ESSENTIALS OF METER STATION DESIGN

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Introduction

The requirements for meter set design can take on many forms. Factors such as customer delivery requirements, company policy, gas quality and the design philosophy of the station designer can have a profound effect on the components used to design a meter station. However, despite these many factors to consider when designing a meter station are there are two components that are essential to every meter station. The selection of the regulation and measurement equipment are the most critical in ensuring a meter station is designed properly and will operate trouble free.

The following paper will describe the parameters required to accurately size these two components and will also discuss the role auxiliary components play in certain types of meter stations.

Design Parameters

The first step in properly designing a meter station is to understand the design parameters for the meter station being installed. This requires not only knowledge of what the requirements are for the customer that is being served, but also the limitations of the distribution and transmission system in the area. Specifically it is important to understand what the flow and pressure requirements are of the customer and making sure that the distribution and transmission system in the area can meet those satisfy those requirements.

The meter station designer must have input from the customer to understand what pieces of equipment will be connected downstream of the meter station. It must be understood not only the size and load of the equipment that is going to be installed, but also how the equipment is going to be used. Are some pieces of equipment only going to be used in backup or an emergency situation? What time of year is the equipment going to be used? Is the equipment solely used for heating during the winter months or is it used as part of a process that is only used certain times of the year or day?

It also must be discussed with the customer as to what the pressure requirements of the equipment are. Equipment manufacturers often specify the pressure delivery requirements for their equipment. Also the customer may have already designed the natural gas piping for the facility and requires a certain pressure to be supplied to an area of the building. The station designer also needs to understand downstream customer piping system and confirm that it is sized correctly. Local building mechanical codes along with internal company policy have influence on the size of the customer houseline and will have an effect on the delivery pressure.

The station designer must also determine if there are MAOP differences between the customer being served and the transmission or distribution system supplying the customer. If so the station designer will use that information to determine not only the proper regulator to use to supply the customer, but also what form of over pressure protection is appropriate.

Once the needs of the customer have been determined then the station designer needs to review the existing distribution and transmission system to confirm that the system can adequately handle the new load. Often times this is just a basic review of the system, but if the load is large enough a need to reinforce the existing system by increasing system pressure or installing additional distribution or transmission main may be required.

In the case of custody transfer stations the customer is the natural gas transmission and distribution system. For this type of meter the pressure is dependant on the MAOP of the piping downstream of the custody transfer station. This MAOP will have previously been determined by the test pressure of the pipe and requirements per the DOT Code 192.

The load range for custody transfer stations can vary significantly and is based on the downstream system and potential growth. The station designer in conjunction with system modeling personnel need to develop a load range so that components are sized properly not only for the current load, but future load as well. Some companies have developed formulas and have size requirements to help determine future load.

Regulator Design

Once the load and delivery pressure for the customer or natural gas system has been established the station designer can now proceeded with determining the proper regulator(s). Some of the factors used to determine the size and type of regulator(s) to use are as follows:

Delivery Pressure – Factors such as customer equipment/houseline, mechanical building codes, MAOP of the downstream system and internal company policy will define the delivery pressure from the meter station. Once this delivery pressure is determined the appropriate pilot and/or regulator spring can be specified.

Downstream/Customer Load – Once the customer load or system load is determined the body size and type of the regulator that should be used can be specified. Downstream/customer load will also be important in specifying the size of orifice or throttle plate to use so that the regulator is not oversized or undersized. Manufacturer published capacity charts are helpful in determining that the correct regulator is being used. Also at this time the decision as to whether use a pilot operated or self operated regulator can be determined. Generally due to the accuracy requirements for meter station design pilot operated regulators are the preferred regulator to use. However, in some instances such as small custody transfer stations where billing accuracy is not required a self operated regulator may be the regulator of choice.

Inlet MAOP & NOP – It is important that the regulator body, connection types and pilot (if used) be sized per the inlet MAOP. The station designer must also have an understanding of the NOP of the system. If the regulator is sized per the MAOP of the system it could be over sized if the system is operated normally at a lower pressure. Also the station designer must be aware of any pressure loss that may occur in the system due to increased usage by other customers in the area which may cause a regulator to be oversized.

Pressure Differential – Regulator manufacturers have design criteria for their products that limit the amount of pressure differential across the regulator body. Understanding the inlet and outlet MAOP across the meter set will help determine the correct regulator to use.

By utilizing these factors the station designer should be able to accurately determine the size and type of regulator that should be used at the meter station. If the load is incorrectly determined or the design factors are not accurate the regulator can be oversized or undersized.

An oversized regulator can cause pressure surges and lead to inaccurate pressure or flow delivery. An oversized regulator can also cause damage to the regulator itself due to excessive wear on the diaphragm or plug.

An undersized regulator will have the opposite affect where the regulator will not be able to keep up with the downstream demand. This will lead to a drop in downstream pressure and will harm the performance of the downstream equipment.

Bypass and Redundant Regulation

For both custody transfer and industrial meter sets bypass regulation is important to allow for maintenance to occur on the meter station without disruption of service. If the downstream load is small enough the meter station can be equipped with a "soft" or temporary bypass that can be used only when maintenance is performed. However, for most industrial meter sets and all custody transfer stations it is recommended that a permanent or "hard" bypass is used. This will allow personnel to easily maintain the primary meter set runs without disruption of downstream service.

When designing a meter station with hard bypass it is critical that the bypass be equipped with a redundant regulator. By using redundant regulator runs personnel can maintain the primary regulator run for a long duration while the other regulator run supports the downstream load.

Meter Design

Meter selection is firmly tied to the load and delivery pressure requirements of the downstream system. While there are many meter types available for station design there are generally two types of meter that are used a majority of the time. Rotary and turbine meters are the meters of choice for industrial meters and custody transfer meter stations. The reason these two meter types are used a majority of the time is because these types of meters provide the billing accuracy that is required for industrial and custody transfer meter stations.

The most common meter used in industrial applications are rotary meters. The main advantage to rotary meters is their rangeability. Manufacturers publish rangeability based on percent accuracy and the exact rangeability depends on the manufacturer, but a typical rangeability for a rotary meter at +/- 2% accuracy can be as high as 50:1. This allows a rotary meter to be used for a customer where there are large swings in load.

This type of meter is especially applicable where there is a large customer with a small heating load, but a large process load. A rotary meter can be very accurate when the customer is not operating a particular process and using minimal heating load. Then when the process begins the meter can be accurate at the higher levels.

As with any piece of equipment there are some disadvantages to using a rotary meter. First rotary meters have a lower maximum allowable pressure to their counterparts. There are a couple of exceptions in the industry, but for the most part the maximum allowable pressure of rotary meters is 175 psig. This relatively low maximum allowable pressure is due to the aluminum casing in many rotary meters. This lower maximum allowable pressure limits the capacity of the meter and therefore the meter station itself.

Second there have been instances where the rotors on a rotary meter have been known to “lockup” due to over spin. If the rotary meter is sized correctly this should not be an issue. However if a rotary meter is installed on a customer that has a high demand during start up this may not be able to be avoided. Manufacturers make orifice plates that can be installed with the meter station to deal with this issue. These orifice plates are often viewed as a relatively inexpensive insurance policy to protect the meter from over spin.

For larger loads (generally over 50 MSCFH) or higher pressures (generally over 100 psig) a turbine meter may be the preferred meter to use. The major advantage of the turbine meter is that if the body is specified appropriately a turbine meter can be installed directly on the pipeline without any overpressure protection. Also as the name of the meter implies a turbine meter uses turbine blades to measure the flow. Therefore in an over spin condition there is not a risk of a “lockup” as in the rotary meters. A turbine meter will lose accuracy or the turbine blades may shear in an over spin condition, but it will not lockup and prevent gas from being delivered to the customer.

There are two main disadvantages to a turbine meter. The first is cost. Due to the materials that the turbine meter is made of the turbine meter is much more costly than a rotary meter. Also turbine meters are equipped with Auto Adjust modules or other instrumentation which can increase the cost significantly.

The second is rangeablilty. Despite the current advances with Auto-Adjust technology and instrumentation a turbine meter still requires a minimum flow in order to achieve a desired accuracy and does not have the rangeablity ratio that a rotary meter has.

Rotary and turbine meters are generally used in industrial meter station applications due to their ability to be billing accurate meters. At custody transfer stations billing accuracy may not be required therefore other types of meters can be used.

Orifice and ultrasonic meters are the two types of meters that can be used at custody transfer stations where accuracy is not as critical. Company policy and agreements with interstate suppliers will help define if these meter types should be used at custody transfer stations.

Fixed Factor vs. "Floating" meter design

Another important consideration when designing a meter station is whether to design the meter station as a Fixed Factor or Floating meter set.

A Fixed Factor meter station is a station where the regulator is installed upstream of the meter. The regulator outlet pressure is set at the customer deliver pressure. Therefore the metering pressure and the customer delivery pressure are the same. For a fixed factor meter station the regulator should be designed to provide a constant pressure will little to no droop. Pilot operated regulators should be used in fixed factor meter stations and often manufactures will specify if a particular regulator can be used in fixed factor meter stations.

A Floating meter station is a station where the regulator is installed downstream of the meter. This means that the meter pressure is equivalent to the distribution pressure in the system. Since the distribution pressure can fluctuate greatly due to increased or decreased demand on the rest of the system a pressure and temperature corrector must be installed on the meter.

The decision as to whether install a fixed factor meter station or a floating meter station is a decision that should be made based on cost and load. The lower the metering pressure the less amount of gas can be metered in a particular size of meter. Therefore if the meter pressure is the same as the distribution (or higher) pressure a smaller meter size can be used. However, as mentioned earlier with a floating meter station an instrument for pressure and temperature correction should be used which adds to the cost of the meter station. A station designer needs to do a cost analysis based on meter cost, instrument cost and the load profile of the customer to determine if a floating or fixed factor meter design should be used.

Auxiliary Meter Components/Design Considerations

As discussed in the introduction the two main components for a meter station design are the regulator(s) and meter. However there are other components and design considerations that are vital to a meter station that must also be selected to complete the meter station design.

Valves

Valves must be installed on the meter station to allow control and maintenance of the meter station. Generally either ball valves or plug valves are acceptable to isolate and control runs on the meter station.

Overpressure Protection

If the inlet and outlet MAOP is different on the meter station or if there is a lower rated component installed on the meter set then a form of overpressure protection must be installed as part of the meter station

This overpressure protection can be in the form of a relief valve installed either external to or internal to the supply regulator that vents to atmosphere. Another option is the use of a monitor regulator. The decision to go with relief valve or monitor regulation is dependant on the location of the meter and the individual company policy.

Some customers and companies are hesitant to install relief valves due to the possibility of natural gas venting to the atmosphere in case of an upstream regulator failure. Therefore monitor regulation may be the preferred method of overpressure protection. If monitor regulation is used then it is important to make sure that a token relief or communications are installed on the meter station to alert personnel of a primary regulator failure.

Another factor to consider when using a monitor regulator is the effect on capacity. A rule of thumb is that the use of a monitor regulator can reduce the capacity of the primary regulator by 30%. Therefore this reduction in capacity must be considered when using monitor regulation to make sure the primary regulator is sized appropriately.

Another form of overpressure protection that can be used is to install regulators with an internal monitor, but does not relieve to the atmosphere. These regulators provide overpressure protection by shutting off the regulator, but do not relieve the gas to atmosphere. Since these regulators do shutoff the flow of gas to a customer in an overpressure event they are not generally used. However they are an option if there is a concern about gas venting to atmosphere.

Filters/Strainers

For meter stations a filter or strainer must be installed upstream of the meter to protect the meter from damage due to debris in the pipeline. The decision as to whether use a filter or strainer should be based on the quality of gas being used and the flow rate through the meter station

Strainers with baskets that are generally perforated with 1/16" holes are acceptable for meters with a lower flow rate (less than 25 MSCFH for 2" and 45 MSCFH for 4") on relatively clean gas systems.

Filters with 20 micron elements are acceptable for higher flow rates or where there are concerns about the cleanliness of the gas system.

Fittings

Fittings such as ½" or ¼" threadolets to allow for personnel to install a gauge and sense lines should be installed as part of the meter station to monitor pressure. The size and importance of the station will define the number and size of fittings installed on the meter station.

Heaters

The expansion of natural gas across a regulator follows a Joule-Thompson throttling effect which results in a pressure and temperature reduction on the downstream side of the regulator. As a rule of thumb for every 100 psig drop in pressure the gas temperature will drop 7 degrees F. A large pressure drop across the regulator could result in the downstream gas temperature being below freezing.

A gas temperature in the pipe of 32 degrees F or lower is generally not a concern. Upstream filtration on meter sets usually eliminates most of the liquids in the gas stream. However if there are liquids in the gas stream and the temperature of the gas is below 32 degrees F then hydrates can form. Hydrates are a compound of water and hydrocarbons that can build up in the pilots of regulators and can plug the orifice or sense line tubing of the regulator. This would cause a regulator malfunction and effect gas delivery.

The larger issue concerning gas temperatures below 32 degrees F is the effect on the exterior of the pipe. Moisture in the air due to condensate in the air or weather could freeze on the exterior of the pipe. The amount of ice on the exterior of the pipe could cause significant damage of the facility itself and could affect the operation of the facility. Ice could build up to the point where valve operators are inaccessible. Also a build up of ice could block atmospheric vent ports causing pressure control issues.

In extreme cases the pipeline could be frozen for an extended distance from the meter set causing undo stresses on the downstream pipeline. In the case of below ground piping frost heave could occur which would not only cause stress on the pipe itself, but could buckle roads or building foundations. In above ground situations ice could add unanticipated stress to pipe supports and hangers.

To mitigate freezing the station designer should install a line heater as part of the meter station. Indirect-fired water bath heaters heat the gas prior to regulation and therefore keep the downstream gas temperature above freezing after regulation. For issues with hydrates the designer should consider installing a catalytic or vortex pilot heater to heat the pilot gas and eliminate the hydrates. In either case the station designer should work closely with heater manufacturers to make sure the appropriate size and type of heater is installed.

Another design solution to avoid icing on a meter set is to install a primary pressure cut upstream of the meter and install the piping downstream of this primary pressure cut below ground. This will allow the ground to increase the temperature of the gas such that the gas will be at such at temperature so that the pressure cut at the meter set will not cause icing. The exact distance upstream this primary pressure cut should be is dependant on pipe size and flow through the pipe. Generally the exact distance upstream is determined based on existing designs and field observations.

Remote Valves or Regulators

Depending on the customer type, location and facilities in the area remote operated valves or regulators may be installed on meter stations. These components will mainly be installed at gate or custody transfer stations. The decision to install these components is based solely on company policies and customer needs.

Site Locations

Another design consideration when developing a design for meter station is location and the impact the station may have on its surroundings. Factors such as vehicular hazards, proximity to residential area, and access for company personnel, underground facilities and electrical facilities are just a few of the items to consider when locating a meter station.

Gate or custody transfer stations generally have more auxiliary equipment and therefore noise may be a factor. It is important that these stations be located in areas that will minimize the affect on people in the area. If this cannot be avoided the station designer may need to look into sound attenuation options available in order to minimize the station impact to the surrounding area.

For industrial and commercial meter sets it is important to work with the customer to agree on a location for the meter set that is agreeable to both parties. In general the customer will want the meter as close to the equipment as possible in order to minimize the size and length of houseline. However that location may not be appropriate for the needs of the station designer or the company personnel maintaining the equipment. Therefore it is important to communicate to the customer the maintenance and security needs of the meter station and find a location that is best for both parties.

It is also important when working with industrial and commercial customers to understand if there are future considerations for the area. An area that may be ideal at the time of installation may become less desirable if the customer adds facilities that put the meter set at risk.

Vehicular hazards may also be a concern when locating a meter station. If the station cannot be located an appropriate distance from local traffic or loading dock traffic then the meter station should be protected by using bollards, posts or fencing.

Security is also a concern for meter station location. Access should be restricted to appropriate personnel by using locks. Also critical valves should be locked so that only appropriate personnel have the ability to operate valves.

Conclusion

A meter station design includes many key components to make sure gas is delivered to the customer or downstream system reliably at the proper flow rate and pressure. While there are many components installed on a meter set to achieve this goal the flow measurement and regulation components on the meter set are the two key components that are essential to every meter station.