API RECOMMENDED PRACTICE 550
FOURTH EDITION, OCTOBER 1980

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Manual on Installation of Refinery Instruments and Control Systems

Part I—Process Instrumentation and Control
Section 8—Seals, Purges, and Winterizing

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Up to date as of June 1984

American Petroleum Institute
2101 L Street, Northwest
Washington, D.C. 20037

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Refining Department

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FOREWORD

This recommended practice is based on the accumulated knowledge and experience of engineers in the petroleum industry. Its purpose is to aid in the installation of the more generally used measuring, control, and analytical instruments; transmission systems; and related accessories to achieve safe, continuous, accurate, and efficient operation with minimum maintenance. Although the information has been prepared primarily for petroleum refineries, much of it is applicable without change in chemical plants, gasoline plants, and similar installations.

Successful instrumentation depends upon a workable arrangement that incorporates the simplest systems and devices that will satisfy specified requirements. Sufficient schedules, drawings, sketches, and other data should be provided to enable the constructor to install the equipment in the desired manner. The various industry codes and standards and laws and rulings of regulating bodies should be followed where applicable.

For maximum plant personnel safety, transmission systems are employed to eliminate the piping of hydrocarbons, acids, and other hazardous or noxious materials to instruments in control rooms. Proper installation is essential in order to use fully the capabilities that are built into the instrument or transmission system.

In the installation of an instrument, the various components must be accessible for efficient maintenance, and certain of these elements must be readable for good operation. Orifices, control valves, transmitters, thermocouples, level gages, and local controllers, as well as analyzer sample points, generally should be readily accessible from grade, permanent platforms, or fixed ladders. In this manual, special consideration is given to the location, accessibility, and readability of the elements.

Users of this manual are reminded that in the rapidly advancing field of instrumentation no publication of this type can be complete nor can any written document be substituted for qualified engineering analysis

Certain systems are not covered in this section because of their highly specialized nature and limited use. When one of these systems gains general usage and installation reaches a fair degree of standardization, this section will be revised to incorporate such additional information.

Acknowledgment is made to all the engineers and operating and maintenance personnel who, through years of study, observation, invention, and sometimes trial and error, have contributed to the technology of instrumentation

Suggested revisions are invited and should be submitted to the director of the Refining Department, American Petroleum Institute, 2101 L Street, N.W., Washington, D.C. 20037.

PREFACE

This section is one of a series which make up RP 550, *Manual on Installation of Refinery Instruments and Control Systems* RP 550 is composed of four parts:

Part I—Process Instrumentation and Control
Part II—Process Stream Analyzers
Part III—Fired Heaters and Inert Gas Generators
Part IV—Steam Generators

Part I analyzes the installation of the more commonly used measuring and control instruments, as well as protective devices and related accessories; Part II presents a detailed discussion of process stream analyzers; Part III covers installation requirements for instruments for fired heaters and inert gas generators; and Part IV covers installation requirements for instruments for steam generators. These discussions are supported by detailed information and illustrations to facilitate application of the recommendations.

The format of RP 550, Part I, has been changed to facilitate continuity of presentation, convenience of reference, and flexibility of revision Each section is now being published individually as follows:

Section 1—Flow
Section 2—Level
Section 3—Temperature
Section 4—Pressure
Section 5—Automatic Controllers
Section 6—Control Valves and Positioners
Section 7—Transmission Systems
Section 8—Seals, Purges, and Winterizing
Section 9—Air Supply Systems
Section 10—Hydraulic Systems
Section 11—Electrical Power Supply
Section 12—Control Centers
Section 13—Alarms and Protective Devices
Section 14—Process Computer Systems

In the preparation of these documents, it was necessary to decide on a logical method of presentation—should each point be examined as fully as possible or should extensive cross-referencing be done between sections?

The publications contain a combination of these methods of presentation. Each section has been made as complete as possible, with cross-referencing done only where very extensive repetition would have been required

Users of this recommended practice are cautioned to obtain a complete set of sections in order to accomplish efficiently any cross-referencing that is required for a full understanding of the subject matter.

CONTENTS

Part I—Process Instrumentation and Control

SECTION 8—SEALS, PURGES, AND WINTERIZING

8.1 Scope

This section discusses recommended practices for sealing, purging, and winterizing measuring instruments and the lines connecting them to their process. The use of these guidelines should ensure reliable instrument performance. The instruments usually requiring sealing, purging, or winterizing are those for measuring flow, pressure, and liquid level but also may include other instruments having sensitive elements normally exposed to the process fluid, such as process stream analyzers.

Seals and purges are used to prevent the process fluid from entering the instrument or connecting lines and causing improper operation or damage resulting from temperature, vaporization, condensation, and viscosity effects; corrosion; or sedimentation.

Winterizing, usually some form of heating, is used to prevent impaired operation of the instrument and connecting lines resulting from the formation of ice, hydrates, and other fluids that solidify at low ambient temperatures. Heating is also used to prevent solidification of a process fluid at a temperature approaching its pour point.

Analyzers often require special winterizing techniques which are discussed in in API RP 550, Part II, *Process Stream Analyzers*.

8.2 General

Sealing, purging, and winterizing systems can be troublesome features of refinery instrumentation, and every effort should be made to keep them simple and reliable. One way of doing this is by selecting the proper types of instruments initially.

The use of low-displacement instruments can simplify sealing procedures. Close-coupled transmitters [that is, transmitters pipe mounted within 2 feet (60 centimeters) of the process take off point] can sometimes completely eliminate the need for heating or winterizing. Their installation will always simplify heating and winterizing if one of the molded insulating plastic enclosures with "hot-bolt" construction (see 8.5.2) or other simple heating means is used.

Transmitters for pressure and differential pressure are also available with diaphragm or bellows elements attached to the transmitting devices with capillary tubing in lengths that will permit accessible transmitter mounting. Such systems are completely filled with a suitable liquid and sealed at the factory. Usually, no purging or heating is required with such systems.

Sealing, purging, and winterizing are all interrelated in that sometimes one can be substituted for another—particularly sealing and winterizing. In some cases, the use of one alone may not completely solve a problem but may simplify the use of another. The following discussion emphasizes the importance of a detailed analysis prior to the selection of a method to be employed for each installation.

8.3 Seals

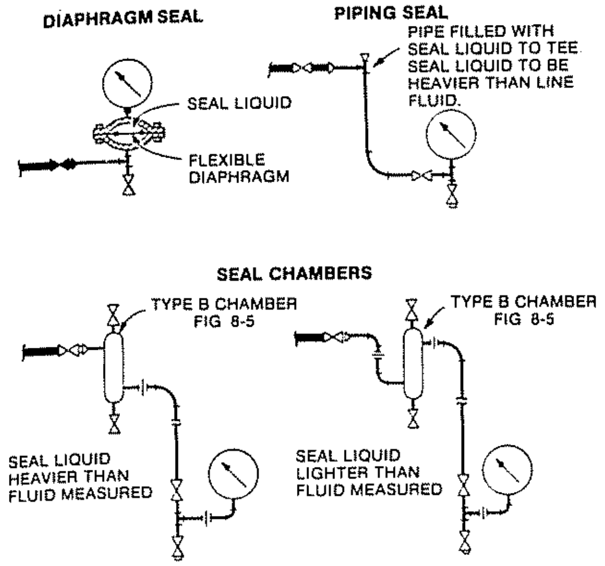
8.3.1 GENEAL

Seals may be the only type of winterizing required for some applications and under certain climatic conditions. The seals also protect the instrument and its connecting lines from damage by preventing entry of the process fluid. Seals can be divided roughly into two types, diaphragm seals and liquid seals

8.3.2 DIAPHRAGM SEALS

One method of sealing involves using a flexible diaphragm or bellows to hold a seal liquid in the instrument and to mechanically separate the sealing liquid from the process fluid. This method, shown in Figure 8-1, is limited primarily to pressure gage protection. The characteristics, advantages, and limitations of this method are discussed further in API RP 550, Part I, Section 4, "Pressure." However, it should be emphasized that the instrument should be close-coupled to the point of measurement and thus the heat from the process is used to avoid other forms of winterizing.

The sealed diaphragm-and-capillary system, shown in Figure 8-2, can be obtained with appreciable lengths of capillary tubing that may permit some flexibility in locating pressure, level, and differential pressure transmitters. Precautions must be observed in selecting the instrument. The most critical feature for both the close-coupled (Figure 8-1) and capillary (Figure 8-2) types is the liquid used in the seal. The liquid must withstand the temperature at the process connection and still maintain its fluidity. In severe climates, the provision of additional heat to the instrument and capillary may be required to maintain seal liquid fluidity. The manufacturer should be consulted to avoid possible problems brought on by abnormal temperatures.



Note: See API RP 550, Part I, Section 4, for details and gage supports.

Figure 8-1—Seals for Pressure Gages

8.3.3 LIQUID SEALS

An instrument is said to be "self-sealed" when it and its connecting lines are filled with the measured process fluid. Depending on the characteristics of the fluid, self-sealing may be entirely satisfactory. Where self-sealing is not acceptable, a common method of sealing instruments makes use of a liquid that is immiscible with the measured process fluid. The immiscible liquid should have a density differing from that of the process fluid. Instruments of low (negligible) displacement may be readily sealed in the piping. Full range change causes no appreciable movement of liquid in the connecting lines (see Figure 8-1 and 8-3).

Instruments with appreciable displacement require seal chambers and special piping arrangements for control of the seal liquid level to prevent hydrostatic errors. Typical seal installations for large-displacement instruments are shown in Figure 8-4.

8.3.4 SEAL CHAMBERS

Several types and sizes of seal chambers or condensate pots that meet most sealing requirements have been developed. Two types of seal chambers are shown in Figure 8-5. Type A is generally used with large displacement instruments. Type B is usually used with negligible displacement instruments. Seal chambers are available from manufacturers. Seal chamber material and fabrication should comply with the specifications of ISA[1] RP 3.1, *Flowmeter Installations, Seal and Condensate Chambers*.

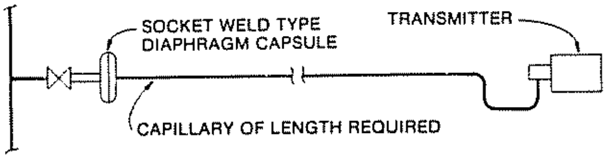
8.3.5 SEALING LIQUIDS

Water is one of the more commonly used sealing liquids where the only purpose is to protect against entry of the process fluid. If the instrument and lines are subject to freezing temperatures, water seals must be protected by some form of heating. An ethylene glycol–water solution is also used extensively for sealing refinery instruments because the low freeze point of this mixture constitutes a form of winterizing that is adequate for many climates. Figure 8-6 shows the characteristics of ethylene glycol–water solutions and attention is called to the explanatory note. Ethylene glycol solutions tend to absorb water from moisture-bearing process streams. Ethylene glycol should be of the inhibited type to prevent corrosion. Other sealing liquids and their properties are given in Table 8-1.

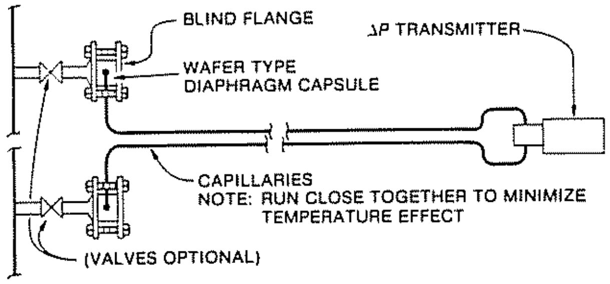
8.4 Purges

8.4.1 GENERAL

Despite the fact that purges are difficult to maintain, some process measurements are made possible only by the



A. PRESSURE TRANSMITTER



B. LIQUID LEVEL OR DIFFERENTIAL PRESSURE TRANSMITTER

Figure 8-2—Hermetically Sealed Diaphragm-and-Capillary System

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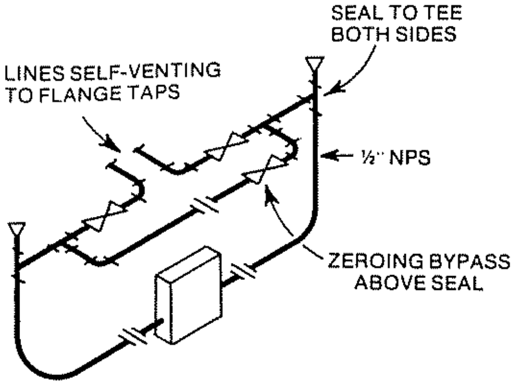
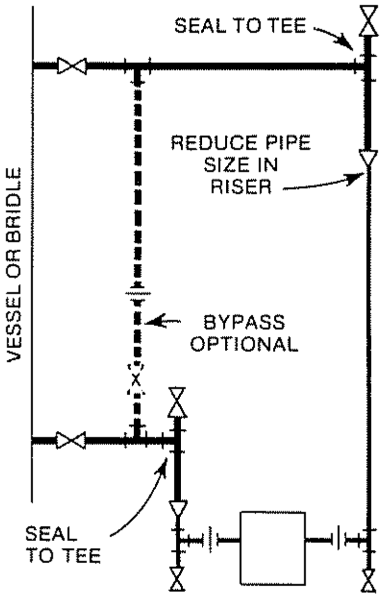
[1] Instrument Society of America, 67 Alexander Drive, Research Triangle Park, North Carolina 27709.



FLOW
SEAL LIQUID
HEAVIER THAN
LINE FLUID
(NOTE 1)



LEVEL
(NOTE 2)

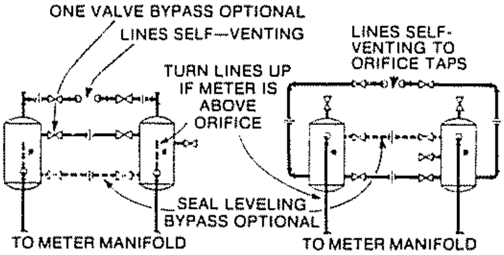
NOTES:
1 See API RP 550, Part I, Section 1, for piping details
2 See API RP 550, Part I, Section 2, for piping details.

Figure 8-3—Seals for Low-Displacement Instruments

use of purging. Purge fluids are introduced into the instrument connecting lines and flow out through the process connections. The purge fluid serves to seal the instrument and sweep the lines clean of the measured process material. Purging systems are commonly used on solids-bearing streams, streams subjected to coking or solidification, and streams carrying acid, caustic, or other contaminants that might damage the instrument or its connections. Figures 8-7 and 8-8 show typical purging arrangements. In these sketches the purge fluid is shown entering the lines close to the measurement connection to minimize pressure drop due to the flow rate of the purging medium. In some instances it is advisable to inject the purge fluid at the instrument as illustrated in Figure 8-9. However, this type of installation requires particular care in designing the connecting piping and establishing the purge flow rate in order to avoid induced errors.

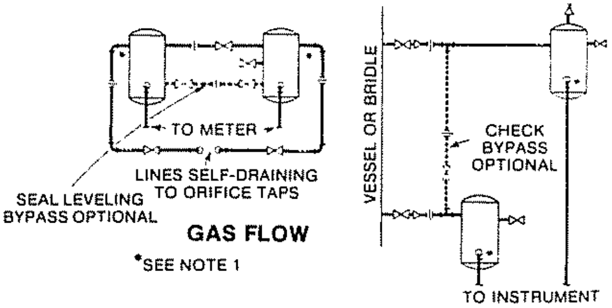
Purge systems do not always eliminate the need for winterizing. Many heavy, viscous streams require "heavy" heat tracing not only for the instrument and its connections but also for the line supplying the purge fluid. The designer should try to avoid complicated dual systems. See API RP 550, Part I, Section 2, "Level," Figure 2-10 for sealing and purging systems specifically applied to level instruments using differential measuring devices.

Purge systems are used for other services in refinery instrumentation. For instance, some control valves are equipped with "wash" connections to which a purge fluid can be connected to minimize damage in dirty streams and coking services. In addition it is sometimes necessary to



LIQUID FLOW
SEAL LIQUID HEAVIER
THAN LINE FLUID

LIQUID FLOW
SEAL LIQUID LIGHTER
THAN LINE FLUID

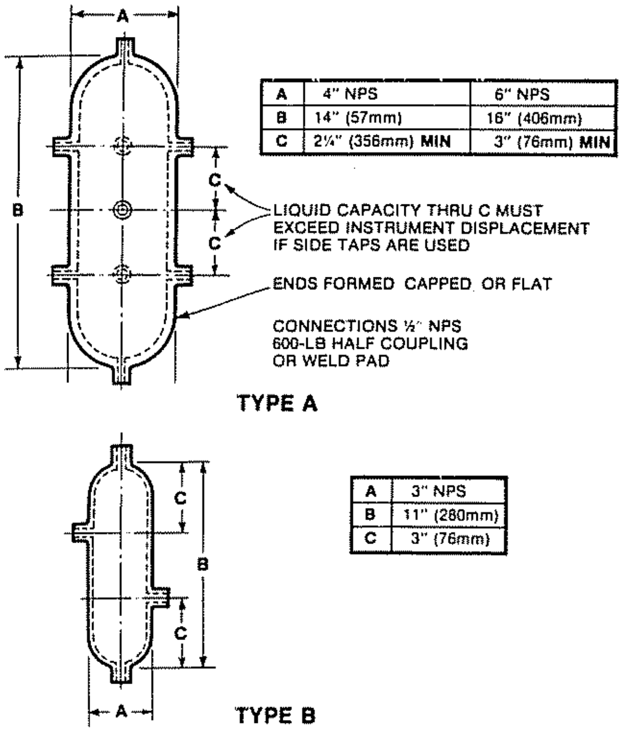


GAS FLOW
*SEE NOTE 1

LEVEL

NOTE: Use of side taps makes vapor trap of top of chamber or sediment trap of bottom.

Figure 8-4—Seals for Large Displacement Instruments



A	4" NPS	6" NPS
B	14" (57mm)	16" (406mm)
C	2¼" (356mm) **MIN**	3" (76mm) **MIN**

A	3" NPS
B	11" (280mm)
C	3" (76mm)

Note: ANSI B 31 3, *Code for Pressure Piping* governs materials and fabrication. Refer also to ISA RP 3 1, *Flowmeter Installations, Seal, and Condensate Chambers*

Figure 8-5—Seal Chambers

purge instrument cases and transmitter enclosures with air or inert gas to prevent damage from corrosive atmospheres. Both of these situations are special cases for which general guides cannot be compiled. Guides for purging instruments involving electrical components in potentially explosive atmospheres are covered in ISA S 12.4, *Instrument Purging for Reduction of Hazardous Area Classification* and in NFPA[2] Code 496, *Purged and Pressurized Enclosures for Electrical Equipment in Hazardous Areas*.

8.4.2 PURGE FLUIDS

Purging instrument lines requires a suitable purge fluid (liquid or gas) at a pressure higher than the maximum process pressure possible at the point of measurement to ensure continuous flow into the process connection. Purge fluid should be clean, free of solids, compatible with and noncontaminating to the measured materials, and free of any tendency to flash at the temperature present at the point of measurement. Too many gas purges on a vacuum process can overload the eductor creating the vacuum. The effect of these purges on unit material balances should be considered.

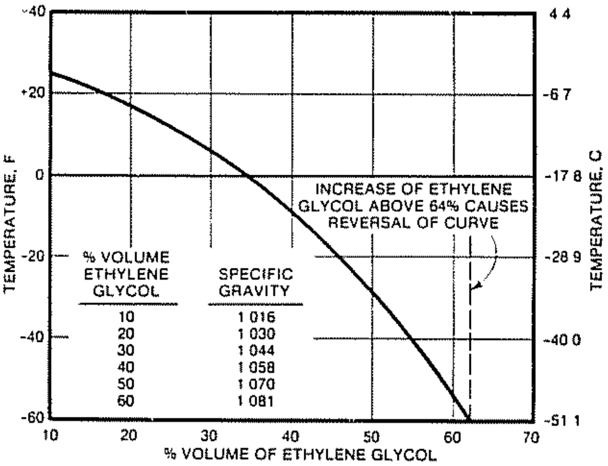
The most important feature about purge fluids is the reliability of the source of supply. Preferably a purge fluid independent of the process itself should be supplied so that it is available even when the process is not operating normally. Temporary stoppage of purge flow is practically unavoidable but usually it is not particularly harmful. However, prolonged outage may result in appreciable damage.

8.4.3 RATE OF FLOW

To be effective the purge fluid must be fed to the system continuously at a controlled rate. Restriction orifices, drilled gate valves, or rotameters, with adjustable restrictions, determine and limit flow. Pressure reducing regulators are usually used with these devices. Where the pressure at the point of measurement varies appreciably, a differential pressure regulator should be used in conjunction with a restriction orifice, a drilled gate valve, or a rotameter to ensure continuous uniform purge flow.

The rate of flow in any purge installation has a range of variance limited on the low side by extremely small orifices or restrictions, which become difficult to maintain, and on the high side by errors produced by excessive purge flow rate.

Too many factors are involved to attempt to set high flow limits. Usually, if errors exist because of purge flow



% VOLUME ETHYLENE GLYCOL	SPECIFIC GRAVITY
10	1 016
20	1 030
30	1 044
40	1 058
50	1 070
60	1 081

NOTE: Curve does not represent the true freezing point of ethylene glycol and water solution. It gives recommended mixtures which assure the proper operation of a sealed instrument at ambient temperatures shown

Figure 8-6—Operating Temperature for Ethylene Glycol and Water Solutions

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[2] National Fire Protection Association, 60 Batterymarch Street, Boston, Massachusetts 02110.

Table 8-1—General Properties of Sealing and Manometer Liquids

	Specific Gravity		Action with Water Vapor	Vapor Pressure (millimeters of mercury)	Viscosity (centipoises)		Freezing Point		Boiling Point		Flash Point		Thermal Expansion	
	60 F/60 F (15.6 C/15.6 C)	68 F/60 F (20.0 C/15.6 C)			60 F (20 C)	68 F (20 C)	F	C	F	C	F	C	F × 10^{-6}	C × 10^{-6}
Water	1.0000	0.9992	—	17.5	1.1249	1.0050	32	0	212	100	Nonflammable	—	115	207
Mercury	13.57	13.56	Negligible	0.0012	1.62	1.6	−38	−38.9	679	359	Nonflammable	—	101	182
Kerosine, 41 deg API at 60 F	0.8200	—	Negligible	—	2.2	2.0	−20	−28.9	300+	149+	120	49	480	864
Ellison gage oil	0.8340	—	Negligible	—	—	—	—	− 4.46	300+	149+	140	60	466	839
Halowax oil	—	1.19 to 1.25	—	0.3[a]	—	—	24 to −42	−41	—	—	203	95	367	660
Ethyl alcohol, C_2H_6O	0.7939	0.7907	Absorbs	43.9	1.3	1.2	−179	−117	173	78	55	12.8	600	1,080
36 percent by volume ethyl alcohol in ethylene glycol	—	1.000	Absorbs	—	—	—	−60	−51	173	78	70	21.1	427	769
Ethylene glycol, $C_2H_6O_2$	1.117	1.114	Absorbs	0.12	25.66	20.9	9	−12.8	388	198	245	118	354	638
50 percent by weight ethylene glycol in water	1.068	1.065	Absorbs	13.3	4.364	3.76	−32	0	225	107	Nonflammable	—	—	—
Butyl Cellosolve (ethylene glycol monobutyl ether), $C_6H_{14}O_2$	—	0.9019	Absorbs	0.85	—	3.3	−100	−73	340	171	155	68.5	—	—
Carbitol solvent (diethylene glycol monoethyl ether), $C_6H_{14}O_3$	—	1.0273	Absorbs	0.13	—	—	−76	−60	383	195	205	96	—	—
Glycerin (glycerol), $C_3H_8O_3$	1.2650	1.2623	Absorbs	9.4	—	1,410.0	64	17.8	554	290	320	160	281	505
50 percent by weight glycerin in water	1.1295	1.1274	Absorbs	—	7.5	5.99	−9.4	−23	223	106	—	—	—	—
Dibutyl phthalate, $C_{16}H_{22}O_4$	—	1.0484	Negligible	0.01	—	20.3	−31	−35	642	339	340	171	439	790
Benzene (benzol), C_6H_6	0.884	0.8794	Negligible	74.7	0.7	0.66	42	5.6	176	80	12	−11	687	1,237
*o*Dibromobenzene, $C_6H_4Br_2$	—	1.959	Negligible	—	—	—	35.2	1.8	430	221	150+	66+	432	778
1,1-Dibromoethane, $C_2H_4Br_2$	—	2.093	Negligible	34.7	1.85	1.7	40	4.46	230	110	150+	24+	532	958
Acetylene tetrabromide (tetrabromoethane), $C_2H_2Br_4$	—	2.969	Absorbs slightly	—	—	—	−4	−20	—	—	Nonflammable	—	370	660
Fluorolubes FS (trifluorovinyl chloride polymers)	1.868	—	—	0.018[b]	—	—	−75	−59	—	—	—	—	—	—
Fluorochemical N-43, $(C_4F_9)_3N$	1.872	—	—	—	—	—	−58	−50	—	—	—	—	—	—
Fluorochemical O-75, $C_8F_{16}O$	1.760	—	—	—	—	—	−148	−100	—	—	—	—	—	—
Kel-F oil (trifluorochloroethylene polymers)	1.910	—	—	—	—	—	<−35	−37	—	—	—	—	—	—

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[a] At 122 F (50 C).
[b] At 100 F (37.8 C).

rate, they become apparent by a momentary interruption of the purge flow. Care should be exercised in applying purge rates to orifice flanges because the orifice tap is bottom-drilled with either a ¼, ⅜, or ½ inch (6, 9.5, or 12 millimeter) drill. The ¼ inch (6 millimeter) orifice drilling may prove restrictive for the higher purge rate. Figure 8-8 suggests purge rates to be used for various tap drilling sizes.

The purge rotameter is the most convenient device to determine and establish purge flow. A standard purge rotameter with a range of 0.38 to 3.8 gallons per hour (0.4 to 4.0 cubic centimeters per second) of water or 0.2 to 2.0 actual cubic feet per hour (0.6 to 16.0 cubic centimeters per second) of air is normally satisfactory for purging against clean fluids; however, where the process fluid tends to clog or deposit sediment, the range should be increased. Other standard purge rotameters are available.

Restriction orifices, properly sized and installed, give reliable service when the pressure across them is properly regulated. Usually, restriction orifices are square-edged and bored to a standard drill size [i.e., 1/16, 1/8, 3/16 inch (1.6, 3.2, 4.8 millimeters) and so on] after the required rate of flow has been established. Rate of flow of liquids through such orifices can be calculated by various formulas found in flow metering, mechanical engineering, and similar handbooks.

Rate of flow of gas through a restriction orifice can most easily be calculated on a weight basis using the formulas found in the handbooks as outlined above and then converted to volume at operating temperature and pressure conditions. Exact values of flow rates of purge gases are seldom required.

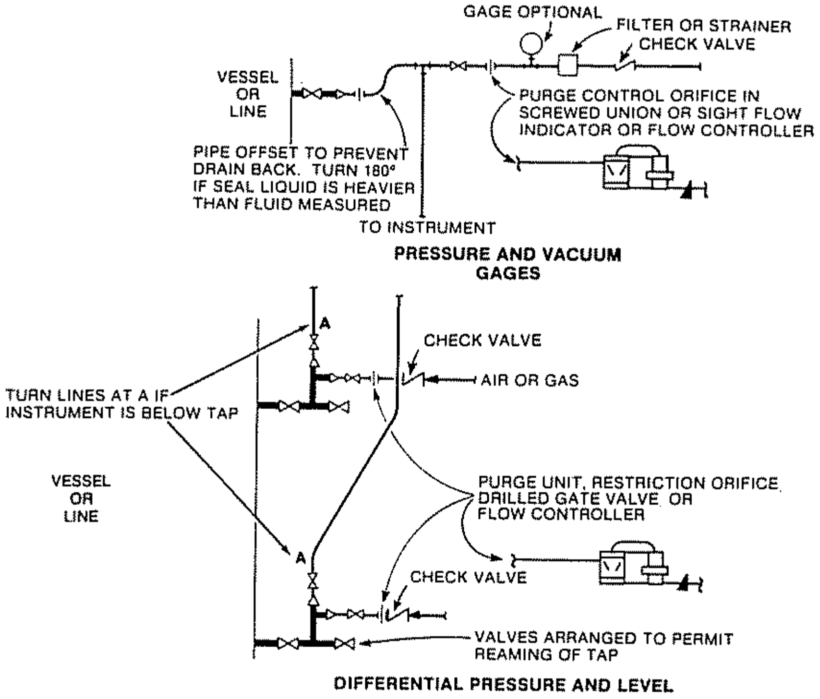


Figure 8-7—Purge Installations

8.5 Winterizing

8.5.1 GENERAL

The need for housing, heating, and insulating instruments and connecting lines will depend on the severity of the winters in the locality. In existing plants, past experience normally will determine the extent of protection required. Where experience is not available, official National Weather Service data should be used. Design should be based on the average low temperature and wind velocity for the coldest month in the year. Results should be checked against the minimum temperature and highest wind velocity to be expected to ensure that the instruments remain operable under the severest conditions. During system design, it is advisable to investigate new protective equipment and materials. Where applicable, the use of either steam or electrical heat-traced tubing bundles can simplify installation and reduce future maintenance problems (see 8.5.2 and 8.5.3). Some manufacturers of heated and insulated enclosures test their products at different temperature and wind velocity conditions and supply performance data which is helpful in system design.

Instruments and connecting lines that contain dry, nonviscous, nonfreezing fluids with pour points below the minimum temperatures encountered require no heating or winterizing protection; however, such materials rarely are found in refinery processing units. Most refineries, particularly those that must design for sub-zero temperatures, consider all process fluid streams to be water-bearing and all process gas streams to be water-saturated, and systems are designed accordingly.

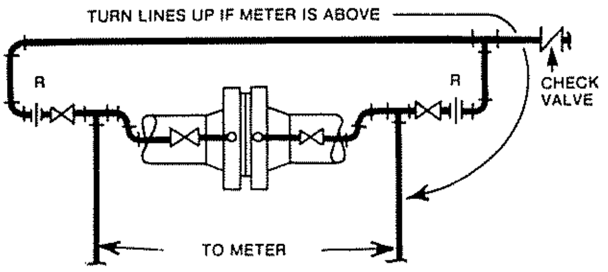
In designing a winterizing system for a large operating unit or plant, it is usually necessary to consider instruments in the following four general categories:

1. Instruments for measuring and controlling process streams such as gases, light hydrocarbons, and intermediate distillates which have pour points below 32 F (0 C). Although some of these streams, when wet, form hydrates that solidify above 32 F (0 C), it is usually sufficient to merely warm such systems to prevent the formation of ice. Therefore, such installations will be designated "warming services."
2. Instruments for measuring and controlling streams having elevated pour points, such as pitch and heavy residuals, and process chemicals, such as phenol, that solidify above 32 F (0 C). In such systems it is necessary to keep the temperature of the process fluid above its pour point to ensure free flow. Such installations are designated "high pour point services."
3. Special instrumentation and piping systems that often require additional protection for operation and maintenance tailored to the service involved. Process stream analyzers and their sample systems should be considered special, but standard methods can be recommended. Such

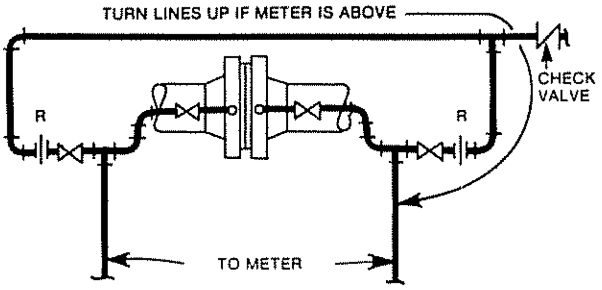
installations are designated "analyzer sample systems" and are discussed in API RP 550, Part II.

4. The specific temperature limitations imposed by the manufacturer to ensure accurate and reliable operation must be taken into account. These are primarily maximum temperature limitations which apply to instruments utilizing electronic circuitry. Minimum temperatures, however, cannot be disregarded. It should be noted that constant temperatures will usually minimize changes in calibration.

Although no well defined limits have been determined for the categories discussed in 8.5.1, each has requirements and limitations that must be considered regardless of the heating method utilized. The most common heating methods are steam heating and electrical heating, and each has specific characteristics that will prove advantageous if used properly.



PURGE LIGHTER THAN FLOW

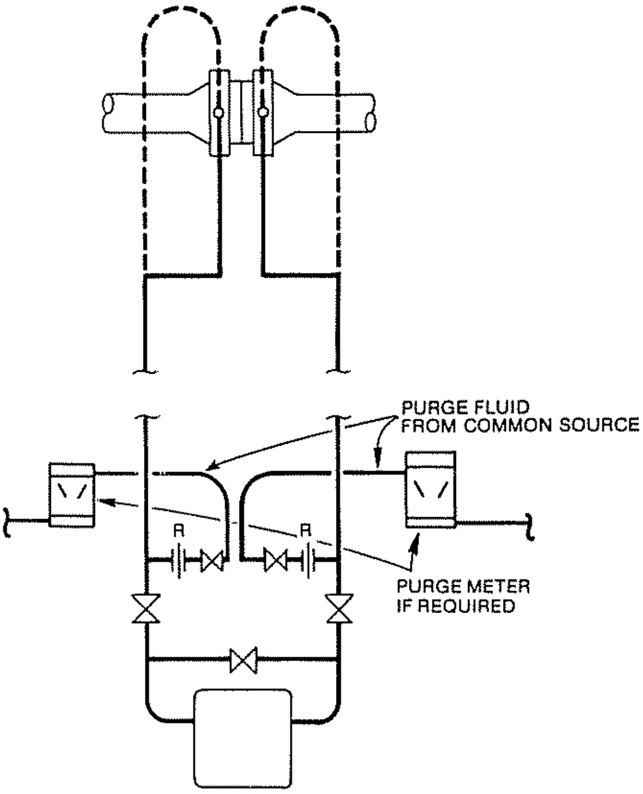


PURGE HEAVIER THAN FLOW

NOTE: Where the restriction (R) is an orifice plate, the following quantities may be used for calculations:

Orifice Flange Drilling		Gas Flow		Liquid Flow	
inches	millimeters	cubic feet per hour	cubic meters per hour	gallons per hour	cubic meters per hour
1/4	6.0	1.0	.03	3.0	.01
3/8	9.5	2.0	.06	5.0	.02
1/2	12.0	5.0	.10	8.0	.03

Figure 8-8—Orifice Tap Purges for Flow Meters



NOTES:
1. Size connecting lines for purge flow rate.
2. Dotted lines indicate that the purge fluid is lighter than the line fluid.
3. Solid lines indicate that the purge fluid is heavier than the line fluid.

Figure 8-9—Purges for Connecting Lines and Orifice Taps

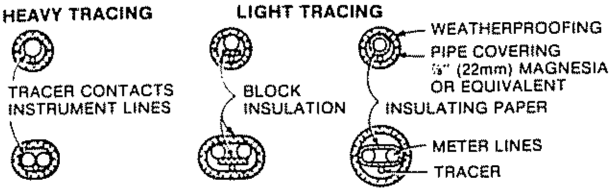
8.5.2 STEAM HEATING

Since steam is normally available around refinery process units, steam heating has the advantage of being readily accessible. In addition, insulation requirements are less stringent than with other methods because steam supplies high-density heat from condensation and large quantities of heat can be obtained from a single tracer line. On the other hand, steam delivers heat at a temperature corresponding to the saturated steam pressure in the tracer, a minimum of 212 F (100 C), which may overheat some instruments or lines unless care is exercised.

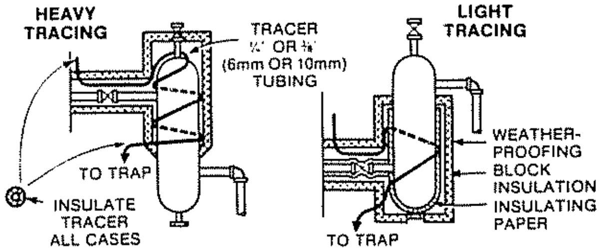
On large installations, it is often desirable to supply a separate steam tracing and heating system that is independent of process operation, equipment maintenance, and unit shutdown. In subzero climates, it may be necessary to take this supply from the main steam header and to provide a pressure-reducing station that can be adjusted to meet winter/summer ambient conditions. Steam pressure can be adjusted to minimize overheating when the "heavy tracing—light tracing" concept, shown in Figure 8-10, is used during initial installation. Note that reducing the pressure may also require desuperheating to obtain the desired steam temperature.

8.5.2.1 Steam Tracing for Warming Services

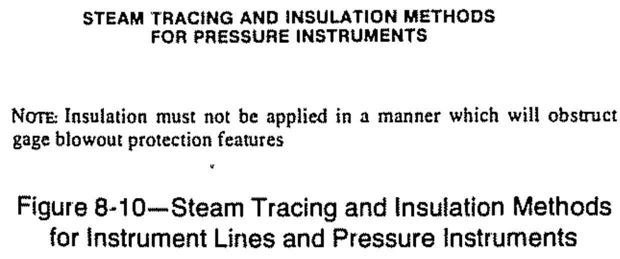
Warming services require steam tracing to prevent the formation of ice and hydrates and undesirable gas condensation. The problem, however, is to avoid overheating, which may cause boiling in the instrument and lines or which may damage parts, such as electronic transmitter equipment. Danger from overheating can be minimized by "light tracing" in which direct contact between the hot tracer and line or instrument is prevented by the use of insulation or spacing (depicted in Figure 8-10)



STEAM TRACING AND INSULATION METHODS FOR INSTRUMENT LINES



TYPICAL FOR SEAL POTS



TYPICAL FOR GAGES

STEAM TRACING AND INSULATION METHODS FOR PRESSURE INSTRUMENTS

NOTE: Insulation must not be applied in a manner which will obstruct gage blowout protection features

Figure 8-10—Steam Tracing and Insulation Methods for Instrument Lines and Pressure Instruments

a. INSTRUMENT HOUSINGS

Where weatherproof transmitters for pressure and flow measurement can be close-coupled to the point of measurement, heating can be simplified by using a molded insulating plastic enclosure which fits snugly around the instrument and is strapped in place to prevent moisure entry This unit provides protection and insulation for the instrument and allows the use of several techniques for heating. One method utilizes the bolts or studs that hold the body of the instrument together. One, or more, of these bolts is drilled so it is hollow and its ends are fitted with connections for steam and condensate so that heat is fed directly into the body of the instrument. One problem with this method is that drilled bolts reduce the pressure rating of the instrument; however, special heat-treated hollow studs that do not reduce pressure rating are available. The instrument manufacturer should be requested to verify the actual derating and type of hollow bolts to be used.

Another method of providing heat to the enclosure is to use a radiant heater. This method simplifies servicing because it is not connected to the instrument

Insulated plastic enclosures are available for all types of transmitters, and special types are available that enclose connection valves and manifolds of specific configuration. These same enclosures can be used for transmitters that cannot be close-coupled. This includes pressure and flow transmitters for which the point of measurement is not accessible and most level transmitters. In these cases, the method shown in Figure 8-11 should be followed with the molded insulating plastic enclosure substituted for the housing shown

Where weatherproof instruments are not used or where the instruments require frequent servicing or access, use of a heated and insulated housing and tracing arrangement, as shown in Figure 8-11, is advisable. Different types of housings and their mountings are shown in more detail in Figure 8-12 Housings should be rainproof, dustproof, and corrosion resistant. They should provide sufficient working space for routine maintenance and should have access doors sized and located for easy removal of the instrument(s). Line entry should be through the bottom or sides of the housing and the housing should be adequately sealed. Glass observation windows should be provided where needed. Insulation and heating coils may be installed in the field. Factory installed coils are available from some manufacturers, if the requirements for temperature and wind velocity are specified.

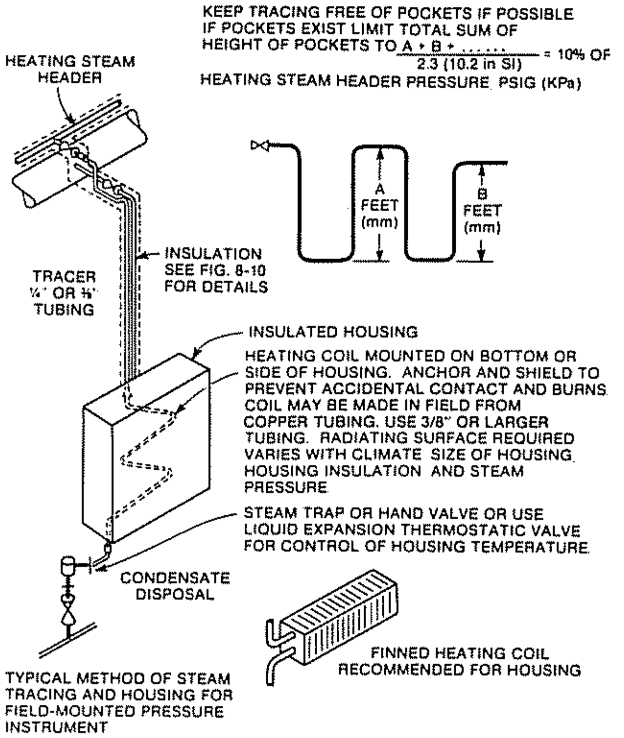
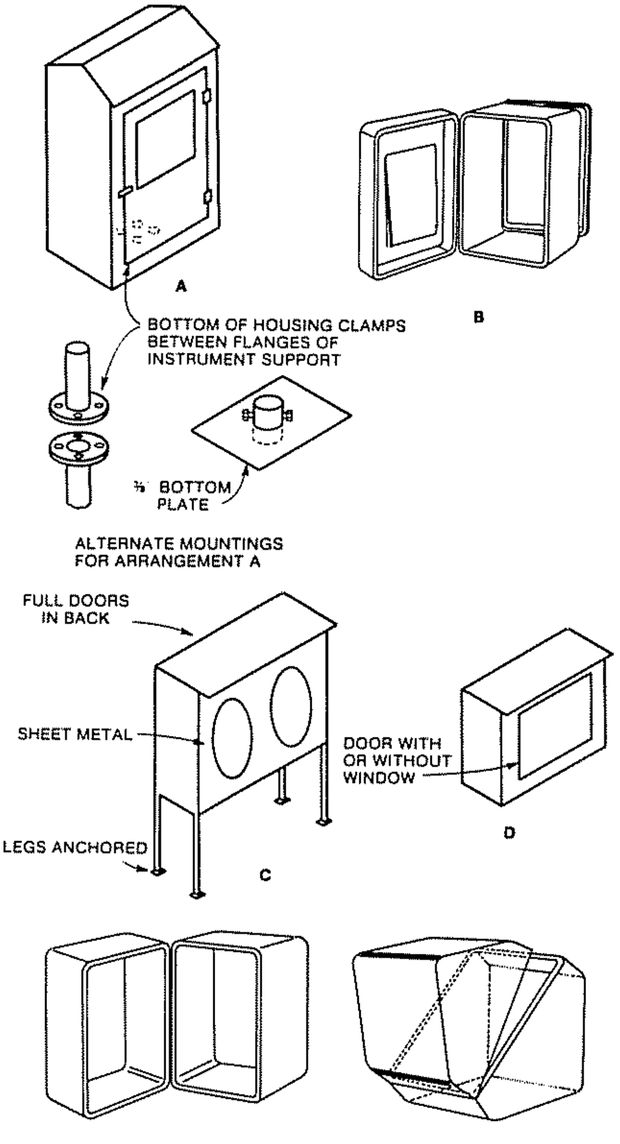


Figure 8-11—Steam Tracing and Heating

b. TRACING METHODS AND MATERIALS

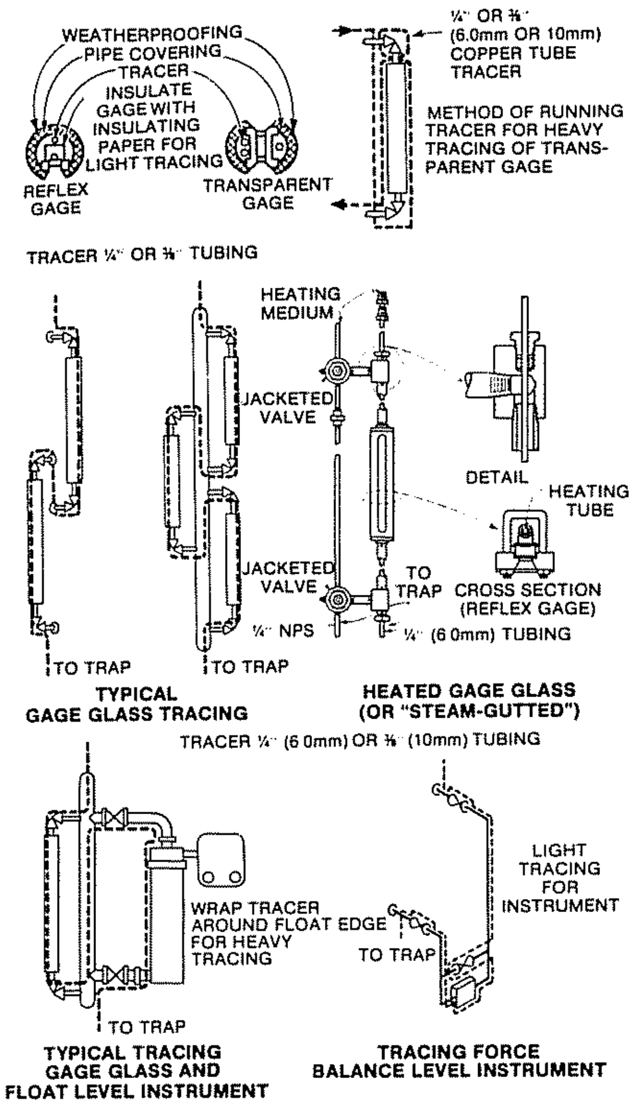
The arrangement depicted in Figure 8-11 is normally used with the "heavy tracing–light tracing" methods shown in Figure 8-10 with minor variations being required for specific cases. The supply header should be at the highest point and a shutoff valve should be provided for each tracer, so that shutting off steam to one housing for servicing does not affect other instruments. Ideally, tracing should slope downward continuously to avoid pockets and facilitate drainage. Where pockets cannot be avoided, refer to the diagram and equation in Figure 8-11 for guidance.

A separate trap and condensate isolating valve should be provided for each tracer. Where steam tracing is extensive, a tracing piping plan should be provided to show the location of steam shutoff valves and associated instruments, traps, and condensate isolating valves. The steam and condensate shutoff valves nearest to the instrument should be permanently tagged with the associated instrument designation. Improved temperature sensitive traps are available that are specifically designed for heating and warming services. These often serve as a combination trap and control thermostat. The isolation valves, traps, and thermostats should be installed to allow for ease of checking and maintenance. Installation procedures and



NOTES:
1. Housing insulation is foil-faced fiberglass, celotex, or insulating paint.
2. Arrangement A shows a typical instrument housing and mountings. Line entry point is optional; door in both front and back; window in front door.
3. Arrangement B is the same as Arrangement A except that a molded polyurethane enclosure is used.
4. Arrangement C shows a self-supporting housing.
5. Arrangement D shows wall- or line-supported housing. Back of box is heavy sheet metal. The housing is bolted to the wall or line bracket and supports the instrument.
6. Arrangement E is the same as Arrangement D except that a molded polyurethane enclosure is installed.
7. Arrangement F is a line-mounted or post-mounted polyurethane enclosure for small instruments.

Figure 8-12—Instrument Housings and Mountings



NOTES:
1 Refer to Figure 8-10 for tracing and insulation methods.
2 Refer to Figure 8-11 for maximum loop height

Figure 8-13—Steam Tracing and Insulation for Level Instruments

maintenance requirements are usually defined by the supplier.

Either copper or stainless steel tubing sized for the particular service should be used to carry the heating steam. Aluminum tubing should not be used because it is subject to corrosion, particularly by magnesia insulation. Carbon steel tubing rusts not only externally but internally when heating is seasonal or intermittent. The internal rust clogs or damages traps.

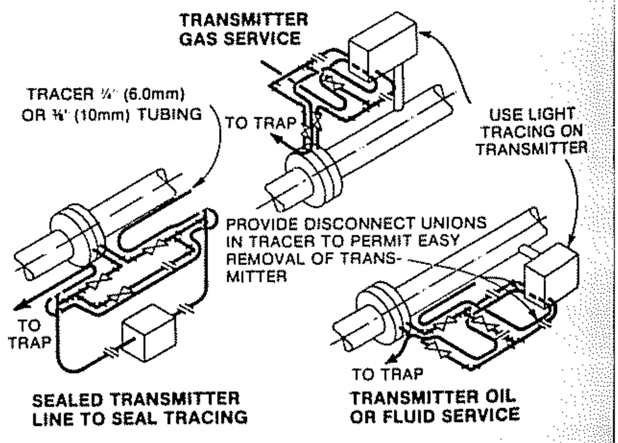
Joints in tracing tubing should be avoided if possible. Where they are necessary, they should be made outside the insulation with expansion loops to prevent stress on the fittings. Only high quality fittings should be used. The loops should be separately insulated for personnel protection. Examples of methods for tracing different types of instruments are shown in Figures 8-13, 8-14, and 8-15.

c. INSULATION AND SHEATHING

The entire tracing system for connecting lines should be carefully insulated and waterproofed using an appropriate method such as that shown in Figure 8-10. Particular care should be used at the point of measurement and at the entry into the insulated enclosure. A durable sheath should be used for protection. The system should be designed and installed to minimize damage to the insulation during routine service or maintenance. Commercially available insulating enclosures can be used that are designed to allow for routine maintenance.

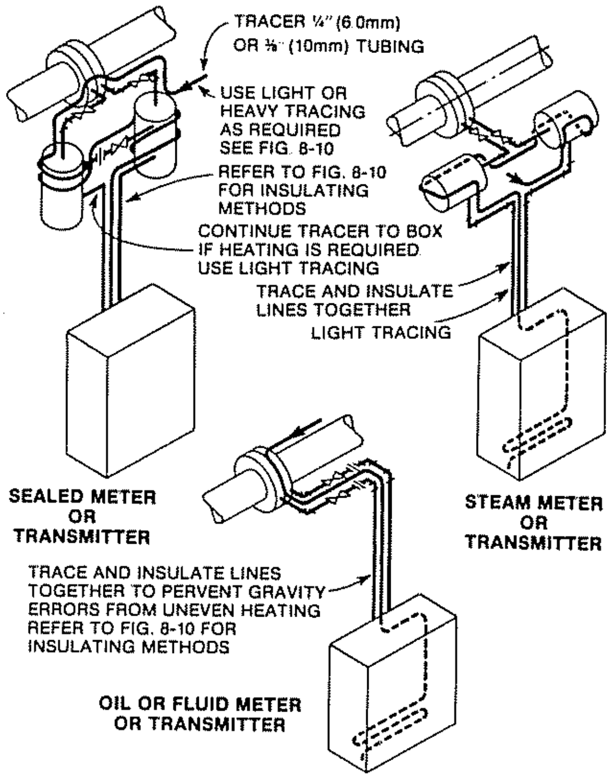
8.5.2.2 Steam Tracing for High Pour Point Services

The principal difference between instruments for measurements and automatic control of heavy distillates, residual oils, pitch, and chemicals and those described for warming services is the temperature level required to keep the material fluid in the instrument and lines. Low pressure steam [less than 50 pounds per square inch absolute (350 kilopascals)] heating usually requires heavy tracing, as shown in Figure 8-10. In this type, the tracing tubing is in direct contact with the connecting lines. Where maximum heat is required, the tracer tubing can be cemented to the



NOTES:
1 All tracers have shutoff valve at source and steam trap or valve at termination for condensate disposal
2 Refer to Figure 8-10 for tracing and insulation methods.

Figure 8-14—Steam Tracing and Insulation for Close-Coupled Flow Instruments



NOTE: All tracers have shutoff valve at source and steam trap or valve at termination for condensate disposal.

Figure 8-15—Steam Tracing and Insulation for Remote Flow Instruments

lines with heat transfer cement or more than one tracer can be used. If this is inadequate, the tracing system must be separated from the low pressure steam system and plant steam utilized, possibly with a separate pressure regulator, in order to deliver heat at a higher temperature.

As a general precaution, care must be taken to ensure that the high temperature limitations of the instruments are not exceeded. With electronic devices, remote mounting of the circuitry can circumvent this problem. Housings may be used to enclose only that part of the instrument which contains process fluid. Consideration must be given, however, to the conduction of heat through the meter body to the electronics.

a. INSTRUMENT HOUSINGS

Housings are usually identical to those used for the instruments in warming services described in 8.5.2.1. The molded insulating plastic enclosure can be used advantageously up to its temperature limits. Where heated boxes are used, a larger coil is required and extra protection may be necessary to prevent maintenance personnel from being accidentally burned. For heating with hollow bolts, two-bolt, rather than one-bolt, construction can be used.

b. TRACING METHODS AND MATERIALS

Tracing methods are similar to those used in warming services except that heavy tracing should be used. Materials for tubing and fittings are identical to those used in warming services.

c. INSULATION AND SHEATHING

These features are similar to those used in warming services except that heavier and more carefully applied insulation may be required for some services.

8.5.2.3 Steam Tracing for Analyzer Sample Systems

Designing plant stream analyzers, particularly those installed separately with short sample lines, requires a study of the manufacturer's recommendations and all operating conditions. Design must be based on these factors and the housing and winterizing techniques discussed in API RP 550, Part II, *Process Stream Analyzers*. This discussion will be confined to heat tracing required by the sample lines, primarily on multiple installations.

In severe climates, several analyzers are usually housed in a common building remote from all sample points, and, therefore, circulating sample loops are required. No problem occurs with circulating samples for light liquids having pour points below the lowest temperature encountered because the sample is usually flowing continuously and ice formation can occur only when the sample flow is stopped. However, some liquid samples will be heavy distillates with high pour points that are free of danger from overheating. Other samples will be very light liquids such as liquid petroleum gas (LPG) that must be vaporized at the sample point and maintained in a vapor state to the instrument.

Both applications require high-density heat. Tracing techniques similar to those described for warming services can be employed; however, lines are usually much longer than those previously described. It may be preferable in such cases to use bundled steam-traced tubing. In these bundles, one or two sample tubes are wrapped in contact with a single steam tube. The assembly is heavily insulated and covered with a polyvinyl chloride (PVC) sheath which is less subject to damage than ordinary insulation. Properly sized, such a tube bundle can be used for a long circulating sample line that is neat, efficient, economical, and free of leaky tracer joints and other problems common to ordinary tracing. However, bundled tubing does have temperature and other physical limitations that should be discussed with the manufacturer. End seals or sealing is required for these bundles.

8.5.3 ELECTRICAL HEATING

The principal advantage of electrical heating is that it can be thermostatically controlled to exact requirements, when designed and installed properly. When selecting heating elements, care should be exercised to ensure that they are not potential sources of ignition. Several types of cable are available (for example, mineral insulated and self limiting). Care must be exercised to use them with fittings, relays, and thermostats suitable for the area classification. To ensure that the installation meets all requirements, it is necessary to refer to NFPA Bulletin No. 70, *National Electrical Code*, Article 500. Local codes and plant practices may also dictate other precautions in installation.

Several special factors are involved in design and installation of electrical heating to ensure that the heating system will operate properly during startup and continued plant operation. The thermostat must be located properly, set at the correct level, and its setting maintained. In addition, a means may be required to indicate that the cable itself is functioning properly on critical circuits. Electrical tracing can be damaged. Special care should be exercised during installation. For instance, the sheath of mineral insulated cable work-hardens and breaks if it is frequently bent or disturbed during the maintenance of the equipment it heats. Tracers thus damaged normally cannot be repaired but must be completely replaced. The factors outlined in 8.5.3.1 through 8.5.3.3 should be considered in designing and installing electrical heating.

8.5.3.1 Electrical Tracing for Warming Services

Electrical heating to prevent the formation of ice and hydrates and the condensation of undesirable gas has proven to be economical and trouble free on many instruments, particularly those with long connecting lines. If the thermostat is located and set properly and the line tracing is designed for the particular heat delivery required, overheating is seldom a problem. As a precaution the thermostat should be installed in a manner such that its setting can be checked in place.

a. INSTRUMENT HOUSINGS

Housings are similar to those used for steam heating. The molded insulating plastic enclosure is also available with electric heaters. In hollow-bolt construction, a cartridge-type heating element is inserted in one of the bolts and a controlling thermostat in another. Most warming installations of this type are quite successful even in severe climates. Where a heated and insulated box enclosure is used, as in Figure 8-16A, the most important factor is the quality and the amount of its insulation. The manufacturer should be consulted to ensure that insulation is adequate. Such boxes can be obtained with bayonet or other radiant-type heating elements instead of the coil of cable illustrated.

b. TRACING METHODS AND MATERIALS

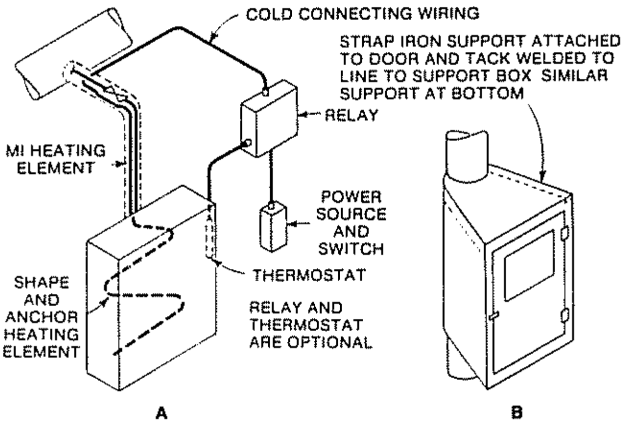
The tracing method shown in Figure 8-16A is adequate for most installations, and the light tracing–heavy tracing concept (see 8.5.2) is less critical than with steam heating. The use of electrically traced bundled tubing, particularly on long lines, may be advantageous. The traced bundle, heat cable, cold connecting wiring, and accessories must be suitable for the electrical area classification. The thermostat must be of a quality suitable for the plant environment because operation of the instrument, and often the plant, is contingent upon its reliability.

c. INSULATION AND SHEATHING

Insulation and sheathing are similar to that used for steam tracing but should be designed and installed for maximum weatherproofing and protection. The system should permit repair or removal of the instrument without damage to either insulation or sheathing.

8.5.3.2 Electrical Tracing for High Pour Point Materials

Electrically traced instruments in high pour point service require essentially the same care as their steam-heated counterparts. They require more heat and higher tempera-



NOTES:
1. Arrangement A shows an electrical heating installation. Connect the instrument as close to the process line as is practical and keep the electrical wiring correspondingly short.
2. Arrangement B shows a process flow heating installation. This type of protection can be used where there is continuous flow and line temperature ranges between 60 F (15 C) and 150 F (65 C). Line remains bare inside the housing. Sides of housing are made of block insulation or metal coated with insulating paint.

Figure 8-16—Electrical Heating and Heating by Process Flow ture than instruments in warming service. Therefore, the heat tracer should be in contact with the connecting lines in all cases and cemented to the connecting lines for good heat transfer in high-temperature services. Sheath materials for cable have definite, usually published, maximum allowable surface temperatures. These figures must be consulted to ensure that the sheath material used has a temperature rating high enough for sufficient heat transfer, particularly for pour points above 300 F (150 C). If bundled tubing is used, the maximum allowable temperature of both the tracer and the bundle insulation must be explored.

a. INSTRUMENT HOUSING

Housings are identical to those described for warming services with additional heat supplied where necessary.

b. TRACING METHODS AND MATERIALS

Methods and materials are the same as those described for warming services.

c. INSULATION AND SHEATHING

Because of the low-density heat, insulation must be heavy and installed with particular care. No bare spots or poorly insulated areas that may cause localized solidification of the stagnant material in the lines or instrument can be allowed.

8.5.3.3 Electrical Tracing for Analyzer Sample Systems

In general, the remarks in 8.5.2.3 also apply to electrical tracing for long circulating sample lines for analyzers. Unlike steam heating, however, heat from electrical tracing will require careful design and installation particularly when used for vaporizing services. In services where the cable method is used, it may be necessary to supply multiple heating cables in contact with the sample line and to attach the cables to the sample line with heat transfer cement.

Insulation and its sheathing must be of exceptional quality and must cover all parts of the system including vent and drain valves and all connections. If the electrically traced tube bundle is used, the manufacturer must be consulted to assure that the amount of heat available is sufficient. The manufacturer should also verify that the bundle insulation is adequate and, since it has temperature limitations, that it will not be damaged by the operating temperature which, in circulating samples, may be considerably higher than that required for maintaining fluidity. If bundled tubing is used, care must be exercised to ensure that heat is not lost at the bundle termination. A bare or poorly insulated drain valve has been known to dissipate enough heat to cause a plug to freeze in a line carrying heavy, viscous material.

Other factors that must be considered for circulating sample lines are the type and location of the thermostat. Because a circulating sample normally operates at a temperature higher than that at which the thermostat is set, the thermostat must be of a type that will not be deformed or have its setting changed by the excessive operating temperature. Furthermore, to maintain fluidity in the entire system, the thermostat must be located at, or near, the return connection to the process.

8.5.4 OTHER HEATING METHODS

Process heat can sometimes be utilized for close-coupled instruments and connections in mild climates subject to infrequent freezing spells. Figure 8-16B depicts a box-type housing suitable for such service. In addition, slightly different boxes have been used successfully with close-coupled line-mounted transmitters. In some cases, boxes have been equipped with auxiliary steam coils or electric heaters to be energized in case of emergency. Line process fluids have also been used in coils like steam tracers for warming where a pressure drop was available for supply and return and where temperature was compatible. Hot water and steam condensate have also been used for special applications where the supply was convenient. These are all special applications, however, that must be designed and installed to meet individual conditions