

The pressure taps shall be above the horizontal centerline (9 o'clock to 3 o'clock) of the primary device. In condensing hot vapor service such as steam, the fluid in the impulse lines is liquid condensed from the vapor. The use of a condensate chamber is mandatory to prevent hot process fluid from damaging the transmitter. The impulse tubing should slope upwards from the cone meter to the condensate pots. A condensate pot can be a tubing tee (for low-volume DP instruments) as shown in Figure 5.1 or a full-size condensate chamber (for high-volume DP instruments) as shown in Figure 5.2. In either case, the condensate pots should be at exactly the same level to ensure accurate differential pressure readings. The line from the bottom of the tee to the transmitter mounted below the tee should be filled to the point where excess fluid can drain back into the meter.

In many cases, water (condensed steam) is used for this fluid fill. However, in cold weather, the fluid must be protected from freezing. The fluid fill requires careful design with heat tracing and insulation to keep it in the liquid phase and to keep both the high-pressure and low-pressure

legs of the tubing at the same temperature (maintaining the liquid fill at the same density). A liquid leg fill fluid other than water should be used if practical. Methanol is a possible substitute, but di-butyl phthalate is the recommended fill fluid because it is immiscible with water and remains liquid throughout a broad temperature range, -31oF to 644oF (-35oC to 340oC).

Important: Care should be taken when using di-butyl phthalate – follow all hazardous material guidelines (CAS No: 87-74-2).

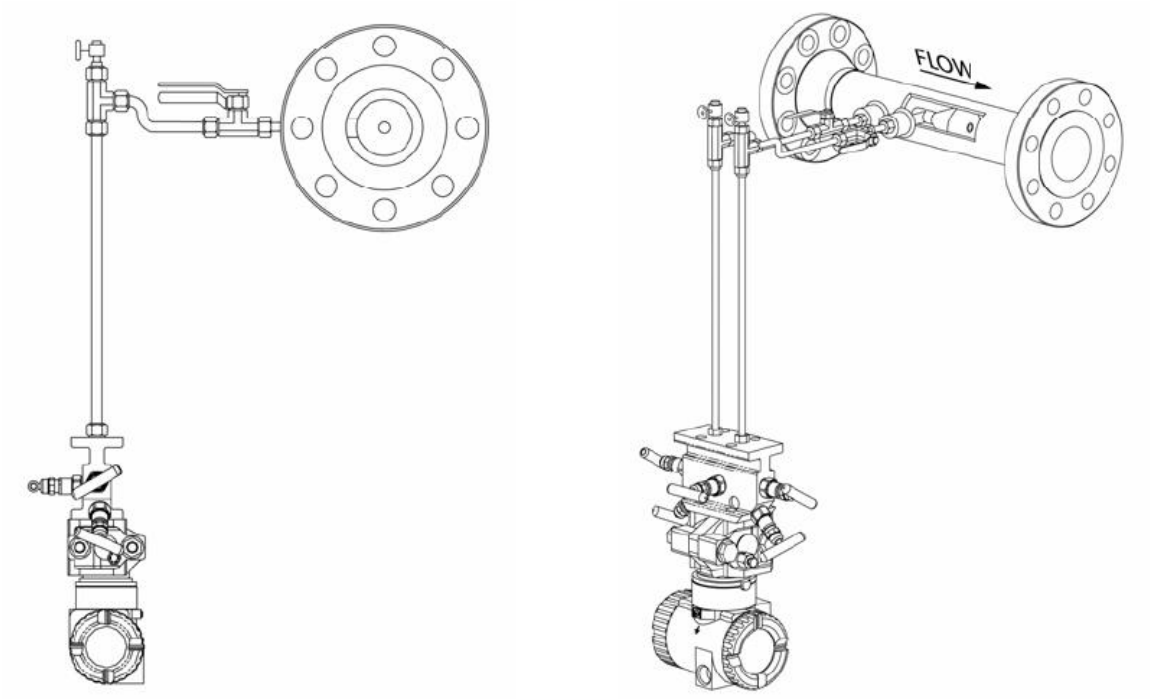

Figure 5.1—Piping installation for steam measurement with a horizontal meter and a low-volume DP instrument (straight-on into transmitter)

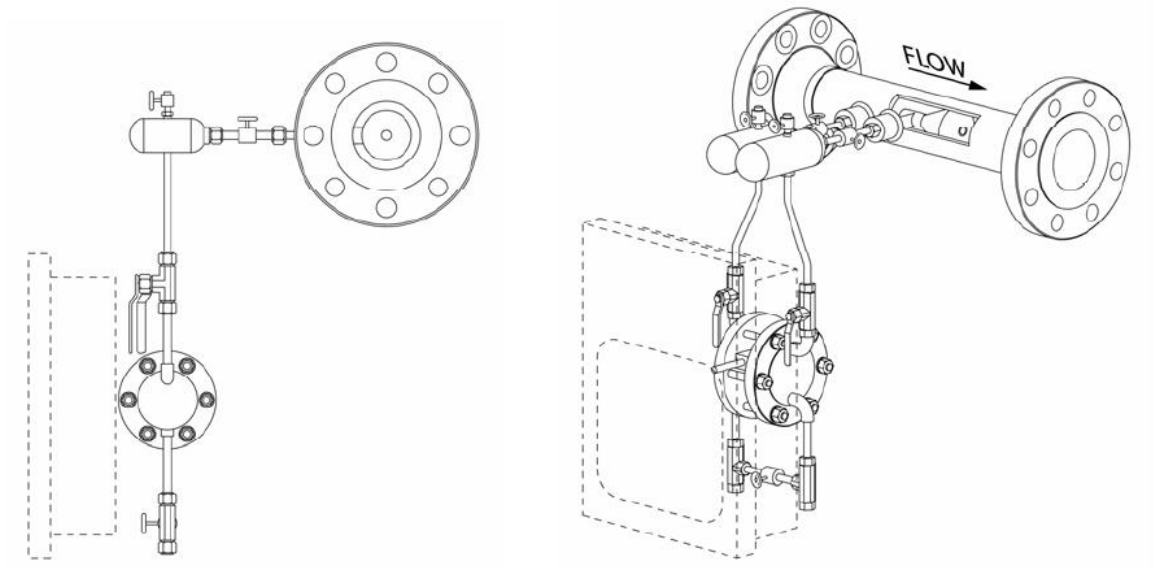

Figure 5.2— Piping installation for steam measurement with a horizontal meter and a high-volume DP instrument such as a chart recorder with DPU.

(1) Vertical Meter Installation

For steam service installations in which the meter is oriented vertically, process piping can be installed following either of two standard designs.

In Method 1, piping from the upstream pressure tap is extended horizontally to an "T" connector. The “T” connector enables a plug to be installed at the top for liquid filling purposes to avoid overheating of the differential pressure Cell. The manifold block is positioned directly below at a distance that ensures the steam will be at a safe operating temperature by the time it reaches the differential pressure transmitter. Both lines are extended to the "T" pieces.

Note:	**This configuration results in a head difference in the differential pressure lines and the differential pressure transmitter must be zeroed when zero flow has been established in the main line.**

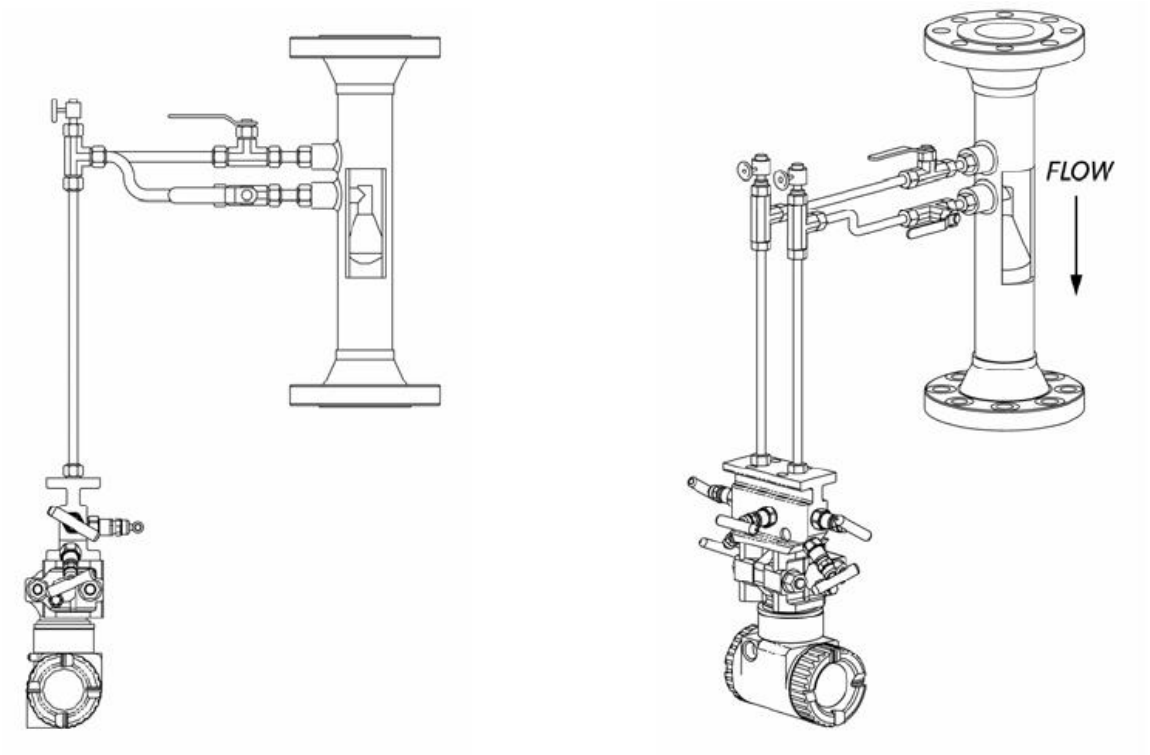

Figure 5.3—Piping installation for downward flow through a vertical meter

3) Transmitter Calibration

Transmitters (differential pressure and/or multi-variable) should be calibrated according to the manufacturer’s recommendations, appropriate national or company standards and contractually agreed methodology. Consideration should be given to the service in which the Cone Meter and transmitter are installed and operated.