EVALUATION OF EXCESS FLOW VALVES IN GAS DISTRIBUTION SYSTEMS

Final Report

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1. Introduction

1.1 Purpose

The U.S. Department of Transportation's Pipeline and Hazardous Materials Safety Administration (PHMSA) has public responsibility for safe and secure movement of hazardous materials to industry and consumers by all modes of transportation. The debate on the effectiveness of excess flow valves (EFVs) has been ongoing between safety advocates, the gas distribution industry and EFV manufacturers. The purpose of this report is to identify if any operational data is available to be used to evaluate the reliability and effectiveness of EFVs and an evaluation of the standards that pertain to EFVs.

1.2 Background

An excess flow valve (EFV) is a safety device designed to automatically shutoff the flow of fluid (natural gas) through a piping service line if it ruptures, thereby mitigating the impact of the rupture. This technology was pioneered about 25 years ago with the development and use of spring actuated EFVs for natural gas service. They are installed on new and renewed service lines near the gas main.

As a safety device, EFVs are designed to automatically shutoff the flow of natural gas if the service line between the gas main and the meter ruptures . They are not designed to shutoff the flow of gas if the line breaks at the connection of a gas appliance in a residence or in the customer's piping system (interior or exterior) on the customer's side of the gas meter.

In general, EFVs are an added optional safety device that has no effect on the gas flow resulting from a small leak, such as a leak caused by corrosion or a small crack. Furthermore, EFVs will not operate in response to a leak within a building where gas service is provided. The valves are intended to respond to line ruptures between the line and the service entrance to the building. EFVs do not prevent accidents; instead, they help mitigate the consequences of accidents where there has been a substantial or catastrophic line break. Where installed, EFVs are complementary to damage prevention programs, one-call systems, and other pipeline safety efforts that focus on preventing accidents caused by outside forces.

2. Methodology and Approach

2.1 Proposed Methodology

To determine if operational data exists, GP originally proposed to research the state regulations to determine which, if any states required the use of EFVs, contact operating companies that routinely install EFVs and contact EFV manufacturers. After the initiation of this contract, it became known that other contractors would be contacting and interviewing operating companies. In order to not exceed the limit on the number of states and companies that could be contacted, GP performed the search exclusively through internet research.

3. Installation and Operational History of EFVs

3.1 State Survey

GP searched the regulations for each state through the state websites and did not identify any additional regulations requiring the installation of excess flow valves upstream of the gas meter. California building code requires the installation of excess flow valves or other acceptable device to isolate the flow of natural gas in the event of a line rupture downstream of the meter. Additionally, other cities such as Frisco, Texas and Houston, Texas also have ordinances requiring excess flow valves downstream of the gas meter.[1]

3.2 Operator History

A number of Operators have published articles stating their position to voluntarily install EFVs under the regulation 49 CFR 192.383 stating that it is more cost effective to install EFVs than to keep track of a customer notification system. Through another task, a number of those Operators were contacted and participated in an OPS survey. A review of the OPS survey results revealed that generally operational data has not been collected but failures are not common.

3.3 International Search

GP proposed to perform an international search to determine what experience may exist with other countries using excess flow valves. To perform this, GP performed an internet search. This search proved to be difficult because different terms are used in different countries for excess flow valves, the regulations for gas distribution is usually at a regional level and not readily available through agency websites, and most documents are not available in English.

French law requires the use of Excess Flow Valve from a government order dated July 2000. The law states "Each new service connection, either Polyethylene / Polyethylene or Steel / Polyethylene has to be fitted with an EFV". Gaz De France covers the cost in their infra-structure[2]. T.D. Williamson France SA, in cooperation with Gaz de France, has designed and developed an Emergency Shut-Off Valve (ESV).

The German organization Deutsche Vereinigung des Gas- und Wasserfaches e.V. - Technisch-wissenschaftlicher Verein, (DVGW) is the German Technical and Scientific Association for Gas and Water and is responsible for the codes and standards related to the gas supply system. The DVGW stands for the industry self-regulation in the gas and water supply industry. Its technical rules are the basis for safety and reliability for German gas and water supply.[3]

[1] www.gasbreaker.com/news/news_cont.html
[2] Email correspondence with Sylvain Cartereau, T.D. Williamson, France.
[3] http://www.dvgw.de/en/index.html

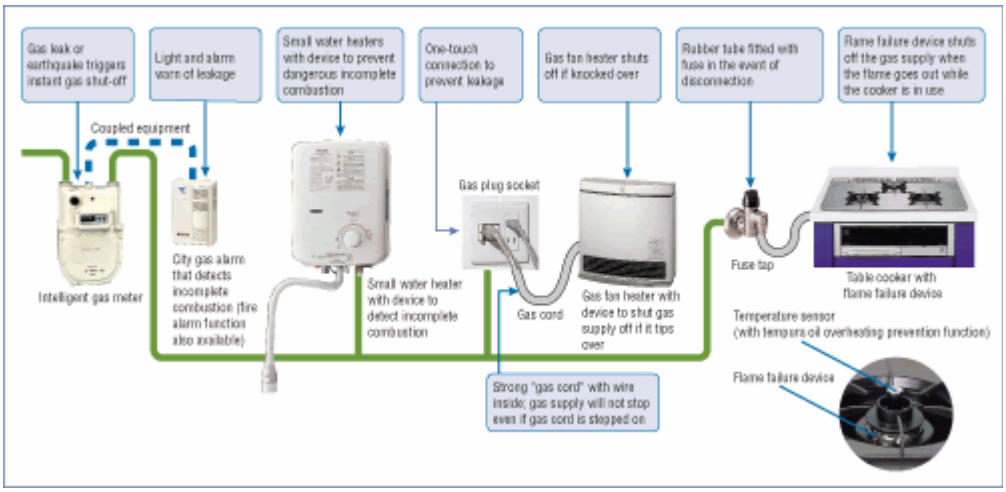
In Germany, excess flow valves are required to be installed on all new service lines[4]. The EFV can be installed on underground service lines between the main and the main shut off valve in the residence or downstream of the main gas shutoff valve in the residence. The Standard VP 305-2 is the German test standard for excess flow valves. It is currently not available in English so a comparison to the ASTM standards could not be conducted. GP did contact the DVGW for information regarding operational data, use of excess flow valves and any other additional information. A copy of the standard in English was also requested. Currently, a response has not been received.

Iran is using EFV mainly for three reasons[5]:

- Limit the gas flow consumption to a contractual pre-set value (if the customer/consumer adds too many additional service connections, then the EFV closes, shutting off service).
- Mitigate the consequences of third party damage
- Provide safety in the event of earth quake

The Japan Gas Association is an organization of city gas utilities. The utilities have set a target to improve safety to reduce deaths from gas related accidents to approach zero by the year 2010[6]. The gas utilities are installing intelligent gas meters to protect the end users.

Figure 3-1 shows the arrangement of the intelligent gas meter with respect to the other components in the residence that was available on the Japan Gas Association website.



Source: http://www.gas.or.jp/gasfacts_e/p_05/

Figure 3-1, Japan Gas Equipment Safety System

[4] 22nd World Gas Conference June 1-5, 2003 Tokyo, Japan, Report of Subgroup 5.3 of Working Committee 5 "Distribution" Regulatory Safety Policies
[5] Email correspondence with Sylvain Cartereau, T.D. Williamson, France.
[6] www.gas.or.jp/

The gas meter is equipped with a microcomputer that monitors gas use around the clock and automatically shuts off the flow when one of the following is detected:

- Significant gas leakage such as a rupture
- Gas appliances left on
- Earthquakes with an intensity of 5 or more

The shut off action in the intelligent meter can be reversed by the customer if desired[7].

Source: Tokyo Gas Company

Figure 3-2, Representative Intelligent Gas Meter

The alarm is located within the residence and notifies the customer by an audible alarm and flashing light when a gas leak is detected.

Source: Tokyo Gas Company

Figure 3-3, Audible Alarm

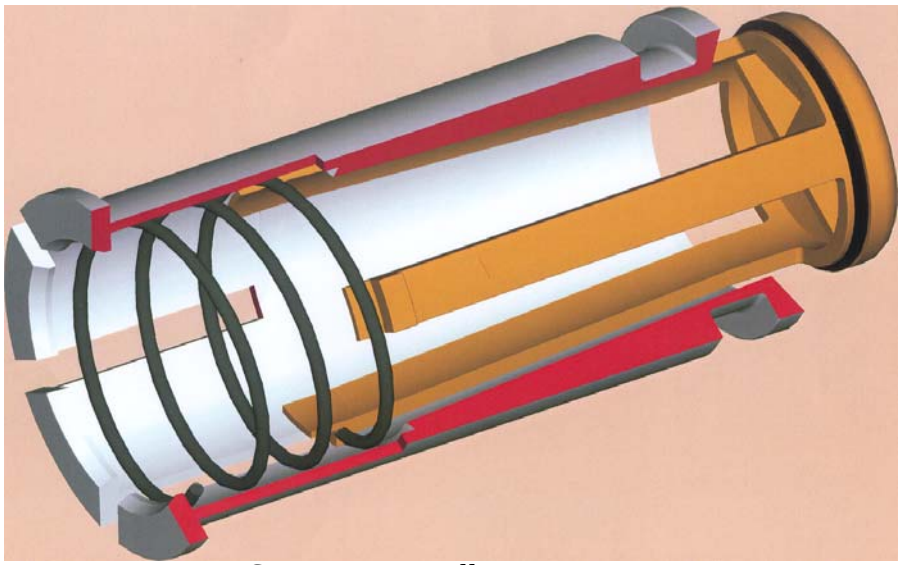
3.4 Foreign Manufactured EFVs

T.D. Williamson France SA

T.D. Williamson France SA (TDW), in cooperation with Gaz de France, has designed and developed an Emergency Shut-Off Valve (ESV) that operates with an inlet pressure between 1 to 4 bars. The ESV is an excess flow valve for polyethylene (PE) service and transitions to steel service. The EFV will isolate the gas supply in the event of a leak or rupture in which the

[7] http://www.tokyo-gas.co.jp/csr/safety_e.html

maximum flow set point is exceeded. The ESV is a positive shutoff without bleed by. The poppet valve closes against a spring, and stops the flow of gas. After the line is repaired, the valve is returned to service and reopened by applying back pressure. Once the differential pressure across the valve is equalized, the valve automatically opens.



Source: T.D. Williamson, France Presentation

Figure 3-4, TDW Excess Flow Valve

The TDW ESV is advertised as having the lowest pressure drop across the valve of any EFV/Gas Stop on the market[8]. This is beneficial if any contamination in the gas exists. Additionally, the shut-off point can be adjusted.

- EFV TDW 1-1/4'' Maximum pressure drop : 0.9 PSI
- Competitor ESV/Gas-stop 32mm pressure drop performance : 1.75 PSI
- EFV TDW 3/4'' pressure drop performance : 0.65 PSI
- Competitor ESV/Gas-stop 25mm pressure drop performance : 1.3 PSI

Pipelife Gas-Stop

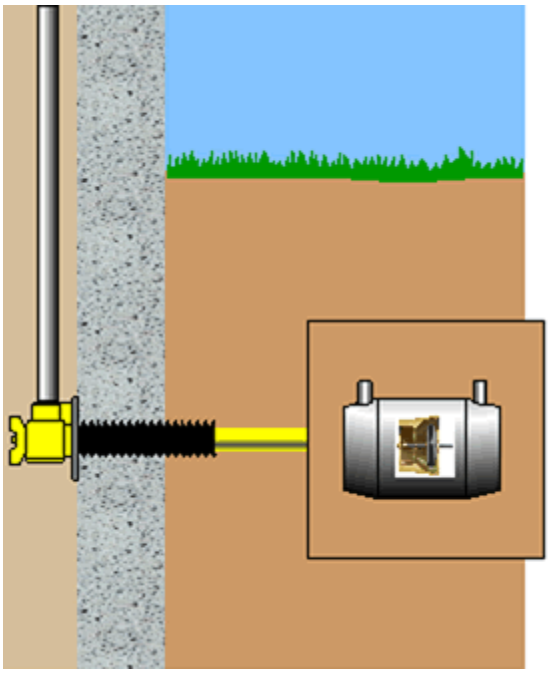
Pipelife Gas-Stop is a company based in Austria and has developed a self activating, high speed shut-off valve for gas service lines. This EFV was developed in conjunction with gas supply companies and is a positive shutoff valve installed between the main line and the pressure regulator. It is designed to isolate the flow of gas immediately when a pre-set flow is reached due to third party damage or improper handling of the shutoff valve inside the building or regulator[9].

[8] T.D. Williamson, France Powerpoint presentation 6/20/05
[9] www.pipelife.at

Pipelife Gas Stop is currently marketed in Europe and meets a number of different specifications in European countries. The EFV is a spring loaded device that is equipped with an O-ring to ensure a gas tight seal when actuated. It is suitable for use from 15 mbar up to 10 bar. It has been also been successfully used in main lines to isolate distribution sections in the event of a rupture.

Mertik Maxitrol

Mertik Maxitrol is a German company that manufactures two models of the Sentry GS EFV for different applications to comply with the German gas installation codes and regulations. The first model is an excess flow valve for underground gas service lines. It is installed underground on the service line between the main line and a single residence with an operational pressure range of 35 mbar to 5 bar. It actuates when the gas flow rate exceeds the shut off flow rate. It is equipped with a bypass and opens automatically when the failure has been repaired and the line re-pressurized. In the open position, the bypass orifice is protected from contaminants that may exist in the gas.



Source: http://www.mertikmaxitrol.com/engl/prod_gse.htm

Figure 3-5, Sentry GS EFV for Underground Installation

The second model is for residential installation and also closes automatically when a predefined gas flow rate is reached. For single residences the EFV is installed after the main gas manual shut-off valve. It can also be used in multi-family dwellings and the EFV is installed upstream of each gas meter. These devices are sized using the total capacity of all the appliances combined. This model is also equipped with a bypass orifice and reopens once pressure is equalized across the valve.

Source: http://www.mertikmaxitrol.com/engl/prod_gsh.htm

Figure 3-6, Sentry GS EFV for Residential Installation

Both valves are spring activated and the valve components are made of corrosion resistant metal with a nitrile butadiene rubber (NBR) O ring for sealing along the sides of the brass housing.

The German EFV manufacturer Mertik Maxitrol has a paper available on their website on the subject of the long term behavior of EFVs in buried service[10]. The paper is written in German and a translation is available. In the paper, several tests are presented including continuous cycle tests and field tests in less than desirable gas systems. The general conclusion is that the valves continue to operate reliable.

[10] Fischer, Ing. Norbert, Dr., Jesses, Klaus W., April, 2002, www.mertikmaxitrol.com/engl/

4. EFV Standards and Regulations

There are several standards that apply to the manufacture of EFVs for natural gas service in the United States:

- ASTM F2138-01, Standard Specification for Excess Flow Valves for Natural Gas Service
- ASTM F1802-04, Standard Test Method for Performance Testing of Excess Flow Valves
- MSS SP-115-1999, Excess Flow Valves, 1 ¼ NPS and Smaller, for Fuel Gas Service

The two ASTM standards are under the jurisdiction of ASTM Committee F17 on plastic piping systems and F2138-01 is the direct responsibility of Subcommittee F17.00 on Gas and F1802-04 is the direct responsibility of Subcommittee F17.40 on Test Methods.

4.1 ASTM F2138-01, Standard Specification for Excess Flow Valves for Natural Gas Service

An excess flow valve (EFV) is defined as a *device installed in a natural gas piping system to automatically stop or limit the passage of natural gas when the rate of passage of natural gas through a device exceeds a predetermined level.*

There are two main types of EFVs, one that allows bleed by or bypass flow (EFVB) and the other that stops the flow of gas (no bypass) after it is tripped (EFVNB). The first type allows for bypass flow that is a small predetermined flow through the valve once closed. This bypass flow allows the upstream and downstream sides to equalize after the leak or rupture has been repaired, allowing the valve to reset automatically. The second type of valve does not allow for bypass flow and essentially forms a gas tight seal. This type of valve requires the valve be reset manually.

It is important to note that the tests required by F 2138-01 are intended to determine the performance characteristics of an excess flow valve installed in a straight piece of pipe. It is possible for an excess flow valve to be installed in a service tee outlet, as part of a mechanical coupling as well as a straight piece of pipe and other configurations. Additionally, excess flow valves covered by this standard are for use in systems from ½ CTS to 2 IPS, maximum inlet pressure of at least 125 psig, and temperature rating range of -20 to 140ºF.

This Standard requires sample testing to establish the following Performance Parameters:

- Trip Flow
- Leak Rate for EFVNB once tripped
- Bypass Flow for EFVB once tripped
- Pressure Drop - maximum pressure drop across the valve for each flow rate
- Reset
- Snap Acting Load
- Cycle testing – After the required cycle testing, the EFV must still meet the requirements for Trip Flow, Leak Rate and Bypass Flow testing

F 2138-01 requires 100% production testing on all EFVs to demonstrate the following Performance Parameters are met:

- Trip Flow
- Leak Rate for EFVNB after trip
- Bypass Flow for EFVB
- Reset Testing

Because the standard requires 100% production testing before an EFV can be shipped, the likelihood of having an EFV activate when there is no failure (trip flow does not reach the minimum flow rate) or failure to active when there is rupture (valve fails to trip when the trip flow reaches the minimum flow rate) is very low. The cause of either of these situations should only be damage due to improper shipping, handling and installation or contaminates in the gas.

The Standard does allow for an EFV from one manufacturer to be supplied for assembly into another manufacturer's product provided that all identification requirements are met.

An EFV manufactured to this standard must be marked with the following:

- ASTM 2138
- Manufacturer's name or trademark
- EFV model
- Date and location of manufacture

4.2 ASTM F1802-04, Standard Test Method for Performance Testing of Excess Flow Valves

This test method applies to both types of EFVs, bypass and non-bypass. The tests use air as the test fluid and the results are then corrected based on the density of natural gas. Tests are performed at standard conditions of 60ºF and 14.7 psia. In contrast to Standard F 2138-01, this test method only covers EFVs constructed to fit piping systems no smaller than ½ CTS and no larger than 1 ¼ IPS, including both pipe and tubing sizes. It is intended that the EFVs would be installed in thermoplastic piping systems. However, the standard states it is expected that the test method may also be used for similar devices in other piping systems.

This test method is intended to apply to EFVs with the following characteristics:

- Pressure rating of up to 125 psig (0.86 MPa)
- Trip flow of between 200 and 2500 ft3/h (5.66 and 70.8 m3/h) at 10 psig (0.07 MPa)
- Minimum temperature rating of 0ºF(-18ºC)
- Maximum temperature rating of 100ºF (38ºC)

The tests are used to establish the following performance characteristics:

- Flow at Trip Point
- Pressure Drop Across the EFV
- Bypass Flow Rate (EFVB)
- Leak Rate (EFVNB after trip)
- Verification that EFV can be reset

The test method includes a section to determine the effect of Kerosene and Kerosene-Ferric Oxide Powder on the EFV's performance to compensate for contaminates that may be present in a natural gas system.

4.3 MSS SP-115-1999, Excess Flow Valves, 1 ¼ NPS and Smaller, for Fuel Gas Service

The Manufacturers Standardization Society of the Valve and Fittings, Industry, Inc. (MSS) has developed the Standard Practice 115 for Excess Flow Valves for 1 ¼ NPS and smaller for Fuel Gas Service.

EFVs covered by this Standard include both EFVB and EFVNB and will have the following characteristics:

- Minimum design inlet pressure of 5" w.c.
- Maximum operating pressure of 125 psig
- Minimum temperature rating of -20ºF
- Maximum temperature rating of 140ºF

Materials used in the construction of EFVs must be compatible with the applicable fuel gas and comply with industry piping standards. All tests are to be performed at standard conditions.

An EFV manufactured to this standard must be marked with the following:

- Manufacturer's identification
- Type of EFV
- Flow direction arrow
- Nominal pipe size
- Pressure rating designation
- Lot identification

The Standard also provides for testing to establish the performance characteristics of the EFV and requires 100% testing on all EFVs prior to shipping. This Standard incorporates by reference ASTM F1802-97 Standard Test Method for Performance Testing Excess Flow Valves when testing high pressure EFVs (5 psig and above).

5. Reliability of EFVs and Risks Associated with their Use

The existing Standards for the Specification, Testing and Manufacture of EFVs have a direct impact on the reliability of EFVs by setting minimum standards to ensure performance through testing. Additionally, under both the ASTM Standard and MSS Standard, 100% of EFVs are performance tested prior to shipping to ensure conformance with the design rating. It is important to consider the conditions under which EFVs are tested to ensure they are similar to the installed operating and environmental conditions. The existing Standards do not include installation methods, configurations and sizing calculations.

There are a number of factors that affect the selection and installation of an EFV for a natural gas system. Typically, the EFV manufacturer can provide assistance with sizing and selection once the following is specified:

- Type (EFVB or EFVNB)
- Trip flow rate
- Maximum inlet pressure (the Standard applies to a maximum inlet pressure of at least 125 psig but this will depend on the system)
- Minimum inlet pressure
- Temperature rating range (the Standard applies to a temperature rating range of -20 to 140ºF but needs to be specified based on location of installation)
- Special considerations based on configuration including service line length

The DOT regulation 49 CFR 192.383 requires notification on the availability of an EFV for a service line to a single residence provided the pressure is at or above 10 psig and continuously in service throughout the year. Notification is not required if the Operator voluntarily installs the EFVs, a device that meets the performance standards is not available, or the Operator has experience with contaminants in the gas stream that would interfere with the valve performance.

In the United States, EFVs are typically placed between the main line and the gas meter. It is also desirable to place the EFV as close the main line as possible to protect as much of the service line as possible. In this arrangement, EFVs can mitigate the effects of a significant leak or rupture due the following:

- Third party damage to service line
- Homeowner digging through service line
- Earth movement
- Service line integrity failure

The regulation requires that EFVs used are manufactured to an industry standard or manufacturer's standard and the performance of each valve is verified prior to shipping. Therefore the risks of a valve failing are minimal and it is far better to have the valve installed than not. The risks associated with the use of EFVs are probably most likely to occur due to a failure to follow the regulation and through a false sense of security, such as the following:

- The installation of an EFV is not properly identified so its presence is unknown when dealing with an emergency situation.

- In a bleed-by or bypass EFV, a small leak below the trip flow rate may exist and will not trip the device but a homeowner with an EFV installed may not understand this is possible.
- A leak downstream of the meter or at an appliance will not be isolated by the EFV but a homeowner with an EFV installed may not understand this is possible.

EFVs are designed to actuate when a pre-determined flow rate is reached. If there is no flow or very little flow, they can not actuate. The conditions in which the EFV is installed can affect the performance and needs to be conveyed to the manufacturer to ensure proper operation[11]. If the gas density is different than natural gas, it will affect the operation of the valve; the valves are tested using air and a correction factor is applied for natural gas (ideal). Significant sludge or liquids in the gas can also affect the operation of the valve.

[11] Most manufacturers assist in sizing an EFV when provided with the required information.

6. Conclusions and Recommendations

There are many challenges to installing a standard device, such as an EFV, in natural gas distribution systems that are comprised of different arrangements, materials of construction, operating pressures, and gas quality. Additionally, large fluctuations in the end user load such as multiple residences are difficult to address because the wide range and swing in flow rate. Aspects of EFVs used in other countries should continue to be analyzed to determine if there are attributes that could address some of the issues faced in the US gas distribution systems.

There are currently three US Standards that apply to Specification, Testing and Manufacture of EFVs for natural gas service. The US Standards should be expanded to include EFV configurations (installation location, number installed, and orientation), guidance on sizing and selecting a particular model based on performance characteristics, and installation guidelines.

Currently, the DOT regulation 49 CFR 192.383 requires customer notification or voluntary installation on service line renewal or newly installed natural gas service lines with a minimum operating pressure of 10 psig. The current technology for EFVs can operate at pressures lower than 10 psig. A review of the feasibility on the use of EFVs on service lines that operate at pressures lower than 10 psig should be conducted. This would allow additional natural gas systems to be covered by the regulation.

Currently the requirement for the Operator to inform the homeowners of the option of an EFV is limited to service line renewal or new construction. This limits the number of people that are informed. Often in new construction, the builder would be informed of the option because the gas service line would be installed prior to the home being acquired by the actual homeowner and the homeowner would never be informed of the option. Additionally, the number of renewals compared with the number of service lines is minimal. DOT should consider conveying the information about EFVs to the public through an outreach program or requiring Operators to include notices with customer bills. Any information provided should clearly communicate the benefits and limitations of EFVs.