Design Guidelines for Installation of Automatic Shut-off Valve (ASV) and Remote Control Valve (RCV) Systems In Natural Gas Transmission Pipelines

American Gas Association

American Gas Association

Design Guidelines for Installation of Automatic Shut-off Valve (ASV) and Remote Control Valve (RCV) Systems In Natural Gas Transmission Pipelines

October 2012
AGA Distribution and Transmission Engineering Committee

DISCLAIMER AND COPYRIGHT

The American Gas Association's (AGA) Operations and Engineering Section provides a forum for industry experts to bring collective knowledge together to improve the state of the art in the areas of operating, engineering and technological aspects of producing, gathering, transporting, storing, distributing, measuring and utilizing natural gas.

Through its publications, of which this is one, AGA provides for the exchange of information within the gas industry and scientific, trade and governmental organizations. Each publication is prepared or sponsored by an AGA Operations and Engineering Section technical committee. While AGA may administer the process, neither AGA nor the technical committee independently tests, evaluates or verifies the accuracy of any information or the soundness of any judgments contained therein.

The purpose of this paper is to provide guidance to natural gas service companies with transmission pipelines in evaluating, implementing and installing ASVs and RCVs. AGA disclaims liability for any personal injury, property or other damages of any nature whatsoever, whether special, indirect, consequential or compensatory, directly or indirectly resulting from the publication, and use of or reliance on AGA publications. AGA makes no guaranty or warranty as to the accuracy and completeness of any information published therein. The information contained therein is provided on an "as is" basis and AGA makes no representations or warranties including any expressed or implied warranty of merchantability or fitness for a particular purpose.

In issuing and making this document available, AGA is not undertaking to render professional or other services for or on behalf of any person or entity. Nor is AGA undertaking to perform any duty owed by any person or entity to someone else. Anyone using this document should rely on his or her own independent judgment or, as appropriate, seek the advice of a competent professional in determining the exercise of reasonable care in any given circumstances.

AGA has no power, nor does it undertake, to police or enforce compliance with the contents of this document. Nor does AGA list, certify, test or inspect products, designs or installations for compliance with this document. Any certification or other statement of compliance is solely the responsibility of the certifier or maker of the statement.

AGA does not take any position with respect to the validity of any patent rights asserted in connection with any items that are mentioned in or are the subject of AGA publications, and AGA disclaims liability for the infringement of any patent resulting from the use of or reliance on its publications. Users of these publications are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, is entirely their own responsibility.

Users of this publication should consult applicable federal, state and local laws and regulations. AGA does not, through its publications intend to urge action that is not in compliance with applicable laws, and its publications may not be construed as doing so.

Changes to these guidelines may become necessary from time to time. Suggested changes to this document should be communicated to AGA by completing the last page of this report titled, **"Form for Proposal to Change Design Guidelines for Installation of ASV & RCV in**

Natural Gas Transmission Pipelines" and sending it to **Operations & Engineering Section, American Gas Association, 400 North Capitol Street, NW, 4th Floor, Washington, DC 20001, U.S.A.**

ACKNOWLEDGEMENT

Design Guidelines for Installation of Automatic Shut-off Valve (ASV) and Remote Control Valve (RCV) Systems in Natural Gas Transmission Pipelines was developed by an ad hoc task group under the sponsorship of Distribution and Transmission Engineering committee. **Individuals who worked hard and made substantial contributions to the development of this document are:**

Dan Menegus (Chairman) – Pacific Gas & Electric
Bruce Paskett – NW Natural
Mike Bermel – Sempra Utilities
Bill Hamilton – DTE Energy/MichCon
Dan Scarberry – Dominion East Ohio
Deborah Sus – EN Engineering

Other individuals who also contributed to the development of the document are:

Joe Ryan – Louisville Gas & Electric
Chris Castronova – South Jersey Gas
John Wyckoff – New Jersey Natural Gas
Jim Finnerty – National Grid
Dave Klimas – EN Engineering
Cheryl Payne – Consolidated Edison
Maria Allison – Louisville Gas & Electric
Andrew Lu – American Gas Association

AGA acknowledges the contributions of the above individuals and thanks them for their time and effort in getting this document developed.

Christina Sames
Vice President
Operations & Engineering

Ali Quraishi, Staff Executive
Engineering Services Director
Operations & Engineering

TABLE OF CONTENTS

1. Introduction

The purpose of this document is to provide information and guidance on the installation design of automatic shut-off valves (ASVs) or remote control valves (RCVs) in existing and new natural gas transmission pipelines. ASVs and RCVs are automated valves that can be utilized for a number of gas control purposes, but this guidance document is focused on their installation in transmission pipeline systems for the specific purpose of providing isolation of pipeline sections upon a pipeline event and subsequent unplanned gas release. ASVs/RCVs are not simply valves but are engineered systems that vary greatly in complexity, autonomy, reliability, cost, etc. The paper provides guidance on the design, installation, operational and maintenance considerations that an operator should take into account to provide for successful utilization. This guideline is intended for use as a reference document by natural gas pipeline operators, federal and state regulators, public interest groups and the general public.

Each operator serves a unique and defined geographic area and its system infrastructures vary widely based on a multitude of factors, including facility condition, past engineering practices and materials. Each operator will need to evaluate the guidance covered in this document in light of system variables, the operator's independent integrity assessment, risk analysis and mitigation strategy. It is recognized that not all of these guidelines will be applicable to all operators due to the unique set of circumstances that are attendant to their specific systems.

Consult the manufacturer(s) or other resources as necessary when considering a particular ASV, RSV or other system component to confirm its performance characteristics will accommodate your particular system's unique characteristics and variables.

2. Background

ASVs and RCVs have been available and used in the natural gas industry for many years. Recent events, technological advances, and new and proposed regulations have brought questions to the forefront regarding the design, installation, operation and maintenance of ASVs/RCVs.

The following background sections describe terms used throughout this document, provide an overview of current regulations affecting ASVs/RCVs and outline some of the potential benefits and challenges of their use.

2.1. Definitions

***Actuator* –** A mechanism to provide the force to operate an automated valve. An actuator may employ pneumatic pressure, electric motor torque, or hydraulic pressure to provide the mechanical advantage to close or open a valve.

***Automatic Shut-off Valve (ASV)* -** A valve that has a powered actuator to close the valve automatically based on data sent to the actuator from pipeline sensors. The sensors send a signal to close the valve based on predetermined criteria, generally based on pipeline operating pressure or flow rate. The ASV does not require human evaluation or interpretation of information surrounding an event to determine if the event is a legitimate pipeline issue and closes automatically based on the established criteria.

***Control Room (also referred to as control center)* -** An operations center staffed by personnel charged with the responsibility for remotely monitoring and controlling a pipeline facility.

***Control Room Management (CRM)* -** Title 49 Code of Federal Regulations (49 CFR) §192.631 requires each operator of a pipeline facility with a controller working in a control room who monitors and controls all or part of a pipeline facility through a Supervisory Control and Data Acquisition (SCADA) system to have and follow written CRM procedures that comply with the requirements of the regulation.

***Gas Control* –** Department with primary responsibility for operation of a pipeline operator's gas system including but not limited to monitoring and control functions.

Gas Controller - A qualified individual who remotely monitors and controls the safety-related operations of a pipeline facility via a SCADA system from a Control Room, and who has operational authority and accountability for the remote operational functions of the pipeline facility.

High Consequence Area (HCA) – See 49 CFR §192.903.

***In-Line Inspection (ILI) Tools* –** Tools used to inspect the physical attributes of a pipeline from the interior of the pipe. They may also be referred to as an intelligent or smart pigging tool.

Maximum Allowable Operating Pressure (MAOP) – The maximum pressure at which a pipeline or section of a pipeline may be operated under 49 CFR, Part 192.

***Pipeline Facility* –**New and existing pipelines, rights-of-way, and any equipment, facility, or building used in the transportation of gas or in the treatment of gas during the course of transportation.

***Operator* –** A person who engages in the transportation of gas (per 49 CFR §192.3). In this document, an operator refers to a company with responsibility for operating and maintaining the pipeline system.

Potential Impact Radius (PIR) – The radius of a circle within which the potential failure of a pipeline would have significant impact on people or property. PIR is primarily a function of the gas transported, the pipe diameter and operating pressure.

Remote Control Valve (RCV) – A valve equipped with an actuator to operate (open, throttle or close) the valve based on an order (signal) from a remote location, such as a control room. The use of a RCV requires operating personnel in the remote location to review and evaluate data in their pipeline system and make a determination whether a pipeline issue exists based on available information, such as operating pressure and flow data transmitted from the pipeline, or communications from the public, emergency responders or company personnel on site. Based on available information, if the gas controller determines that there is a problem that would require a valve operation, they may execute a command to operate the valve remotely.

Remote Terminal Unit (RTU) - A microprocessor-controlled electronic device through which objects in the physical world interface with a SCADA system by transmitting/receiving telemetry data to/from the system, and by using messages from the SCADA system to control connected objects.

Specified Minimum Yield Strength (SMYS) **-** A property of steel pipe. In 49 CFR §192.3, SMYS is defined as **–**

(1) for steel pipe manufactured in accordance with a listed specification, the yield strength specified as a minimum in that specification; or

(2) for steel pipe manufactured in accordance with an unknown or unlisted specification, the yield strength determined in accordance with §192.107(b).

Supervisory Control and Data Acquisition (SCADA) System - A computer-based system or systems used by a controller in a control room that collects and displays information about a pipeline facility and may have the ability to send commands back to the pipeline facility.

2.2. Regulations

2.2.1. Title 49 Code of Federal Regulations (49 CFR), Part 192, Subpart O

Title 49 CFR §192.935 requires a pipeline operator to evaluate additional measures beyond those already required by Part 192 to prevent or mitigate specific threats to the pipeline in a High Consequence Area (HCA). One potential measure is the use of ASVs/RCVs, which is addressed in 49 CFR §192.935(c). Specifically:

"192.935(c) Automatic shut-off valves (ASV) or Remote control valves (RCV). *If an operator determines, based on a risk analysis, that an ASV or RCV would be an efficient means of adding protection to a high consequence area in the event of a gas release, an operator must install the ASV or RCV. In making that determination, an operator must, at least, consider the following factors—*

swiftness of leak detection and pipe shutdown capabilities, the type of gas being transported, operating pressure, the rate of potential release, pipeline profile, the potential for ignition, and location of nearest response personnel."

2.2.2. Potential Future Regulations Mandated by the 2011 Pipeline Safety Reauthorization Legislation

In December 2011, Congress passed the Pipeline Safety, Regulatory Certainty, and Job Creation Act of 2011. The president signed the pipeline safety bill into law on January 3, 2012. Section 4 of this law deals with ASVs and RCVs for new and entirely replaced transmission lines. It mandates that the U.S. Department of Transportation (DOT), not later than two years after enactment and if appropriate, to require by regulation the use of automatic or remote-controlled shut-off valves, or equivalent technology, where economically, technically, and operationally feasible on transmission pipeline facilities constructed or entirely replaced after DOT issues the final rule.

It also requires the Comptroller General of the United States to conduct a study on the ability of transmission pipeline operators to respond to a hazardous liquid or gas release from a pipeline section located in a HCA and report to Congress not later than one year after enactment. The study must consider the swiftness of leak detection and pipeline shutdown capabilities, location of the nearest response personnel and the costs, risks and benefits of installing automatic and remote-controlled shut-off valves.

2.3. Benefits of Using ASVs/RCVs

The potential benefits of installing ASVs/RCVs include the following:

- Timely interruption of the fuel source to a gas pipeline event allowing improved emergency response to the affected area.
- Providing a means to more rapidly close valves compared to manually operated valves located in difficult to respond to areas.

- Closing valves more rapidly provides the opportunity for maintaining gas service to customers located outside of the affected pipe section by maintaining gas pressure to these customers.

- Reducing the economic and environmental issues associated with a large unplanned gas release.

- Providing additional system control functionality for dealing with planned pipeline maintenance and shutdowns, and abnormal operating situations other than unplanned gas releases.

2.4. Potential Concerns with the Usage of ASVs/RCVs

When utilizing ASVs/RCVs, there are a number of potential concerns that need to be taken into consideration. These include the following:

- Unintended or inappropriate automated valve closure. For ASVs, this could possibly result from increased flow rates or reduced pipeline pressures during winter peak load conditions and other less frequently occurring operational variations at normal times. For RCVs, this could potentially be caused by a human decision-making error in deciding when to close an RCV. Industry experience has shown that ASVs are much more susceptible to unintended or inappropriate valve closures than RCVs.

- A valve closure, whether intended or unintended, may lead to widespread customer outages where re-establishing service could take days or weeks with the potential for human hardship and property damage in certain climate conditions.

- Susceptibility to physical and cyber security threats and vandalism.

- Possibility of equipment failure causing the valve control system and the automated valve to fail to function as designed.

- Realization that not all unplanned gas releases would necessarily trigger an ASV to operate, or for an RCV, be identified by the SCADA system for a gas controller to take action.

As discussed further in this paper, the proper selection, engineering design, installation and operation of ASVs/RCVs in a pipeline system can assist a pipeline operator in addressing these concerns.

3. System Design and Installation Considerations

3.1. System Design Philosophy and Objectives

Every pipeline operator, whether installing a single ASV/RCV, or developing a comprehensive system of ASVs/RCVs for complex pipeline system isolation, should begin with a clear and consistently applied set of guidelines and criteria for the utilization and installation of automated valves. In developing these guidelines and criteria, the following factors may be considered:

- Specific physical criteria related to the pipeline :
    - pipeline diameter, operating pressure and associated PIR or other metric;
    - pipeline SMYS, pipe condition and or material/fabrication properties.
- Threats from natural forces, such as seismic zones, rivers, washout, landslide, subsidence zones and other special geographical features.
- Human impact consequence factors, such as location class and adjacencies with special high-density facilities (e.g. stadiums/arenas), including those that would be difficult to evacuate.
- Maximum acceptable time to identify and isolate an affected pipeline section and subsequently to depressurize the pipeline.
- Valve location and accessibility, including location of nearest operator personnel with consideration given to man-made, seasonal or geographic inhibitors to rapid response.
- Minimum magnitude of a pipeline event that realistically can be detected and managed through ASV operation. (Normal operations also can cause pressure changes on a pipeline that mimic a pipeline event).
- Customer service impact:
    - risk-tolerance for customer loss in the event of accidental closure,

- magnitude of customer loss that can be managed if a pipeline event occurs, giving consideration to the logistics of restoration of service to a large number of customers, and
- consideration of communicating with downstream major and critical customers about pipeline shutdown plans, both in advance and during a pipeline event.

- Capital and operating costs.

Considering each of these elements will help an operator define where and what type of sectionalizing block valves to install and operate, and the scope of such installations on their pipeline system(s). As pipeline operational requirements and dynamics change over time, such as from capacity expansions, customer load changes or regulatory requirements, operators must update their system isolation strategy and tactical plans accordingly.

3.2. Pipeline Sectionalization Design Considerations

While each operator should develop its own pipeline isolation design philosophy, it is assumed for the discussion presented below that the objective in deploying ASVs or RCVs is to provide for rapid pipeline isolation in case of an unplanned gas release, while making every attempt to sustain service to critical customers and/or large population centers served by interconnected pipelines. The design of an ASV/RCV system for which loss of service to one or more customer(s) is a minor consideration may look very different than one in which sustaining customer service is imperative. While an operator's final deployment philosophy may be different than that assumed above, the fundamental considerations are common. While there are a number of factors that should be considered, the primary consideration is protection of the public.

3.2.1. Limitations imposed by pipeline network configuration

The ability of any system of ASVs/RCVs to isolate a section of pipeline involved in a pipeline event while minimizing customer impacts depends, in part, upon the basic piping configuration of the system under consideration, and how amenable that pipeline system is to taking discrete sections (mainline valve to mainline valve) out of service, while still maintaining service to critical customers. These customers may reside downstream of an isolated pipeline section or be partially fed from the isolated pipeline section itself, and they may include interconnected pipelines, electricity generation plants, petroleum refineries, major manufacturing facilities and local natural gas distribution companies. For many operators, the base design of their pipeline system is such that it may take days or even months to determine and plan for the shutdown of key sections of pipeline for maintenance or repair operations while sustaining service to customers. Pre-work for such sections might include installation of bypass piping, installation of new valves, arranging temporary supplies using compressed natural gas (CNG) bottles or vessels, and/or rerouting system supplies via secondary pipelines. These same considerations must be given to any system design to isolate such pipeline sections with ASVs and RCVs in a much shorter planning interval. Without such consideration, installation of ASVs or RCVs may provide for reduced closure and event isolation time, but also may lead to loss of customers when the valves are closed.

3.2.2. Common Types of Piping Configurations:

Figure 3-1 shows the simplest form of pipeline configuration that can be equipped with automated valves to isolate an unplanned gas release. This configuration is representative of a simple long-distance gas transmission pipeline without taps in a section of pipe. When MLV2 and MLV3 are closed to isolate the affected pipeline section, service to customers downstream of the isolated section will be at-risk when the stored volume of gas (line-pack downstream of MLV3) is expended, unless these customers have access to some alternate source of fuel supply.

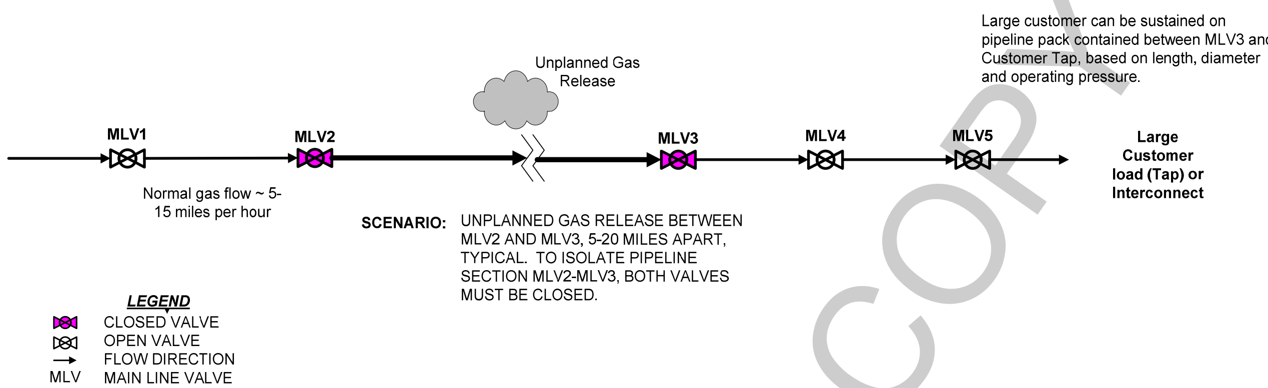


Figure 3-1

Simple Long Distance Gas Transmission Pipeline w/o Complex Piping

Valve spacing, relative tap locations and piping interconnection schemes all play a critical role in achieving isolation success coupled with sustained customer service. Additional consideration should be given to any local production feeds into the transmission line. Some pipeline systems are designed to serve customers via taps from multiple locations, including

- tap valves "bridled" around both sides of a mainline valve,
- taps which may take off several miles apart from (different isolation sections of) the same pipeline to feed a distribution center or large customer,
- long-distance interstate pipeline configurations where a single local gas distribution company (LDC) or large customer might be supplied by two or three pipelines that run parallel to one another at a single location,
- taps that feed into metropolitan "networked" pipeline systems (a grid of interconnected and interrelated high-pressure pipelines providing gas to customers), which might be served by several transmission lines located miles apart or even at different delivery points from independent pipelines or pipeline companies.

All of these configurations can create complications and warrant special consideration when attempting to fully isolate a section of pipeline during an emergency. How gas flows to, from and through these taps and laterals may be considered as part of the plan for installing ASVs or RCVs. In many instances, effective isolation and/or continued delivery of gas to customers can be achieved only by having some control over tap, crossover and lateral valves in addition to mainline valves on a primary transmission pipeline. Figures 3-2 through 3-5 show valve closure alternatives, under the respective pipeline configurations noted above that might be employed to isolate main sections of transmission pipelines, while also sustaining service to customers.

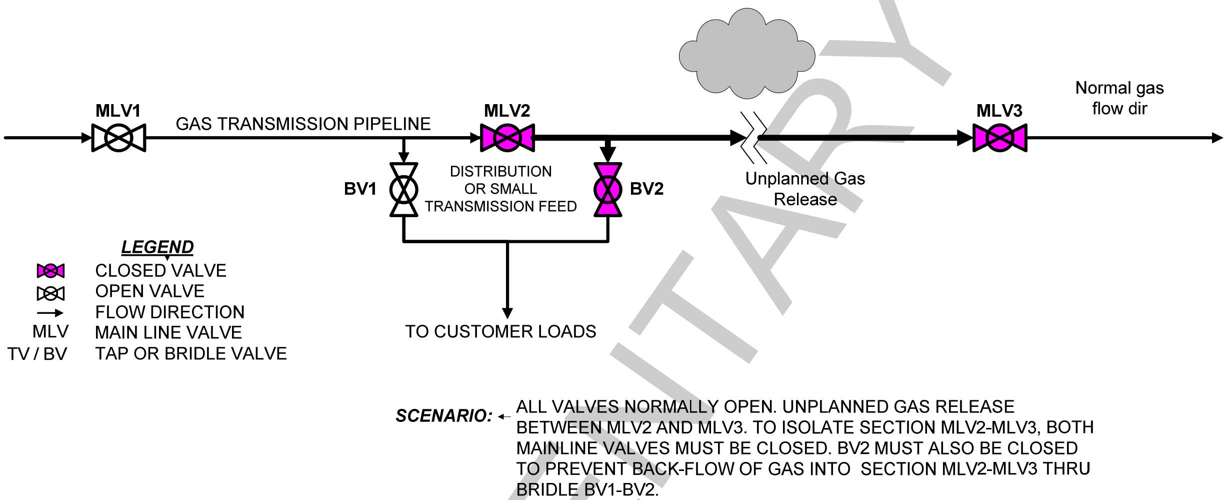


Figure 3-2

Isolating Affected Pipeline Section with Simple Bridled/Tap Feed to Customer(s)

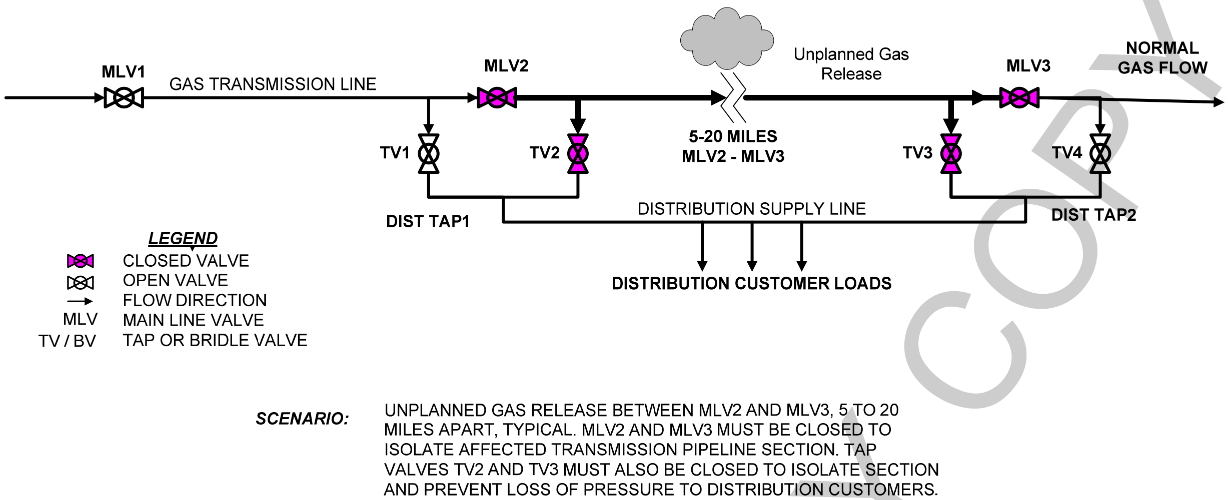


Figure 3-3

Isolating Affected Pipeline Section with Multiple Bridle Feeds on Same Pipeline — Miles Apart

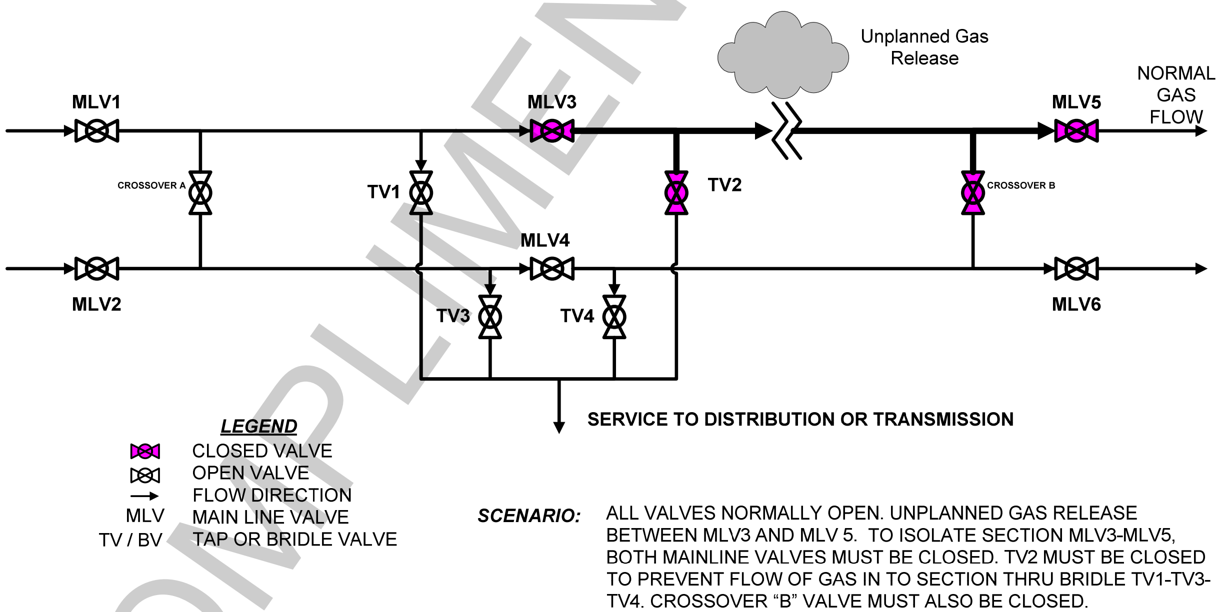


Figure 3-4

Isolating Typical Interstate Pipeline with Customer Tapped from Multiple Pipelines

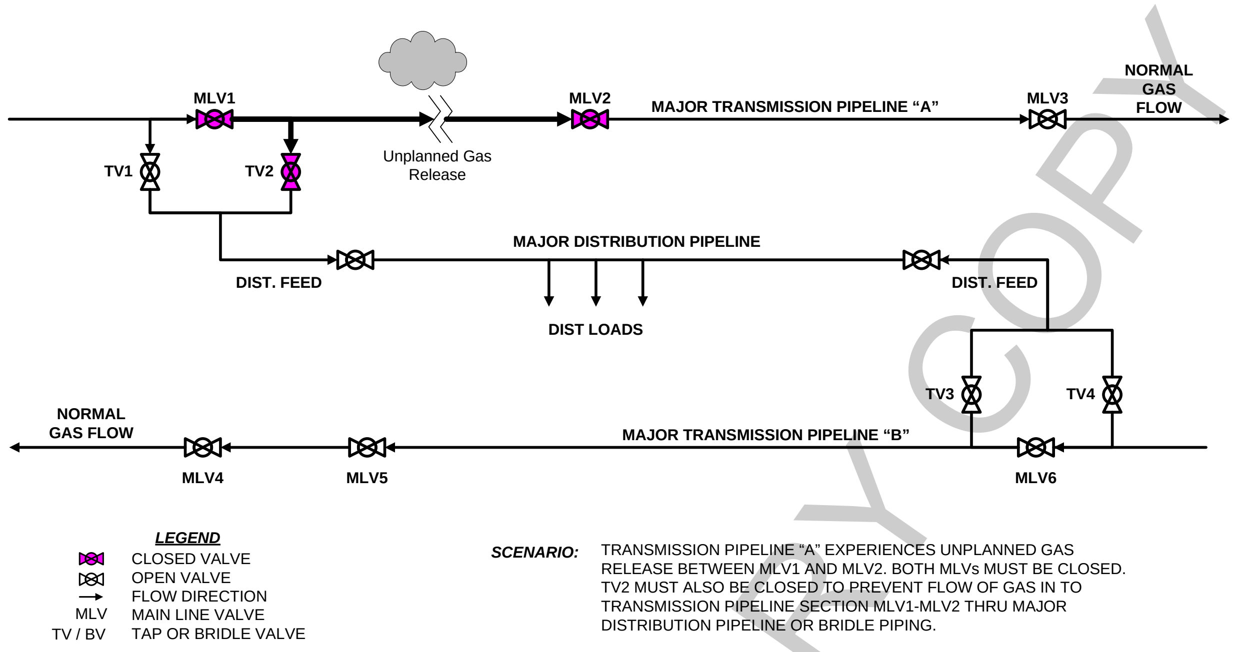


Figure 3-5

Isolating Affected Pipeline Sections Serving Complex Pipeline Network Fed from Multiple Pipelines

3.2.3. Preventing Backflow to a Pipe Section

In addition to sustaining customer service, operators must consider gas that might flow back into an "isolated" section of a pipeline from service taps, lateral lines, pressure regulating stations or cross-connection pipe sections between parallel pipelines. The size and capacity of these gas sources combined with potential back flow of gas becomes an important design consideration. For example, it may be feasible for a pipeline operator to temporarily operate with an open 4-inch crossover or regulator station back flowing gas to a 36-inch pipeline with an unplanned gas release until manual isolation of that crossover/station can be achieved. However, a 16-inch crossover back-feeding this same36-inch pipeline would complicate section isolation objectives because it would supply the affected section of pipeline with a potentially large source of gas. It is these types of situations that should be considered in the isolation design process. Figures 3-2 through 3-5 show, in addition to mainline transmission valves, other valves that must be considered under the respective piping configurations to prevent the backflow of gas to the affected section of pipeline from taps, laterals and cross-overs.

3.2.4. Hydraulic modeling

Computer hydraulic modeling or network analysis of a pipeline system may provide an effective way to evaluate an ASV/RCV scheme prior to installation. Approaches to hydraulic modeling/network analysis of ASV/RCV functionality could include modeling proposed isolation sections under a transition from normal operation to a major unplanned gas release, modeling isolation conditions where taps and crossovers are feeding and/or isolated from the section, and modeling the distribution systems that are fed from transmission pipelines subject to ASV/RCV closure.

The benefits of performing such an analysis early in the design process include:

- forecasting the ability of the operator's system to isolate sections of pipelines while maintaining service to customers under a variety of abnormal operating conditions.

- determining if there is a need for further isolation of branch connections, such as taps and tees and feeds to regulator stations.

- determining the impact of various weather/load combinations and ASV/RCV closure conditions on maintaining service to customers.

Additionally, these analyses potentially provide gas control personnel with a better understanding of pipeline dynamics for abnormal or emergency operating conditions and assist them in recognizing these conditions based on deviations from normal predicted pressure and flow values during specific weather-related conditions.

Pre-planning how ASV/RCV schemes will affect the pipeline network under various potential conditions also will allow for improved management during any unplanned gas release or emergency event.

3.2.5. Pipeline Line Pack:

Pipeline line pack is the volume of gas residing in a section of pipeline. The amount of line pack is affected by pipeline diameter, length and gas pressure. The compressible characteristic of natural gas allows the use of line pack to compensate for fluctuations in gas demand in many situations. Line pack downstream of an isolated pipeline section can be used to help sustain customers for a period of time and should be considered in system design.

If there is a large section of transmission pipeline downstream of an isolated section of pipeline, the large volume of high-pressure gas in this downstream section gives an operator additional time to provide service to customers until manual operation or other special arrangements to serve customers for the longer-term can be implemented. This line pack becomes highly valuable by providing the ability to sustain customer gas service for hours after the upstream supply source has been interrupted. However, for pipelines where customers are being served by line pack only a few miles downstream of an isolated pipeline section and no alternative gas delivery or supply path exists, the ability to sustain customer service becomes very challenging. In such an instance, one ASV or RCV as far upstream as practical to achieve desired isolation time objectives may be the best option in lieu of a secondary supply source. Figure 3-1 provides some insight into the concept of sustaining service to a customer(s) with line pack while isolating a section of pipeline during an event. As the distance of pipe between shut-off valves MLV4 and MLV5 is lengthened, the ability to serve a customer at the end of the isolated pipeline improves (for an interim period) by use of the line pack between these two valves. Depending on connected loads and pipeline dynamics, one can expect to continue providing service to customers from a matter of minutes to a much longer time frame for each mile of line pack that resides upstream of the customer delivery point. This same mile of extra line pack, however, might take additional time to depressurize for an event occurring in section MLV4-MLV5. The operator must evaluate the added value of line pack against the impact of depressurization time when considering isolation section spacing. These characteristics and tradeoffs are unique in each pipeline.

In summary, having a full understanding of gas flow dynamics within a specific pipeline system configuration can be useful to ensure ASV/RCV system effectiveness in new, fully replaced and retrofit applications. Depending on how these interfaces are addressed in the design process, each section, tap and lateral can support or complicate the objective of providing balance between system isolation and sustained customer gas supply deliveries.

3.3. Overall Valve Operational Considerations

3.3.1. Valve Isolation Alternatives - ASVs, RCVs and Manual Operation:

Once an operator has determined their operational, isolation and depressurization objectives for a gas transmission pipeline system or sub-sections of a pipeline, they can then develop a strategy for the type of isolation valves to be utilized. This strategy may include use of manually-operated valves, ASVs, RCVs, or any combination of the three. In certain applications, check valves also may provide protection for pipelines with unidirectional flow patterns.

In many instances, the objective to isolate a pipeline within a specific period of time is a major driver in selection of the type of valve closure technology deployed. It is not uncommon, however, for the complexities and/or attributes associated with different types of deployments to drive an operator to lend greater weight to other considerations. Every consideration given to closure response time must also be tempered with the reality that valves, actuators, power systems, communications, vehicles and access roads can fail. In addition, human factors can play a significant role. Response time provisions for contending with these issues become just as important as the isolation objectives themselves.

At the most basic level, the advantages and challenges of the following elements should be considered by operators.

3.3.1.1. *Field Responder Capability and Access Limitations:* This can range considerably between operators and for locations on an operator's system. The principal advantages of using field responders are that there are personnel on the scene as soon as possible after the event and accurate situational status can be verified prior to closing valves. The negatives include potential response time delay and uncertainty. This response mode is also subject to other factors, including traffic delays, vehicle failure, employee health and access road conditions. In a region-wide emergency situation, such as a major earthquake, hurricane or act of terrorism, the operator cannot depend on road accessibility and the normal movement of traffic. An operator's ability to contend with multiple events simultaneously under such a scenario is also diminished. Actual time to physically close the valve may also add to the elapsed time for gaining control of a pipeline event. For large valves that are not equipped with power actuators, it may take responding personnel 15 minutes or longer to fully close a manually operated valve after they arrive, based on a number of factors.

3.3.2. SCADA and Control Room Operator Capability:

SCADA systems provide operators with updated information from field locations at intervals ranging from several seconds to several minutes or longer. This information may include alarms and warnings about abnormal pressure levels, excess flow rates or other pipeline physical attribute changes indicative of an unplanned gas release. Factors that affect elapsed time for response and action should be considered in the implementation of an ASV/RCV program. For an RCV, these factors include –

- time for alarms or other data to be generated and received by the gas control center;
- time for the data to be analyzed by the gas controller(s), which could vary considerably due to the data volume and complexity, the supportive or inconclusive nature of the data, the availability of confirmatory reports from the field, and the skills training and experience of the individual gas controller(s);
- time to analyze the consequences on supply to points downstream of valve closure;
- time to activate the command for the RCV to close; and
- time for a command to be received and implemented by the control system at the valve location.

In the case of a gas control center receiving data clearly indicative of an unplanned gas release on a section with minimal customer impact, and at a time that the gas control center is staffed by multiple gas controllers, the elapsed time to valve closure can be expected to be relatively short. Conversely, when post event data is inconclusive or requires a great deal of analysis due to the complexity of the pipeline sections involved, where field reports are not available, and when a valve closure may severely impact thousands of customers, the elapsed time to valve closure can be expected to be much longer. In particular, smaller releases can be difficult to detect due to their minor impact on system pressures.

3.3.3. Communication Systems Reliability:

Whether closing a valve to isolate an affected pipeline section, attempting to open an RCV remotely or simply trying to gather information from remote pipeline locations, communication system reliability is a critical component for event management success. Expected control system responses, default conditions and capability when communication systems fail must be carefully considered. ASVs that are self-contained at the valve site provides a solution to the possibility of an RCV failing to close when an event renders remote communications inoperable or compromises communicated data integrity. If RCVs are to be deployed, an operator may consider redundant communication paths to a particular valve site. A mix of RCVs and ASVs, and/or hybrid communications architecture (50% land-based, 50% radio or other wireless technology to the different sites) also can be used to mitigate single-point failure risks. If there are no reliable cost-effective communication options in a particular area, self-contained ASV systems or manual valve closure may constitute a more appropriate alternative for managing an unplanned gas release.

3.3.4. Basic Valve System Reliability and Failure Modes:

Even with the latest in technology deployed and a well-planned and well executed maintenance program implemented, equipment failures do happen. Valve assemblies can be designed and specified to behave differently under such failure conditions. Options include fail-open, fail-closed or fail-in last position. It is of critical importance to evaluate each proposed valve site for the consequences of failure under different scenarios, such as loss of power, control signal or pneumatic pressure to drive actuators. When operator intolerance for uninitiated closures is a key driver, RCVs with fail-in-last position design may be preferred. When isolation under any scenario is given critical weighting, ASVs with fail-closed configuration may be the preferred alternative.

3.3.5. Managing Multiple Events Occurring at the Same Time:

ASVs that are not dependent on SCADA measurements from remote locations or gas controller interpretations and actions can be a consideration for simultaneously addressing multiple events triggered by a region-wide emergency. They will close under major release conditions until field operating personnel arrive at each location for secondary protocol execution. RCVs provide response capability one layer removed from ASVs in this situation, with each event requiring additional opportunities for identification and valve closure initiation. If a controller is overwhelmed with alarm information from multiple events, each event may be managed sequentially, extending overall response time.

3.3.6. Pipeline Network Complexity:

When pipeline systems are very complex and or pressure excursion signatures on a pipeline system approximate those associated with a significant pipeline event, consideration should be given to RCVs over ASVs. If rapid closure of an isolation valve might cause a cascading effect of pressure drops down stream sufficient to activate an ASV, RCVs should be considered in the pipeline isolation and incident management plan.

3.3.7. Pipeline Network Distance to Major Customer Load:

If a pipeline isolation will cause loss of a major customer downstream within one to two hours of closure (or the expected time for arrival of field personnel), operators may want to consider the use of RCVs over ASVs. ASVs typically experience more false closures due to pressure sensing or other control system malfunctions than a valve set up in conventional RCV operating mode.

Section 3.9 provides specifics on how control of sectionalizing block valves using either RCVs or ASVs can be accomplished, including the layering of ASV on top of RCV technology to implement a hybrid operations plan.

3.4. Cost Considerations

The range of costs for the installation of an ASV or RCV is significantly affected by a multitude of factors such as:

- Number of valves to be installed or modified at the site.

- Material and installation cost of a new valve and/or actuator when required for automation. This cost will increase with increasing pipe diameter.
- Cost of engineering and design work.
- Cost of underground vault and associated components to dewater or above ground buildings and other structures.
- Proximity to unrelated facilities, such as electric, water and sewerage lines that could require complex design, test holes and relocation of other facilities.
- Excavation requirements and potential costs associated with dewatering.
- Specialized welding or other construction requirements for existing pipe.
- Security requirements – fence, cameras, locking devices, etc.
- Cost of additional communication equipment, instrumentation, RTUs, backup communication and electric/pneumatic power systems, etc.
- Cost of modifying existing SCADA database and displays to incorporate new monitoring and control points.
- Cost of installing power and communication facilities at the location, if required.
- Costs associated with shutting down a pipeline section (if required) and potential costs of mitigating service impacts to customers during construction.
- Permitting, land acquisition and environmental requirements.
- Restoration requirements – paving, concrete, etc.

APPROXIMATE COST RANGES PER INSTALLATION	
Materials - valve, actuators, controls, etc.	$10K to $250K
Need for a new/replaced valve – basic construction	$75K to $300K
Need for a new/replaced valve – complex construction	$200K to $750K
Pipeline outage/customer service continuity	$50K to $600K
Power and communication availability	$10K to $250K
Permitting, land, environmental constraints	$10K to $250K
Site improvement/restoration	$5K to $200K

When and where it can be accomplished, the cost of converting an existing manual valve to an ASV or RCV will typically range from $100,000 to $1,500,000 per valve. The high end of this range typically would involve conversions of existing valves that include vault installations in city streets.

The cost to install a new ASV or RCV in an existing transmission pipeline typically will range from $200,000 to $2,000,000 per valve. The high end of this range typically would involve large diameter, complicated valve installations that require much more work than simply cutting a new valve into an existing pipeline or simply replacing an existing valve. These installations could require replacing significant quantities of pipe, valves and fittings to accomplish the automated valve work, relocating a pipeline or other underground utilities to allow for an automated valve to be installed, and/or the installation of a vault for the new valve. In addition, the high end of this range typically would involve costly requirements to maintain customer service when taking a section of pipeline out-of-service to install the new or replacement valve. This may include the need to install a bypass pipeline or pressure control fittings to accomplish the installation.

The cost to install a new ASV or RCV on a new transmission pipeline or fully replaced transmission pipeline typically will range from $100,000 to $1,000,000 per valve. The high end of this range typically would involve a large diameter pipeline for which automating a valve requires significant additional effort due to constraints and limitations imposed by the site. This could be driven by such things as power and communication being very costly to provide, the need to install a vault, or costly mitigative measures being required to meet permitting, land and environmental requirements.

It should be noted that the cost to convert an existing ASV to an RCV, or an existing RCV to an ASV, often is minimal relative to the costs of a new installation because typically the major components (valve, actuator, controls, etc.) already exist.

Costs and cost ranges given above are based on actual costs incurred by a representative group of AGA members companies when installing ASVs/RCVs. As discussed, specific installation costs will vary broadly based on the many factors mentioned.

3.5. ASV/RCV Citing and Spacing Considerations

When considering the location and spacing of ASVs/RCVs, it should be recognized that 49 CFR §192.179 establishes spacing for transmission line sectionalizing block valves based on population density (class location). These spacing requirements were developed based on minimizing operational and maintenance impacts when isolating a pipeline section. They provide a natural starting point when considering the spacing for ASVs/RCVs. However, not all sectionalizing block valves installed in accordance with §192.179 will need to be automated. Specifically, the federal requirements contained in 49 CFR §192.179 relative to the maximum spacing for transmission line sectionalizing block valves are as follows.

- Each point on a pipeline in a Class 1 location must be within 10 miles of a valve
- Each point on a pipeline in a Class 2 location must be within 7 ½ miles of a valve
- Each point on a pipeline in a Class 3 location must be within 4 miles of a valve
- Each point on a pipeline in a Class 4 location must be within 2 ½ miles of a valve

Some additional factors for consideration in determining the location of automated transmission block valves may include the following.

3.5.1. Maximum Acceptable Number of Customers Affected:

This may vary greatly due to the characteristics of the gas infrastructure in the impacted area. In a large, densely populated area with many gas customers served from a pipeline, the operator may choose to reduce the space between valves to limit the number of customers that would be impacted during a shutdown, assuming the customers downstream of the pipeline event can be back fed from another supply source. Conversely, areas that contain a small number of gas customers may allow for a larger distance between ASVs/RCVs. Regulatory and tariff *requirements may affect customer outage tolerance.*

3.5.2. Transmission Pipelines with Elevated Exposure to Damage:

Consideration needs to be given to installing valves at locations that may have a higher potential for damage, such as in areas that are susceptible to seismic activity or other outside force damage, or mains that are on a bridge or within a tunnel crossing.

3.5.3. Gate Stations:

Consideration should be given to installing ASVs/RCVs at gate stations (facilities connecting larger long-distance pipelines to localized pipeline systems that provide gas service to customers). This would allow the gas operator the ability to shut down the station in the event of a downstream pipeline incident, thus serving as the upstream isolation point.

3.5.4. Depressurization Time:

The operator should consider the impact that valve spacing will have on the depressurization time for the pipe protected by the ASVs/RCVs. Depressurization times for densely populated areas, areas near tunnel or bridge crossings, or any areas where a prolonged time would cause elevated public concern should be considered for closer spacing between valves. It should be noted that for large gas releases, depressurization times will not vary significantly for moderately different lengths of pipe (e.g., 5-mile vs. 8-mile spacing). For small gas releases, depending upon a number of factors (pipe diameter, pipe length, operating pressures, size of leak, etc.) the depressurization times will increase with increasing distance between valves. Depressurization times can also be decreased, especially for smaller releases, by opening blow down valves located in an isolated pipeline segment. However, these smaller types of releases may be more manageable and may not warrant operation of the ASVs/RCVs.

3.5.5. Permitting and Availability of Suitable Valve Sites:

Consideration should be given to permitting requirements of local municipalities. Limits on disturbing parklands, wetland or newly paved or restricted streets may make it more desirable to avoid these locations. Likewise, access to electric power or telecommunications may limit the number of acceptable sites, and availability of sites either through purchase, lease or easement can also be a factor.

3.5.6. Geographical:

Consideration should be given to the surrounding geography of a selected location. Water conditions, road and/or pavement conditions, traffic conditions, site accessibility, location of nearby underground facilities, and other factors may impact not only constructability, but also operating and maintenance activities during the life of the valve.

3.6. Site Related Design Considerations

3.6.1. Specific Location Considerations:

There are numerous specific location considerations to take into account when designing an ASV/RCV installation. Some of these considerations are in common with those for valve siting, but since there is often no ideal valve location and many times the location is driven by the limitations imposed by the existing pipeline and valve locations, issues that cannot be eliminated by site selection need to be mitigated by design. These include –

- existing land rights and easements, and if they are adequate for the expanded facilities being installed at the site,
- the physical footprint required compared with that available for equipment installation,
- permitting requirements related to the site,
- environmental issues and constraints associated with the site,
- site accessibility for construction and future operations and maintenance,
- site security and vehicular traffic risk mitigation measures that should be implemented,
- site proximity to utility electrical power,
- site telecommunications limitations and constraints,
- potential construction and operational impacts on residences and businesses in the vicinity of the site, and

- weather related issues, such as water in a vault, that could influence equipment specification or require protective measures to ensure reliable operation of equipment.

3.6.2. Above vs. Below Ground Installation Determination:

Whether the ASV/RCV actuator equipment should be installed above ground or below ground in a vault typically is based upon the site conditions, and the specific location often will determine the type of installation. For example, if the valve automation must occur beneath a city street, the only option available without finding a new location is a below ground vault installation.

The sectionalizing block valve may be located above ground or below ground with a valve stem extension that bring the mounting flange for the valve actuator above ground. For below ground installations, the valve actuation is located below grade within a vault.

Above ground valve actuation typically involves the installation occurring inside of a building or a fenced and secured yard. This provides easier access to the valve actuation and controls, but also makes them vulnerable to vehicular traffic damage and elevates security risks. In addition, since above ground installations are more visible and require acquisition of greater land rights, these installations typically will result in a more lengthy and costly permitting and land acquisition process for new sites or sites requiring an expanded footprint to allow for valve automation.

For automation of existing valves, the cost typically will be lower for an above ground valve automation than for a below ground automation, especially for those not requiring a new building. This is because of the potential need to install or modify a vault to contain the valve actuation equipment and the added complexity of installing instrumentation, conduit and controls for the below grade installation. A below grade installation of automation equipment may also require lowering of the pipeline if inadequate cover exists to install the automated valve within a vault.

Water intrusion into a vault is a concern in below grade installations. Operators, therefore, should consider waterproofing of the vault using gasketed manhole covers, and the use of water level alarms and sump pumps within the vault. Maintenance task in below grade installations will be more difficult to perform due to confined space issues and may also require additional maintenance personnel due to safety requirements related to working in a vault. Weather related issues may also be of concern for above ground installations not within a building.

For below grade installations, the control, communication and power cabinet(s) will still need to be located above ground. In addition, below grade vault installations typically require ventilation for the vault

Operation of an ASVs/RCVs can produce considerable noise when the valve is not fully open or closed. Noise considerations should be taken into account during the design phase. This could influence the determination of above ground versus below ground valve actuation or the particular type of above ground design. This is an issue only during ASV/RCV activation which is typically an infrequent occurrence.

(Provided by National Grid. Used with permission.)

Figure 3-6

Pair of Automated Valves installed in a Vault

(Provided by Pacific Gas and Electric Company. Used with permission.)

Figure 3-7

Pair of Automated Valves installed with Actuator Installed Aboveground

3.7. Automated Valve System Design Considerations

3.7.1. Typical Components of an ASV/RCV:

When considering the use of automated valves to isolate a pipeline section using an ASV or RCV closure plan, one or more methods may be employed to identify pipeline events and to trigger and achieve valve closure objectives. These methods, while different, require some commonality in base assets as follows.

- A valve that needs to be equipped with an actuator.
- An actuator mechanism to provide the mechanical motive force to operate the valve. This actuator may employ pneumatic pressure, electric motor torque or hydraulic pressure to provide the mechanical advantage to close or open a valve. Actuator mechanisms typically provide for both manual and automated operation.

- Various control components could include pressure or flow sensors, pneumatic regulators, instrument filters, valve positioners and position switches, instrument spool valves and electrical solenoids.

- Control and measuring devices to read pipeline pressures, rate-of-pressure drop, and compute and compare measured values with preset parameters (suggestive of "normal" operations) or devices to interpret/acknowledge remote-initiated commands to hold pressure or change valve status; and to send a control signal to the valve(s) to operate accordingly. These devices can be as simple as a pneumatic system of switches, or as complex as an electronic control system equipped with a multitude of electronic sensors and programmed with intricate logical sequencing to compute when to close or open a valve.

- Power and communication assets, when needed to fully effect a control scheme. These assets are not required for the most basic of ASV functions, but always are required for remote control and complex operations.

3.8. Pipeline Isolation Valves

3.8.1. Typical Types of Valves:

Typical valves used for pipeline isolation in natural gas systems include ball, plug, gate, and check valves. The most effective and efficient valve choice will need to take into consideration the pipeline operating and maintenance requirements, the required valve functionality, and the unique benefits and limitations associated with each valve type. For example, a check valve can be utilized only on a single direction pipeline and only to prevent backflow in that pipeline. A plug valve generally cannot accommodate the passage of an ILI tool for internal pipeline inspection.

The type of valve selected can have a significant impact on the design of the ASV/RCV control system and the equipment required to automate the valve. For example, a gate valve, which is a multi-turn valve, cannot utilize a pneumatic piston actuator, which is a very common type of actuator used for quarter-turn ball and plug valves. Even for valves of the same type, the specific valve design can have significant consequences. A floating ball valve will require a much larger actuator than a trunnion-mounted ball valve. The following is a list of the common valves used and engineering issues associated with each type.

3.8.1.1. *Ball Valve* – A ball valve is similar to a plug valve but uses a rotating ball with a cylindrical hole through it. A full port ball valve allows passage of an ILI tool since the hole in the ball is approximately the same size as the inside diameter of the pipe, while a reduced port ball valve generally cannot accommodate traditional ILI tools. Trunnion mounted valves allow the ball to be supported in the body and as mentioned, require much less torque to close the ball compared with floating ball valves. Ball valves have multiple actuator options when retrofitting an actuator to the valve. Ball valves are the most common type of sectionalizing block valves used for new gas transmission pipelines. Below is a picture of a full port ball valve that is provided with a valve extension and pneumatic piston actuator.

(Provided by Pacific Gas and Electric Company. Used with permission.)

Figure 3-8

Full port ball valve with a valve extension and pneumatic piston actuator

3.8.1.2. *Plug Valve* – Plug valves are used primarily for an on-off application and some throttling applications. Flow is controlled by means of a cylindrical or tapered plug with a trapezoidal hole in the center that lines up with the flow path of the valve when the valve is open. Plug valves are utilized in applications that do not require the passage of ILI tools, such as for tap or crosstie valves since the plug acts as a restriction in the flow of gas. For these applications, the pressure drop across the plug can be used to aid in the identification of the location of an unplanned gas release.

3.8.1.3. *Gate Valve* – Gate valves are generally used as shut off valves in mainline valve applications. Gate valves have a flat faced, vertical disc or gate that slides down through the valve to block the flow. The cost of a gate valve is typically higher than for a similar sized ball valve. A gate valve requires multiple turns to close, thus it has less available actuator options than a quarter-turn valve. Actuators typically are larger for these valves due to the high torque necessary to close them, especially for large diameter gate valves. Gate valve designs often allow passage of an ILI tool.

3.8.1.4. *Check Valve* – Check valves are self-acting valves and limit flow in a piping system in a single direction. Check valves are used to prevent back flow in a pipeline and in some cases can be a cost effective alternative to automating a block valve. Depending on the design, check valves may allow the passage of an ILI tool.

3.8.2. New vs. Existing Valves:

When considering the implementation of an ASV/RCV strategy, consideration should be given to the use of existing pipeline valves by the addition of a valve actuator and associated controls, and the installation of new valves. The choice to retrofit an existing valve versus installing a new valve will have major impacts on the equipment required and on the overall project cost. This section describes the potential advantages and disadvantages of these two options.

3.8.2.1. Use of Existing Valves – Potential Advantages

- Avoided Cost of Purchasing and Installing a New Valve – The use of an existing valve eliminates the need to purchase and install a new valve, which could translate into a very significant cost savings.

- No Pipeline Shutdown Required – The use of an existing valve eliminates the need to shutdown the pipeline segment in which the valve is located. Avoidance of a shutdown can have significant cost savings and customer service benefits. Avoided cost elements may include installation of pressure control fittings, gas vented to the atmosphere, cross-compression to minimize the venting of gas, installation of a pipeline bypass and use of a portable CNG/LNG supply source to maintain customer service during a shutdown.

- Reduced Site and/or Permitting Requirements – The use of an existing valve may reduce permitting requirements for the installation since the valve is already installed in the pipeline. An operator may have to obtain a permit for additional land for auxiliary equipment or for a vault to contain the ASV/RCV.

(Provided by Pacific Gas and Electric Company. Used with permission.)

Figure 3-9

Excavation of an existing valve site where valve replacement and a complex pipeline shutdown was required to install an RCV valve.

3.8.2.1. Use of New Valves – Potential Advantages

- Valve Type and Application – The use of a new valve will enable the engineer to select the best valve for the new application.

- Optimal Location – The use of a new valve will give the engineer the flexibility to select a location that optimizes the valve's functionality for the pipeline system.

- Better Assurance of Reliable Operation – Use of new equipment, newer technology, and a control philosophy that is not restricted due to an existing valve installation may increase the reliability and effectiveness of the ASV/RCV implementation. Replacing older valves may result in valves that have fewer operational and maintenance issues. Additionally, existing valves often require a larger actuator than a new valve due to the higher torque required to turn a worn valve. It may be more cost effective to replace a valve that is operational but near the end of its useful life at the time the valve is automated.

- Valve/Actuator Package Factory Quality Assurance – Using a new valve allows the valve and actuator assembly to be assembled and tested as a complete package at the factory prior to installation in the field.

3.8.3. Valve Actuators:

The actuators available for use in ASV/RCV service fall into three general categories: pneumatic piston, electric motor, and gas/hydraulic. In choosing an actuator, a number of considerations should be taken into account including the valve type, site risks and limitations, pipeline operating conditions, control system design, and company design standards. An operator should consider the probability of outages to critical support services, such as electricity and communication, when deciding which type of actuator to use. Additionally, an operator may choose to diversify the type of actuators deployed in its system to minimize risk, but must also keep in mind that using different types of equipment may result in additional maintenance and training costs. The three types of actuators typically used for ASV/RCV service are described in the following paragraphs along with considerations applicable to each of them. Additional information on valve actuators is provided in the Appendix.

3.8.4. Pneumatic Piston:

The pneumatic piston style actuator is the simplest method of valve automation. It generally consists of a piston driving a scotch yoke mechanism to drive a quarter turn valve. These actuators are available in either a spring return or double-acting pneumatic piston. The use of spring return allows the operator to select a failure mode on loss of pressure, but may not be practical for large diameter high pressure transmission pipelines due to the size of spring required. These actuators are suitable for use of pipeline gas to power the piston; thus eliminating the need for a separate power source to turn the valve. Other considerations include, but are not limited to, the following.

- Potential use of an accumulator tank to power the actuator if the line pressure drops below minimum requirements.
- These actuators are primarily designed for on/off service, and may not be the best choice if the valve will regularly be used in modulating service.
- Speed of closure is somewhat difficult to control, and can vary with differential pressure across the valve, but it generally will be the quickest method of valve closure.
- The power gas supply system, such as regulators, filters, solenoid valves, etc. will add to maintenance tasks and can be a source of nuisance leaks.
- Limit switches and position transmitters are generally separate units added onto the actuator.
- Both spring return and double-acting actuator types can be equipped with manual override capabilities.
- Applications on large valves require a significant amount of space and will need to vent gas during actuation. This may not be suitable for vault or locations near populated areas.

3.8.5. Electric Motor:

The electric motor actuated valve generally can be thought of as a gear-operated valve in which an electric motor replaces the hand wheel. The actuators offer the advantage of providing a smooth closure where the time to close can be set and are also available in modulating designs. Electric actuators are the most compact type of actuator and also do not require the venting of gas; thus they offer distinct benefits for urban areas. Other considerations include, but are not limited to, the following.

- The reliability of electric power supply at the site, particularly during events that may require a line shut down. The reliability of electric power is particularly applicable to large-scale events such as earthquakes or hurricanes where large scale power outages may occur.
- Robust asynchronous three-phase AC motors are used most commonly as the driving force especially for large station facilities, but single-phase DC motors are available and often used when only battery back-up power is available and the actuator needs to be available if primary utility power is lost.
- The electric motor and controls must be designed to meet the electrical hazardous area classification requirements for the installation location and may require special housings to prevent ignition in the event of a gas leak.
- These actuators are not limited to quarter-turn valves and can be used on ball, plug or gate valves.
- Limit switches and position transmitters often are available integrated already into the actuator.
- Electric actuators are available with manual override systems.

3.8.6. Gas/Hydraulic:

Gas/hydraulic actuators are very similar to pneumatic actuators. The main difference is the medium used to drive the valve open or close. Gas/hydraulic actuators utilize hydraulic fluid versus air or natural gas to drive the valve, with gas being used only to pressurize the fluid. Hydraulic pressure generates thrust that is applied directly to the valve stem through the piston/rod assembly to provide full, direct power to the valve stem. There are two main types of gas/hydraulic actuators used in pipeline operations. The first is for quarter-turn valves such as ball and plug valves. The second type is for linear gate valves. Other considerations regarding design and selection of gas/hydraulic actuators include, but are not limited to, the following.

- Potential use of an accumulator tank to power the actuator if the line pressure drops below minimum requirements.
- These actuators are designed primarily for on/off service, and may not be the best choice if modulating service is required.
- Speed of closure is somewhat difficult to control and can vary with differential pressure across the valve.
- The power gas supply system, which includes regulators, filters, solenoid valves, etc. will add to maintenance tasks and can be a source of nuisance leaks.
- Limit switches and position transmitters generally are separate units added onto the actuator.
- Manual override systems generally are available.
- Many of the same limitations apply as those for pneumatic piston actuators (e.g. size and venting of gas).
- The use of both a high pressure gas system and a hydraulic system greatly increases the complexity of the actuator, resulting in increased maintenance costs, and increased probability of failure.
- Generally, this is the highest initial cost option, except on the very large valves or for very high differential pressures.

3.9. Control Systems

3.9.1. Control System Packages:

There are a number of control system packages that can be used for automated valves. For ASVs , control can be accomplished by –

- pneumatic local line break controls,
- electronic local line break controls (control algorithm can be part of a vendor supplied controls package or the local RTU),
- electronic line break controls with remote line break closure signal provided by an automatic control algorithm within the SCADA system, or
- a combination of the above

In addition, an ASV connected to the SCADA system can be configured so that the valve close trigger signal is delayed for a set time span after the line break automatic controls have identified a pipeline event. This allows time for a gas controller to review the situation and potentially override the automatic closure command. This is referred to as an “ASV with remote override.”

For RCVs, valve closure is accomplished by an electronic or electrical signal to the valve automation control system based upon a remote signal provided via the SCADA system. The control system then provides power gas to operate a pneumatic piston or gas/hydraulic actuator, or electricity to operate an electric motor actuator. RCV functionality can co-reside on a valve equipped with ASV functionality with little complication.

In addition to the valve control system package selection and determining the desired automated valve functionality, a decision needs to be made about the level of valve and control data communicated to the SCADA system. This could range from no data for valve sites without SCADA communication, to simple valve position data only, to detailed operational data regarding the automated valve and the pipeline system.

The operating features of various ASV and RCV control system packages are discussed in the following sections.

3.9.2. ASV Control:

There are a number of types of ASV control system designs. The simplest and also highly autonomous system uses a gas-powered actuator along with a mechanical-pneumatic pilot control device that monitors pipeline pressure and upon sensing a deviation beyond predetermined limits, it automatically closes the valve**.** These mechanical-pneumatic control systems can be designed to trigger valve closure based upon low pressure and/or high rate of pressure decline. Low pressure pilots must be set well below typical operating pressures so that in case a pipeline event occurs at a high operating pressure, there is a delay before the valve closes as the line pressure reduces to the low pressure pilot setting. High rate of pressure drop pilot systems do not have this delay.

Mechanical-pneumatic control systems require no site communication or electric power (unless the operator desires to monitor pressure or valve status). ASV's using mechanical-pneumatic pilots generally present no special operating or maintenance issues beyond typical calibration and maintenance. However, due to simplicity of pneumatic pilot control systems and how they are designed, they have been associated with a disproportionate number of false valve closures.

A modern variant of mechanical-pneumatic pilot control system uses a gas-powered actuator along with a local electronic line break control package. Power typically is provided by solar panels with battery backup, but could also be provided by utility power or thermo-electric generator. The local electronic line break controls have greater functionality and capability than a simple mechanical-pneumatic control system lessening the risk of false closure, but they still are limited by the fact that the pipeline event must be detected locally at the valve site.

An ASV equipped with a mechanical-pneumatic or electronic local control package can use a vendor provided package or an operator-designed package. This decision typically is based upon the needs and capabilities of each operator.

Local ASV line break detection systems also can be equipped with or without SCADA monitoring. SCADA monitoring will provide earlier notification of a pipeline event and valve activation to the gas control personnel, but this requires additional investment to provide remote communication and power. For ASVs installed in a pipeline providing gas to a large number of customers where the pipeline is short coupled to the gas distribution facilities serving these customers, SCADA monitoring may be critical in maintaining service to these customers in the event of an ASV closure. For ASVs located far from customers, SCADA monitoring still may provide value to the operator.

The most complex system for ASV controls is one in which a complex control algorithm, typically running within the SCADA system and involving analysis of data from multiple sites, is used to identify an unplanned gas release and initiate a valve closure. This type of system, if properly designed, has the greatest capability to detect unplanned gas releases within more complex piping networks and further lessen the risk of false closures, but it requires a high level of sophistication to implement. Since it involves using the SCADA system, it also needs to have SCADA communication available. The need for backup power and/or backup communications may also be considered during design.

For all cases where SCADA monitoring is provided and electronic control packages are utilized, ASVs with remote override capability will reduce the likelihood and potential detrimental effects of a false closure but this functionality will result in a delayed closure time.

There are multiple ways in which an ASV control system can be configured to detect a gas transmission system problem indicating a major unplanned gas release. The most common ways by which the occurrence of a pipeline event may be detected, and valve closures initiated, are as follows.

- Rate-of-pressure drop in a pipeline, typically expressed in psi per minute (typical values: 10-30 psi/min range) and occurring for some minimum period of time, typically ranging from 1 to 5 minutes.

- Absolute pressure in the pipeline reaching a minimum level (also known as low pressure closure).

- Pressure differential measured across a reduced port valve (where valve port diameter is less than full-pipeline diameter, causing a restrictive pressure drop-typically 1-10 psi or greater, which can be measured, when excessive flow occurs).

- Flow measured from a transmission pipeline gas meter indicating rates exceeding “normal” values, indicating an unplanned gas release in a section of pipeline served by gas flowing through the meter.

- Any combination of the above that can be effectively-programmed, tested, calibrated, set and maintained by field personnel. This might include a combination of rate-of-pressure drop, corroborated with flow measurement, which triggers a valve closure only when a coincident low pipeline pressure is detected. Combination triggers are easier to implement with electronic control systems and often provide more reliable line break detection systems.

Pressure and rate-of-pressure drop sensing controls typically are the least expensive to implement, but will have reduced pipeline event detection capability when located far from the site of the event. Where feasible, flow and rate of flow deviation sensing devices may be considered when there is longer spacing between sensors.

The detection configuration chosen for a particular situation will need to take into account pipeline system complexity, the consequence of a false trip of a valve or an unplanned gas release undetected by the controls, the technical capabilities of those maintaining the control system or the existing equipment that can be used in detection of a pipeline event and its reliability. In addition, the operating parameters of the system need to be considered in determining the most appropriate control configuration. The stability of the pipeline pressure can be different for a cross country transmission system versus that of a local transmission/distribution system. When normal operating pressure deviations in a pipeline might approximate or exceed the rate and magnitude of pressure changes associated with an unplanned gas release located at a distance from sensors, the effectiveness of ASVs operating on rate-of-pressure drop detection may be limited. Under such operating conditions, the settings required to activate an ASV may be such that a partial, or in some cases even a full, pipeline severance would not be detectable from normal but infrequent pressure deviations. In such cases the operator may elect to install additional SCADA pressure and flow points on its system and develop a refined history of pressure changes at specific locations on its pipelines prior to activating ASV functionality for a given valve site. Proper system characterization is essential for design and installation of appropriate sensing technology and delay schemes to minimize the risk of an unintended closure. ASVs used within networked transmission systems providing gas service to local population centers likely will require complex sensing designs to identify and locate an unplanned gas release. In the event of a misidentification and false closure, there likely would be only a short amount of time for a gas operator to respond before gas service potentially is lost to a significant numbers of customers.

3.9.3. RCV Control:

RCV's remove the autonomous operation ability associated with ASV's, and require the intervention of qualified personnel typically located at a gas control room to initiate valve closure when intended. The advantage of human intervention is that the gas controller can factor into the decision process additional information such as knowledge of unique operating conditions, customer demand and piping system configurations that may create unusual pipeline conditions.. The gas controller will also have pipeline information for multiple points upon which to base any decision. Additionally, by requiring a gas controller to activate the valve, a control system failure has much lower potential to cause a false valve closure. Because of these reasons, industry experience indicates that RCVs are much less susceptible to unintended or inappropriate valve closures than ASVs. RCVs also allow for greater operator flexibility in managing an unplanned gas release, especially when robust flow and pressure measurements are available to gas control personnel.

The disadvantage of requiring human intervention is that greater time typically is needed to identify a pipeline event, evaluate the situation and make the decision to close the correct isolation valve(s) because multiple data points need to be analyzed and potentially conflicting information resolved. In addition, RCVs require some type of electric power at the site, and also require communication from the site to the designated control location(s). RCV operation relies on the ability of an RTU to send information to the SCADA system and to receive a command from the gas controller via SCADA back to the RTU to close or open the valve.

RCV operation only needs the ability to receive a close/open command from the remote location, but often pipeline monitoring equipment is installed at the site to provide the gas controller with additional pipeline data from the site, such as pipeline pressure and flow. As mentioned, the gas controller also will have pipeline data from other SCADA points along the pipeline, as well as alarm notifications that have been programmed into the SCADA system to alert an operator of an abnormal or emergency situation. In addition, complex control algorithms can be developed using SCADA data to provide the gas controller with improved situational awareness of a potential abnormal condition. The level of information provided to the gas controller for decision making will depend on each pipeline operator's philosophy on the use and operation of RCVs including any time targets to close valves in response to a pipeline event.

In the simplest design, remote valve control utilizes simple open and close commands sent by a gas controller over a communication system to the RTU at the site, where the command is used to trigger a solenoid or motor to operate and power an actuator. Remote control valve closure functionality can also be achieved by using valves that are equipped with more complex control systems than open/close control modes.

The following are examples of how a remote control set point change could be utilized to close a valve in lieu of using a remote close command for RCVs equipped with more complex control system.

3.9.3.1. *Downstream Pressure Control* - The valve opens to allow gas flow to attempt to hold a pressure downstream and closes when the pressure approaches the "set-point." When a valve is remotely-operable under this configuration, setting a zero value for downstream pressure set point closes the valve in the event of a significant pipeline event. Without a set point change, this valve will continue to allow the gas to flow through the pipe even as the pressure downstream drops.

3.9.3.2. *Backpressure Control* – The control valve is used to hold a specific pressure upstream to support operations, the valve remains closed until pressure upstream reaches set-point, at which point the valve opens and gas is allowed to move downstream to alleviate upstream pressure. If a valve is remotely operable under this configuration, setting a back-pressure value well above normal will cause the valve to close. A valve with backpressure control will likely close in the event of an unplanned upstream gas release even without making a set-point change, since the upstream pressure will likely drop below the backpressure set-point.

3.9.3.3. *Volume/Flow Control* - The control valve attempts to hold the flow rate of gas passing through a nearby meter by controlling the valve position. When the flow set point value is remotely set to zero, the valve will close, allowing it to be utilized for isolating a pipeline section.

Finally, it is also important to note that if an operator has designed an RCV system with electronic controls, which include a PLC or RTU and pressure measurement, the controls normally can be configured to operate as a functional ASV with proper programming. Little, if any, additional hardware is required in such an instance to add ASV functionality to an RCV system. Converting from simple ASV to RCV functionality, however, typically is not as simple a process, especially when the ASV is based on mechanical/pneumatic control technology.

3.9.4. Failure Modes:

A key concern in all control system designs is how the system will operate during an abnormal operating situation such as a loss of power or control signal to various control devices.

For both ASV and RCVs, these abnormal operating situations (i.e., operation under various failure conditions) need to be evaluated carefully to reduce risk to the overall gas pipeline system.

Various failure situations that should be considered include –

- loss of power to the actuator
- loss of power to the control system
- loss of SCADA communications
- loss of control signal

It is important to evaluate the results of any of these failure situations and how they will affect the overall valve control. Whether the valve will fail closed, open or hold its last position can have significant system impacts. A valve failing to close could result in loss of service to customers. Backup or redundancy for key control system components should be considered to improve reliability of the ASV/RCV system.

3.9.5. Valve Closure and Open Time:

There are a number of considerations when determining acceptable opening and closing speeds for automated valves. Pneumatic piston operated valves can close very quickly. For pneumatic piston actuators equipped with manual hydraulic override capability, speed controls can be added to the hydraulic circuit to slow the operation of the valve closure. As a rule of thumb, valve closure times should not exceed ½ second per inch diameter of the valve size to avoid overstressing the valve stem. A valve closure that is too slow could result in inadequate power gas being available in the event of a significant pipeline event near the valve unless the valve is equipped with an accumulator tank. There may be operational considerations as well that are unique to different gas systems in determining acceptable valve closure speeds. For pipelines equipped with ASVs, a valve closing too quickly could result in cascading closures of ASVs located downstream due to transient flow. Another consideration is whether the valve will be able to close if pipeline pressure is very low. If the closure time takes minutes, this increases the potential that inadequate pipeline pressure may exist to operate the valve.

Electric motor operated valves typically will close more slowly than pneumatic piston operated valves due to constraints imposed by the electric motor and gearing. A key consideration is to ensure a backup power source is provided that is capable of powering the valve actuator if utility power is lost. The cost of the electric motor actuator and the number of batteries (or type and size of generator) required to provide backup power needs to be evaluated in relation to the closure speed requirements. A maximum valve closure time of 5 seconds per inch diameter of the valve size typically can be obtained without significant cost and backup power impacts.

Regarding valve opening times, operational considerations need to be taken into account. When there are significant differential pressures across the valve, a sudden valve opening could result in creation of unacceptable pressure and flow transients in the pipeline system. An ASV opening too rapidly could result in cascading closures of valves located upstream of the opening valve due to pressure transients. Valve opening algorithms can be created to protect against potential transient effects. This could include, but is not limited to the following:

- Not allowing the valve to open when there is more than a specified differential pressure across the valve, or opening the valve at a set rate based upon the initial differential pressure.

- Opening the valve a set maximum percentage until the differential pressure is nearly equalized.

- Controlling the valve opening using pressure control and ramping the set point at a specified rate until pressures are equalized.

3.10. Power and Communication

Reliable source of telecommunication and motive power (either pneumatic pressure or electrical) are required in order for the ASV/RCV to operate on command. The location of the ASV/RCV typically determines the method of primary power used and the type of telecommunication available. The operator also should consider minimum backup power requirements for each site or establish system wide standards (i.e. one valve stroke, 24 hour SCADA backup, etc.). This includes backup power (electrical, pneumatic or other) for valve controls, a communication system and the motive force for valve actuation.

3.10.1. Electrical Service:

If utility electrical service is located near the ASV/RCV installation, this would provide a hard wired power source for the RTU and the SCADA system. A battery backup system located in the RTU or a standby generator would be needed only in the event of a temporary electricity interruption.

Utility electrical service is not always available readily near an ASV/RCV site. These locations may be able to utilize a photovoltaic solar system or a thermo-electric generator to provide electrical power.

The batteries for a photovoltaic installation would operate the SCADA system. The photovoltaic system would provide continuously power and charge the batteries in the RTU. The batteries would provide power in the event of a charging disruption. The extent and reliability of solar installations will vary greatly by location. Solar installations can be affected adversely by tall buildings or trees blocking or limiting sun exposure or by geographic climates that are prone to limited sun exposure during extended periods of the year. In some areas, maintaining the cleanliness of the photovoltaic panels can also be an issue limiting their effectiveness.

Thermo-electric generation that uses pipeline gas to produce electricity is another electrical option when utility power is unavailable. The advantage of thermo-electric generation is its ability to produce a continuous level of power day and night, and for varying weather conditions. This equipment typically is more complex and costly to install than a simple solar system, but for certain geographic locations, it may be a good alternative to consider for providing electrical power.

Electrical power also will be needed for valve actuation if electric motor actuators are installed. The use of electric actuators will significantly change the electrical power requirements and the need for backup power at the site, and add to the complexity and magnitude of the electrical requirements.

3.10.2. Power Gas (Drive Gas):

For pneumatic piston or gas/hydraulic actuators, a power gas system will be required to operate the valve. Power gas is provided most commonly by using natural gas from the pipeline. The power gas often needs to be reduced in pressure, depending upon the specific requirements or working pressure of the actuator. In certain cases, compressed air or nitrogen cylinders may be available at the site, and could be utilized to provide power gas.

For increased reliability, if two pipe lines are running together, the power gas may be supplied from both pipe lines. This enables the valve to still operate as required if one of the lines loses pressure. If only one pipe line is available, a backup source of power gas such as an accumulator tank could be installed to operate the valve. An accumulator tank typically should be sized for 3-4 valve operations (i.e. open to close, or close to open).

3.10.3. Telecommunication:

Telecommunication with an RCV will provide the operator with the information to monitor pipeline operating conditions and control the valve. Pipeline operating conditions communicated back to the control room may include valve positions, pipeline pressures and flows, and SCADA equipment status such as low batteries. For an ASV, generally telecommunication is not required for automatic shut-off, but may be provided to allow the controller to better understand current pipeline operating conditions. For complex interconnected piping systems, an operator should consider the use of telecommunication at valve sites and additional pressure and flow monitoring to assist gas controllers in minimizing the potential impact of an ASV closure and managing an event.

Telecommunication options include dedicated leased phone lines, cellular phone, satellite, and various radio technologies. For the most critical sites, consideration should be given to providing a backup communication path, such as use of a land lease line with a radio backup system. This may be especially important in locations where a single natural forces event (e.g., earthquake or hurricane) may stress the availability or reliability of public communication systems.

Due to the sensitivity associated with safe RCV operation, it is important to ensure physical and cyber access to the valve mechanisms is not compromised by a nefarious actor trying to disrupt the gas delivery. Particular attention should be given to securing the signal transmitted to the valve, so that what is issued by the gas control operator is the correct command that cannot be altered by an unauthorized party. Encryption or other form of signal protection may assist in this objective.

4. Operational Considerations

4.1. SCADA/Gas Control

The installation of ASVs/RCVs has many implications to gas control personnel. Issues include:

- the process for safely placing these new system control assets into service without negatively impacting existing operations;
- training and deployment of new gas control tools to ensure gas controllers are fully equipped to effectively utilize this new system control functionality, and
- increased gas system visibility and understanding that may be required for deciding when to activate RCVs and detecting if an ASV has operated.

The CRM requirements contained in 49 CFR §192.631, mandates gas control management be involved during the planning of major changes to the pipeline operations, gas control personnel participate in point-to-point testing of new SCADA point, all monitoring and control points meet alarm management requirements, and gas controller training be established that provides a controller with working knowledge of the pipeline system and, in particular, how to respond to abnormal operating conditions. All of these CRM requirements are applicable to the installation and use of ASVs/RCVs.

4.1.1. Change Management:

Gas control personnel should be included in the decision process for the location of ASVs/RCVs and the type of information to be brought into the SCADA system from those locations. Operators should consider the potential effects of inadvertent closures when ASV/RCV locations are selected. When adding ASVs/RCVs to a gas system, attention should be paid to the additional complexity of system operations due to increased system automation.

4.1.2. Point-to-Point Testing:

Point-to-point testing of new points coming into the SCADA system is a requirement of the CRM rule, section 49 CFR §192.631.c.2. Operators should accomplish this in accordance with their CRM procedures. Typically, field technicians activate each point or alarm, the SCADA engineers confirm the data are being brought into the SCADA system and the gas controller confirms the data or alarm reached the controller's SCADA display or alarm display.

4.1.3. Alarm Management:

Many of the SCADA points for ASVs/RCVs may be considered safety-related alarms. The CRM rule has specific requirements for monitoring and evaluating safety-related alarms, which may increase the workload within gas control. To evaluate and respond to these alarms may require that additional pressure and flow readings be brought into the SCADA system, not only from the ASV/RCV locations but also from additional locations on the pipeline to aid in the determination of a possible pipeline event. Additional safety related alarms may have an impact on gas controller activity.

4.1.4. Gas Control Tools and Training:

As ASVs/RCVs are added to a system, additional procedures, guidelines, policies and training for gas controllers should be implemented to ensure uniform emergency response. These procedures and policies should be developed jointly by engineering, system integrity, field operations and gas control personnel, and be formally documented and approved.

The procedure for closing RCVs and the authorizations required should be clearly understood and documented. This may include criteria for RCV activation and authorization for execution. This includes the level of field verification, if any, required before actuating an RCV. For many companies, field verification of the emergency typically is required before shutdown (unless it is an ASV). Gas controllers also should be trained on recognizing and responding to the inadvertent closure of an ASV/RCV.

To assist in the development of realistic emergency scenarios, modeling of pipeline events can be used to demonstrate to controllers the impact of a pipeline event. SCADA records of actual pipeline events can be used to develop tabletop exercises. Development and use of drills or simulations also should be considered to aid in training of gas controllers and relevant personnel.

In evaluating a possible pipeline event, the use of additional pressure and flow points on the pipeline system and the use of enhanced SCADA alarming may also be considered. Simple rate of change or low pressure alarms at a particular valve site may be considered in the decision making process to close an RCV, along with additional pipeline operating data, such as a reversal of normal pressure gradient, decreasing pressures at additional locations or additional rate of change alarms at adjacent valve locations. Such corroborating information, along with any information received from field operations, emergency response personnel or the public, may be helpful in confirming a pipeline event, and then determining the location of the event and the proper response. Information from the public or emergency response personnel is likely to come in the form of geographic location, without knowledge of specific operators, pipelines, mileposts or adjacent valve locations or numbering. Integration of such data may be facilitated by pipeline mapping tools that would assist in determining the pipeline(s) at that location, the associated mile posting and the appropriate valves that could be used to isolate the section, if necessary.

4.2. General Operational Guidelines for Use of ASVs/RCVs

Because of potential customer impacts, emergency closure of RCVs typically is initiated only with appropriate authorization, whereas an ASV is programmed to close automatically under certain conditions. Each operator needs to develop its own protocols and policies regarding the closure of RCVs.

To activate an RCV, the gas controller “arms” the valve control, and then either opens or closes the valve, as appropriate. This two-step process minimizes the potential for an inadvertent RCV closure.

If a sectionalizing block valve is closed inadvertently, there only may be a short time available in which to reopen the valve before a large differential pressure develops across the valve and the downstream system is affected. If a valve is opened too quickly when a large differential pressure exists, it can cause unacceptable transient pressure effects in the pipeline. Clearly documented procedures should be established for appropriate response to an inadvertent closure.

Individual company operating procedures should define when a valve is considered fully secured. Consideration should be given to the risk of a closed RCV being re-opened prematurely after an unplanned gas release prior to the determination that the site is safe and the pipe can be safely re-pressurized. Design of lockout functions that prevent remotely opening a valve that is closed based upon an identified emergency situation should be taken into consideration as an additional safety measure.

Once an RCV/ASV is closed due to a pipeline event, it should not be re-opened without appropriate level of authorization after proper on-site field verification that the situation is safe. Generally, gas control will require field operations personnel to re-open the valve (after it’s determined to be safe) in order to do so in a gradual and controlled manner while also monitoring pipeline system pressure using gauges or other local indicators, assessing the situation and executing any procedures that have been developed to return the system to normal operation. The procedure for opening a valve after an ASV/RCV emergency activation should be documented clearly. In addition, operating an automated valve during routine operations should be accomplished in accordance with company procedures and protocols.

4.3. Enhanced Liaison with Emergency Responders

LDCs should have a close relationship with emergency responders (e.g., fire and police department personnel). Advanced coordination with them is the key to improving responses in the event of a pipeline incident. Public awareness communication programs should be evaluated periodically for effectiveness and enhanced as necessary. Most routine leaks are managed exclusively by the LDCs, but local emergency responders are sometimes called for assistance. LDCs should work also with emergency responders to prepare for events that could result in a major release of gas

Improved communication and coordination at the local level is the best way to enhance emergency response. In addition, responding to the potential impacts of isolating a section of pipeline, including service restoration and potential customer re-lights, needs to be documented in emergency preparedness plans.

5. Maintenance Considerations

ASV/RCV maintenance protocols should be established to ensure that the valves are fully functional and that any operability issues are quickly addressed to maximize operational availability. In addition, design considerations should take into account the ability to safely perform future maintenance activities.

Other considerations include:

- standardization of design, equipment and spare parts,
- training of maintenance personnel regarding ASVs/RCVs,
- designing to minimize maintenance issues – weather, traffic, security,
- developing effective testing requirements and operating procedures and
- budgeting for the cost of annual maintenance and testing of additional automated valves and RTU sites.

ASV/RCV installations should be engineered to standardize the equipment installation and control system design as much as possible. This will minimize the potential for operation or maintenance errors by technicians performing work, and facilitate troubleshooting of an equipment or control problem. The standardization of equipment and the stocking of critical spare parts will minimize out-of-service time created by an equipment problem. In determining spare parts and equipment inventory, a number of factors may be considered, including the availability of parts and equipment from suppliers, company guidelines regarding equipment being out of service, and the number of ASV/RCV units in service and their criticality.

When installing ASVs/RCVs in places where limited operating experience exists with these types of valves, care should be taken to provide adequate training to potential operating and field maintenance personnel. For each installation, the operating and field personnel should be educated on the function of the equipment, design of the control system, maintenance requirements and any features unique to that particular installation.

ASV/RCV installations should be designed to minimize maintenance issues, including those related to weather, vehicular traffic and acts of vandalism. Equipment should be installed such that it avoids public complaints associated with gas venting (odor and/or noise), provides maximum personnel safety and can be readily accessed by personnel throughout the year. Potential concerns include water intrusion into vaults, installation of vaults in high vehicular traffic areas, installation of equipment in high crime areas and installation of equipment in areas that are difficult to access. For areas where site security is an issue, consideration should be given to the use of special locks, security alarms, security cameras and lighting to prevent equipment from being stolen, vandalized or inappropriately used.

ASVs/RCVs should be tested on a regular basis to ensure that they are fully functional. Considerations include the frequency of the testing, the extent of the testing (i.e. partial test or full functionality testing, component or system testing), and the operating procedures required to perform the desired testing. Testing and inspection plans should include any electrical power and power gas systems, the instrumentation and control system, SCADA communication, valve operability and the full system functionality. This should include verifying calibration of critical control components such as pressure, flow and position transmitters. The frequency and extent of testing should be based on the specific gas transmission system design, customer service requirements, equipment risks and manufacturer’s recommendations. Design of ASV/RCV installations also should take into account testing requirements and minimization of the flow impact to the gas transmission system from testing automated valves. The impacts of valve testing should always take into consideration the effects on gas system operation and the potential pressure and flow transients, and associated impacts that could be created by quickly closing or opening valves.

6. Appendix

6.1. Valve Actuators

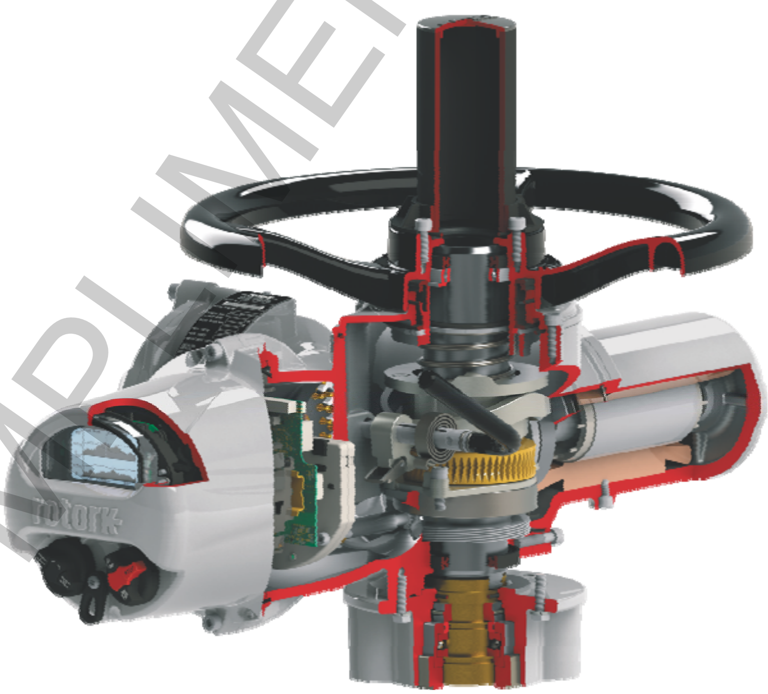
There are many actuators used throughout industry. Many smaller valves (on pipelines nominally size 4-inches and below) utilize a direct hand wheel or wrench operator. Larger pipelines and valves 6-inches or larger typically utilize a gear-operator. This is because the torque required to operate the valve increases with the size of the valve, making mechanical advantage necessary for larger valves. Normally, these valves are operated manually and the mechanical advantage minimizes the ergonomic impact on field personnel.

Power actuators often are utilized on pipelines 16-inches and larger and for more critical valves, such as meter and compressor stations, and for line valves designed to be remotely or automatically controlled. The point at which a power actuator is specified for a valve depends on many factors, including size of the valve as well as operational considerations and the overall critical nature of the valve to the piping system. Actuator types include pneumatic, electric and gas/hydraulic systems. As discussed earlier, there are many control configurations that are utilized in industry to provide the logic sequencing, which sends an open, close or modulating command to an actuator. These configurations can include a reference to pressure, rate of pressure change, flow-rate, flow-rate change and in some instances gas quality change. Another configuration is a remote control valve or electronic signal operation to shut down a station based on a monitored parameter such as pressure, flow, gas composition etc. ASVs/RCVs can utilize an electric, pneumatic or gas/hydraulic actuator to operate the valve. The main difference is an ASV utilizes an electric or gas powered actuator to operate the valve mechanically, based on data sent to the actuator from pipeline sensors, while an RCV utilizes an electric, pneumatic or hydraulic actuator to operate, based on a signal from a remote location, such as a gas control room.

6.1.1. Electric Motor Actuators:

Many brands of actuators are used throughout the pipeline industry. Each manufacturer and model has unique specifications that address actuator concerns and requirements. Overall, all electric actuators will have a motor that drives a gear, which in turn, moves a valve. The movement of the valve by the motor is dependent on limit switches, which act as a feedback loop based on the control signal.

Below is a cut-away view of an electric actuator. Robust asynchronous three-phase AC motors usually are used as the driving force, but single-phase AC or DC motors are available and used for some applications. Single-phase DC motor usage is particularly common when only battery back-up power is available and the actuator needs to be available if primary utility power is lost. Often a worm gearing is used to reduce the high output speed of the electric motor. Self-locking gearing prevents accidental and undesired changes of the valve position by acting upon the valve's closing element.

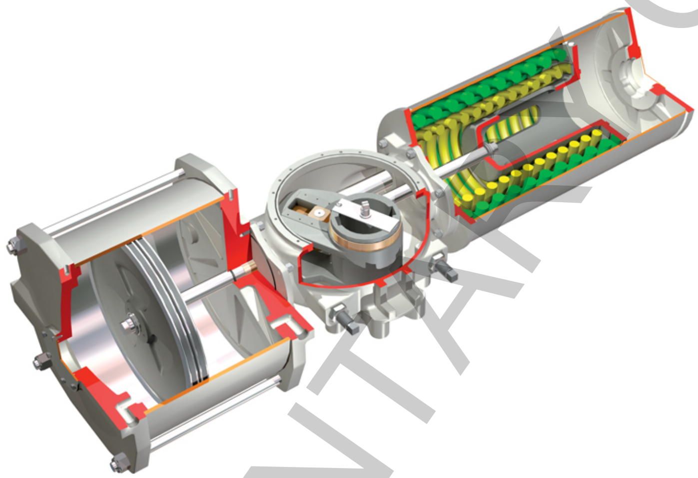


(Provided by Rotork. Used with permission.)

Figure 6-1
Electric Multi-turn Actuator with Controls

6.1.2. Pneumatic Piston Actuators:

Pneumatic actuators are the most common type in use today. Pneumatic actuators utilize compressed air or natural gas to move a valve. Figure 2 shows a cut-away view of a scotch yoke single-acting pneumatic piston actuator with a spring return.



(Provided by Flowserve. Used with permission.)

Figure 6-2
Pneumatic Scotch Yoke Actuator (Spring Return)

The scotch yoke actuator represents a fairly simple and cost effective solution for operating large diameter quarter turn pipeline valves, such as trunnion-mounted ball valves or plug valves. The scotch yoke actuator converts pneumatic pressure to quarter-turn rotary motion. The actuators require minimal maintenance and can operate via compressed air or regulated natural gas medium from the pipeline. A scotch yoke actuators are well-suited for on/off valve applications. Pneumatic scotch yoke valve actuators typically are provided in two different configurations:

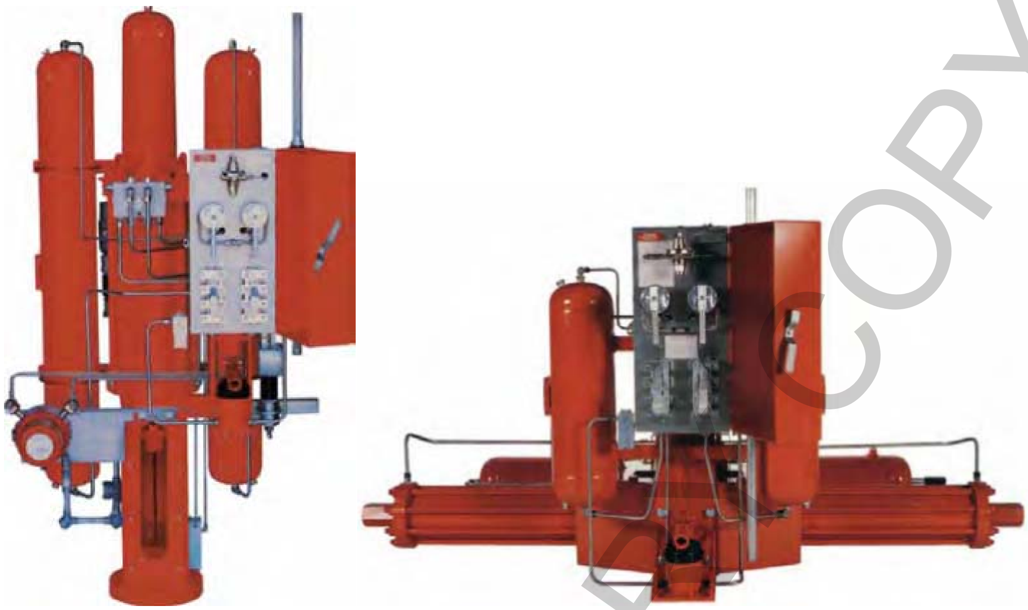
- double-acting piston
- single-acting – spring return

Single-acting spring return actuators are pressurized on one side, with atmospheric pressure on the other side. Double-acting piston designs accept pressure on both sides of the piston to provide motive force. Actuator configurations can be selected based on required "failure mode." Single-acting spring return actuators typically are selected when a guaranteed failure mode is required to close or open the actuated valve upon loss of supply pressure. Single-acting spring return actuators are inherently larger and more expensive than double-acting actuators. Hence there are cases where double-acting actuators are selected in conjunction with an "air spring" solution when guaranteed failure mode is required.

6.1.3. Gas/Hydraulic Actuators:

Gas/hydraulic valve actuators (often referred to as "gas-over-oil" type) use a high pressure gas supply (typically 300 to 1,480 psig) as their power source, and often are used in gas/transmission pipelines in which the pipeline medium is used for the actuator's power source. Gas/hydraulic actuators are similar to pneumatic piston actuators, but they utilize hydraulic fluid versus air or natural gas to drive the valve. They convert pipeline gas pressure into a powerful hydraulically controlled thrust to open/close the valve. Gas/hydraulic actuators are available from many manufacturers.

There are two main types of gas/hydraulic actuators in use. The first is for quarter-turn valves such as ball and plug valves. The second type is for linear gate valves. Figure 6-3 shows two examples of gas/hydraulic actuators.



For Linear Gate Valve   For Quarter-Turn Valve

(Provided by Emerson Process Control. Used with permission)

Figure 6-3

Gas/Hydraulic Actuators

7. References

"AGA White Paper, Automatic Shut-off Valves (ASV) and Remote Control Valves (RCV) on Natural Gas Transmission Pipelines," AGA Distribution and Transmission Engineering Committee, March 25, 2011.

Form for Proposals to Change Design Guidelines for Installation of ASV & RCV Systems in Natural Gas Transmission Pipelines

Send to: **Operations and Engineering Section**
American Gas Association
400 North Capitol Street, NW, 4th Floor
Washington, DC 20001, U.S.A.
Fax: (202) 824-7082

Name____

Company____

Address____

Tel. No. ________________________ **Fax No.** ________________________________

Please Indicate Organization Represented (if any)

____

1. Section/Paragraph____

2. Proposal Recommends: (check one)

☐ **new text**
☐ **revised text**
☐ **deleted text**

3. Proposal (include proposed new or revised wording, or identification of wording to be deleted, use separate sheet if needed): (Proposed text should be in legislative format; i.e., use underscore to denote wording to be inserted (inserted wording) and strike-through to denote wording to be deleted (~~deleted wording~~).

4. Statement of Problem and Substantiation for Proposal (use separate sheet if needed): (State the problem that will be resolved by your recommendation; give the specific reason for your proposal including copies of tests, research papers, etc.)

5. ☐ **This proposal is original material.** (Note: Original material is considered to be the submitter's own idea based on or as a result of his/her own experience, thought or research and, to the best of his/her knowledge, is not copied from another source.)

☐ **This proposal is not original material; its source (if known) is as follows:**

____

Type or print legibly. If supplementary material (photographs, diagrams, reports, etc.) is included, you may be required to submit sufficient copies for all members of reviewing committees or task forces.

I hereby grant the American Gas Association the non-exclusive, royalty-free rights, including non-exclusive, royalty-free rights in copyright, in this proposal and I understand that I acquire no rights in any publication of the American Gas Association in which this proposal in this or another similar or analogous form is used.

Date: ________________________

____
Signature (Req

FOR OFFICE USE ONLY

Log # ____________________

Date Rec'd _________________

American Gas Association
400 N. Capitol Street, N.W., 4TH Floor
Washington, DC 20001
U.S.A.
202/824-7000
www.aga.org

Catalog No. XL1202
October 2012

American Gas Association