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GAS MEASUREMENT MANUAL

DESIGN OF METER AND REGULATOR STATIONS

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PART NINE
DESIGN OF METER AND REGULATOR STATIONS

SECTION 9.1—INTRODUCTION
SECTION 9.2—STATION SPECIFICATIONS
SECTION 9.3—REGULATORS
SECTION 9.4—SAFETY CONTROL VALVES
SECTION 9.5—VALVES AND PIPING CONFIGURATIONS
SECTION 9.6—MEASUREMENT
SECTION 9.7—AUTOMATION
SECTION 9.8—PREPARATION OF NATURAL GAS FOR MARKET

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Part 12 Meter Proving (XQ0278)
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CONTENTS

SECTION 9.1 – INTRODUCTION

	Page
Design Purpose Classification	9.1.1
Flow Range Consideration	9.1.1
Flow Characteristics and Other Considerations	9.1.1

SECTION 9.2 – STATION SPECIFICATIONS

	Page
Scope	9.2.1
Volume	9.2.1
Peak Loads	9.2.1
Average Hourly Load	9.2.1
Minimum Hourly Load	9.2.2
Pressure Conditions	9.2.2
Inlet Pressure	9.2.2
Outlet Pressure	9.2.2
Type of Load	9.2.2
Gas Conditions	9.2.2
Ambient Conditions	9.2.3
Site Conditions	9.2.3
Sample Station Survey Form	9.2.3

SECTION 9.3 – REGULATORS

	Page
Downstream Pressure Control	9.3.1
Parallel Installations	9.3.1
Vent Requirements	9.3.1
Working Space Requirements	9.3.1
Installation and Removal Accommodations	9.3.2
Pressure Sensing Point	9.3.2
Inlet and Outlet Connections	9.3.2
Noise Abatement	9.3.2
Safeguards for Reliable Service	9.3.3
General	9.3.3
Pressure Pilots	9.3.3
Relative Location to Metering	9.3.3
Pilot Supply	9.3.3
Diaphragm Relief Valves	9.3.3
Parallel Sets and Bypass Installations	9.3.4

SECTION 9.4—SAFETY CONTROL VALVES

	Page
Purpose	9.4.1
Monitor Regulators	9.4.1
Principle	9.4.1
Installation Consideration	9.4.1
Pressure Relief Valves	9.4.2
Principle	9.4.2
Installation Consideration	9.4.2
Automatic Shut-off Valves—Or Trip-out Valves	9.4.3
Principle	9.4.3
Installation Consideration	9.4.3
Other Considerations	9.4.3

SECTION 9.5—VALVES AND PIPING CONFIGURATIONS

	Page
Scope	9.5.1
Header and Piping Concepts	9.5.1
Geometric Header Considerations	9.5.1
Log or Modular	9.5.1
Ring or Donut Type	9.5.3
Box Type	9.5.3
Streamlined Type	9.5.3
Pressure Drop	9.5.3
Examples	9.5.7
Types of Valves	9.5.8
Gate Valve	9.5.8
Ball Valve	9.5.12
Taper Plug Valve	9.5.14
Globe Valve	9.5.14
Butterfly Valve	9.5.16
Check Valve	9.5.16

SECTION 9.6—MEASUREMENT

	Page
Types of Meters	9.6.1
Head-Class Orifice Meter	9.6.1
Volumetric-Class Meter	9.6.2
Velocity-Class Meter	9.6.2

SECTION 9.7—AUTOMATION

	Page
Multiple Run Station	9.7.1
When Required	9.7.1
Operation	9.7.1
How to Size Orifice	9.7.1

SECTION 9.8 – PREPARATION OF NATURAL GAS FOR MARKET

	Page
Impurities	9.8.1
Limitation of Impurities	9.8.1
Gas Scrubbers and Cleaners	9.8.1
Types of Solid Impurities	9.8.1
Sizing of Cleaning Equipment	9.8.1
Types of Cleaners	9.8.2
Filters	9.8.2
Liquid Bath Scrubbers	9.8.2
Rotating Vane Scrubbers	9.8.2
Cyclone Scrubbers	9.8.2
Freezing in Meters, Regulators, and Pipelines	9.8.3
Prevention and Removal of Freezing and Hydrate Formation	9.8.5
Gas Dehydration	9.8.5
Gas Heaters	9.8.6
Indirect-Fired Water Bath Heaters	9.8.6
Catalytic Combustion Infrared Heaters	9.8.6
Reduction of Line Pressure	9.8.7
Introduction of Inhibitors	9.8.7
Example	9.8.7

FIGURES

Figure		Page
9.2.1	Data form for meter and regulator station design	9.2.4
9.5.1	Typical measuring and regulating station layout w/DLC	9.5.2
9.5.2	Log type header	9.5.2
9.5.3	Ring type header	9.5.4
9.5.4	Box type header	9.5.4
9.5.5	Streamline type header	9.5.5
9.5.6	Piping configuration	9.5.6
9.5.7	Cv for standard welding reducers	9.5.9
9.5.8	Cv versus K values for valves	9.5.10
9.5.9	Resistance coefficients vs. equivalent length	9.5.11
9.5.10	Equivalent resistance coefficients vs. diameter ratios	9.5.11
9.5.11	Piping configuration	9.5.12
9.5.12	Gate valve cut-away	9.5.13
9.5.13	Ball valve cut-away	9.5.13
9.5.14	(Taper) Plug valve cut-away	9.5.14
9.5.15	Typical plug openings	9.5.15
9.5.16	Globe, flanged cross section	9.5.15
9.5.17	Angle	9.5.15
9.5.18	Y type globe	9.5.15
9.5.19	Butterfly valve	9.5.16
9.5.20	Motor operated-wafer body, butterfly valve body	9.5.17
9.5.21	Lightweight check valve cut-away and operation	9.5.17
9.5.22	Swing check valve cut-away	9.5.17
9.7.1	Orifice sizing chart #1 for dual automatic tube station (estimated)	9.7.3
9.7.2	Orifice sizing chart #2 for dual automatic tube station (actual)	9.7.4
9.8.1	Water vapor content of compressed natural gas	9.8.4
9.8.2	Gas hydrate freezing point depression versus weight percent methanol in liquid	9.8.8
9.8.3	Ratio of methanol vapor to liquid composition versus pressure	9.8.9
9.8.4	Gas hydrate equilibrium for natural gas	9.8.10

TABLES

Table		Page
9.5.1	K Factors for Welding Fittings	9.5.7
9.5.2	Resistance Coefficients (K)	9.5.12
9.8.1	Analysis of Gases' Represented by Curves of Figure 9.8.4	9.8.10

Section 9.1
INTRODUCTION

Sustained safety, accuracy, and control are the primary considerations in the design of meter and regulator stations. Many particulars must be considered and assembled into specifications and drawings to ensure safety and to provide accuracy, accessibility and work space for operations. These factors can be combined into a piping structure with adequate foundation and a partial or complete shelter arranged to fit the site. The station should be designed with predicted load changes considered and to require a minimum of piping alteration with unpredicted load changes. Most metering and regulating stations are likely to be in service for a long time. Whether for measurement from wells, a field, or major transmission or distribution system, the life of station may be unlimited. This requires careful listing of all features of the station. It should be emphasized that the meter station is the key to accurate billing for gas deliveries.

DESIGN PURPOSE CLASSIFICATION

There are three major classifications into which measurement stations may be divided:

1. Stations where both metering to establish the value of the gas and control monitoring at the same site are equally important because of safety or pipepline operational requirements
2. Stations where measurement to establish the value of gas bought or sold is of primary importance and control and monitoring the flow is of minor importance
3. Stations where control and monitoring gas flow are the principal functions and the value of the gas is of secondary concern

FLOW RANGE CONSIDERATION

If measurement is to establish value, the first step is to estimate the volume of the gas. Since the range of volumes that may pass through a meter station is fairly wide, no single figure can be set, but it should be possible to estimate the probable maximum demand and normal flow. A commercial measuring station should be designed for maximum precision.

FLOW CHARACTERISTICS AND OTHER CONSIDERATIONS

Some gas is being measured to the satisfaction of both buyer and seller by the use of minimum requirements, but experience shows that a meter station may be subjected to unfavorable conditions such as erratic flow or other situations where minimum requirements may be inadequate. Billings based on the measurement should be free from complaints and refund claims. Poor and costly service can be avoided by a well-designed station. Provisions for gas measurement are usually in the tariff and service agreement or an equally binding agreement such as a purchase or sales contract. Meters used for indication of flow, such as for gas dispatching or process plants, may require less precision than those used for purchases or sales. The study of related subjects in other parts of this manual is essential to understanding overall station design. For instance, metering units, auxiliary instruments, and pressure regulators—for which requirements and limitations of the site are often of initial importance—are discussed fully in other parts.

Section 9.2
STATION SPECIFICATIONS

SCOPE

There are many details to assemble in the development of station specifications. These details are basically volume and pressure data, with many other considerations to ensure safe and proper operation. Some stations may be designated for metering purposes only, while others could combine control and metering or be designated strictly control. Regardless of the type of station involved, certain data are necessary for the proper design of a satisfactory installation, and other data are necessary to ensure that the station performs satisfactorily over a long period of time. Although the following items are obvious considerations, the designer is cautioned to seek all relevant information (such as all code requirements) to ensure that proper consideration is given to the individual site and its present requirements and future demands. Certain data are often agreed upon in a contract by the location of the station and those conditions surrounding that particular site. The form for gathering the data is left to the designer and those who negotiate contracts. However, the major items are described below with some explanation of their importance.

VOLUME

The volume passing through a given station is the result of a contract or a need by the supply company. In a contract situation, necessary information includes the daily delivery requirement (summer and winter) peak hourly requirements, minimum hourly requirements, and the agreed-upon measurement. In addition, future requirements may be agreed upon at the time of the contract. In non-contract installations, load surveys of the area will indicate the volumes required, and projections of the future load requirements will be dictated by economic projections for the specific geographical area. Diligence in seeking factual data and making reasonable predictions will be manifested in a station properly designed for today's loads and readily modified for future loads.

Peak Loads

Peak loads will be different from average volumes determined by the average daily load. The design should be based on peak load requirements and not the daily average. The ratio of peak hour to daily delivery will vary among different services. Industrial loads may be predominantly eight-hour loads, while feeder lines could have peaks at one or more times per day. The peak load in winter will be different from that in summer, and the largest peak conditions must be considered in sizing meters and regulators.

A ratio of peak hour to average hour of between 1.25 and 1.33 has been used by some pipelines, where peak-hour requirements were not known and had to be estimated from daily demands. Some operations use six percent of estimated maximum daily demand for peak-hour load. Adequate load surveys will minimize the amount of estimation required. However, the load survey should give consideration to unusual conditions and not to average conditions.

Average Hourly Load

The average hourly load is generally determined by dividing the daily requirements by 24 hours. This figure can be used to determine the average value of the gas passing through the station on an hourly rate.

Minimum Hourly Load

The minimum hourly load should be known or determined to ensure that the regulators and meters to be installed have satisfactory rangeability. This information will also indicate whether the regulator shall be required to provide tight shut-off.

PRESSURE CONDITIONS

The pressure conditions for each installation are the inlet pressure to the station and the outlet pressure of the station or the customer required pressure. Each condition influences the design of the station.

Inlet Pressure

The inlet or supply pressure to a station will vary depending on the system feeding the particular station. The minimum inlet pressure is the basic factor in sizing regulators and the metering equipment for the maximum demand rate. The maximum pressure will be the factor determining the shell strength of the regulation and measurement equipment and is also needed to size over-pressure protection equipment. The pressure condition may vary between winter and summer, and these variations must be considered in the design.

Outlet Pressure

The outlet pressure of a regulating station will be set by contract or operational requirements. Metering stations without regulating equipment will have an outlet pressure rating equal to the inlet pressure. The regulating station specifications should indicate the quality of outlet pressure control required and the minimum and maximum outlet pressure acceptable to the customer or system. The amount of pressure reduction is a major indication of whether a single stage pressure regulator will be satisfactory or if multiple stage reduction is required.

TYPE OF LOAD

Contract conditions will indicate whether the load is firm (high priority) or interruptible (low priority) or a combination of the two. In addition, the load should be analyzed to determine if it is steady or highly cyclic. Cyclic loads require further information, since the peak demand may exceed averages and cause improper operation of the station in supplying the system requirements. Metering equipment sized to meet peak loads may not be capable of metering off-peak loads unless multiple meter runs are installed with switching equipment (see Section 9.7, Multiple Run Station). Loads that go to zero flow will require regulators capable of tight shut-off or arrangements must be made for manual or automatic valve closure ahead of the regulator. The type of load, economics of meter selection, and the variation in station inlet pressure may dictate that the metering pressure be held constant at some value below the minimum inlet pressure and a second cut be made to supply the proper outlet pressure level for the system. Load characteristics also influence the type of meter selected for the installation.

GAS CONDITIONS

Usually the gas contract will specify the minimum BTU content of the gas and may specify the maximum allowable amount of H_2O in the gas. Other conditions concerning the gas, such as amount of H_2S, CO_2, N_2, etc., may also be specified in the contract. In addition, for sizing purposes, the average specific gravity of the gas and the average gas temperature should be estimated or assumed to be at conditions of 60°F and 0.6 specific gravity. Any unusual gas conditions also should be known in order to protect the installed equipment and provide proper operation. Measurement and control of untreated field gas will impose problems requiring preheating or dehydration facilities unless the gas condition is known to be satisfactory. Most pipeline-quality gas is dry and clean, but dust conditions could cause severe velocity erosion of regulator trim. If dust or other particular matter is present, filtering equipment should be installed upstream of the station.

AMBIENT CONDITIONS

The maximum, minimum, and average ambient temperatures for the area should be known. Very low temperatures will require special considerations to prevent freezing of the equipment. Likewise, the station site elevation will indicate the average barometric pressure to be used in measurement calculations. If orifice meter measurement is used, the latitude of the station should be determined to permit the use of the location factor in the orifice meter calculation. High relative humidity can cause external ice formation on piping if the piping temperature reaches 32°F due to the temperature drop caused by pressure reduction. If such a possibility exists, special attention should be given to all piping placement in order to eliminate potential freezing damage.

SITE CONDITIONS

The characteristics of the station site or proposed area should be considered to determine the type of external station design. A regulator station creating noise levels of greater than 85 db will not be tolerated in a populated area, while the same station in a rural area may be satisfactory. If population growth is in the direction of the site, then this should be considered early in the design because it will have an influence on what protective measures must be taken to make the station satisfactory over a long period of time. Prior to design, in addition to becoming familiar with local inordinances and regulations concerning site improvements, consideration should be given to flooding, ease of access to the site during adverse weather, and outlet lines crossing roadways and presenting frost-heaving problems. These and many other details should be considered when gathering facts to prepare the station design.

SAMPLE STATION SURVEY FORM

The sample form shown in Figure 9.2.1. can be used as a guide for the preparation of a form to suit individual company requirements. This form is not regarded as complete but does list many of the items necessary to develop specifications for proper station design. Although there is no mention of base conditions for measurement, since each company has standards on these items, it is considered to be good practice to have the base conditions listed. The following sections of this Part will provide additional information as to the type of details and facts that must be gathered in the specifications prior to the actual station design.

Data Form For

METER AND REGULATOR STATION DESIGN

Station Name ______________________ Location No. __________

City __________ County __________ State ________ Div. ______ Dist. ______

Pipeline ______________________ Mile Post __________

Service to ______________________ Address __________

Contract

Pressure Max. ________ Min. ________ Delivery-Hourly ______ Daily ______

H_2O lbs/MMCF ______________________ Max. MCF __________

Min. BTU/cf ______________________ Min. MCF __________

Other ______________________

Predicted Daily Load: 1st yr. ________ 5th yr. ________ 10th yr. ________

Interruptible: Yes ______________ No ________ MCF ________

Operating Conditions

Line Pressure:	Summer	Winter	Other
Max.	______	______	______
Min.	______	______	______
Avg.	______	______	______
Flow: MCF			
Peak Day	______	______	______
Peak Hour	______	______	______
Min. Hourly	______	______	______
Avg. Day	______	______	______
Avg. Gas Temp.	______	______	______

Ambient Temp: High ______ Low ______ Summer Avg. ______ Winter Avg. ______

Gas Condition ______________________

Remarks (customer's installation and operating characteristics which affect design, etc.) ______________________

____

Site Conditions

Elevation ______________________ Latitude __________

Access to Site ______________________

Electric Available: Yes ________ No ________ Voltage ________

Distance to Nearest: Electrical Power ______ ft. Telephone Lines ______ ft.

Special Considerations Due to Site Location: ______________________

____

Figure 9.2.1 Data form for meter and regulator station design

Section 9.3
REGULATORS

Pressure reducing valves are frequently required to control the delivery pressure from a station. In addition, control valves may be used to control flow, control inlet pressures, and to act as a pressure-monitoring device. The regulator is a component of the system and, therefore, its selection and installation should be based on the system requirements.

DOWNSTREAM PRESSURE CONTROL

The majority of regulators are installed to control the pressure downstream of the regulator. These installations are designed to provide a safe and adequate operating pressure in the downstream system. A regulator is sized for the maximum anticipated flow requirement with the minimum inlet pressure. Consideration of load changes and the anticipated minimum flow requirements when the maximum inlet pressure is available should also be factors in sizing the regulator.

Parallel Installations

Although many regulator designs can operate over a wide flow and pressure range, often it is necessary to consider parallel runs to provide proper control. A regulator required to operate nearly closed over long periods of time will have more valve and seat damage than a unit that is sized to have the valve open at least ten percent. A small regulator can be installed in the one line to handle low flows and a larger regulator installed in the parallel line to handle the large flows up to the required capacity for the station. Good practice would also dictate the use of parallel regulators for the purpose of redundancy. Since there are many different types and styles of regulators, refer to Section 9.5 to determine the characteristics of the various types in regard to their ability to handle low flows.

VENT REQUIREMENTS

The diaphragm cases of self-operated regulators and pressure pilots should be protected from insects and plugging so that the case can breathe. Controllers can be vented to the atmosphere. However, if they are located in a building or a vault, the bleed gas should be vented outside to prevent hazardous accumulations. The outside vent termination should be protected from the elements to prevent plugging and freezing. The vent termination should be in such a location that there will be no accumulation of gas. The vent line should be of sufficient size as to not create back pressure on the controller or diaphragm case. Consideration must be given to the venting of the gas should the station be near or in a populated area, since the odorization of the gas will be a cause of complaint. Suitable methods for handling vent gas in such instances should be considered.

WORKING SPACE REQUIREMENTS

Routine maintenance of regulators requires that they be installed in such a fashion to provide easy access to the valve plugs, seats, and other working parts.

INSTALLATION AND REMOVAL ACCOMMODATIONS

Adequate head room must be provided for removing actuators, and provision must be made for setting up portable lifting equipment should this be required. For large regulators, hoist equipment should be designed into the structure of the building to provide the necessary lifting power for removing the regulator and maintenance of the unit. Some types of regulators require removal from the line for inspection. Large regulators requiring removal from the line can be fitted with spacer plates at the regulator flanges to allow easy removal. Another method is to use a flanged elbow on the inlet or outlet piping to the regulator, so that this section can be removed with the regulator or prior to the regulator's being lifted from the line.

PRESSURE SENSING POINT

All regulators have a pressure sensing point, and those with an external control line should have a sensing pressure tap several pipe diameters downstream of the regulator on a straight run of pipe. Each regulator should have a separate sensing tap and control line. A common practice is to use ten pipe diameters downstream for the sensing pressure tap with five pipe diameters usually considered to be minimum. The control line may be ¼-inch, ½-inch, or ¾-inch pipe or tubing, depending on the type of regulator and the distance from the pressure sensing point to the regulator. Long sensing lines should be adequately supported and should slope slightly toward the point of connection to the pipe. Pressure taps should not be located on elbows, expanders, or other fittings that would introduce false or unstable pressure registration. At the pressure sensing connection, a valve should be installed to enable isolation of the sensing line, thus permitting the regulator to be taken out of service without shutting down the station. In addition to the sensing line connection, another tap with a valve for checking or recording pressure should be located as near as possible to the sensing line connection. A single tap with a tee can be used to provide the attachments.

INLET AND OUTLET CONNECTIONS

The piping to and from the regulator should be supported adequately to minimize pipe strains. The piping should be designed to have adequate capacity for the expected maximum flow and the pressure conditions. Velocities in regulator valve passages can reach sonic velocity conditions. High velocities create noise, so piping should be sized to keep gas velocities at a reasonable level. There are specific pipeline velocity limits used by many companies to maintain a relatively quiet pipeline system and to keep pressure losses low. Such limiting velocities range between 50 feet per second to a maximum of approximately 400 feet per second. There are situations where higher velocities may be required for short distances; however, the designer should calculate the pipe velocities to be encountered and determine the steps that may be necessary to maintain satisfactory noise levels.

NOISE ABATEMENT

With the continuing emphasis on noise pollution, it is recommended that Section 10.3 concerning noise generation and abatement in gas meter and regulator stations be reviewed and that all efforts be made to assure the optimum installation to control the noise levels that may be encountered. Designers should give consideration to the noise levels that will be in the immediate vicinity of the regulator and other equipment since these levels may restrict personnel movement and/or actions during maintenance and operations.

SAFEGUARDS FOR RELIABLE SERVICE

General

Continuity of operation should be considered in any installation. Some regulators can sustain failure from plugging, freezing, and similar events that will cause them to fail closed. Parallel runs will provide protection since the stand-by regulator can be either a "fail-closed" type or a type that would "normally" fail open. "Normal failure" is difficult to define but is generally considered failure from diaphragm rupture or loss of pilot or controller supply pressure. Supply pressure failures can be minimized if each regulator is provided with a separate supply pressure system. If pipeline liquids could result in freezing a regulator into an inoperative condition, these liquids should be removed and/or the temperature of the gas raised to such a point that the liquids would be prevented from freezing. Reference should be made to Section 9.8, Freezing in Meters, Regulators, and Pipelines, concerning the prevention of freezing in station design. Dust and dirt in the pipeline system should be removed by a filter or other means should they be considered of sufficient quantity to cause operating problems.

Pressure Pilots

Pressure pilots require a clean and dry operating supply. This is also true of instrument-type controllers. Filters and dryers should be considered where gas conditions are known to be dirty and moisture laden. Alcohol bubblers, glycol bubblers, or dry desiccant dehydrators can be used in the pilot supply to provide protection against freezing. On small regulators where heavy moisture conditions and freezing occurs, small infrared heaters can be used to prevent freezing. (See Section 9.8, Preparation of Natural Gas for Market, for greater detail.)

Relative Location to Metering

Inlet pressures to a station may vary widely and, to achieve high-precision metering, regulators are often installed to control the meter pressure. The second stage regulator may then be required to provide the required pressure to the downstream system. Regulators feeding meter runs should be located a sufficient distance upstream of the meter or should discharge into headers to prevent their discharge flow pattern from affecting flow profile in the meter section. Reference should be made to Section 9.6. and 9.7, Measurement and Automation, respectively, for the distances that are required.

Pilot Supply

Pilot-loaded regulators used in locations with widely varying inlet pressures can have a pilot supply pressure regulator to eliminate the variations in supply to the pilot. This practice provides the pilot with a constant supply pressure and eliminates variations in controlled pressure caused by inlet pressure variations to the pilot. The pilot supply regulator should be set for a pressure exceeding the required outlet pressure plus sufficient pressure to stroke the main valve. This technique should be used only for pilot operated, globe-style regulators.

Diaphragm Relief Valves

Pilot-loaded regulators will drive the main diaphragm and valve to the fully open position if the regulator cannot provide the required capacity for the downstream demand. The pilot will pressurize the loading side of the diaphragm to the limit of the supply pressure thus causing the diaphragm differential to increase beyond that required for full opening. If this pressure differential becomes excessive, the diaphragm assembly could be damaged or the diaphragm ruptured. If a pressure differential cannot be maintained, the regulator will go closed. To prevent damage to the regulator diaphragm relief valves should be installed across the diaphragm if they are not built into the diaphragm case of the pilot regulator. Protection against over-pressure as described above can be accomplished by the installation of a relief valve in the supply gas line.

Parallel Sets and Bypass Installations

Bypasses and parallel runs are useful in performing routine maintenance. With parallel runs, the regulator to be worked on can be taken out of service with the parallel run assuming the load. If a parallel run is not used, a manual bypass can be used to control pressure manually until the regulator that is removed for maintenance is restored to service. In the piping design, provisions should be made for testing standby regulators and/or regulators in parallel runs to ensure that they are operative and will respond with sufficient speed to maintain service should they be called upon.

Section 9.4
SAFETY CONTROL VALVES

PURPOSE

The safety of the downstream piping is a prime concern in the design of any regulator station. This usually refers to some form of over pressure protection. Typical over-pressure protection devices that normally are installed include monitor regulators, relief valves, and safety trip-out valves. In each case, the over-pressure safety device senses an approaching over-pressure condition and takes an automatic action to prevent it. This type of protection is necessary any time the inlet pressure at a regulator station is higher than the design or MAOP of the equipment on the downstream side.

MONITOR REGULATORS

Principle

A second regulator in series with an operating regulator can be used as a safety control valve. This safety control valve or monitor regulator has a sense line, which uses the outlet pressure of the operating regulator as its control point. In normal operation, the monitor regulator will be wide open, letting the operating regulator control the pressure. When the operating regulator fails in an open position and the outlet pressure increases, the monitor regulator will take control and keep the pressure within acceptable limits.

Installation Consideration

Monitor regulators are used where blowing gas is considered too wasteful or the noise of a relief valve cannot be tolerated. The placement of a monitor regulator, either upstream or downstream of the operating regulator, should be considered for each installation and type of regulator. Self-operated regulators are subject to stem thrust, which subtracts from the weight load or spring load and changes the regulator setting under high flow conditions. If the monitor is set for an outlet pressure close to the downstream pressure, it will tend to be active under varying conditions. There are many factors that must be considered in monitor locations and installation conditions, and each failure type should be analyzed in the design. The length of pipe between the units should be considered. An operating regulator with a monitor regulator downstream will permit the monitor to hold back the pack in the line between the regulators in the event of a control regulator's falling open. Under no circumstances should the monitor control line and the operating regulator control line be the same line or be connected in any manner. The control line should be well supported to prevent any damage. Monitor with a sufficient distance so that any one incident will not incapacitate both devices. On diaphragm-operated regulators, the pilot will force the main diaphragm to the open position, and, to protect this diaphragm, relief valves must be installed across the diaphragm according to the manufacturers recommendation.

In all cases where a series operated monitor regulator is used—whether the monitor is upstream or downstream of the operating regulator—the first regulator in the series will have inlet pressure exposed to its diaphragm and pilot parts. Each case should be analyzed separately, but, in general, all parts of the first regulator will require an inlet pressure rating.

All types of regulators have been used as monitor regulators; plug valves, gate valves, and ball valves have been automated to provide monitor control of an entire station with one valve. Regardless of the type of regulator used, provision should be made for easily checking the monitor regulator to ensure its operation at the proper set point on a regular schedule. Any self-operating, pilot-operating or instrument-controlled regulator or control valve can be adjusted easily to make it come into operation.

To insure the monitor regulator or valve will come into operation as required, the set point should