INTERIM EVALUATION:
NTSB RECOMMENDATION P-01-2

EXCESS FLOW VALVES IN APPLICATIONS OTHER THAN SERVICE LINES SERVING ONE SINGLE FAMILY RESIDENCE

US Department of Transportation
Pipeline and Hazardous Materials Safety Administration (PHMSA)

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1. PURPOSE

The National Transportation Safety Board (NTSB) advocates that Excess Flow Valves (EFV) are an effective way to save lives and protect property and has long recommended their use. The NTSB position is that when sized and installed properly, an EFV can offer additional assurance against the risks associated with gas service line ruptures by instantaneously shutting off the flow of gas. Between 1971 and 2001 NTSB issued more than ten recommendations that dealt with utilization of EFVs. The most recent NTSB proposal, Safety Recommendation P-01-2, advocated that the Pipeline and Hazardous Materials Safety Administration (PHMSA) "*[r]equire that excess flow valves be installed in all new and renewed gas service lines, regardless of a customer's classification, when the operating conditions are compatible with readily available valves*."

The *Pipeline Integrity, Protection, Enforcement, and Safety Act of 2006* (PIPES Act of 2006) mandated that PHMSA require operators of natural gas distribution systems install excess flow valves on new and renewed service lines serving single family residences (SFR) that operate at or above 10 psig when technically feasible and commercially available. PHMSA codified this requirement in 49 CFR 192.383.

The PIPES Act of 2006 did not mandate that EFVs be installed on service lines of branched single family residences, apartment buildings, other multi-residential dwellings, commercial properties or industrial facilities, all of which are susceptible to the same risks caused by damaged gas lines serving single family residences. In response to NTSB Recommendation P-01-2, PHMSA is exploring issues surrounding, and alternatives to, the installation of EFVs on the classes of service that were not included in the Congressional mandate. PHMSA believes the recommendation needs to be evaluated, to avoid a potential final NTSB classification of this recommendation as "unacceptable".

Three applicable technical standards apply to the specification, testing and manufacture of EFVs for natural gas service. The scope of these standards does not extend to the larger EFVs required for some high demand applications. However, EFVs are currently manufactured for use in service lines with flow rates greater than those required by single family residences. Additionally, the technical standards do not cover topics which directly impact the performance and reliability of EFVs such as installation configuration and methods, sizing and selection, or performance testing of EFVs after installation.

The purpose of this report is to summarize current information on EFVs in order to:

- Respond to the NTSB safety recommendation with respect to applications other than service lines serving one single family residence (above 10 psig).
- Build a foundation for an economic analysis.
- Consider the need for enhanced technical standards or guidelines.
- Suggest that any new technical standards include criteria for pressure drops across the EFV.

This report addresses issues related to the installation of EFVs on branched service lines serving more than one single family residence, multi-family residential dwellings such as apartments, commercial services and industrial applications on systems which operate above 10 psig where outside force damage could occur to a Department of Transportation (DOT) jurisdictional service. Installation of EFVs on non-DOT jurisdictional piping is not included in the scope of this report.

The report addresses the following topics:

Section 2:	Background of the NTSB Recommendation and PHMSA Actions Taken to Date
Section 3:	Stakeholder Views
Section 4:	Technical Standards and Guidelines for EFVs
Section 5:	U.S., State and International Regulations
Section 6:	Operating Experience with EFVs
Section 7:	EFV Manufacturers
Section 8:	Characteristics of U.S. Distribution Systems
Section 9:	Technical Challenges Associated with Use of EFVs in Non-SFR Service
Section 10:	Economic Analysis Considerations
Section 11:	Summary

2. BACKGROUND OF NTSB SAFETY RECOMMENDATIONS AND PHMSA ACTIONS TAKEN TO DATE

2.1 BACKGROUND OF THE SAFETY FUNCTION EFVS PERFORM

Transportation by pipeline is safeguarded with many layers of protection designed to prevent pipeline incidents and mitigate the consequences of accidents that inevitably occur. Pipeline incidents are prevented by the utilization of established and proven pipeline designs, along with manufacturing and construction standards, and by adherence to regulatory requirements that require pipeline operators to monitor, inspect, maintain and protect their pipelines. Personnel working on pipelines must demonstrate that they are qualified to perform the work.

PHMSA continually evaluates pipeline operator inspection and incident data to determine if and when operational practices need to be improved or corrective actions taken. In recent years, PHMSA has expanded regulatory requirements aimed at reducing the risk of pipeline incidents. These measures have in large part been directed to lowering the likelihood of failures by preventing damage to pipelines. Pipeline operators are required to develop and implement public awareness campaigns to communicate with people living along the pipeline, excavators, emergency responders and government officials. They must inform these stakeholders about the potential hazards created by the pipeline in their neighborhoods and provide guidance concerning recognition of, response to, and reporting of pipeline accidents. On rare occasions, the layers of protection fail and the results can have serious consequences.

To minimize hazards to life and property, operators must have the capability of emergency shutdown and pressure reduction on all sections of the pipeline system. NTSB Safety Recommendation P-01-2 is directed at the need to quickly shut down services in an emergency. EFVs automatically close to shutdown the service line instantaneously when large leaks that exceed the closure flow rate trip setpoint occur.

The use of an EFV is intended to shut off the gas when the gas flow exceeds design limits. As a safety device, EFVs are designed to “trip” and greatly reduce the flow of natural gas if the service line between the gas main and the meter/regulator set is substantially damaged. EFVs being considered here are not designed to shut off the flow of gas if a line break occurs on the customer’s side of the gas meter in the customer’s interior or exterior piping system or at the connection of a gas appliance inside a residence. Historically, EFVs have been considered an optional safety device. EFVs have no effect on the gas flow resulting from a small leak such as one caused by corrosion, a loose fitting or a small crack. EFVs do not prevent accidents. By greatly reducing the amount of gas released to the atmosphere when significant damage occurs, EFVs help mitigate the potential consequences of a high rate, high volume gas release. Where installed, EFVs are complementary to damage prevention programs and other pipeline safety efforts that focus on preventing accidents caused by outside forces.

2.2 NTSB SAFETY RECOMMENDATIONS CONCERNING EFVS

The National Transportation Safety Board is an independent Federal agency created by Congress to investigate transportation accidents. With respect to the transportation of hazardous materials by pipeline, NTSB investigates significant pipeline accidents that involve a fatality or substantial property damage; establishes the facts, circumstances and probable cause; and makes safety recommendations to government agencies, operators and trade associations concerning prevention of similar accidents in the future. A safety recommendation originates from accident investigation reports, safety studies or special investigations. Recommendations are the focal point of the NTSB's efforts to improve the safety of the nation's transportation system. After the Board approves a safety recommendation, it is tracked from the date of issue until it is closed; safety recommendations are closed by vote of the Safety Board.

The NTSB has no regulatory or enforcement powers and is completely independent of the DOT. The NTSB exerts influence based on the independence and accuracy of its accident investigations and the authority of its recommendations. The average acceptance rate for safety recommendations is over 82 percent according to the NTSB 2008 Annual Report to Congress.

NTSB first recommended the use of EFVs in the 1970 report, Special Study of Effects of Delay in Shutting Down Failed Pipeline Systems and Methods of Providing Rapid Shutdown.[1] Initially the Safety Board advocated using EFVs on service lines to buildings such as schools and other facilities in which large numbers of people gathered. As EFVs became cheaper and more readily available, the Safety Board began advocating their installation on all service lines. Because EFVs were not mandatory, the Safety Board recommended the installation of EFVs on new and renewed service lines. This recommendation was included in its 1990 list of most wanted safety recommendations, a list the Safety Board maintains of the safety recommendations which offer the greatest potential for saving lives.

During the 1980s and 1990s, NTSB made repeated recommendations in support of the mandatory installation of EFVs in distribution service lines. Appendix A includes brief descriptions of significant distribution pipeline accidents that were investigated by NTSB and NTSB's subsequent recommendations related to EFVs. These events are also depicted on a timeline (Figure A.1).

NTSB activity regarding EFVs culminated on June 22, 2001, when NTSB issued recommendation P-01-2. The open recommendation reads as follows:[2]

> *Based on its investigation of the pipeline accident and fire in South Riding, Virginia, the National Transportation Safety Board makes the following safety recommendations to the Research and Special Programs Administration:*

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[1] Special Study of Effects of Delay in Shutting Down Failed Pipeline Systems and Methods of Providing Rapid Shutdown, National Transportation Safety Board, December 30, 1970 (NTSB/PSS-71/1).

[2] NTSB Safety Recommendation P-01-2, dated June 22, 2001, from Carol J. Carmody, Acting Chairman NTSB to Ms. Elaine Joost, Acting Deputy Administrator Research and Special Programs Administration (predecessor of PHMSA).

Require that excess flow valves [EFVs] be installed in all new and renewed gas service lines, regardless of a customer's classification, when the operating conditions are compatible with readily available valves.

On September 21, 2009, NTSB provided Cynthia Douglass, Acting Deputy Administrator, Pipeline and Hazardous Materials Safety Administration, the following response to PHMSA's update of the status of 12 open safety recommendations. With respect to P-01-2, NTSB stated:

In its November 19, 2008, letter regarding the June 25, 2008, NPRM, the NTSB pointed out that the Pipeline Integrity, Protection, Enforcement, and Safety (PIPES) Act of 2006 mandated that PHMSA require operators of distribution pipeline systems to install EFVs after June 1, 2008, on all new and replacement services for service lines serving single family residences. The PIPES Act further mandated that the requirement be incorporated in the integrity management rulemaking for distribution pipeline systems. Because the rulemaking was delayed, PHMSA issued an advisory bulletin (ADB-08-04) on May 30, 2008, which was published in the Federal Register on June 5, 2008. The bulletin advised operators that, effective June 1, 2008, EFVs must be installed on new and replacement service lines serving single family residences that operate continuously at a pressure above 10 pounds per square inch, gauge, and that are not connected to a gas stream with a history of contaminants.

Although the NPRM and the advisory bulletin may satisfy the mandate of the PIPES Act, they fail to require EFVs for branched service lines serving single family residences, apartment buildings, other multifamily dwellings, and commercial properties, which are susceptible to the same risks from damaged service lines as single family residences. Safety Recommendation P-01-2 was issued because the NTSB had determined in its investigation of the 1998 South Riding, Virginia, accident that the service line to the home had failed, an uncontrolled release of gas had accumulated in the basement, and the gas had subsequently ignited. Had an EFV been installed in the service line, the EFV would have closed after the hole in the service line developed, and the explosion likely would not have occurred.

The NTSB again urges PHMSA to amend its NPRM to require EFVs on all new and renewed service lines for all gas service customers regardless of their classification, as specified in the recommendation, when the operator's conditions are compatible with readily available valves. If the final rules are not revised as requested, final classification of this recommendation may be "unacceptable." Pending a response from PHMSA about this requested change, Safety Recommendation P-01-2 remains classified "Open—Acceptable Response."

2.3 PHMSA ACTIONS IN RESPONSE TO NTSB RECOMMENDATIONS

2.3.1 PHMSA ACTIONS RELATED TO ROLE OF EFVS IN REDUCTION OF THE FAILURE CONSEQUENCES

Based on their incident investigations, NTSB has made multiple recommendations [3] that PHMSA study or consider promulgating regulations that would require operators to install EFVs. Appendix B presents a chronology and timeline (Figure B.1) of the regulatory responses to NTSB recommendations. The following is a summary of recent key actions regarding EFVs.

On December 29, 2006, the *Integrity, Protection, Enforcement, and Safety (PIPES) Act of 2006* was signed into law. Section 9 of the Act requires that:

- PHMSA prescribe minimum standards for Distribution Integrity Management Programs by December 31, 2007.
- After June 1, 2008, excess flow valves be installed on new and replacement service lines serving one single family residence (SFR), where:
  - The service line operates continuously at an inlet pressure of 10 psig or higher.
  - The service line is not connected to a gas stream where the operator has had prior experience with contaminants.
  - The installation of an EFV is not likely to cause a loss of service to the residence or interfere with necessary operations or maintenance.
  - EFVs are commercially available.
- Operators report annually the number of EFVs installed in their systems on SFRs.

A Distribution Integrity Management Program (DIMP) Rule was already under development and the DIMP Phase 1 investigation report, developed by a multi-stakeholder group, was released in December, 2005.[4] In the report, the stakeholder group recommended that:

> *As part of its distribution integrity management plan, an operator should consider the mitigative value of excess flow valves (EFV)s. EFVs meeting performance criteria in 49 CFR 192.381 and installed per 192.383 may reduce the need for other mitigation options. It is not appropriate to mandate excess flow valves (EFV) as part of a high-level, flexible regulatory requirement. An EFV is one of many potential mitigation options.*

The International Association of Fire Chiefs (IAFC) was unable to participate as actively as others in the DIMP stakeholder group. On behalf of itself and other organizations representing fire fighters, IFAC supported a different conclusion. Their perspective is provided in section 3.1.4.

PHMSA published a Notice of Proposed Rulemaking (NPRM) for DIMP on June 25, 2008. Section 192.1011 of the proposed rule addressed the installation of EFVs on new and replacement service lines to single family residences unless the exceptions of the PIPES Act of 2006 are applicable. However, the

[3] See Appendix A for a list of NTSB recommendations.
[4] Integrity Management for Gas Distribution, Report of Phase 1 Investigations, December, 2005.

proposed rule did not address EFV installation in other classes of service. Therefore, the DIMP regulatory initiatives did not fully address the NTSB recommendation.

Because the DIMP rule was not in place by June 1, 2008, PHMSA issued *Advisory Bulletin 08-04*[5] encouraging operators to begin installing EFVs on SFRs in accordance with the PIPES Act of 2006.

On December 4, 2009 the Department of Transportation announced that the DIMP rule had been finalized. It was published in the Federal Register on December 4, 2009[6]. As a result of the PIPES Act of 2006 and the final DIMP Rule, PHMSA implemented the requirement to install EFVs on new and replaced service lines serving one single-family residence installed after February 2, 2010.

2.3.2 PHMSA ACTIONS RELATED TO REDUCING THE LIKELIHOOD OF FAILURE OF SERVICES

In addition to regulatory responses directly involving EFVs, PHMSA has implemented regulatory requirements and non-regulatory initiatives targeted at reducing the occurrence of failures on service lines. These initiatives include public awareness and damage prevention programs.

PUBLIC AWARENESS

Current regulations (49 CFR 192.616 and 49 CFR 195.440) require pipeline operators to develop and implement public awareness programs consistent with the guidance provided by the American Petroleum Institute Recommended Practice 1162, *Public Awareness Programs for Pipeline Operators.*

These regulations:

- Stipulate that pipeline operators provide the affected public with information about how to recognize, respond to and report pipeline emergencies.
- Emphasize to all stakeholders the importance of using the Notification System prior to excavation.
- Require operators to advise affected municipalities, school districts, businesses and residents of pipeline locations.
- Require operators to periodically review their programs for effectiveness and improve the programs as necessary.

DAMAGE PREVENTION

5 Federal Register, Vol. 73, No. 109, June 5, 2008, 73FR32077.
6 Federal Register / Vol. 74, No. 232 / Friday, December 4, 2009 / Rules and Regulations, 74 FR 63906.

PHMSA has historically taken a non-regulatory approach to pipeline damage prevention. PHMSA has promoted a broad array of initiatives designed to engage all stakeholders in efforts to reduce the risk of excavation damage to pipelines.

The PIPES Act of 2006 emphasized the reduction of excavation damages to natural gas pipeline facilities by:

- Addressing One-call civil enforcement.
- Providing incentives to states to increase the effectiveness of state excavation damage prevention programs relative to the nine elements of effective damage prevention identified in the PIPES Act of 2006.
- Making available grants for promoting public education and awareness with respect to the 811 national excavation damage prevention phone number.

STATE DAMAGE PREVENTION LAWS

In 2010 PHMSA enlisted the help of the North American Telecommunications Damage Prevention Council to survey and summarize state damage prevention laws relative to specific characteristics, such as requirements applicable to excavators and utility operators. This information is based only on a review of state excavation damage prevention laws and regulations. In some states, other laws or regulations may also address the topics covered in the summary. The results are presented on PHMSA's Stakeholder Communications website and can help stakeholders assess and improve their state damage prevention programs.

STATE DAMAGE PREVENTION PROGRAM CHARACTERIZATION (SDPPC)

In 2009 PHMSA initiated an effort to assess the extent to which each state is taking steps to incorporate the nine elements of effective damage prevention programs cited in the PIPES Act of 2006 into the state's damage prevention program. Working with state pipeline safety program managers and centers, PHMSA sought to analyze the successes of, and challenges existing in, state damage prevention programs. PHMSA is utilizing this information to identify needed improvements on which it can focus its assistance. The results of the SDPPC initiative are available on PHMSA's Stakeholder Communications website and can help stakeholders assess and improve their state damage prevention programs.

DIG SAFELY

The DIG SAFELY damage prevention campaign was sponsored and led by PHMSA and involved damage prevention stakeholder representatives in developing the highly successful campaign. The focus of the DIG SAFELY campaign was to enhance communications regarding steps excavators should take to prevent underground facility damage. It raised public awareness of the One-call damage prevention process and provided templates for tools that could be used to disseminate information concerning safe digging.

COMMON GROUND ALLIANCE (CGA)

In 1999, PHMSA published the *Common Ground Study of Systems and Damage Prevention Best Practices*. The common ground study established best practices concerning excavation damage prevention for all stakeholders. With PHMSA support, the CGA initiative evolved to a nonprofit organization that continues to provide stewardship for the *Damage Prevention Best Practices*. Over 1400 CGA members represent stakeholder groups that share responsibility for damage prevention. The CGA committee structure focuses efforts on best practices, education, research and development, data collection, One-call centers and regional partnerships. The CGA Damage Information Reporting Tool (DIRT) is a secure web application for the collection and reporting of underground damage information. With the goal of reducing the occurrence of these incidents in the future, the CGA publishes an annual *DIRT Report* to identify the contributing factors and root causes of underground utility damages and near misses.

COMMUNITY ASSISTANCE AND TECHNICAL SERVICES (CATS) PROGRAM

PHMSA believes that building relationships with pipeline safety stakeholders is a very effective way to enhance pipeline safety. PHMSA CATS managers can help initiate and facilitate discussions among stakeholders who may be exploring opportunities to strengthen state damage prevention programs.

COMPREHENSIVE REPORT ON PIPELINE MECHANICAL DAMAGE

In April 2009 PHMSA issued the *Mechanical Damage Final Report.* This report reviews and summarizes the current state of knowledge and practice related to mechanical damage in natural gas and hazardous liquid steel pipelines. The report focused on operator practices for detection, characterization, and mitigation of mechanical damage on both gas and liquid transmission and gas distribution pipelines (the latter examined for comparison purposes). Operator practices associated with prevention of mechanical damage primarily resulting from excavation damage were extensively covered. The report included information from gas distribution companies that reported on their experience with distribution systems consisting of both steel and plastic pipe, the latter reviewed for a comprehensive discussion of the operator's damage prevention programs and issues.

DAMAGE PREVENTION ASSISTANCE PROGRAM

PHMSA has developed guidance, *Strengthening State Damage Prevention Programs,* to assist stakeholder damage prevention efforts. The guidance draws on the definition of effective damage prevention programs found in the PIPES Act of 2006, examines the nine elements of effective damage prevention programs specified in the Act and makes suggestions for implementing them at the state level.

GRANTS TO STATES AND COMMUNITIES

Each state has established laws, regulations and procedures that shape their state damage prevention program. PHMSA provides grant opportunities intended to help states improve their damage prevention programs. States seeking damage prevention program grants must incorporate the nine elements of effective damage prevention programs identified in the PIPES Act of 2006 into their programs. PHMSA's guide, Strengthening State Damage Prevention Programs, provides more information. PHMSA also offers technical assistance grants to communities and grants to state agencies to use in promoting damage prevention. Additionally, PHMSA offers technology development grants to any organization or entity (not including for-profit entities) for the development of technologies that will facilitate the prevention of pipeline damage caused by demolition, excavation, tunneling, or construction activities.

TECHNOLOGY PILOT PROJECT

PHMSA partnered with damage prevention stakeholders in Virginia to use existing GPS technology to enhance the quality of communication among excavators and owners of underground facilities. The Phase I Project Report includes guidance on how other states could incorporate GPS technology in their Center communications.

NATION-WIDE 811 CALL BEFORE YOU DIG NUMBER

PHMSA supported the CGA in calling for and securing the FCC's issuance of the nationwide 811 telephone number to facilitate excavator calls to One-call centers to notify underground facility operators of planned excavations and request underground facility locates.

RESEARCH AND DEVELOPMENT

The importance of damage prevention is recognized within PHMSA's R&D program by establishing a distinct category for projects geared toward damage prevention. Damage prevention research and development projects are designed to provide stakeholders with improved tools that reduce the risk of excavation damage.

ADVISORY BULLETINS

Advisory bulletins have been used to emphasize important actions pipeline operators can take to protect their pipelines. In May 2002, PHMSA urged pipeline operators to follow the CGA Best Practices for damage prevention. In January 2006, PHMSA described preventable accidents caused by construction related damage and called on operators to ensure that they use qualified personnel to perform critical damage prevention tasks. In November 2006, PHMSA emphasized the importance of following damage prevention best practices, especially for marking the location of underground pipelines prior to excavation.

2.3.3 PHMSA EVALUATION OF DATA RELATED TO INCIDENTS ON SERVICES

Each operator of a distribution pipeline system is required to submit an incident report form after detection of an incident. An incident is defined in 49 CFR 191.3 as any of the following events:

(1) An event that involves a release of gas from a pipeline or of liquefied natural gas or gas from an LNG facility and
    (i) A death, or personal injury necessitating in-patient hospitalization; or
    (ii) Estimated property damage, including cost of gas lost, of the operator or others, or both, of $50,000[7] or more.
(2) An event that results in an emergency shutdown of an LNG facility.
(3) An event that is significant, in the judgment of the operator, even though it did not meet the criteria of paragraphs (1) or (2).

In response to NTSB's latest comments, PHMSA evaluated incident data to determine if the operators' emergency shutdown and pressure reduction capabilities of failed service lines need to be enhanced or other preventive measures taken to minimize hazards to life or property.

March 2004-December 2009 data from the PHMSA gas distribution incident database was used to create the following graphs and statistics. During this timeframe, 914 incidents were reported.

All incidents cannot be prevented or mitigated by an EFV installed on a service line. PHMSA evaluated each of these 914 incidents to identify those incidents where the consequences might have been prevented or mitigated if an EFV had been installed. PHMSA evaluated each incident with respect to the following parameters:

- The location of the leak (incidents on service lines).
- The reported cause of the leak (leaks due to damage).
- The maximum allowable operating pressure (MAOP) of the system (> 10 PSIG).
- Additional information about the leak's characteristics (large leaks and ruptures).
- Classification of customer (customers other than stand-alone service line serving a single family residence).

2.3.3.1 LOCATION OF THE LEAK (INCIDENTS ON SERVICE LINES)

Since EFVs are installed in services lines, they have no effect on preventing or mitigating leaks on distribution mains or any facility or equipment upstream of the service line. Of the 914 incidents reported during March 2004 through December 2009, 476 occurred on service lines or customer regulators/meter sets.

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[7] PHMSA established a cost reporting threshold of $50,000 for gas pipeline incidents in 1984. Since then, inflation and the rapid rise in the cost of natural gas have caused the cost of incidents to rise significantly along with an increase in the number of incidents reported. To account for the cost increases, PHMSA now considers incidents significant from a cost perspective if they exceed a total cost of $50,000 in 1984 dollars.

In 2009, distribution operators reported 1,210,722 miles of distribution main and approximately 869,000 miles of service line. During 2004 through 2009, the incident rate on mains was 0.00025 incidents/mile, and the incident rate on service lines, including the meter set, was 0.00056 incidents/mile. Therefore, the incident rate for service lines is twice that for distribution mains.

2.3.3.2 REPORTED CAUSE OF THE LEAK (INCIDENTS DUE TO DAMAGE)

Incidents were further filtered to exclude those whose primary cause was not likely to result in a gas release rate high enough to have actuated an EFV. Gas distribution incidents where fire/explosion was the primary cause of failure, such as a house fire that subsequently resulted in, but was not caused by, a distribution line failure are excluded because the gas leak in this scenario typically occurs from customer piping or appliances inside the house. Incidents whose primary leak cause was reported as corrosion, material or weld failure, equipment failure, incorrect operations, miscellaneous or unknown were also excluded because these incidents are typically the result of slow leaks which are not likely to actuate an EFV. Out of the 476 service line incidents, 220 were due to targeted causes (excavation damage, outside forces, natural forces). This eliminated 256 incidents from consideration.

2.3.3.3 MAXIMUM ALLOWABLE OPERATING PRESSURE (MAOP) OF THE SYSTEM

Incidents where the MAOP of the system was less than 10 PSIG were excluded as possible candidates because their application is considered technically impractical. Five incidents were excluded because they occurred on services lines operating at pressures less than 10 PSIG.

2.3.3.4 ADDITIONAL INFORMATION ABOUT THE LEAK’S CHARACTERISTICS

Finally, PHMSA reviewed the specific information reported about each of the remaining 215 incident scenarios, to determine if the scenario was one for which an EFV likely would have actuated (had an EFV actually been installed at the time of the incident). This review eliminated an additional 67 incidents.

Incidents were included as candidates for EFV mitigation if the incident was reported to be a:

- Leak with a puncture
- Rupture
- Catastrophic failure (incident description included terms such as lightening strike, severe, pull out, frozen, destroyed, sheared, or broke off)

Incidents were excluded if:

- There was no information about the leak type.
- The leak type was reported as “other” and the description did not indicate catastrophic failure.
- Incident occurred on customer piping downstream of the meter set.
- Incident was described as initiated by a fire.

A total of 148 incidents met all of the aforementioned criteria. These results are shown in Figure 1.

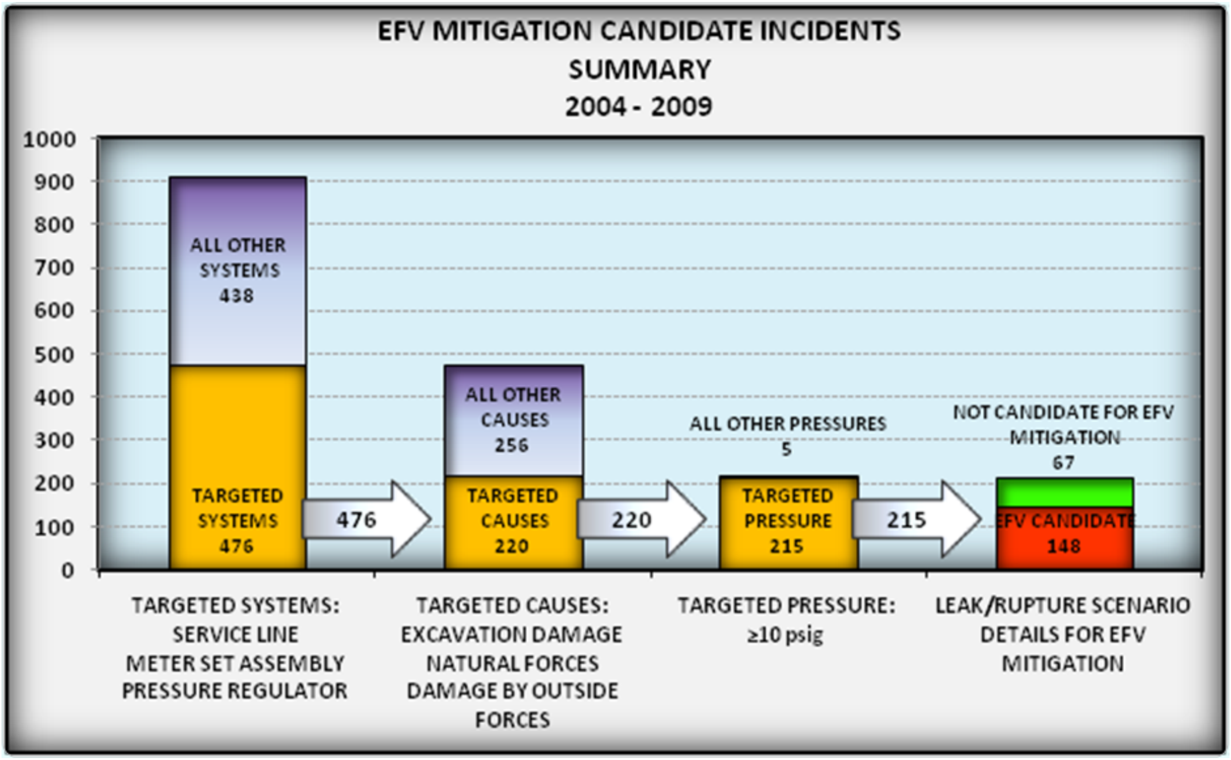

Figure 1 – Identification of incidents that are candidates for EFV mitigation

2.3.3.5 CLASSIFICATION OF CUSTOMER (NON-SFR INCIDENTS VS. SFR INCIDENTS)

Existing regulations require EFVs for service lines serving one single family residence. PHMSA made an effort to determine which of the 148 candidate incidents occurred on lines serving a single family residence (covered by existing regulations) and which occurred on lines serving other classes of customers (to which this study applies).

Operators are not required to report the classification of the customer being served by the service line on which the incident occurred. However, they are required to report the address of the incident. PHMSA used available public domain information such as telephone directories, maps and aerial photographs to determine if the incident occurred on a single family residence or on another classification of service such as multi-family residence, commercial, public or industrial. (Note, in cases where the customer was a SFR, PHMSA was not able to determine if the SFR was served by a dedicated service line or a branched connection.) While it was not always possible to make a definitive determination, PHMSA is reasonably satisfied with the results. PHMSA estimates that 41% (approximately 60) of the 148 incidents deemed to be candidates for EFV mitigation occurred at single family residences[8]; 10% (approximately 15) occurred on multiple family residences; and 49%

[8] Incident reports do not identify branched single family residences so they are included with single unit residences.

(approximately 73) occurred on commercial, industrial, public or other services. Therefore, approximately 41% of those incidents deemed to be candidates for EFVs are currently covered under existing EFV regulations. See Figure 2.

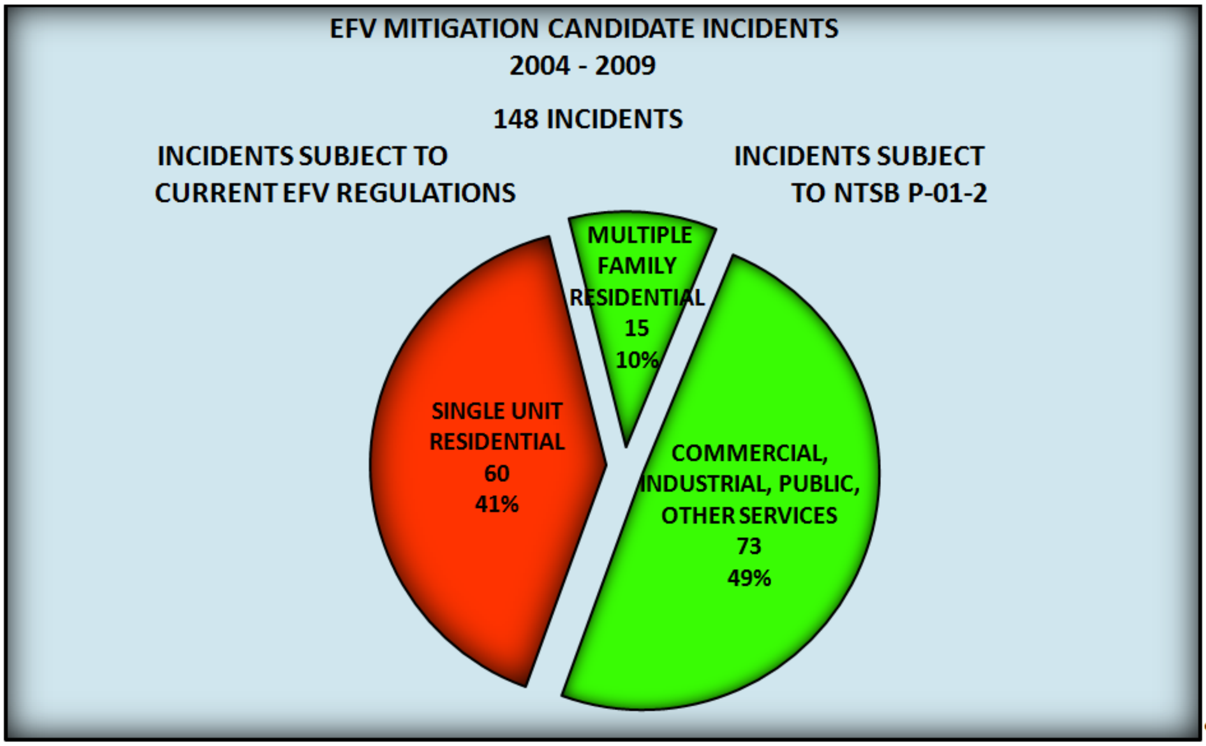

Figure 2 – Relative number of incidents on SFR, MFR, and commercial, industrial, public, or other services

According to AGA's web site[9], there are 64 million homes and 5 million commercial sector natural gas customers (Figure 3). The rates of incidents which are candidates for EFV mitigation during the 2004 through 2009 timeframe are estimated to be:

- 75 Incidents / 64,400,000 Homes = 1.16 x 10^{-6} incidents per residential service line
- 73 Incidents / 5,475,000 Commercial, Industrial Sector = 1.33 x 10^{-5} incidents per commercial, industrial sector service line

This data suggests that the incident rate per service line is approximately 12 times greater for non-residential service than for residential service, but that incident rates in both cases are very low.

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[9] http://www.aga.org/Legislative/issuesummaries/ResidentialandCommercialMarkets.htm

CUSTOMERS (69+ million)

	Number of customers	% of Total U.S. Natural Gas Consumption
Residential *(61% of all U.S. households use natural gas. Of all heated U.S. households:* • *51% heat with natural gas* • *33% heat with electricity* • *8% heat with fuel oil* • *6% heat with propane*	64,400,000	22%
Commercial *(restaurants, retailers, hotels, offices, and so forth)*	5,275,000	14%
Industrial *(incl. manufacturing)*	200,000	33%
Electric Power Generation *(incl. electric utilities, independent power producers and industrial electricity sold back to the grid)*	2,600	31%

SOURCES: American Gas Association; Census Bureau; Potential Gas Committee; U.S. Department of Energy, February 2008

Figure 3 – American Gas Association Information on Classes of Gas Service

2.3.3.6 CONSEQUENCE OF CANDIDATE INCIDENTS

Operators are required to provide consequence data for each incident reported. The reported consequences of the 148 incidents that are candidates for EFV mitigation are shown in Table 1.

Primary Cause	Incidents	Fatalities	Injuries	Property damage	Gas Ignited	Gas Explosion	Evacuations
Natural Forces	14	4	4	$ 21,711,355	12	4	5
Excavation Damage	96	7	23	$ 15,813,727	45	29	31
Other Outside Force	38	5	8	$ 5,354,851	31	4	15
Totals	148	16	35	$ 42,879,933	88	37	51

Table 1 – Consequences of the 148 Incidents that are Candidates for EFV Mitigation

2.3.3.7 EFFECTIVENESS OF EXISTING DAMAGE PREVENTION EFFORTS

An evaluation of incidents caused by excavation damage shows that there has been a decrease in the number of excavation caused incidents and the number of leaks (caused by excavation damage) repaired with a corresponding decrease in some consequences (refer to Figures 3 and 4 discussed in further detail later).

- Although incidents caused by excavation damage after a One-call Notification trend upward, the data shows a significant decreasing trend in incidents caused by excavation damage over this time period.
- In the August, 2009 report *CGA DIRT Analysis & Recommendations*, Robert Kipp, President of the CGA reported that, "The CGA estimates a decrease of approximately 50% in the total number of

damages occurring in the US since 2004 with the total number of damages occurring in 2008 estimated to be 200,000. The overall decrease in the estimate of the number of damages is due in part to less construction activity, but mostly I suspect, to increased awareness of the total damage prevention process and to your efforts, the damage prevention stakeholders – simply amazing."[10]

- Excavation damage is a new metric which operators will be reporting starting in 2012. The metric will be normalized on the number of locate tickets.
- Some reduction in excavation incidents may also be due to an increased number of EFVs being installed on operators' systems. Manufacturers point out that over 7 million EFVs have been sold since 1965, suggesting a little over 10% of service lines in the US have EFV protection (see section 3.1.8).

Figure 4 suggests that the number of leaks caused by excavation damage that were repaired or eliminated is decreasing. This improvement may be due to damage prevention efforts. However, the data is not normalized for the amount of excavation activity taking place in a given year. While the frequency of damages is reduced when a One-call Notification is placed, the notification system does not eliminate all reportable incidents (Figure 3). Of the candidate incidents caused by excavation damage, approximately one-half occurred after a One-call Notification. The decreasing incident frequency during 2004-2009 did not always translate into a corresponding reduction in consequences. During this period, injuries trended upward (Figures 5). Fatalities, evacuations, and explosions show slight downward trends and fire frequency remains static. The trend in property damage consequences trends up sharply because of one incident in 2008 that resulted in $20 million in losses (Figure 6).

10 http://www.commongroundalliance.com/Template.cfm?Section=DIRT_Overview&CONTENTID=5541&TEMPLATE=/ContentManagement/ContentDisplay.cfm

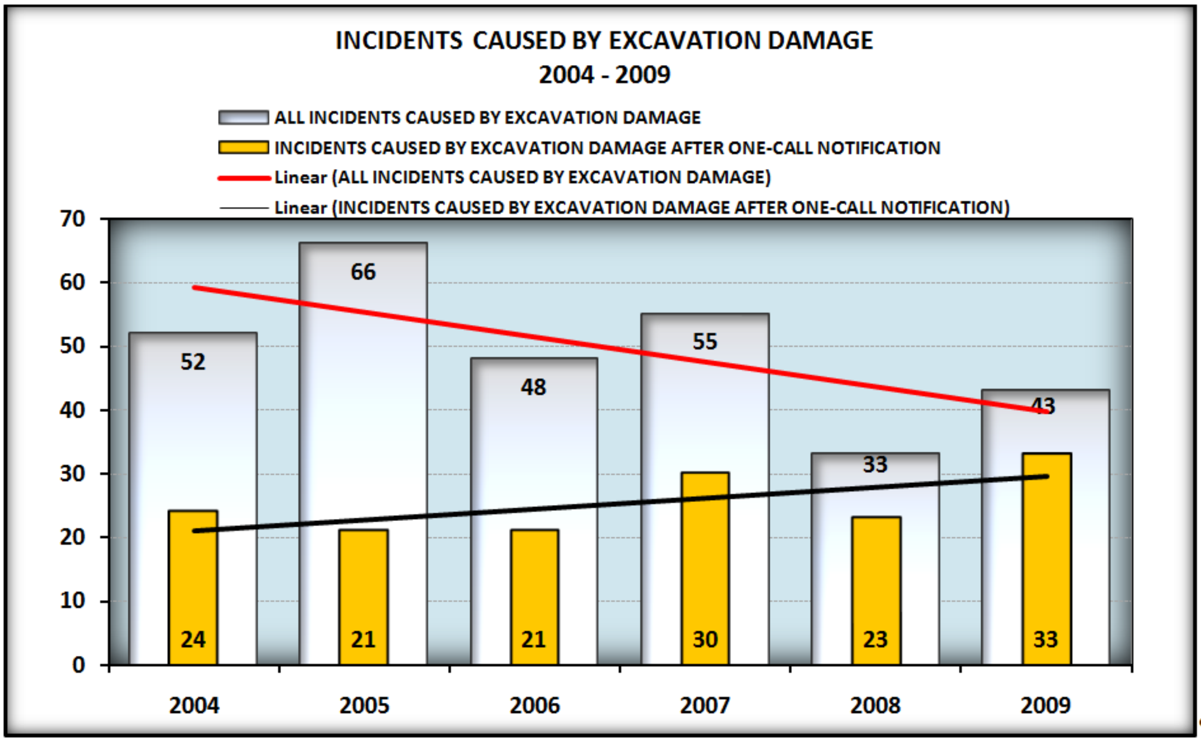

Figure 3 – Incidents caused by excavation damage compared to incidents caused by excavation damage after One-call notification

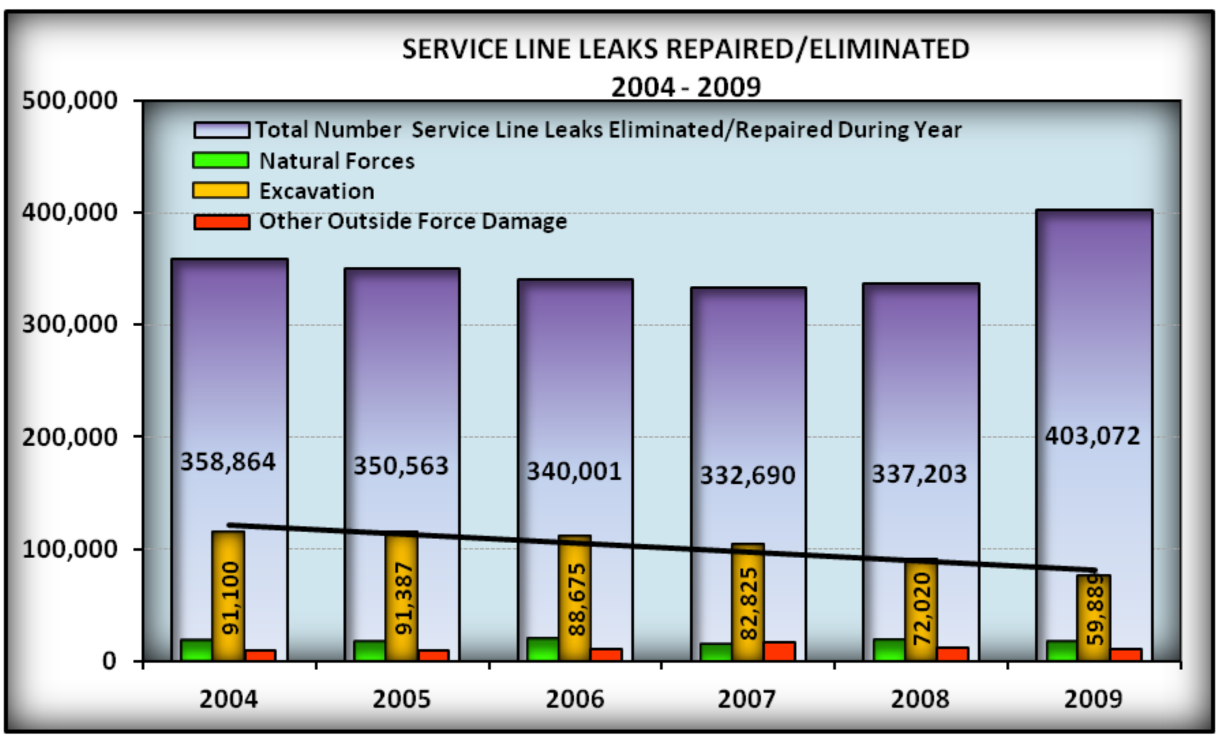

Figure 4 – Service line leaks repaired/eliminated by cause

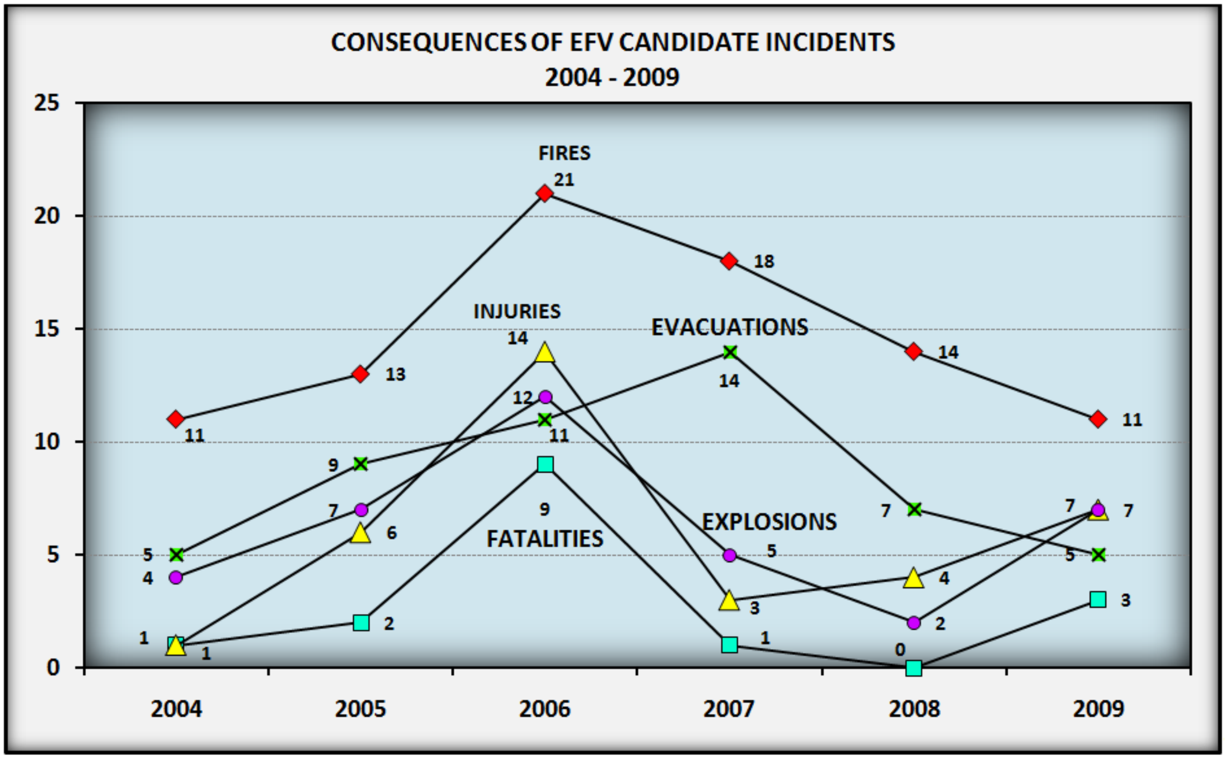

Figure 5 – Consequences of incident candidates for EFV mitigation

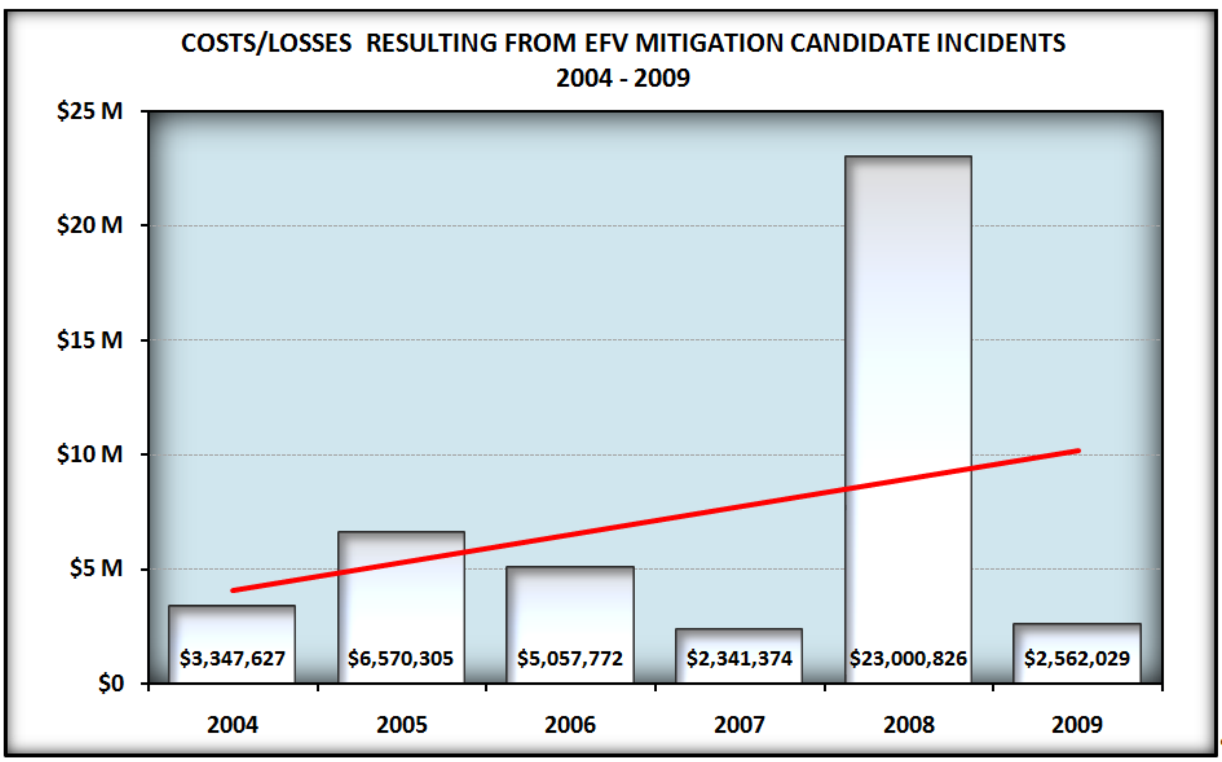

Figure 6 – Property damage of incident candidates for EFV mitigation 2004-2009

3. STAKEHOLDER VIEWS

3.1 STAKEHOLDER MEETINGS

PHMSA held a meeting with stakeholders on June 23, 2009 and a follow-up conference call on August 25, 2009. The perspectives of the National Association of Regulatory Utility Commissioners (NARUC), the National Association of Pipeline Safety Representatives (NAPSR), the International Association of Fire Chiefs (IAFC), the National Association of State Fire Marshals (NASFM), natural gas distribution operators, trade associations and the Pipeline Safety Trust (PST) are presented in the following subsections. Stakeholder views noted below were expressed at the meeting or conference call, or were obtained from notes of public meetings.

3.1.1 NATIONAL TRANSPORTATION SAFETY BOARD (NTSB)

NTSB related historical data from NTSB investigations of approximately 10 gas service incidents that occurred between 1968 and 2000 at locations other than SFR: apartment complexes, commercial establishments, nurseries, office buildings, schools. All resulted in fatalities and/or injuries and extensive property damage and could have been mitigated if an EFV had been installed on the line. Analysis of these incidents led NTSB to release multiple recommendations concerning EFVs between 1971 and 2001. P-01-2, issued on June 22, 2001, is the most recent.

There are many buildings other than SFR (churches, commercial and office buildings, schools, apartment buildings, industrial sites) that can be protected by installation of an EFV. NTSB recognized that an EFV could be impractical on some services. If an EFV is available for the service and can safely perform the intended function, NTSB advocates that an EFV should be installed, and that regulations should require operators to document a justification for any exceptions.

3.1.2 NATIONAL ASSOCIATION OF REGULATORY UTILITY COMMISSIONERS (NARUC)

NARUC is an association representing the state public service commissioners who regulate essential utility services, such as electricity, gas, telecommunications, water and transportation. NARUC's members include all fifty states, Puerto Rico, the Virgin Islands and the District of Columbia. NARUC has been involved in the efforts to develop regulations for the use of excess flow valves in high demand situations.

In March, 2008, Donald Mason, Commissioner of the Ohio PUC representing NARUC, testified before Congress on the *Pipeline Inspection, Protection, Enforcement and Safety Act of 2006.*[11] In his testimony

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[11] Before the United State House of Representatives, Testimony of the Honorable Donald L. Mason, Commissioner, Public Utilities Commission of Ohio on Behalf of the National Association of Regulatory Utility Commissioners, March 12, 2008.

Mr. Mason affirmed NARUC's endorsement of the PIPES Act of 2006 and NARUC's intent to work closely with PHMSA to implement the mandates of the Act.

> At a meeting in February, 2005, NARUC considered the issue of assuring integrity of distribution pipeline systems. NARUC adopted a resolution at that meeting supporting the efforts of PHMSA, gas distribution pipeline operators and other stakeholders to develop an approach to better assure distribution pipeline integrity. At a meeting on EFVs in June, 2005[12] NARUC expressed the following opinions:
>
> - Commissioners noted that new costs must be justified and that the benefits must be weighed against the costs.
> - The best decisions are those made locally with full knowledge of the local conditions, benefits and costs.
> - Commissioners generally expressed support for decisions on the use of EFVs being made by operators in the context of Integrity Management Programs.

3.1.3 NATIONAL ASSOCIATION OF PIPELINE SAFETY REPRESENTATIVES (NAPSR)

NAPSR is an organization of state pipeline safety personnel who promote pipeline safety in the U.S. NAPSR has been heavily involved in the evolution of the Distribution Integrity Management Program and is a participant in the deliberations on requiring excess flow valves for all service lines. NAPSR participated in the June 2009 meeting and the August, 2009 teleconference, and provided the following summary of NAPSR member input on the use of EFVs beyond single family residences.

- Installation of EFVs for commercial, multi-family, master meter and industrial customers must be carefully considered because of the variability in loads that can occur at such establishments. Sources of variability:
    - Commercial establishments: expansion or contraction of the business or change in commercial operation type.
    - Multi-family buildings: load peaks occurring in the mornings and evenings.
    - Master meters: either or both of the above could occur.
    - Industrial plants: very large variations likely due to high-fire on startup, low-fire during normal production and pilot when production ebbs. It is commonly believed that industrial customers will be difficult to protect using EFVs.
- A drastic change in gas load downward can cause the EFV to become oversized and, therefore, compromise the EFVs ability to provide protection; a change in gas load upward can result in an

[12] Addendum D-1, Report of Phase 1 Investigations, Integrity Management of Gas Distribution, December, 2005.

unplanned shutoff which would be intolerable for many commercial and industrial establishments.

- EFVs could probably be installed to protect small commercial establishments of certain categories (e.g. offices that only use gas for space heating and hot water) but the system operator would have to monitor the load profile and be prepared to replace the EFV if the load changes enough to cause a false valve trip. Replacement becomes a problem if the valve is under pavement.
- Before installing EFVs on service lines other than SFR, a study should be completed to determine the best location for the valve. Consideration should be given to the fact that the EFV may require maintenance and/or replacement.
- Installation of EFVs based on risk is an acceptable idea. Examples of higher threats would be locations with high level of construction activity, wall to wall paving, history of previous hits, etc.
- Data should be collected about the effect of residential EFVs on safety statistics before mandating EFVs on other classes of customers.
- Installation of EFVs should not be retroactively mandated.
- Before mandating the use of EFVs for classes of service other than SFR, PHMSA should conduct a benefit-cost analysis for each customer class. Considerations should include distribution of installation costs. It hardly seems fair that residential ratepayers should subsidize non-residential customers.

3.1.4 INTERNATIONAL ASSOCIATION OF FIRE CHIEFS (IAFC)

The IAFC represents the leadership of over 1.2 million firefighters and emergency responders. A representative of IAFC participated in the August, 2009 teleconference and provided input to PHMSA on proposed regulations for the installation of EFVs. IAFC also provided their perspective in the DIMP Phase 1 Report. Their position remains that the universal use of EFVs should be a requirement rather than an option. IAFC believes that the need to rapidly stop the flow of gas from major ruptures of service lines is universal for all classes of service lines. They also believe that the installation of an EFV on all new and renewed gas services that have operating characteristics compatible with off-the-shelf EFVs is a universal corrective action requiring no further assessment. Simply stated, EFV use should be a requirement, not an option.

IAFC states that uncontrolled gas leaks pose a significant hazard to firefighters and the public. Emergency responders are most at risk from natural gas leaks. In any risk assessment, the greatest attention should be given to those who are the most at risk.

IAFC stated in the December 2005 DIMP Phase 1 Report, “Over the past 100 years, the gas industry has not developed and used a means to rapidly stop the flow of gas from major service line ruptures. Since the development of the EFV over 35 years ago, the gas industry has failed universally to install EFVs in service lines to rapidly stop the flow of gas from major ruptures. Since the DOT promulgated a rule six years ago that requires customer notification or EFV installation, the gas industry has not universally adopted the installation of any device such as an EFV on service lines to stop the flow of gas rapidly from major ruptures.

We do not believe that gas operators should be permitted to determine whether to employ specific safety devices, particularly when the lives of our first responders and the American public are on the line. Incorporating the decision on EFV installation in new or renewed gas services into integrity management only allows some gas operators who have long fought against added federal regulation to further deny protection essential to the safety of emergency response personnel and the public. We are concerned that few, if any, of those operators now opposed to the installation of EFVs will change their practice and begin installing EFVs under the proposed PHMSA integrity management rule."

The presence of an EFV can be a critical factor in the suppression of a gas leak at the scene of an incident where a first responder's ability to control gas flow is limited and dependent on the availability and arrival of gas company personnel. While not frequently activated, an EFV is a critical tool in the event of a large volume release.

The IAFC recognizes that there are technical challenges and availability issues concerning installation of the appropriate EFV in some situations, but the technology exists to use EFVs on many commercial applications.

Additional papers and presentations by Steve Halford, Fire Chief, Nashville, TN and IAFC member, provide further details of the fire chiefs' perspective on this issue.[13]

3.1.5 NATIONAL ASSOCIATION OF STATE FIRE MARSHALS (NASFM)

The NASFM represents the most senior fire official of each of the 50 states and the District of Columbia. A representative of NASFM participated in the August, 2009 teleconference on Large EFV Applications.

The position expressed by NASFM is that the safety of the general public and first responders is their primary concern. They believe that previous EFV benefit-cost studies have been used to confuse complex EFV issues and are, therefore, of limited value. NASFM supports NTSB Recommendation P-01-2, considers EFVs to be of critical importance, and supports installation of EFVs on all gas services. NASFM acknowledges the need for more advanced technology for unique applications and encourages installation of EFVs in all cases except where they clearly would not be beneficial. Installation of EFVs should not be delayed while waiting for further data. The current knowledge and technology supports proceeding with the installation of EFVs on all but the most problematic applications. NASFM considers the One–call Notification System important but realizes that it cannot prevent 100% of incidents. The organization believes redundant systems are crucial for safety and that EFVs provide redundancy, are

[13] Joint Fire Service Position on Excess Flow Valves, Statement of Steve Halford, Nashville Fire Department, June 17, 2005.
"Don't Settle for Living in Excess", Fire Chief, Steve Halford, September 11, 2009.

worth the cost of installation and maintenance, and should be required by regulation. Operators should provide appropriate documentation for exceptions.

3.1.6 AMERICAN GAS ASSOCIATION (AGA), REPRESENTING DISTRIBUTION OPERATORS

The American Gas Association is an advocate for natural gas utility companies and represents 202 local energy companies that deliver natural gas throughout the United States. Representatives of AGA and member distribution operators participated in the June 2009 meeting and the August 2009 teleconference.

AGA noted that the discussion regarding the installation of EFVs in SFR has changed dramatically over the last few years. In June 2008, AGA member companies voluntarily began installing EFV in single family dwellings on new or fully replaced services even though a Distribution Integrity Management final rule requiring installation of EFVs had not yet been promulgated. AGA believes there are very good working relationships between gas utilities and emergency responders. The technology and practices for SFR EFVs is well defined because operators have many years of experience and SFR installations have only a few EFV specifications. The technology and practices associated with large volume EFVs are different. The more complex installations must be individually engineered.

Of significant importance to AGA and distribution operators is the positive impact (in terms of a reduction of incidents) of advances in pipeline safety initiatives within the last three years (such as 811, public awareness plans, state damage prevention laws and the DIMP rule). These beneficial impacts should be reflected in the benefit-cost analysis. Based on the findings of the Phase 1 Report, DIMP Rule and the 2006 PIPES Act, there is a strong emphasis on excavation damage prevention by natural gas operators and regulators. These efforts are producing significant reductions in excavation damages (e.g., Virginia improved from 4.49 damages/1000 tickets in 1996 to approximately 2.0 currently). AGA advocates that the safety improvements realized from these initiatives be more carefully analyzed before proceeding with new rules that focus on mandating additional EFV installation. AGA also notes that the benefit-cost analysis should not assume that services had EFVs installed retroactively or that installation would be practical on all services in the proposed categories: multi-family, industrial, commercial. Snap loads, highly variable loads and service lines of limited diameter are examples of factors that make installation of EFVs impractical.[14]

AGA also provided the following specific comments:

- AGA believes that PHMSA should recognize the work done in the DIMP Phase 1 Report that concluded that EFVs can be a valuable risk mitigation tool to be evaluated by operators

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[14] Note: PHMSA provides additional discussion of the technical challenges to specifying an effective EFV for lines servicing customers other than single service SFR in section 9.

- EFVs cannot distinguish a major leak from a load.
- EFVs should not be mandated for all customers, except as required for new and replaced single family residential services, or other identified customers, where loads are relatively static.
- PHMSA should recognize that the National Association of Utility Regulatory Commissioners (NARUC) and the National Association of Pipeline Safety Representatives (NAPSR) passed resolutions to the effect that EFVs should be voluntarily installed where they are determined to be effective for the system. This is particularly true for larger services for commercial and industrial customers, where loss of gas service can drastically impact the conduct of normal business operations. Also the total cost of EFV installation and possible modification of service should be recognized in any cost-benefit analysis. The cost should include a reasonable estimate of the cost of EFV failure/false closures as well.
- Multi-family, commercial and industrial customers have far more load variability, and routinely add equipment and loads (new boiler, process load, seismic valves, etc.) without notifying the gas supplier. Commercial establishments are subject to frequent changes of ownership, consumer product, gas equipment and load making an existing EFV and perhaps the service, unsatisfactory and therefore costly to resize and re-install.
- It is very expensive, or extremely difficult to remedy incorrectly sized EFVs due to excavation costs and municipal restrictions on street openings.

3.1.7 PIPELINE SAFETY TRUST (PST)

The stated mission of Pipeline Safety Trust is to promote fuel transportation safety through education and advocacy. Pipeline Safety Trust has been an advocate of the installation of excess flow valves. A representative of PST participated in the August 2009 teleconference. The primary issue regarding the expansion of EFV use is the delineation of easy and complex applications. Many services have characteristics similar to single family residences and are candidates for EFVs. Analysis of complex installations should not delay installation of EFVs in relatively straightforward applications.

In a paper published in July, 2005[15] the Pipeline Safety Trust made the following observations:

- Education is not preventing many service line failures.
- Increases in gas system pressure and the increased use of plastic service lines increases the risk of service line disasters.

In July, 2006, Carl Weimer, Executive Director of Pipeline Safety Trust, testified before the Senate Committee on Commerce, Science and Transportation.[16] The message conveyed was the same as in the above referenced report.

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[15] A Simple Perspective on Excess Flow Valve Effectiveness in Gas Distribution System Service Lines," Richard B. Kuprewicz, President, Accufacts Inc., undated.

3.1.8 EFV MANUFACTURERS

Manufacturers stated that EFVs are not sophisticated "smart" type devices. EFVs are intended for full pipe rupture only. European practice is often to "oversize" the EFV based on capacity of the service line rather than more finely tune the flow rate based on customer loads. Operators may currently be sizing EFVs at capacities based on loads, and not on a larger capacity capable of flowing through the service line. Drastic changes in load, by definition, will likely change the necessary engineering behind the gas system design. Further, designing an EFV for a partial break in the pipe is outside the capability of the device, since the device cannot distinguish between an incremental increase in load and a small leak.

It is the manufacturers understanding that many companies simply charge the customer if the gas load changes such that they need to change the pipe size, meter set, and EFV. The design focus should be on providing the largest capacity EFV that the pipe and service conditions will accommodate.

Instances of meter change-outs on retail buildings are rare. If the meter does not have to be changed, it is very unlikely that the EFV will need to be changed.

Manufacturers have reported that approximately 7 million EFVs have been sold since 1965, suggesting that EFVs are currently installed in approximately 10% of service lines.[17]

3.1.9 EPA GAS STAR PROGRAM

In its winter 2005 Natural Gas STAR Partner Update, EPA recognized the benefit to safety and to the environment of installing EFVs. A properly sized EFV will shut off natural gas flow when the flow rate in the service line exceeds a predetermined level. EPA stated that the presence of an EFV on a severed gas line is known to greatly reduce the amount of escaping methane gas, comparing EFVs to circuit breakers on natural gas service lines. The article indicated that an EFV can also be installed downstream of the gas meter which in the event of an earthquake and gas lines inside of homes rupture, the EFV would prevent gas leaks. A secondary benefit of an EFV is the reduction of methane emissions, estimating that 16,000 SCF of methane per hour are released from a ruptured one-half inch service line operated at 50 psig.

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[16] Testimony of the Pipeline Safety Trust Before the United States Senate Committee on Commerce, Science and Transportation, Hearing on Reauthorization of the Pipeline Safety Program, November, 2006.
[17] Letter from John McGowan, Jr., CEO, UMAC, Inc., to US DOT-PHMSA, dated April 1, 2010.

4. TECHNICAL STANDARDS AND GUIDANCE FOR EFVS

The current DOT regulation applicable to excess flow valve standards is 49 CFR §192.381, Service lines: Excess flow Valve Performance Standards. The regulation requires excess flow valves to be manufactured and tested by the manufacturer according to an industry specification or to the manufacturer's written specification. While not incorporated by reference, there are three applicable technical standards that address the specification, manufacturing and testing of EFVs. For further information, a summary of the existing standards is included in a 2006 report on EFVs prepared by General Physics.[18] The standards are:

- MSS SP-115-2006 – Design, Performance & Test
- ASTM F1802-04 – Standard Test Method for Performance Testing of Excess Flow Valves
- ASTM F2138-01[19] – Standard Specification for Excess Flow Valves for Natural Gas Service

The MSS Standard Practice was developed for EFVs on fuel gas services installed in 1¼ NPS or smaller.

ASTM F1802 applies to EFVs with a trip flow rate between 200 and 2500 scfh at 10 psig. The standard covers EFVs installed in thermoplastic piping systems no smaller than ½ CTS and no larger than 1¼ IPS.

ASTM F2138 covers piping systems no smaller than ½ CTS and no larger than 2 IPS.

Current standards may need to be modified to encompass larger EFVs that might be required for some services.

A number of factors impact the performance and reliability of EFVs such as installation location, configuration, selection, sizing, or installation method. ASTM F2138 addresses some of these factors at a high level in Nonmandatory Appendix X1 *Guidance on EFV Selection and Installation*.

The Gas Piping Technology Committee (GPTC) has developed draft guidelines for implementing the proposed DIMP rule which are incorporated into *ANSI/GPTC Z380, Guide for Gas Transmission and Distribution Piping Systems* (The Guide) in Appendix G192-8. The DIMP EFV guidance covers topics beyond the existing guidance for EFV performance, operation, installation, identification and testing considerations. The guidelines include expanding the use of EFVs as an additional and accelerated action that an operator may choose to mitigate the consequences of damages to distribution service lines caused by natural forces, excavation and other outside forces. The Guide references two of the technical standards, MSS SP-115 and ASTM F1802.

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[18] "Evaluation of Excess Flow Valves in Gas Distribution Systems", Final Report, Mona C. McMahon, General Physics Corporation, January 2006.

[19] Note that ASTM F2138 was subsequently revised. The current edition of the standard is ASTM F2138-09

In addition to codifying standards for performance, operation, installation, identification and testing of EFVs, there are additional reasons to consider enhancing and incorporating by reference current applicable technical standards. Operators have reported false closures. Through the examination of the causes of these failures, technical standards or guidelines could be modified to incorporate operating experience to prevent future false closures. Additionally, incorporating by reference the current standards would provide PHMSA a mechanism to ensure that any changes to the standards did not lessen public safety. New editions would be reviewed as part of the periodic update of technical standards prior to adoption.

5. U.S., STATE AND INTERNATIONAL REGULATIONS

5.1 PHMSA – U.S. REGULATIONS

The installation of EFVs on residential services in the United States was first regulated in 1999. Operators were given the option to voluntarily install an excess flow valve when they were available and technically feasible or to notify the customer that an EFV is available for the operator to install if the customer bears the costs associated with the installation. In 2007 the National Regulatory Research Institute (NRRI) conducted the *Survey on Excess Flow Valves Installations, Cost, Operating Performance and Gas Operator Policy* with the cooperation of four hundred ninety-seven gas operators.[20] At the time of the study, the requirement for voluntary installation or customer notification had been in effect for 7 years. As reported by gas operators who provided both the total number of service lines and the total number of EFVs installed, EFVs had been installed on 7% of new or renewed services. Ninety-six percent of the EFVs were installed voluntarily by operators. Forty percent of gas operators had not installed an EFV and 69% of operators' policy was to install EFVs only after a customer requested installation. Two percent of customers who were notified requested an EFV be installed.

With the DIMP final rule of December 2009, the installation of EFVs on most single family residences became mandatory. The U.S. requirements for EFVs are in

- §192.381 Service Lines: Excess Flow Valve Performance Standards.
- §192.383 Excess Flow Valve Installation. Section 192.383 requires installation of EFVs on new or replaced service line serving single family residences.

The definition of a service line serving one single family residence has been clarified and the annual reporting of the number of EFVs installed is now required.

U.S. regulations also require a service line valve on every service line in accordance with the requirements of §§192.363 and 192.365. The purpose of the service-line valve is to be able to shut off the supply of gas to the building. Each service line valve must be installed upstream of the regulator or, if there is no regulator, upstream of the meter per CFR 192.365. These shut off valves are to be placed in a readily accessible location that, if feasible, is outside of the building. Typically they are located aboveground just upstream of the regulator/meter on the outside of an exterior wall. If they are installed underground, they must be located in a covered durable curb box or standpipe that allows ready operation of the valve. However, the valve is often inaccessible during a due to its close proximity to the structure or obstructions over a buried valve. Emergency responders would likely shut off the gas

[20] A footnote in Section III of the NRRI Report stated that the 497survey respondents represented ≈ 62% of all US services in 2005. The Largest numbers of respondents were from Tennessee (63), Louisiana (49) and Oklahoma (41). No respondents replied from Alaska, Arizona, Connecticut, Hawaii, Kentucky, New Hampshire, South Carolina, Vermont, West Virginia or Wisconsin.

following an incident, if they could access the shut off valve. However, if a structure is on fire, emergency responders often cannot access shut off valves located at the wall or inside the structure. Operators should consider access to and operability of the valve under reasonably anticipated circumstances including emergency conditions. Some operators install a service line valve, often referred to as a curb valve or shut-off valve, close to the main. This practice is more prevalent for larger services or services which serve public buildings as schools, churches, commercial buildings, as well as services with indoor residential meters. Some operators install a combination valve which incorporates a full shut-off EFV inside the curb valve. In accordance with 192.365, the valve is located in a covered durable curb box or standpipe that allows ready operation of the valve. Additionally, some operators designate these valves as necessary to the safe operation of their distribution system and check and service them annually per § 192.747 "Valve maintenance: Distribution systems." The location and operability of these valves are relevant issues to the control of the flow of gas in emergency situations.

Finally, related to rapidly shutting down the flow of gas, operators must meet the requirements of §192.615(a)(6). To minimize hazards to life or property in an emergency, operators must be able to shutdown or reduce pressure in any section of the operator's pipeline system. In addition, §192.615(a)(3) requires the operator response was "prompt and effective to a notice of each type of emergency." PHMSA has not collected historical data for operator response time required to shutdown a service line when an accident or release occurs.

5.2 STATE REGULATIONS

New York State Regulation, 16 NYCRR 255.197(c) (effective August 8, 2005),[21] states that, "Any service line operating at 125 psig or more serving customers requiring regulation is to be equipped with either an excess flow valve or must have the first stage regulator at least 50 feet from the building or, if 50 feet cannot be attained without entering the roadway, located at the property line."

The New York State Regulation referenced here refers to EFV or pressure regulation requirements for service lines operating at more than 125 psig. This situation is not applicable for the vast majority of service lines across the nation.

5.3 INTERNATIONAL EFV REGULATIONS

Currently there are no regulations in Canada, the UK, or Mexico requiring the installation of EFVs on services in the vicinity of the service/main connection. France and Germany do require the installation of EFVs according to a 2006 study by General Physics (GP).[22] This study was prepared for PHMSA under contract to Oak Ridge National Laboratories. The following are key findings from the GP study:

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[21] Minutes of the State of New York Public Service Commission held in Buffalo, N.Y., July 20, 2005.
[22] Ibid, 3

- French law requires the use of an EFV from a government order dated July 2000. The law states that each new service connection, polyethylene / polyethylene or steel / polyethylene, has to be fitted with an EFV. Gaz De France covers the cost in their infrastructure. T.D. Williamson, France SA, in cooperation with Gaz de France, has designed and developed an Emergency Shut-Off Valve.
- The German organization Deutsche Vereinigung des Gas- und Wasserfaches e.V.-Technischwissenschaftlicher 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. DVGW's technical rules are the basis for safety and reliability for German gas and water supply. In Germany, excess flow valves are required to be installed on all new service lines The EFV can be installed on underground service lines between the main and the primary shut off valve in the residence or downstream of the primary gas shutoff valve in the residence. The German test standard for excess flow valves is DVGW VP 305-2.

6. OPERATING EXPERIENCE WITH EFVS

6.1 DOMESTIC EXPERIENCE - NATIONAL REGULATORY RESEARCH INSTITUTE (NRRI) SURVEY[23] RESULTS

In 2006-2007, the NRRI conducted the *Survey on Excess Flow Valves Installations, Cost, Operating Performance and Gas Operator Policy* which provided the following insights into operators' experience with EFVs installed on single family residential service lines:

- Of the 497 operators who responded to the survey, the 483 who answered questions concerning number of service lines accounted for a total of 34.6 million services.
- Almost 2.5 million EFVs had been installed, virtually all in SFR applications.
- 1,108 actuations, i.e., successful terminations of gas flow in response to a severe service line break, were reported.
- 32 operators reported 223 false closures, i.e., closing of an EFV when no severe service line break occurred. 67 of the 223 false closures were attributed to EFV failures; 65, to line contaminants; 81, to added load; and 10, no cause.
- 3 operators reported 26 failures to close when a service line ruptured or was damaged.
- Utilities reported that the number of false closures was evenly distributed between debris in the line, EFV failure, and an increase in load.

U.S. operators have gained considerable experience with EFVs since 1999; BEGAS's experience (see International Experience) began in 1993. The NRRI survey did not capture specific details about the causes of EFV false closures or EFV failures to close. Respondents reported 223 false closures were due to added load, more than one third of these were on SFRs. The data appears to recognize problems associated with increases in the customer load, while operators appear to have experienced the opposite, a reduction in load due to more energy efficient natural gas equipment such as boilers, furnaces, and hot water heaters.

The false closure and failure to close rates, while higher than that reported by Pipe Life Gas Stop in Europe (see section 6.3), is small compared to the total number of EFVs installed. A notable design difference between domestic EFVs and the Pipe Life Gas Stop EFV is that the latter has a screen which filters out contaminants.

6.2 DOMESTIC EXPERIENCE WITH USE OF EFVS IN NON-SFR SERVICE

[23] "SURVEY ON EXCESS FLOW VALVES: INSTALLATIONS, COST, OPERATING PERFORMANCE AND GAS OPERATOR POLICY", Ken Costello, The National Regulatory Research Institute, March 2007. A footnote in Section III of the NRRI Report stated that the 497 survey respondents represented ≈ 62% of all US services in 2005.

The industry has over 25 years of experience with EFVs including large volume EFVs. The bulk of these have been installed on single family residences. Section 7.0 provides further details. Two operators have shared their limited experience with non-SFR service lines below.

6.2.1 NISOURCE

Both Bay State Gas, and Columbia Gas of Maryland are local distribution company subsidiaries within NiSource. NiSource has developed a standard for installing EFVs in multi-family and commercial facilities and has begun limited installation of EFVs in selected non-SFR service lines. NiSource has not experienced significant problems to date, but recognizes that the practice is so new there is little operating history.

6.2.2 BAY STATE GAS

Bay State began installing EFVs on selected multi-residential and commercial facilities in 2007. Over 1,400 installations have been made.

6.2.3 COLUMBIA GAS OF MARYLAND

Columbia Gas of Maryland has proposed replacement of its bare steel and cast iron infrastructure, approximately 138 miles of distribution main and 5,559 steel service lines, over a 20 year period. As part of this program CGM would install EFVs on service lines connected to new mains and on new service lines, in accordance with its EFV standard. The cost to install an EFV was estimated at $25.00 each.

6.2.4 NW NATURAL

NW Natural (NWN) shared key insights from SFR operating experience:

- No identifiable avoided incidents on NWN system.
- Inability to clean service lines of foreign matter is an issue.
- Excavation damages occur without appropriate notification.
- An incorrectly sized EFV does not function appropriately. Both failure to trip and false trips occur.
- Added customer loads, such as tankless water heaters and emergency generators result in false closures.
- It is expensive and/or extremely difficult to remedy incorrectly sized EFVs due to excavation costs and municipal restrictions on street openings.
- Installation of EFVs may require a larger service line that may materially increase the cost of the service by hundreds of dollars.
- EFVs can’t distinguish a major leak from a customer load of the same size.

NW Natural concerns related to the installation of EFVs on multi-family, commercial and industrial service lines:

- The operator generally does not know the life cycle load (50-100 years) at the time of service installation, making proper service line and EFV sizing impossible.
- Multi-family, commercial and industrial customers have far greater load variability, routinely adding equipment and associated loads without notifying the gas company (new boilers, process loads, etc.).
- Commercial establishments are subject to frequent changes of ownership, product, gas equipment and associated loads, making EFV sizing impossible.

As with SFR applications, it is expensive and / or extremely difficult to remedy incorrectly sized EFVs due to excavation costs and municipal restrictions on street openings. The cost to replace an incorrectly sized EFV on a multi-family, commercial or industrial customer service line may be $5,000 to $25,000, not including extraordinary street repair costs imposed by the municipality.

6.2.5 KANSAS GAS SERVICE (KGS)[24]

On May 4, 2007 a tornado hit the town of Greensburg, KS. The town was almost completely destroyed. Nine hundred sixty one homes and 110 businesses were completely destroyed. The estimated gas venting was estimated at 2 million cubic feet per day; however, gas flow was terminated in 1.5 hours when the city gate valve was closed.

KGS developed a recovery plan which called for replacing all service lines to all facilities as new construction occurred. Each new service line would include an excess flow valve.

6.3 INTERNATIONAL EXPERIENCE

Peter Masloff of BEGAS.[25] the government owned gas company in Eastern Austria, presented a paper in 2003 about Pipe Life Gas Stop EFVs. The need for this safety equipment was based on the constantly increasing instances of excavation damage to service lines and the associated risks and accidents, including personal injuries, caused by the uncontrolled leakage of gas. The EFVs have been installed since 1993 on service lines to hospitals, large facilities, production plants, etc. Out of 26,000 BEGAS installations there have been no spurious failures. In 2,000,000 installations of Pipe Life Gas Stop EFVs in Europe and elsewhere there has been one spurious failure reported. In more than 4,000 instances, the Gas-Stop units have fulfilled their intended function and closed after damage to service lines.

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[24] Presentation by Kansas Gas Service on the May 4, 2007 Greensburg, KS Tornado

[25] "Operational Experiences with Excess Flow Valves for Service Lines and Main Lines in Network Operation", Peter Masloff, Technology Department Director, BEGAS - Burgenlandische Erdgasversorgungs AG. http://pipelife-gasstop.com/media/gasstop/pdf_englisch/GWF_7_2003_Excess-Flow-Valves_Experience-report.pdf

BEGAS began installing EFVs in service lines to high load facilities when economic factors for system expansion required the installation of medium pressure plastic pipe operating at 65 psig. The Pipe Life Gas Stop EFV is currently designed for use in systems operating up to 90 psig.

BEGAS reports that since October, 2004, in 177 of 184 instances of damage to a service line, the EFV operated properly to stop gas flow. In 7 instances, the gas flow was below the minimum shutoff point of the EFV. The Pipe Life Gas Stop EFV is designed with a filter to allow for use where dirt and dust may be present. The filter is designed with a smaller mesh area than the throat area of the EFV. Many European vendors have removed EFVs that have been in place for years and inspected them for corrosion and dust and dirt accumulation. They have also performed bench tests of removed valves. No vendor has reported finding problems.

7. EFV MANUFACTURERS

A number of manufacturers supply EFVs for use in distribution service lines and most have extensive experience with both single family service and branch or multi-service applications. While the number varies among manufacturers, up to 25% of EFV production is high volume, generally for large SFR applications. Their experience in the U.S. and abroad with larger commercial applications is more limited. The manufacturers' representatives indicated that their international experience is generally limited to two family branch/townhouse and standard single service line type commercial applications.

The EFV device is relatively simple and will reliably function under specific conditions. The principles of operation remain the same as sizes become larger and trip points are increased. The device only becomes an excess flow valve when it is properly sized for the service system. Not all situations will derive the same benefits from the installation of an EFV. Larger EFVs with bypass require a longer time to reset.

EFV issues identified by manufacturers:

- Failure to select the proper size EFV for the service line application.
- Future loads increase over present loads, resulting in the installed EFV becoming undersized.
- False trip during purge: avoided by throttling of valve or use of a rate cap.
- Problems created by third parties such as
  - Unreported excavation damage.
  - Unauthorized repairs.
  - Improper reset procedures.

Currently EFVs are manufactured in sizes from ½" CTS to 2" IPS; can accommodate service line inlet pressures of 5 psig to 125 psig for plastic, 250 psig for composite materials and 1000 psig for steel lines. The pressure limit is normally constrained by the design of the carrier pipe; and a flow capacity of 400 CFH to 5,500 CFH at 10 psig. A summary of the most widely used products is provided in Appendix C.

8. CHARACTERISTICS OF U.S. DISTRIBUTION SYSTEMS

8.1 SERVICE LINE SIZE, MATERIAL, AND PRESSURE

Characterization of the U.S. distribution system was developed using data from the 2009 Annual Reports submitted by operators to PHMSA and the Gas Distribution Incident Report current thru 2009. This data is provided in Appendix D.

- Size of Services
  As depicted in Figure 7, approximately 97% of all service lines are less than 2” in diameter. EFVs are commercially available for the majority of services.
- Service Line Materials
  As depicted in Figure 8, in 2009 over 96% of service lines were either polyethylene or steel.
- System Pressure at Incident Location
  As can be seen in Figure 9, 79% of all 2004-2009 gas distribution incidents occurred at operating pressures between 10 and 100 psig.

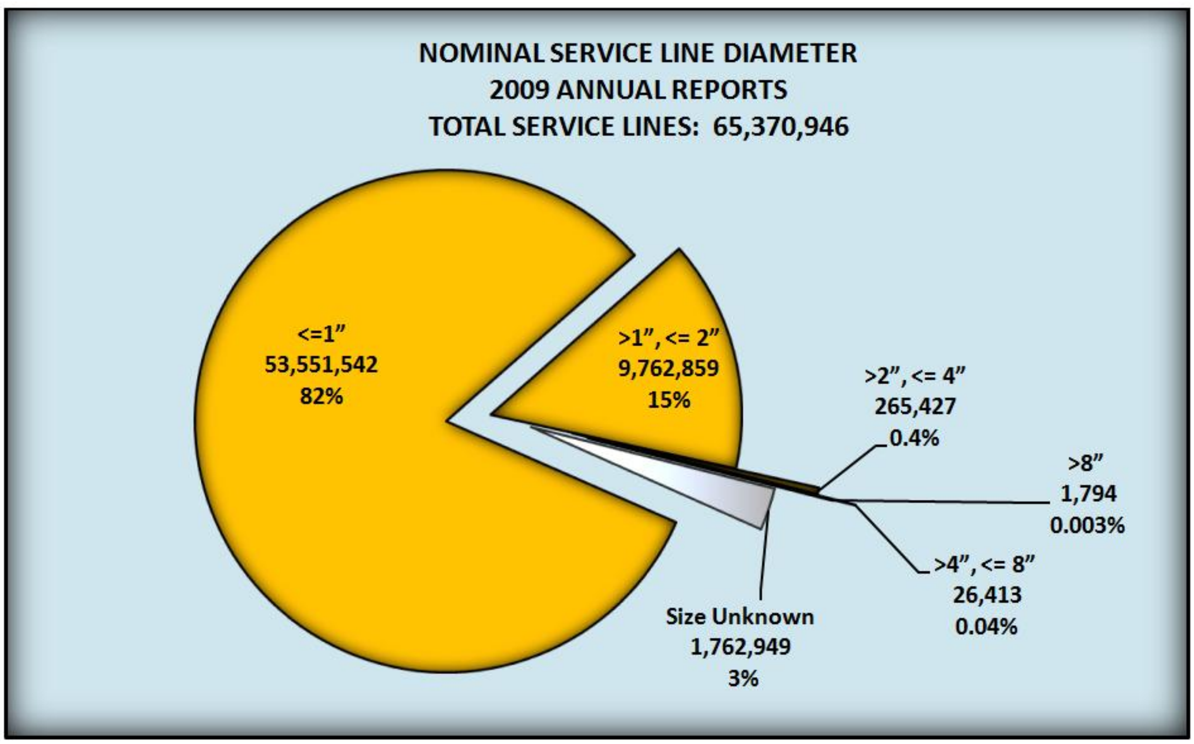

Figure 7 – Nominal service line diameter in 2009

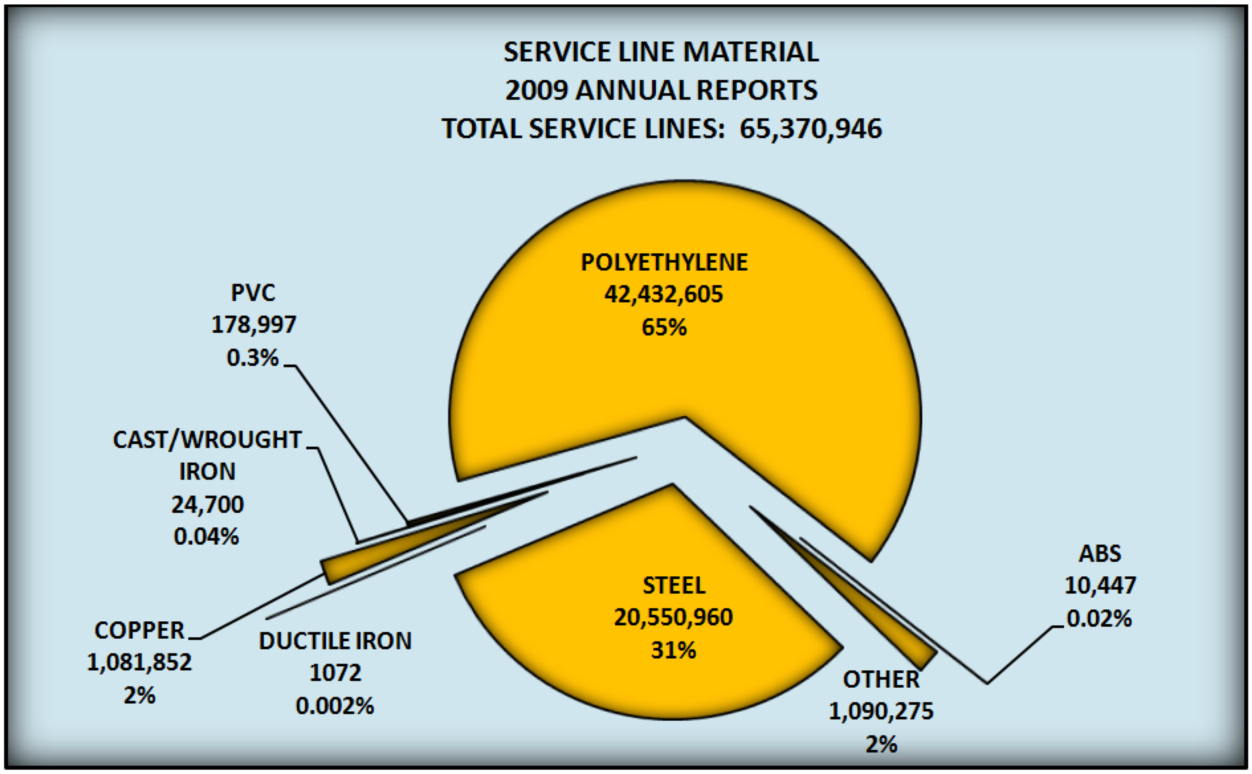

Figure 8 – Service line material distribution in 2009

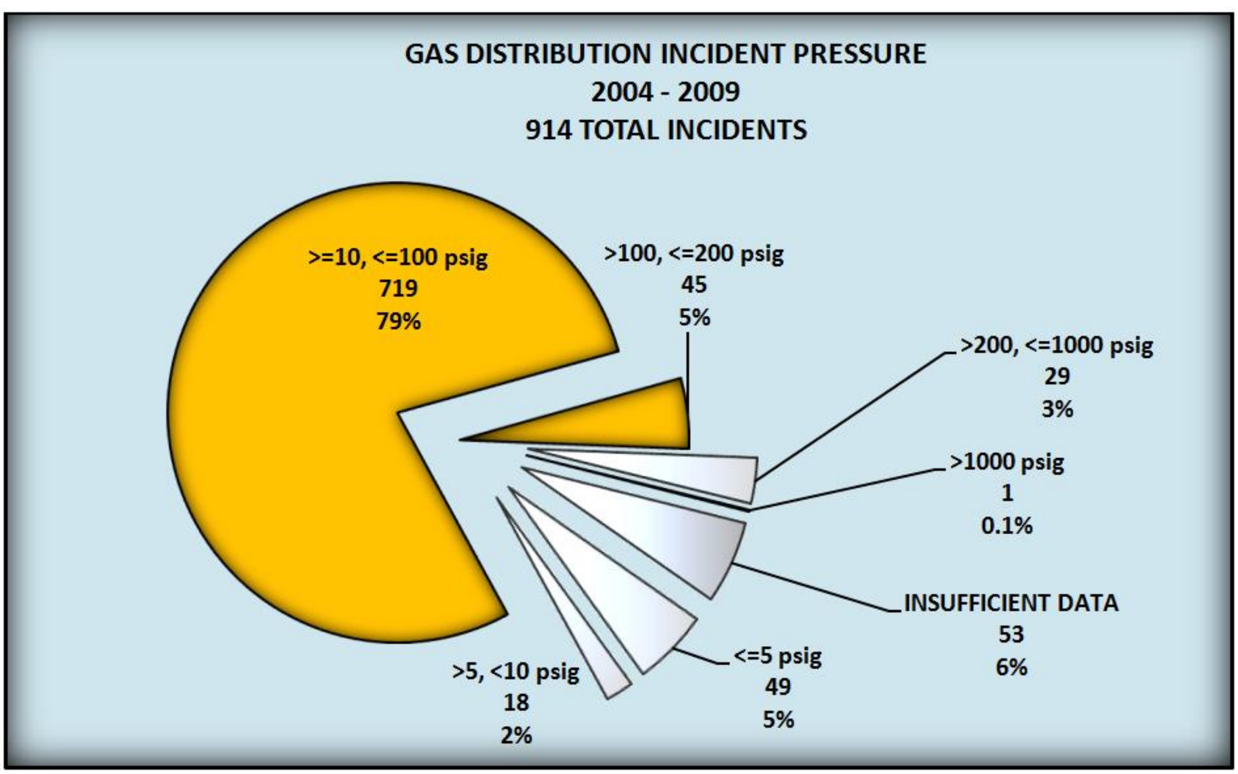

Figure 9 – Operating pressure at time of Gas Distribution incidents

8.2 PERSPECTIVE ON EXCESS FLOW VALVE EFFECTIVENESS IN GAS DISTRIBUTION SYSTEM SERVICE LINES

The following description of a gas distribution system has been adapted from a paper prepared for the Pipeline Safety Trust, *A Simple Perspective on Excess Flow Valve Effectiveness in Gas Distribution System Service Lines.*[26]

In the U.S., distribution systems consist of network grids of larger pipe supply mains, smaller pipe service lines and meter assemblies. Operating pressures within gas mains and service lines connected to the mains can run from inches of water column to several hundred psig pressure for transmission lines, depending on the design or operation of the specific system. The service line brings gas from the main (usually in the street) to the service regulator and meter set where pressure is further reduced down to that of utilization pressure of the customer piping system which is usually at most a few psig or normally, inches of water column pressure.

Distribution systems have been constructed of a variety of materials. Cast or wrought iron is found in some older systems, while steel or various plastics have been utilized in recent decades. A small percentage of distribution systems are constructed of other metals such as copper. A service line is a pipe, smaller in diameter than the main, that runs from the main to the meter/regulator station. Service lines to single family homes are usually 1 inch or less in diameter and vary in length from a few feet to many hundreds of feet. Approximately 98% of all services, regardless of customer classification, are 2 inches or less in diameter. New service lines are constructed either of steel or plastic. Even though the percentage of plastic versus steel service lines varies from region to region, plastic is now the predominant material in new service line installations across the country.

Ownership of service lines, as well as responsibility for leak repair, varies across the U.S. In some states the distribution company owns and is responsible for the service line, usually up to the meter, before gas enters the home. In some states the homeowner owns and is responsible for the service line. In other states the homeowner may own the service line but the gas distribution company is responsible for leak checking the pipe periodically. The many operator/homeowner combinations of service responsibility/ownership across the country can leave homeowners confused.

There is no consensus standard for locating of service lines, service regulators or meters, as these issues are usually determined by local distribution companies or controlled by local codes. The most common configuration is one in which the service line runs from the main to the service regulator and meter set (M&R), which is located next to a building. However, in some areas the M&R is located near the street,

[26] A Simple Perspective on Excess Flow Valve Effectiveness in Gas Distribution System Service Lines, Richard B. Kuprewicz, Accufacts Inc. July 18, 2005.

or property line, and a low pressure supply line (not a service line[27]) runs from the M&R to the building. In this case, the supply line will be at the lower utilization system pressure. Pressure in the service line is determined by the pressure on the gas main, or header, it is connected to.

It is worth noting an important risk factor for gas distribution systems. Because of growth demand, many distribution companies are faced with increasing their system pressures to increase gas supply within existing infrastructure. Such a pressure increase raises the risk of higher gas volume releases when service line failures occur for the same size damage.

[27] The USDOT code for transmission and distribution of gas only applies to gas facilities when gas is in transportation. According to federal terminology gas is no longer in transportation after it passes through the final sale point, generally the meter. Gas lines beyond the meter are termed house lines or privately owned gas lines on private property

9. TECHNICAL CHALLENGES ASSOCIATED WITH USE OF EFVS IN NON-SFR SERVICE

9.1 EFFECT OF CHANGING GAS USAGE PATTERNS ON SELECTION OF EFV SIZE

Gas service lines are designed based on a number of customer specific factors, including the anticipated gas demand. EFVs are selected based on an EFV trip point that exceeds the gas demand or load served by the service line and the size of commercially available EFVs.

One concern identified by some stakeholders is the effect of increased customer gas usage over time after the service line and EFV have been installed. The concern is that the EFV may be undersized and trip as a result of the increased customer load. On the other hand, the EFV may become oversized and fail to trip as a result of decreased customer load. One example given was strip malls, where each tenant may have widely differing gas usage needs and tenants may change frequently, resulting in varying loads.

Other stakeholders commented that EFVs are intended for full pipe rupture only, and that designing an EFV for a partial break or for an incremental gas flow increase above normal load is outside the capability of the device. Apparently, some operators may currently be sizing EFVs at capacities based on loads, and not on the larger capacity capable of flowing through the service line. The concern of changing customer load patterns may be resolved by identifying a consistent approach to size EFVs based on the capacity of the service line.

One approach that PHMSA is considering to address stakeholder views on this issue is to select and size EFVs with a trip point less than, but closest to, the gas flow rate of a full pipe break. This will avoid the scenario of undersized EFVs (inadvertent false closures) in cases where loads increase. This is because no load can draw more flow than the distribution system can deliver. PHMSA is considering development of technical guidance to clarify that EFVs should be sized for full service line breaks.

9.2 SNAP LOADS

EFVs on services with high instantaneous demand appliances and equipment, such as “instant-on” water heaters, must be sized properly in order to prevent trips under normal load. The problem may manifest itself when combinations of appliances come on simultaneously (e.g., water heaters plus heating unit). There does not appear to be any documented experience that snap-acting loads affect properly sized EFVs; if an EFV were to trip upon an increase in load due to a snap load, then the EFV would not have been properly sized for a full line break capacity. Regarding snap loads as well as the concern with changing gas demands, the issue appears to center on correctly sizing an EFV based on the maximum flow of the service line.

9.3 BUSINESS-CRITICAL GAS SUPPLY APPLICATIONS

Certain industrial gas customers require a highly reliable gas supply. Should an EFV inadvertently trip or trip under high demand but normal load, the interruption of manufacturing processes could result in a great expense. Also, very high volume EFVs take longer to reset because the service lines are typically longer and larger in diameter. Manufacturers indicate their EFVs are highly reliable and do not experience false closures when sized correctly.

Stakeholders were in general agreement that even if EFVs are highly reliable, there may be specific customer situations that are supply critical where an inadvertent EFV closure would result in unacceptable consequences. This may involve extended loss of service and dangers to the public, environment and loss of product such as food, chemicals, metals involved in heat treating processes, glass, computer wafers or chips, etc. Some specific examples follow:

- In an industrial process when a batch of steel or glass is being manufactured. The gas supply for that run is critical and cannot tolerate a supply interruption without the loss of the entire product run. If interrupted, the result would be considerable loss of business and product.
- In a service line serving a chemical process where the interruption of a phase of the process might result in unacceptable by-products such as noxious or toxic by-products, possibly endangering workers, the surrounding environment, or affecting the local population.
- In a large apartment complex served by a master meter, should the supply be inadvertently interrupted, the entire complex would have to be without gas supply, until all of the individual apartments could have their gas appliances individually shut off before individual apartments might begin to be re-energized and gas appliances re-lit.

9.4 SYSTEM CONFIGURATION

Operators identified technical challenges to installing EFVs due to complex system configurations. The location of the EFV should be as close to the main as practical. However, multi-customer locations such as apartments or strip malls require multiple branch connections. Based on the definition of "service line" and "main" in CFR 192.7, complex service configurations may not be very common. A pipeline that serves more than two customers, customers that are not adjoining or adjacent, or to more than one meter header or manifold is, by definition, a gas main. A main is defined as "*a distribution line that serves as a common source of supply for more than one service line*." This study is limited to excess flow valves installed on service lines. A service line is defined as "*a distribution line that transports gas from a common source of supply to an individual customer, to two adjacent or adjoining residential or small commercial customers, or to multiple residential or small commercial customers served through a meter header or manifold.*" A service that serves two adjacent or adjoining residential or small commercial customers is referred to as a "branched service" or "split service".

Figure 11 is an illustration of a branched service to adjoining residential customers. The service to "CHI" is not connected to a natural gas main and has another service as its source of supply.

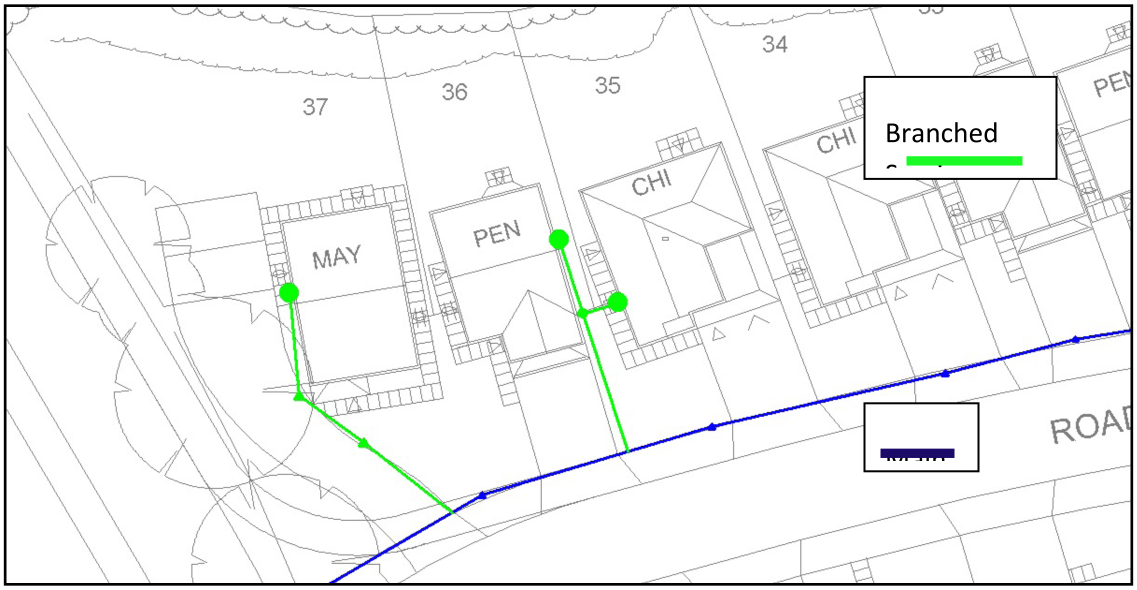

Figure 11 – Branched Residential Service

Figure 12 is a picture of a service serving a meter manifold. Note that the pipes on the right hand side of the meter are customer fuel lines.

Figure 12 - Service through a Meter Manifold

Based on the definition of a main and a service, there are three possible configurations of installing an EFV on a branch service line. The choices are the same whether the service is residential or small commercial services. They are:

1. Install one EFV close to the main sized to serve all connected load. Size the EFV at the main for the total of both loads.
2. Install two EFVs, one close to the main and a second EFV on the branched service close to the first service. Sizing the EFV at the main so that it does not trip under normal load conditions for both customers could mean the EFV would not trip if only the branched service is hit. A second EFV could be installed when the branched service is installed.

3. Install three EFVs, one close to the main, a second EFV on the branched service close to the first service and a third EFV on the first service but just downstream of where the branched service will be tapped off of the first service. The location for installing the third EFV can be difficult because the second residence may not be built until much later, in which case it would not yet be known where the second service with be branched from the first.

9.5 PRESSURE RATINGS

Currently, normal minimum pressure design is 10 psig (minimum anticipated design pressure). The maximum pressure of composite materials (250psig), plastic (125 psig) and steel (1000 psig and up) does not pose a problem. There is no pressure limit on EFV performance except that, when activated, the EFV seat must be able to withstand the pressure. The pressure limit is normally constrained by the design of the carrier pipe. EFVs covered by ASTM F2138 must have a maximum inlet pressure of at least 125 psig, while ASTM F1802 applies to EFVs with a pressure rating of up to 125 psig. However, for very high volume EFV applications, such as industrial customers, technical standards may need to address operating design pressures that exceed 125 psig.

9.6 SIZE OF COMMERCIALLY AVAILABLE EFVS

EFVs are commercially available for piping diameters of 2” IPS or less and loads of up to approximately 5,500 scfh, larger than that typical of a single family home. Some manufacturers report making EFVs larger than 2” IPS and at least one manufacturer is developing a 10,000 scfh EFV. The principles of operation remain the same as size and trip point increase, making EFVs for large loads and pipe sizes technically feasible.

10. ECONOMIC ANALYSIS CONSIDERATIONS

The OMB A-94 guidelines are to be followed in analyses submitted to OMB in providing estimates, in compliance with Executive Order No. 12291, "Federal Regulation," and the President's April 29, 1992 memorandum requiring benefit-cost analysis for certain legislative proposals. The circular includes two types of economic analysis, benefit-cost and cost-effectiveness. Public safety *benefit-cost analysis* attempts to measure the change in societal wellbeing resulting from the imposition of a new practice. *Cost-effectiveness analysis* is a less comprehensive technique for economic analyses, but it can be appropriate where a policy decision has been made that the benefits must be provided. A candidate solution is cost-effective if, on the basis of life cycle cost analysis of competing alternatives, it is determined to have the lowest costs (among all options considered) expressed in present value terms for a given amount of benefits.

The economic analysis of installation of EFVs on services other than SFRs involves challenges related to quantification and monetization of costs and/or benefits. Therefore, it will be important to consider input from a variety of stakeholders. OMB A-94 provides additional information about benefit-cost analyses and cost-effectiveness analyses.[28]

10.1 PREVIOUS BENEFIT-COST ANALYSIS FOR SINGLE FAMILY RESIDENCES

A previous benefit-cost analysis, *A Benefit/Cost Analysis of the National Transportation Safety Board's Safety Recommendation P-01-2,* was performed in December, 2002 by the Environmental Engineering Division at the John A. Volpe National Transportation Systems Center. The purpose of the study was to estimate and compare the benefits and costs associated with NTSB Safety Recommendation P-01-2 as applied to SFR. The benefit-cost ratio of this version was 5.03. The request for public comments was issued and at least one comment questioned the validity of the assumptions upon which the study was based. In September of 2003 a second version was issued in which the benefit-cost ratio was modified to 0.29. The authors of the study concluded that because the benefit-cost ratio calculated for Safety Recommendation P-01-2 was less than 1.0, the recommendation was not expected to be cost beneficial.

The focus of the current NTSB recommendation and therefore, of the benefit-cost analysis, is the extension of EFV regulation to services other than SFR: branched SFR services, multiple unit residential, commercial and industrial services. The previous analysis was limited to single family residences while a future analysis would need to evaluate the benefit-cost to remaining services categorized by the customer type and type of load they are likely to use. The Volpe study did not include the number of EFVs added per year. Because the number appeared in both the numerator and the denominator of the benefit-to-cost ratio, the number of EFVs installed was assumed to have no impact on whether Safety

[28] Circular OMB A-94 Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs http://www.whitehouse.gov/omb/rewrite/circulars/a094/a094.html#5

Recommendation P-01-2 was cost beneficial. The projection of the number of EFVs to be installed is needed because the costs and benefits of each service category are different. Some EFVs are more expensive due to size or the amount of design required to correctly specifying an EFV. The consequences of an incident on an industrial service may be larger than the average consequences to all services. Furthermore, the probability of the costs and benefits being realized is proportional to the total number of service lines in each category with an EFV to the total number of services.

The fundamental approach to determining the costs and benefits could mirror that performed in 2002 with the incorporation of the modifications made to the first study, differentiate the various categories of natural gas customers, and reflect the increase in the percentage of services with EFVs.

The VOLPE benefit-cost analysis did not look at alternatives to EFVs. Future benefit-cost analysis should include the benefit-cost of installing and maintaining a curb valve and box. The alternative should first be evaluated for efficacy. The safe distance from which a curb valve could be operated would be estimated to determine how far it would need to be located away from a burning building. This distance could be compared to the average length of service. If the curb valve would be inaccessible during most fires, then this may not be a viable alternative.

Listed and discussed below (see §10.3) are factors stakeholders identified at the June 23, 2009 meeting and at the August 25, 2009 teleconference that should be considered for incorporation into the benefit-cost analysis.

10.2 IDENTIFYING AND DEFINING THE TARGET PROBLEM AND CANDIDATE SOLUTION(S)

PROBLEM DEFINITION

The uncontrolled release of gas poses a safety hazard to emergency responders, the public and gas operating personnel. There needs to be a way to quickly or instantaneously control the gas flow during and after a breach of integrity on the service line for services where EFVs are not currently mandated.

CANDIDATE SOLUTION #1

Install EFVs in all new and renewed gas service lines, regardless of a customer's classification, when the operating conditions are compatible with readily available valves. Document the justification for exceptions.

CANDIDATE SOLUTION #2

Install EFVs in all new and renewed gas service lines, regardless of a customer's classification, when the operating conditions are compatible with readily available valves. No exceptions allowed. Operators would have to apply for a special permit for waivers.

CANDIDATE SOLUTION #3

Enhance requirements for manually operated emergency shutoff valves to facilitate quicker manual shutoff by first responders. Such requirements may need to consider location (away from structures), design (especially heat resistance), periodic inspection/testing, maintenance, signage and training/education of first responders. Because of increased time required for valve closure compared to instantaneous closure by an EFV, this approach would be less effective at preventing or mitigating explosions/fires caused by service line leaks, but would avoid the potential problem of inadvertent actuations.

CANDIDATE SOLUTION #4

Install EFVs in all new and renewed gas services for selected categories of service lines (for example, branch lines or single service lines with single meters for commercial properties; see §10.3.2) when the operating conditions are compatible with readily available EFVs. Document the justification for exceptions. For categories of service lines without a mandatory EFV, enhance requirements for manually operated emergency shutoff valves to facilitate quicker manual shutoff by first responders (refer to the discussion in candidate solution number 3, above).

CANDIDATE SOLUTION #5

Make no change to current regulations with respect to service line shutoff.

10.3 DEFINING THE SCOPE AND PARAMETERS OF THE ANALYSIS

10.3.1 FEASIBILITY/PRACTICALITY

The following are examples of cases where installation of EFVs s may not be feasible or practical:

- Operating conditions not compatible with readily available valves. This exception is explicitly stated in the NTSB recommendation. Currently, EFVs are not available for flow rates greater than 5,500 scfh or pressure ratings greater than 125 psig for plastic services, 250 psig for composite materials, and 1,000 psig for steel services. Since higher capacity EFVs are technically feasible, manufacturers will probably respond to industry needs and produce them.
- Service lines greater than 2 inches diameter. Currently, EFVs for use in service lines greater than 2 inches diameter are not available. Since larger EFVs are technically feasible, manufacturers will most likely respond to industry needs.
- Low pressure lines operating at less than 10 psig. It is clear from the NRRI survey that operators believe EFVs may not function reliably below 10 psig. This is reflected in both the congressional mandate and the DIMP rule, which apply to service lines operating greater than 10 psig.
- Business-critical or mission-critical services where very high reliability is required.
- Customers who experience instantaneous loads, much greater than their normal flow rate that would trip the EFV.

- Locations where contaminants are present in the gas stream that could clog the EFV and cause malfunction.

10.3.2 CATEGORIES OF SERVICES

The NTSB recommendation relates to all service lines "*regardless of the customer's classification."* All customer classifications need to be considered in the benefit-cost analysis, including but not limited to, branched service lines serving more than one single family residence, multi-family residential dwellings, commercial buildings, public buildings, and industrial facilities.

Multi-family residences vary greatly in style and the number of units per building. They include styles such as townhouses, duplexes, row houses, patio homes, garden apartments, and high-rises. Multi-family residential services have a single service to a meter, meter bank or manifold. They may also have branched services that serve two adjacent or adjoining customers such as duplexes. If the pipeline serves more than one meter bank or manifold, it is a main. A high-rise is generally considered a building with five or more stories above grade level. Historically a service is run to a meter bank on the ground level and the owner extends fuel lines to serve individual units. In recent years, as a way to lower a developer's first cost of gas, operators are locating the meter headers or manifolds in central gas meter rooms on every floor. By definition, the pipeline that distributes the gas to each floor is main (sometimes referred to as vertical main) and the pipeline from this main to the central meter bank on each floor is service.

The commercial sector accounts for 14% of natural gas consumption,[29] and includes public and private enterprises, like office buildings, schools, hospitals, stores, churches, hotels, restaurants, government buildings, and other commercial establishments. Commercial uses of natural gas are often very similar to residential uses. The main uses of natural gas in this sector include space heating, water heating, and cooking. Restaurants and other related establishments use natural gas for cooking. A limited number of commercial settings use natural gas for dehumidification and onsite power generation. The *Energy Information Administration* periodically conducts a national-level energy consumption survey of commercial buildings that are larger than 1,000 square feet in size. The principle building activity categories could be used to estimate the number of commercial customers whose primary gas consumption is for space and water heat and thus estimate the number of customers where a specification of an EFV would require additional engineering analysis.[30] From the CFECS survey, building activities classified as Food Sales, Food Service, Health Care, or Service buildings could be considered candidates for requiring more complex analysis. Service buildings are those such as dry cleaners, car washes, gas stations, service centers, and post offices. The remainder of the building activities would likely use gas for space and water heat.

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[29] http://www.eia.doe.gov/energyexplained/index.cfm?page=natural_gas_use

[30] *Energy Information Administration, 2003 Commercial Buildings Energy Consumption Survey.* http://www.eia.doe.gov/emeu/cbecs2003/introduction.html

Industrial consumption of natural gas is primarily in the pulp and paper, metals, chemicals, petroleum refining, stone, clay and glass, plastic, and food processing industries. Natural gas is also used for waste treatment and incineration, drying and dehumidification, biomedical manufacturing, fueling natural gas buses, and industrial boilers. Industrial applications for natural gas also include the same uses found in residential and commercial settings - heating, cooling, and cooking. Although industrial consumption accounts for 27% of natural gas consumption in the United States, it is concentrated in a relatively small number of industries.

Electric power generation is a special category of industrial consumption that alone accounts for 30% of natural gas consumption.

AGA notes that in 2008 there were approximately 200,000 natural gas industrial customers and 2,600 electric power generation customers. Of the technical challenges operators identified for proper implementation of EFVs, industrial customers are most likely to have business-critical gas supply applications.

The cost of implementing an EFV in any particular service line is less associated with the customer classification and more directly associated with a customer's gas usage, the type of gas equipment, the amount of engineering analysis to specify an appropriate EFV, and the supply chain cost of a larger number of EFVs. For this reason, with respect to EFV utilization, the categories of services to be considered should be based on their need for application-specific engineering. Considering all applicable classifications of service together in a single analysis might fail to identify subsets of distribution service that would be cost-beneficial to implement.

For these reasons, PHMSA plans to frame the economic analysis on the following categories:

- "*Branched service line serving single-family residence*" meaning a service line which transports gas from a common source of supply to two adjacent or adjoining single-family residential customers served in part through a shared service.
- "Service line serving one (or two adjoining) multi-family residential building(s) with one meter or one meter header or manifold" means a gas service line that begins at the fitting that connects the service line to the main and serves only one multi-family building. Townhouses, row houses, patio homes, and duplexes are often served this way. This also includes multi-family units with one meter bank. This also includes branched service lines to adjacent or adjoining multi-family residences that each have one meter.
- "*Non-residential services to space and water heat customers*" means a gas service line or branched service line that begins at the fitting that connects the service line to the main and serves a non-residential meter, meter header or manifold. The gas usage is similar to a residential customer (space heat, cooking, and water heat).

- "*Other applications where the service line configuration or EFV specification is more complex*" meaning a non-residential service line to Commercial Building Activity of Food Sales, Food Service, Health Care, or Service (as defined by *Commercial Buildings Energy Consumption Survey.* (*CBECS) Principal Building Activities*[31]
- Industrial customers.

As specified in the NTSB recommendation, the analysis should not include the retrofit of existing services with an EFV.

10.4 DEFINING COST FACTORS

Stakeholders have identified the following issues related to costs associated with mandatory EFV installation that should be considered when performing the benefit-cost analysis.

- Design costs
  - Cost of initial design and engineering. Especially important when considering complex installations.
- Installation costs
  - Cost of the EFV and any pup pieces or additional prefabrication costs to fuse or weld the EFV to other fittings.
  - Cost of an increased service line size necessary for proper function of the EFV.
  - Cost of installation. The cost of installation may vary depending on the type of fitting to which the EFV will be joined. EFVs are frequently combined with a tee, or pup pieces (referred to as a stick) so that there are fewer fusions to perform in the field.
  - Cost of materials management, storage and inventory.
- Supply chain costs - If EFVs are required for all customers which are compatible for the various service materials, operators will need to stock a greater variety of EFVs. Some sizes and types may have low turnover rates. They will also require additional space to store the EFVs. There will be an additional supply chain management costs such as those to deliver, source, transport, sort, pick and pack the EFVs.
- Maintenance costs
  - Cost of excavation, failure analysis, and replacement if the EFV fails (does not close when designed or closes when not intended).
  - Cost of responding to customer calls and relighting in cases of spurious trips.
  - Cost of EFV excavation and replacement if customer load changes.
  - Cost of replacement.
  - Cost of failure of an EFV to reset.

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[31] *Energy Information Administration, 2003 Commercial Buildings Energy Consumption Survey.* http://www.eia.doe.gov/emeu/cbecs2003/introduction.html

- Opportunity costs
    - For industrial facilities, the cost of lost production, restart, non-compliance and other impacts of spurious trips.

10.5 DEFINING BENEFIT FACTORS

Stakeholders have identified the following issues related to quantifying the net benefit of mandatory EFV installation that should be considered when performing the benefit-cost analysis. The benefits that would be expected if Safety Recommendation P-01-2 is implemented are:

- Reduced instances of fire/explosion caused by breaks in service lines.
- Quicker mitigation of fire following instances where fire/explosion does occur.
- Reduction of the amount of gas lost caused by breaks in service lines.
- Quicker rescue and fire suppression due to quicker access to the scene by emergency responders.
- Averted excavation costs to shut off the gas following a fire/explosion.
- Averted impacts to the health, safety, and property of people whose lives and livelihood would be adversely disrupted.

APPROACH

The suggested approach for approximating the benefits that would result from the implementation of Safety Recommendation P-01-2 is as follows:

- Estimate the number of added EFVs that would be installed as recommended by NTSB.
- Estimate the number of incidents that might be mitigated by the presence of the added EFVs installed under the safety recommendation.
- Estimate the value of the incident consequences potentially mitigated when an EFV has been installed in a service.

Using estimates for the number of incidents impacted and incident consequences avoided, the expected benefits of the safety recommendation could be calculated. The present value of the expected benefits stream could then be estimated and compared to the estimated cost. Uncertainties associated with the derivation of the benefits should be identified, benefit alternatives specified and the present value of the expected benefits stream for each of those alternatives calculated. Those alternative present values could then be compared with the present value calculated for the base case.

10.5.1 QUANTIFYING EXPECTED NUMBER OF INCIDENTS OR CONSEQUENCES AVERTED

Historical incident statistics may not be a reliable indicator of the benefit of EFVs in terms of incidents averted or mitigated for two reasons.

First, the PHMSA incident data base does not contain enough specific details about the incidents to know if an EFV might have mitigated any given incident. PHMSA filtered its database of 914 distribution incidents that occurred between 2004 and 2009 and estimated that 148 incidents caused by excavation damage, natural force damage, and outside force damage might have been mitigated with an EFV (Figure 1). However, there is not enough information available to know, with certainty, if any particular historical incident would have been prevented or mitigated if an EFV had actually been installed at the time. For example, it is possible that significant incidents occur as a result of a slow leak of gas that migrates to a location such as the basement of a building where it accumulates before being ignited. In such cases, an EFV might not prevent an explosion if the leak is not large enough to trip the EFV (although it might terminate gas flow following the explosion to mitigate the extent of any subsequent fire). PHMSA estimates that approximately 148 incidents might have been mitigated with an EFV during this 6 year period.

Second, a number of recent initiatives to improve the safety of gas distribution pipelines are expected to reduce instances of third party damage to gas service lines. Among these are the 811 Notification System, rules for public awareness plans, state damage prevention laws and distribution integrity management rules. These initiatives are expected to significantly reduce the number of gas distribution service line leaks, thus reducing the number of future incidents for which EFVs would be needed. Figure 4 shows that there has been a decrease in the number of incidents caused by external damage. The number should be normalized on the number of locate requests to insure that the reduction was not due to decreased third party excavation. Alternatively, Figure 3 suggests that while One-call Notification results in fewer incidents than no notification, it does not prevent all incidents.

10.6 AVAILABILITY OF DATA RELATED TO APPLICATION OF EFVS IN NON-SINGLE FAMILY RESIDENCE SERVICE

PHMSA has identified the following data sources to inform the benefit-cost analysis:

1. Gas Distribution System Annual Data (http://www.phmsa.dot.gov/pipeline/library/data-stats)
2. Gas Distribution System Incident Data (http://www.phmsa.dot.gov/pipeline/library/data-stats)
3. Significant Pipeline Incidents (http://primis.phmsa.dot.gov/comm/reports/safety/SigPSI.html?nocache=1361#_ngdistrib)
4. A Benefit/Cost Analysis of the National Transportation Safety Board's Safety Recommendation P-01-2, September 2003. Volpe
5. Survey on Excess Flow Valves: Installations, Cost, Operating Performance, and Gas Operator Policy, The National Regulatory Research Institute (http://nrri.org/pubs/gas/07-CO.pdf)
6. U.S. Department of Housing and Urban Development Periodicals, U.S. Housing Market Conditions, Historical Data (http://www.huduser.org/portal/periodicals/ushmc/winter09/hist_data.pdf)
7. Market Share of Private Housing Completions by Heating Fuel, Appliance and Housing Dat. (http://www.aga.org/NR/rdonlyres/8F6B395C-883D-4BC0-BD13-5FB3454A889C/0/Table104.pdf)
8. AGA, Snapshot of U.S. Natural Gas Consumption (2008) (http://www.mudomaha.com/naturalgas/pdfs/customers.08.pdf)

9. U.S. Energy Information Administration Independent Statistics and Analysis, 2003 Commercial Buildings Energy Consumption Survey. (http://www.eia.doe.gov/emeu/cbecs2003/introduction.html)
10. Common Ground Alliance http://www.damagereporting.org/annual/2008/index.html
11. U.S. Department of Transportation Office of the Assistant Secretary for Transportation Policy, Revised Departmental Guidance: Treatment of the Value of Preventing Fatalities and Injuries in Preparing Economic Analyses (http://ostpxweb.dot.gov/policy/reports/080205.htm)
12. Time to make a fusion http://www.isco-pipe.com/pdf/English%20Fusion%20Manual%20Version%203.1%202006.pdf
13. Salaries http://www.payscale.com/research/US/Degree=Welding/Hourly_Rate/by_Employer_Type
14. Logistics and Supply Chain Management www.usm.maine.edu http://www.google.com/search?sourceid=navclient&ie=UTF-8&rlz=1T4WZPA_enUS260US260&q=average+supply+chain+management+costs+per+item

11. SUMMARY

11.1 KEY OBSERVATIONS

PHMSA has implemented significant regulatory requirements and non-regulatory initiatives (detailed in section 2.3.2) targeted at reducing the occurrences of excavation damage on service lines. Since excavation damage is the greatest threat to distribution pipeline safety, PHMSA's actions, in conjunction with efforts by NAPSR, operators and other excavation stakeholders, are expected to produce substantial improvements in pipeline safety, and a corresponding reduction in serious incidents.

Service lines serving one single-family residence represent approximately 70% of new and replaced natural gas service lines. EFVs are required by the PIPES Act of 2006 and the Distribution Integrity Management Program (DIMP) Rule.

Stakeholders identified applications (beyond service lines serving one single family residence) where the operating conditions are compatible with readily available valves.

Stakeholders also acknowledged that EFVs may be inappropriate for installation in some applications.

An inadvertent EFV shutoff of commercial and industrial facilities, like hospitals, manufacturing plants, electric power generation plants, or chemical plants, may result in unacceptable consequences, and could create greater safety hazards than the gas release the EFV was intended to address.

Several stakeholders, including NAPSR, AGA and natural gas operators, have expressed concerns about the installation of EFVs on all classes of service lines due to significant load variability over the life of the service that may result in false EFV closures, loss of business for multiple days and the need to replace the EFV with a properly sized unit at considerable expense. However, manufacturers claim properly sized EFVs will not be affected by significant load variability, or snap loads, and will not result in false closures or the need to replace the EFV, unless the service line itself needs to be replaced to increase flow capacity. PHMSA's approach to address stakeholder views on this issue is to select and size EFVs with a trip point less than, but closest to, the gas flow rate of a full pipe break. This will avoid the scenario of undersized EFVs (inadvertent false closures) in cases where loads increase or in cases of snap loads. This is because no load can draw more flow than the distribution system can deliver.

11.2 NEXT STEPS

The following activities are based on the information provided in this report and could be used to develop a response the NTSB recommendation P-01-2:

11.2.1 DETAILED REGULATORY ANALYSIS

1. A survey of distribution operators and state regulators could be conducted to gather the information needed for the economic analysis as described in Section 10. Data could be gathered from state regulators and/or operators on significant historical distribution service line

incidents to identify cases where an EFV likely could have mitigated the incident (if an EFV had been in place) and the potential consequences that might have been averted. This should focus on branched single family residential, multi-family residential, commercial and industrial incidents that occurred within the last five years.

2. PHMSA could perform an economic analysis as described in Section 10 to address identified categories of services. As a minimum, this would need to be done as part of any future rulemaking. An economic analysis could help inform PHMSA decision-making with respect to its response to NTSB.
3. Additional information/data could be gathered concerning the European experience with EFVs. It appears to be different than that in the U.S. The ample operating experience in Europe with EFVs in high demand applications could inform U.S. regulatory development and decision making.

11.2.2 IMPROVE TECHNICAL STANDARDS

A new or existing industry committee could develop guidelines for a standard approach to sizing and installation of EFVs. Industry guidelines have already been developed for implementation of DIMP by the GPTC and industry gas associations. This effort could be expanded to produce guidelines to size EFVs based on a full service line pipe break. Guidelines could also address, in a more comprehensive manner, selection, installation, and performance testing of EFVs for a variety of design considerations and service line configurations. Operating conditions and system configurations under which EFVs are not compatible or potentially not advisable should be identified and integrated into the guidelines. PHMSA's recommended approach is to select and size EFVs with a trip point less than, but closest to, the gas flow rate of a full service line pipe break. This will avoid the scenario of undersized EFVs (inadvertent false closures) in cases where loads increase or in cases of snap loads. This is because no load can draw more flow than the distribution system can deliver. The standards may need to be revised to address pipe diameters greater than 2" IPS. This should be evaluated by the applicable standards committee. Vendors are currently manufacturing EFVs larger than 2" IPS. The standard should also develop guidance for operators and regulators concerning EFV installation exceptions for critical use customers.

APPENDIX A. NTSB INVESTIGATIONS OF DISTRIBUTION INCIDENTS

A.1 STUDIES AND SERVICE LINE INCIDENT REPORTS LEADING UP TO NTSB RECOMMENDATION P-01-02

Since the early 1970's NTSB has recommended the installation of EFVs on natural gas distribution pipelines. In June, 2001 NTSB issued recommendation P-01-2, which stated that PHMSA should require that operators install EFVs on all new and replacement service lines, regardless of customer classification. Since NTSB first recommended the installation of EFVs, PHMSA has expanded pipeline safety regulations which, when implemented, have reduced the risk of service line failures. Operators have also gained extensive experience in operating and maintaining gas systems. Significant related regulatory amendments influenced by other NTSB recommendations include:

- Changes to emergency plans which require operators to establish and maintain an adequate means of communication and cooperation with appropriate fire, police and other public officials.
- Requirements that operators participate in Notification Systems.
- Operator performance of damage prevention, operator qualification and public awareness programs.
- Performance of leakage surveys conducted with leak detector equipment.
- Installation of EFVs on services to single family residences.
- Clarification of issues surrounding operator's scope, which must include application of safety provisions for service lines regardless of ownership (Interpretations).

Additionally, PHMSA amended the regulations to require operators to develop and implement integrity management (IM) programs to enhance safety by identifying and reducing pipeline integrity risks.

The following are descriptions of studies and incidents cited by NTSB.

A.1.1 SPECIAL STUDY OF EFFECTS OF DELAY IN SHUTTING DOWN FAILED PIPELINE SYSTEMS AND METHODS OF PROVIDING RAPID SHUTDOWN, DECEMBER, 1970. (NTSB PSS-71-01)

This study was conducted by NTSB in response to pipeline accidents in which a delay in shutting down the failed pipeline system magnified the effects of the accident. The study pointed out that by reducing the time between failure and shutdown, the accident consequences could be minimized or eliminated. Equipment available at the time and procedures, which could have prevented the accidents discussed in the study if they had been employed, included EFVs. At the time of the study, use of rapid shutdown equipment and plans varied greatly within the industry, mainly because there were no industry guidelines or Federal requirements that defined 1) a reasonable period of time between a failure and a shutdown or 2) an emergency situation. There had been no analysis of the relative importance of avoiding shutdown and of avoiding hazard. Conditions that warrant shutdown had not been identified, nor had a determination of the level of risk to the community been related to the various degrees of rapidity of shutdown. Situation analyses regarding risk and rapidity of shutdown had not been documented or published at the time the study was issued.

The following incidents were cited in the December 30, 1970 NTSB study, *Special Study of Effects of Delay in Shutting Down Failed Pipeline Systems and Methods of Providing Rapid Shutdown* to illustrate the effects of delay in the shutdown of a failed service. The study notes that excess flow valves would have prevented the Hapeville, GA and Reading, PA incidents.

A.1.1.1 HAPEVILLE, GA[32], MAY, 1968

During grading activities in preparation for an expansion of a children's nursery, a bulldozer hit and ruptured a 1" medium-pressure service line to the facility. Gas migrated into the facility. Bulldozer operator was unable to locate the buried shutoff valve. Explosion occurred a few minutes after the line ruptured and resulted in the death of 7 children and 2 adults. Another nine were injured.

A.1.2.1 READING, PA, JANUARY 8, 1968

Reading workmen digging in the street to repair a water main hit a ¾" medium pressure gas service but did not break the pipe at that spot. The service line was separated from the main. About 2 hours later, an explosion occurred in a building killing 9 people. More than an hour was required for the gas company to shut off the gas in the area.

A.1.2 LAKE CITY, MN[33], OCTOBER, 1972 (NTSB PAR-73-01)

A bulldozer struck and ruptured a natural gas service line which resulted in gas accumulating in a nearby department store. The flow of gas through the failed service line was not shut off expeditiously, because the necessary valve key was on a service truck miles from the scene. The accumulated gas exploded resulting in the collapse of the department store roof and the death of six persons, including three children, and injuries to 10 others. As a result of their investigation, the NTSB issued safety recommendation P-73-2.

NTSB Recommendation P-73-2 states:

> *Undertake a study of failsafe devices which will stop the flow of gas from ruptured lines. Based on the results of this study, OPS should consider amending 49 CFR 192 to require the installation of such devices at appropriate locations in gas distribution systems.*

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[32] Hapeville, GA Broken Gas Main Explodes, May, 1968,http://www3.gendisasters.com/georgia/12237/hapeville-ga-broken-gas-main-explodes-may-1968
[33] http://www.ntsb.gov/Recs/letters/1973/P73_2_11.pdf

A.1.3 NEW YORK, NEW YORK[34], APRIL, 1974

The rupture of a six inch gas service line inside a 25 story commercial building resulted in the collapse of one wall of the facility and 70 persons injured. The incident was caused by the rupture of a hydro-pneumatic pressure tank located directly under the service line in the basement of the building and upstream of the meter bank. Gas leakage continued for about 30 minutes after the rupture until the curb valve located outside the building wall was closed. NTSB noted in their report that EFVs usually operate in the 3 psig range and above, but there are some valves which manufacturers claim will operate at a pressure of 7 inches water column. The practicality of these excess flow valves has been argued but research is continuing.

Based on their investigation, NTSB made three recommendations, transmitted to the Department of Transportation in 1976.

Recommendations P-76-9 through P-76-11 state:

> *Determine the availability, the practicability and the state of the art in the manufacture of excess low valves for use on low pressure gas distribution systems. Based upon the results of these findings, amend 49 CFR 192 to incorporate the use of these valves in commercial buildings. (Recommendation P-76-9A)*
>
> *Amend 49 CFR 192 to define more realistically an operator's responsibility for gas pipeline inside buildings. (Recommendation P-76-10)*
>
> *Expedite its review of the study of "Rapid Shutdown of Failed Pipeline Systems and Limiting of Pressure to Prevent Pipeline Failure Due to Overpressure" and determine what regulatory action is necessary concerning the use of excess flow valves. (Recommendation P-76-11)*

A.1.4 NATIONAL TRANSPORTATION SAFETY BOARD SPECIAL STUDY

Rapid Shutdown of Failed Pipeline Systems and Limiting of Pressure to Prevent Pipeline Failure Due to Overpressure [35]*, Research Conducted by Mechanics Research, Incorporated of Los Angeles, California, for the Office of Pipeline Safety, U.S. DOT, October 1974 (PB 241-325). October, 1974.*

The National Transportation Safety Board conducted a study of excess flow valves designed for use in gas distribution systems. The study, completed in October 1974, concluded that excess flow valves would improve safety, are commercially available, technically feasible and economically feasible.

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[34] Memorandum, Webster Todd, Jr. Chairman NTSB to William Coleman Jr, Department of Transportation, Safety Recommendations P-76-9 through P-76-11, April 9, 1976.

[35] Appendix B of NTSB's Accident Report for Allentown, PA June 9, 1994 contains information from the Rapid Shutdown of Failed Pipeline Systems and Limiting of Pressure to Prevent Pipeline Failure Due to Overpressure http://www.ntsb.gov/publictn/1996/PAR9601.pdf

A.1.5 NATIONAL TRANSPORTATION SAFETY BOARD SPECIAL STUDY

Analysis of Accident Data From Plastic Pipe Natural Gas Distribution Systems, (NTSB/PSS-80/1).

On January 29, 1980, RSPA conducted a 1-day conference in Washington, D.C., to gather information about EFVs. Unintended EFV closures were cited by operators as being a serious problem but could not support the claim with evidence.

On September 19, 1980, the Safety Board issued its report that analyzed OPS accident data on plastic pipe distribution systems. Analyses of the data indicated essentially no difference in the incident rate for plastic and steel service lines. The Safety Board encouraged the installation of EFVs in all new service lines, stating that "these valves cannot prevent damage to plastic pipe, but in some circumstances can minimize the consequences of the damage".

A.1.6 STANDARDSVILLE, VA[36], OCTOBER, 1979 (NTSB-PAR-80-3)

A contractor hit a 1-1/4" steel service line that was operating at 15 psig while excavating next to the Greene County, VA County Clerk's Office. The service line was broken at the gas meter. Emergency responders could not locate the curb valve and entered the building to shut off the valve located on the service line next to the meter at the foundation wall. The gas ignited while the emergency responder was turning the valve. Twelve minutes elapsed from the time of the hit until the explosion destroyed the County Clerk's Office and the County Courthouse. There were no fatalities; however, 13 persons were injured.

The Notification System was not in operation in Greene County at the time. Since this accident, operators must participate in damage prevention programs including Systems. Operator personnel were located within 3 miles of the accident site. The operator was notified of the accident 10 minutes after the pipe was hit. The pipeline was shut down 33 minutes after the explosion and the operator arrived 40 minutes after the hit. The report states that a properly designed and installed EFV would have prevented this accident.

Appendix D, *Accidents in which Automatic Shutoff Devices Could Have Favorably Influenced Outcome,* provides a list of accidents after 1972 that NTSB report indicated would have benefitted from an EFV. The accidents are (two previously referenced above):

[36] Memorandum, James King, Chairman NTSB to Howard Dugoff, Administrator RSPA, P-80-54 and -55, June 23, 1980.

Accident Date	Location	Event	Pressure (psig)	Casualties
10/30/72	Lake City, MN	Pullout	36	6 fatalities
10/31/72	Maple Grove, MN	Coupling Pullout	60	17 injuries
2/15/76	Rudolph, WI	Pullout Compression Coupling	35	1 fatality
6/19/76	Enola, PA	Outside Force Damage	52	3 fatalities
8/24/76	West Hartford, NY	Outside Force Damage	22	1 fatality
12/10/77	Tempe, AZ	Outside Force Damage	38	1 fatality
2/6/78	Oxon Hill, MD	Vandalism	20	6 injuries
6/5/79	Detroit, MI	Bypassed with Hose; Hose Blew Off	Unknown	1 fatality
7/25/79	Albuquerque, NM	Excavation damage; Compression Pullout	38	2 fatalities
8/15/79	Seat Pleasant, MD	Pullout	18	1 injury
10/13/79	Chrisman, IL	Backhoe Hit line	28	1 fatality
10/24/79	Standardsville, VA	Backhoe Pullout	15	13 injuries
2/21/80	Cordele, GA	Pullout	22	3 fatalities 5 injuries

The NTSB issued two recommendations based on their investigation .

Recommendation P-80-55 states:

> Expedite rulemaking to require the installation of excess flow valves on all newly installed or renewed high-pressure gas distribution system service lines.

A.1.7 INDEPENDENCE, KY[37], OCTOBER, 1980 (NTSB-PAR-81-1)

The operator was uprating a gas system from 60 psig to 200 psig. The operator's inaccurate records showed that the school's 2 inch service was connected to a parallel main, not to the main being uprated. A compression coupling located on the upstream side of the gas meter set assembly in the boiler-room pulled out allowing the 165 psig gas to be released into the building. The first explosion occurred seconds after the coupling pulled out. The operator could not locate the buried shut off valve or valve box and could not rapidly shut off the flow of gas. Thirty minutes later a second explosion ensued. After excavating with a backhoe, the curb valve was located 8 inches below grade. The gas was shut off one hour and forty-five minutes after the first explosion. There was one student fatality and 37 injuries as a result of the explosion. CFR 192.365 requiring that each service line have a shutoff valve in a readily accessible location was not in effect until after the installation of the service in 1967. NTSB states that if an EFV had been installed the severity of the first explosion may have been lessened and the second explosion may have been avoided. EFVs are not required to be installed as part of an uprating.

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[37] Memorandum, James King, Chairman NTSB to Howard Dugoff, Administrator RSPS, P-81-8 through P-81-10, May 13, 1981.

As a result of their investigation NTSB issued recommendation P-81-9.

Recommendation P-81-9 states:

> *Initiate rulemaking to require the installation of excess flow valves on all newly installed or renewed high pressure gas distribution system service lines with priority given to service lines supplying schools, churches, and other places of public assembly.*

A.1.8 NTSB SPECIAL STUDY, *PIPELINE EXCESS FLOW VALVES*, SEPTEMBER 1981 (NTSB/PSS-81/01). [38]

The National Transportation Safety Board conducted a study of excess flow valves designed for use in gas distribution systems. In order to gain an insight into the potential impact of excess flow valves on gas distribution safety, the Safety Board obtained technical data from several manufacturers and used these to develop criteria under which excess flow valves may be expected to perform their intended function. These criteria were used to screen a 2-year sample of Materials Transportation Bureau (now PHMSA) leak reports. It was found that excess flow valves could potentially have been activated in 23 percent of the reported distribution leaks in 1978 and 1979. These leaks accounted for 8 percent of the fatal accidents, 20 percent of accidents causing personal injury, 17 percent of the explosions and 22 percent of the accidents in which gas ignited.

The Safety Board concluded that EFVs save lives, protect property and generally enhance public safety. Based on its findings, the Safety Board concluded that additional documentation on EFV effectiveness should be undertaken and it recommended that the Gas Research Institute (GRI):

> *Plan and conduct a test and evaluation of existing EFVs to determine and document, on a comparable basis, their operating and design characteristics, such as reliability, service pipe size and length, operating pressure range, maximum service load, and susceptibility to contamination. (P-81-35)*
>
> *Determine the conditions and locations (other than those for which the Safety Board is recommending immediate regulatory action--i.e., high pressure single family residential services) for which EFVs can be effective in preventing or minimizing the potential for various types of accidents resulting from leaks on high pressure service lines. Among the conditions which should be evaluated are gas demand variations, minimum operating pressure, service line size, length, and configuration, major leaks on house piping, cleanliness of gas, and effect on peak shaving operations. (P-81-36)*

The Safety Board also recommended that RSPA (now PHMSA):

[38] Special Study, *Pipeline Excess Flow Valves*, September 1981 (NTSB/PSS-81/01).

Initiate rulemaking to require the installation of excess flow valves on all new and renewed single-family, residential high pressure services which have operating conditions compatible with the rated performance parameters of at least one model of commercially available excess flow valve. (Recommendation P-81-38)

Using the findings of the Gas Research Institute concerning additional locations where effective use can be made of excess flow valves to prevent various types of accidents, extend the requirements for the use of excess flow valves. (Recommendation P-81-39)

In 1985, the GRI published its report *Cost and Benefits of Excess Flow Valves in Gas Distribution Services*.[39] The stated objective of the report was to compare the cost and benefits of installing EFVs in gas distribution services operating at pressures equal to or greater than 10 psig. Among the findings were the following:

- Certain EFVs available today are reliable and require a minimum of maintenance. The problems that occasionally arise with new EFVs are largely attributable to human error.
- Although it may not be justifiable on the basis of a cost-benefit analysis basis, societal perception of risk suggests that it would be prudent for the gas distribution industry to utilize a specially designed reliable gas detection/alarm/shut-off system to protect buildings designed for public assembly against all combustible gas leaks. Existing EFVs are not adequate for this purpose, but a reliable system can be developed from existing technology.
- The potential for a large volumetric loss of gas from a ruptured farm tap suggests that it would be economically prudent to install an EFV on farm taps even though the risk to the public from such an event is small.
- The use of EFVs having low bleed-by flow rates on service stubs attached to medium and high-pressure mains intended for new housing developments should be considered by the gas industry from economic, convenience and employee safety standpoints.

In 1986, PHMSA advised the Safety Board that since the GRI report did not demonstrate a definite cost benefit or confirm the reliability of EFVs, it was not practical or reasonable to propose safety regulations that could impose significant economic or operating burdens on the industry with questionable benefits to the public.

The Safety Board told PHMSA about the numerous deficiencies in the GRI report. The Board said that it was clear that the GRI work did not satisfy the intent of Safety Recommendations P-81-35 and -36 and

[39] Final Report (April 1982 - August 1984), Assessment of Excess Flow Valves in Gas Distribution Service Lines, Gas Research Institute, Chicago, Illinois 60631, August 1985.

that consequently, PHMSA would not receive the guidance it needed to accomplish the intent of Safety Recommendation P-81-39. The Board classified Safety Recommendation P-81-39 "Closed--Reconsidered" and advised PHMSA that it had not tied compliance with Safety Recommendation P-81-38 to the findings of the GRI study and did not believe that the GRI study was relevant. Because PHMSA's letter did not include plans for acting on the recommendation, the Safety Board classified it "Closed—Unacceptable Action" and urged RSPA to take the actions necessary for requiring the installation of EFVs on all new and renewed single family residential high-pressure services.

A.1.9 BURKE, VA, OCTOBER, 1982[40]

During installation of service lines to new housing a worker was asphyxiated while installing a tee to a gas service line under pressure. A supervisor and a helper mechanic were in the area but not at the site where the mechanic was asphyxiated. Proper company procedures were not followed. NTSB issued recommendations to Washington Gas and Light, but no recommendations were made regarding excess flow valves.

A.1.10 KANSAS POWER AND LIGHT COMPANY GAS DISTRIBUTION SYSTEM INCIDENTS ACCIDENTS SEPTEMBER 16, 1988 TO MARCH 29, 1989 NTSB/PAR-90-03[41]

In April, 1990, NTSB issued recommendation P-90-12 based on its investigation of 5 natural gas accidents in the Kansas City-Topeka, Kansas area. NTSB found that two and possibly three of the incidents could have been prevented or the consequences mitigated had EFVs been installed. Two of the three Kansas City service line accidents were ruptures at pipe joints that had been weakened by corrosion and failed due to earth settlement.

On September 16, 1988, in Overland Park, a house exploded injuring three people. The gas migrated from four corrosion-caused holes on the 1-1/4" steel service line. The system pressure was not included in the report.

Memorandum, Jim Burnett, Chairman NTSB to Donald Heim, President, Washington Gas Light Company, P-83-8 and -9, March 24, 1983.

On November 25, 1988, a residence in Kansas City, Missouri, exploded, killing 1 and injuring five. An attempt was made to repressure the 1 1/4-inch diameter steel service line to the house, but it would not hold pressure. A meter was connected to the service line, gas at 28 psig was fed into the service line and the rate of gas escape was measured and determined to be 1,200 cubic feet per hour. Uncovering the service line revealed a large opening at the bottom of the pipe at a threaded joint. The opening had

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[40] Memorandum, Jim Burnett, Chairman NTSB to Donald Heim, President, Washington Gas Light Company, P-83-8 and -9, March 24, 1983.

[41] Memorandum, James Kolstad, Chairman NTSB to Travis Dungan, Administrator RSPA, P-90-12 through -21, April 20, 1990.

been caused by a combination of joint weakening from corrosion and downward pressure from soil settlement.

On February 10, 1989, a residence in Oak Grove, Missouri, exploded, killing two. An attempt was made to repressure the steel service line, but, like the Kansas City service line, it would not hold pressure. Uncovering the service line revealed a large opening at the bottom of the pipe at a threaded joint similar to the November 25, 1988, pipe rupture at Kansas City, Missouri, in failure opening size and failure mechanism, corrosion.

Although EFVs are not normally considered to be effective in stopping the flow of gas from corrosion holes, damage to the service lines described above permitted the release of gas at a rate that might have activated an EFV. The Safety Board concluded that the consequences of these accidents would have been substantially reduced had the service line been equipped with an EFV.

At the time of these incidents, KPL did not perform maintenance on customer-owned service lines. PHMSA has issued various interpretations which clearly state that operators responsibilities include the service line and the extent of a service line. These accidents resulted in 5 fatalities, 12 injuries and 4 residences destroyed.

Based on their investigation, NTSB issued recommendation P-90-12 to RSPA.

Recommendation P-90-12 stated:

> *Require the installation of excess flow valves on new and renewed single family, residential high pressure service lines which have operating conditions compatible with the rated performance parameters of at least one model of commercially available excess flow valve.*

A.1.11 SANTA ROSA, CA[42], DECEMBER, 1991.

Pipeline Incident Report: http://www.ntsb.gov/recs/letters/1992/P92_16_18.pdf

An explosion occurred at 4:26 a.m. in a 2-story, 8 apartment, wooden framed structure resulting in two fatalities and three injuries. The investigation of the incident revealed damage to multiple gas service lines that was caused by excavation activities for installation of sewer and water lines. Natural gas, escaping under a pressure of 50 psig from separated pipe, migrated underground into the apartment building where it ignited, exploded and then fueled the resulting fire. PGE squeezed off the gas at 10:49

[42] Memorandum, Susan Coughlin, Acting Chairman NTSB to Richard Clark, President, Pacific Gas and Electric Company, P-92-16 through -18, May 21, 1992. http://www.ntsb.gov/recs/letters/1992/P92_16_18.pdf

a.m. Other leaks were found and repaired before any additional fire or explosion could occur. PGE had evaluated the use of excess flow valves in the 1960s and 70s, but felt that the technology was immature.

Excavation equipment struck and damaged the gas service line. The PG&E received no notice of the service line damage, possibly because at the time of excavation, the service line was not completely separated from the compression coupling and no gas was escaping. Traffic vibration, pipe shrinkage caused by significant temperature differences between the time of the service line displacement and the time o f the accident, or other yet undetermined actions provided the force to separate the plastic pipe from the compression coupling.

NTSB issued recommendation P-92-16 to PGE on May 21, 1992.

P-92-16 states:

> *Install excess flow valves on new and renewed high pressure, single customer residential gas service lines at or near their connection to the gas main.*

A.1.12 ALLENTOWN, PA[43], JUNE, 1994 (PAR-96-01)

Pipeline Incident Report: http://www.ntsb.gov/publictn/1996/PAR9601.pdf

On June 9, 1994, a 2-inch-diameter steel gas service line operating at 55 psig that had been exposed during excavation separated at a compression coupling about 5 feet from the wall of a retirement home in Allentown, Pennsylvania. The escaping gas flowed underground, passed through openings in the building foundation, migrated to other floors and in less than 15 minutes exploded. A second explosion occurred about 5 minutes later. The shut off valve had been located but the excavator was unable to close it as he lacked the necessary tools. The line was designed to provide 15,000 to 20,000 cubic feet of natural gas an hour for boiler fuel. The accident resulted in 1 fatality, 66 injuries and more than $5,000,000 in property damage.

NTSB issued recommendation P-96-2 based on their investigation.

Recommendation P-96-2 states:

> *Require gas distribution operators to notify all customers of the availability of excess flow valves; any customer to be served by a new or renewed service line with operating parameters that are compatible with any commercially available excess flow valve should be notified; an operator should not refuse to notify a customer because of the customer's classification or the diameter or operating pressure of the service line.*

[43] Memorandum, Jim Hall, Chairman NTSB to D. K. Sharma, Administrator RSPA, P-96-2, March 6, 1996.

A.1.13 SOUTH RIDING, VA[44], JULY, 1998 (PAR-01-01)

Pipeline Incident Report: http://www.ntsb.gov/Publictn/2001/PAR0101.htm

An explosion and fire destroyed a newly constructed single family residence at 12:25 a.m. An arc between an electrical line and the gas service line led to the failure of the ¾ inch polyethylene gas service line. The subsequent uncontrolled release of natural gas accumulated in the basement and ignited. Precipitating the electrical service line failure was damage done to the electrical service line during installation of the gas service line and/or during excavation of the electrical line. The operator closed the shut off the valve at the meter at 1:00 a.m. The leakage flow rate was measured and calculated to be about 6,500 cubic feet per hour. There was one fatality and 3 injuries. Five other homes and two vehicles were damaged.

NTSB issued Recommendation P-01-02 based on their investigation.

Recommendation P-01-02 states:

> *Require that excess flow valves be installed in all new and renewed gas service lines, regardless of a customer's classification, when the operating conditions are compatible with readily available valves.*

A.1.14 ST. CLOUD, MN[45], DECEMBER, 1998 (PAR-00-01)

Pipeline Incident Report: http://www.ntsb.gov/publictn/2000/PAR0001.pdf

About 10:50 a.m. on December 11, 1998, while attempting to install a utility pole support anchor in a city sidewalk in St. Cloud, Minnesota, a communications network installation crew struck and ruptured an underground, 1-inch-diameter, high-pressure plastic gas service pipeline, thereby precipitating a natural gas leak. The operator received the call at 11:09 a.m. Around 11:30 a.m., while utility workers and emergency response personnel were taking preliminary precautions and assessing the situation, an explosion occurred. The operator stopped the flow of gas to the damaged gas line at 12:25 p.m. As a result of the explosion, 4 persons were fatally injured; 1 person was seriously injured; and 10 persons, including 2 firefighters and 1 police officer, received minor injuries. Six buildings were destroyed

NTSB issued recommendations to RSPA, but not on the matter of excess flow valves. NTSB cited the recommendations issued in 2000, P-01-02 and added:

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[44] Memorandum, Carol Carmody, Acting Chairman NTSB to Elaine Joost, Acting Deputy Administrator RSPA, P-01-1 and -2, June 22, 2001.

[45] NTSB Report PAR-00-01, Pipeline Accident Report: Natural Gas Pipeline Rupture and Subsequent Explosion, St. Cloud, Minnesota, December 11, 1998.

When NSP [the operator] converted the gas service line from low pressure to high pressure, the line itself was not replaced; therefore, the most recent Safety Board recommendations regarding EFVs would not have applied to this service line. Nonetheless, the Safety Board is convinced of the usefulness of EFVs in preventing pipeline accidents and concludes that had the gas line in this accident been equipped with an EFV, the valve may have closed after the pipeline ruptured and the explosion may not have occurred.

A.2 POST P-01-02 NTSB INCIDENT INVESTIGATIONS RELATED TO EFVS

From January 1, 1999 through July 15, 2009, 97 gas distribution incidents have been reported that involved at least one fatality and 347 that have involved at least one injury. These incidents have resulted in a total of 130 fatalities and 520 injuries. Below is a synopsis of some of the incidents investigated by NTSB since the South Riding incident.

A.2.1 BRIDGEPORT, AL[46], JANUARY, 1999 (PAB-00-01)

Pipeline Incident Report: http://www.ntsb.gov/publictn/2000/PAB0001.htm

While excavating a trench, a contractor damaged a ¾-inch steel gas service line, operating at 35 psig. One leak occurred where the backhoe bucket had contacted and pulled the natural gas service line. The other was a physical separation of the gas service line at an underground joint near the meter, which was close to the building. Gas migrated into the adjacent building at 406 Alabama Avenue, where it ignited and exploded about 10:02 a.m. The explosion caused three fatalities, 6 injuries, one of which resulted in an additional death 14 months after the explosion, and three buildings destroyed.

A.2.2 WILMINGTON, DE[47], JULY, 2002 (PAB-04-01)

Pipeline Incident Report: http://www.ntsb.gov/publictn/2004/PAB0401.htm

A contractor struck a gas service line causing separation inside a building. The line was a 1-1/4 inch steel service line operated at a pressure of 6 to 8 inches water column. Although the service line did not leak where it was struck, the contact resulted in a break in the line inside the basement of 1816 West 3rd Street, where gas began to accumulate. An explosion ensued resulting in four buildings destroyed, 14 persons injured and displacement of residents for one week.

A.2.3 DUBOIS, PA[48], AUGUST, 2004 (PAB-06-01)

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[46] NTSB Report PAB-00-01, Natural Gas Service Line and Rupture and Subsequent Explosion and Fire, Bridgeport, Alabama, January 22, 1999.

[47] NTSB Report PAB-04-01, Excavation Damage to Natural Gas Distribution Line Resulting in Explosion and Fire, Wilmington, Delaware, July 2, 2003.

Pipeline Incident Report: http://www.ntsb.gov/publictn/2006/PAB0601.htm

During an excavation, National Fuel accidentally damaged a 2-inch plastic main line pipe within a few feet of a butt-fusion joint. The operating pressure was 50 psig. The damage resulted in a leak in the butt fusion joint, which resulted in a fire and explosion, the death of two members of a single family residence and the destruction of the residence. Safety Board investigators could not determine the undisturbed position of the pipe to assess its bending.

A.2.4 BERGENFIELD, NJ[49], DECEMBER, 2005 (PAB-07-01)

Pipeline Incident Report: http://www.ntsb.gov/publictn/2007/PAB0701.htm

An apartment building exploded in Bergenfield, New Jersey, after natural gas migrated into the building from a damaged 1-1/4-inch steel natural gas distribution service line operating at 11.5 psig. The gas service was not properly protected during excavation and during the night the ground surrounding the pipeline collapsed. The next morning the excavator tied one end of a rope to the gas pipeline and the other end to the oil tank vent pipe at the building wall in an effort to help support the pipeline. A service tee separated from the service line. The operator was notified via the police of the hit and arrived about 20 minutes after contact but was unable to close the curb valve near the main. The building exploded after the operator detected a positive gas reading inside the boiler room door and started moving away from the building.

The investigation examined whether an excess flow valve that was compatible with the operating conditions for the apartment building would have been effective. They were unable to determine whether an excess flow valve would have activated after the service line was broken in this accident. There were 3 fatalities and 5 people

A.2.5 PLUM BOROUGH, PA[50], MARCH, 2008 (PAB-08-01)

Pipeline Incident Report: http://www.ntsb.gov/publictn/2008/PAB0801.htm

The failure of a 2 inch steel natural gas distribution pipeline operating at 10 psig occurred due to a 270 degree circumferential rupture apparently caused by mechanical damage. The resultant fire and explosion resulted in 1 fatality and 1 injury and the destruction of a single family residence. Dominion operated two gas distribution pipelines in the neighborhood: a 2-inch carbon steel main pipeline in front

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[48] NTSB Report PAB-06-01, Pipeline Accident Brief: Natural Gas Service Line Leak, Explosion and Fire in DuBois, Pennsylvania, August 21, 2004.

[49] NTSB Report PAB-07-01, Pipeline Accident Brief: Natural Gas Service Line Break and Subsequent Explosion and Fire, Bergenfield, New Jersey, December 13, 2005.

[50] NTSB Report PAB-08-01, Pipeline Accident Report: Natural Gas Distribution Line Break and Subsequent Explosion and Fire Plum Borough, Pennsylvania March 5, 2008.

of the destroyed home and an 8-inch carbon steel main pipeline across the street from the destroyed home. The 2-inch pipeline provided gas to the homes on the street; the 8-inch pipeline passed through the neighborhood.

At 1:44 p.m., Dominion was notified of the explosion by a neighbor who had called Dominion's emergency dispatch telephone number. At that time, Dominion dispatched personnel to the scene. By 2:12 p.m., a Dominion customer serviceperson had arrived at the scene. At 2:17 p.m., the maintenance crews arrived. About 2:20 p.m., Dominion supervisors arrived.

After arriving, Dominion began to shut down both pipelines. According to a Dominion crewmember, the crew had to shut off four gas control valves to stop the flow of gas to the two pipelines. Two other crew members told a Safety Board investigator that although they were able to close the shut-off valves, the valves were a bit snug. Consequently, the 2 inch pipeline was not shut down until about 5:50 p.m., and the 8-inch pipeline was not shut down until 5:55 p.m. Dominion provided the following explanation for the 4 hours needed to close the four shut-off valves. The two pipelines were two-way feeds in which pressurized gas flowed from either direction; thus, shutting them down required closing four valves. Two of the four valves closed properly; however, two other valves did not close completely. A Dominion crew had to dig up and fix the faulty valves before they could completely shut off the gas flow. Since the fire department had the fire under control at 2:20 p.m., the 4 hours needed by Dominion to close the four control valves did not increase the severity of the accident.

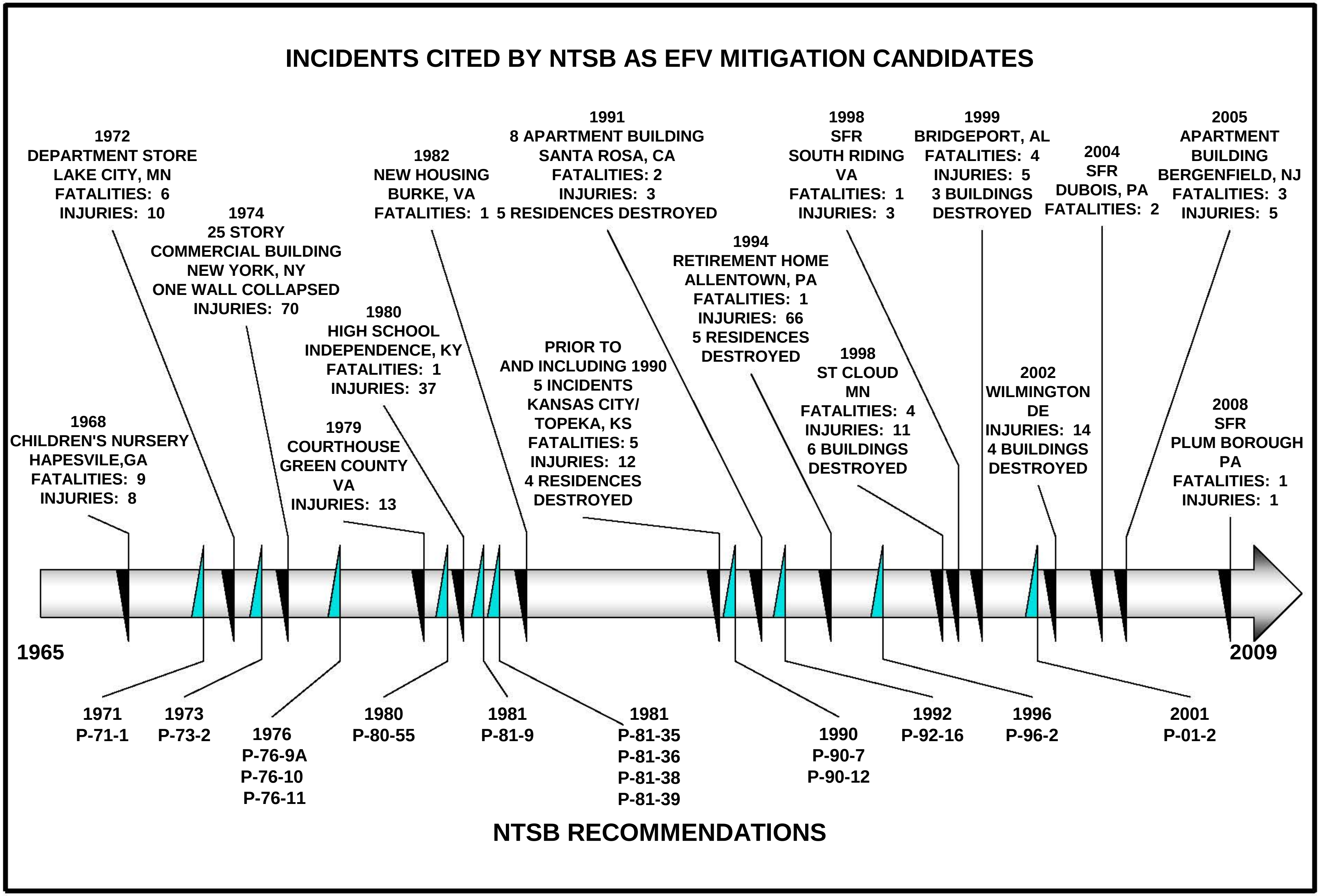
INCIDENTS CITED BY NTSB AS EFV MITIGATION CANDIDATES
1972
DEPARTMENT STORE
LAKE CITY, MN
FATALITIES: 6
INJURIES: 10
1974
25 STORY
COMMERCIAL BUILDING
NEW YORK, NY
ONE WALL COLLAPSED
INJURIES: 70
1982
NEW HOUSING
BURKE, VA
FATALITIES: 1
1991
8 APARTMENT BUILDING
SANTA ROSA, CA
FATALITIES: 2
INJURIES: 3
5 RESIDENCES DESTROYED
1998
SFR
SOUTH RIDING
VA
FATALITIES: 1
INJURIES: 3
1999
BRIDGEPORT, AL
FATALITIES: 4
INJURIES: 5
3 BUILDINGS
DESTROYED
2004
SFR
DUBOIS, PA
FATALITIES: 2
2005
APARTMENT
BUILDING
BERGENFIELD, NJ
FATALITIES: 3
INJURIES: 5
1980
HIGH SCHOOL
INDEPENDENCE, KY
FATALITIES: 1
INJURIES: 37
PRIOR TO
AND INCLUDING 1990
5 INCIDENTS
KANSAS CITY/
TOPEKA, KS
FATALITIES: 5
INJURIES: 12
4 RESIDENCES
DESTROYED
1994
RETIREMENT HOME
ALLENTOWN, PA
FATALITIES: 1
INJURIES: 66
5 RESIDENCES
DESTROYED
1998
ST CLOUD
MN
FATALITIES: 4
INJURIES: 11
6 BUILDINGS
DESTROYED
2002
WILMINGTON
DE
INJURIES: 14
4 BUILDINGS
DESTROYED
2008
SFR
PLUM BOROUGH
PA
FATALITIES: 1
INJURIES: 1
1968
CHILDREN'S NURSERY
HAPESVILE,GA
FATALITIES: 9
INJURIES: 8
1979
COURTHOUSE
GREEN COUNTY
VA
INJURIES: 13
1965
2009
1971
P-71-1
1973
P-73-2
1976
P-76-9A
P-76-10
P-76-11
1980
P-80-55
1981
P-81-9
1981
P-81-35
P-81-36
P-81-38
P-81-39
1990
P-90-7
P-90-12
1992
P-92-16
1996
P-96-2
2001
P-01-2
NTSB RECOMMENDATIONS

Figure A.1 - Significant Distribution Pipeline Accidents Investigated and Recommendations by NTSB Related to EFVs

APPENDIX B. REGULATORY RESPONSE TO NTSB RECOMMENDATIONS

On December 20, 1990, RSPA issued an Advanced Notice of Proposed Rule Making[51] (ANPRM) seeking information on the desirability of requiring the installation of EFVs on gas distribution service lines to reduce the damage from service line ruptures. The ANPRM also contained a questionnaire to collect current operational data on the use of EFVs by natural gas distribution operators.

On April 21, 1993, RSPA published a Notice of Proposed Rulemaking[52] (NPRM) titled "Excess Flow Valve Installation on Service Lines" that proposed to amend 49 CFR 192 to include the installation of EFVs on new and replaced service lines to single family residences operating at a pressure of 10 psig or more. The NPRM also proposed performance standards for EFVs and conditions under which EFVs must be installed. Due to objections to mandatory EFV installation on new and replaced service lines to single family residences, that portion of the proposed rule was dropped and the performance standards were adopted by Amendment 192-79 (discussed below). In a poll conducted by NARUC of its members, only two states, Massachusetts and New York, favored a federal mandate on EFV installation.

On April 4, 1995, RSPA notified Congress by letter that it had decided not to require universal installation of EFVs and instead would issue performance standards and customer notification requirements for EFVs. In a September 28, 1995, letter to RSPA, the Safety Board expressed its disappointment with this decision. The Board noted the continued strong evidence that a way was needed to quickly restrict the flow of gas to a failed pipe segment. On September 28, 1995, as a result of RSPA's failure to issue EFV requirements, the Safety Board classified Safety Recommendation P-90-12 "Closed-Unacceptable Action."

On June 20, 1996, Amendment 192-79[53] was published in the Federal Register with an effective date of July 22, 1996. This amendment created 192.381 which required all EFVs to be installed on service lines operating at a pressure not less than 10 psig to be manufactured and tested in accordance with industry specifications, or the manufacturer's written specification. This section was amended in January, 1997 by 192-80 and in July, 1998 by192-85[54].

In 49 U.S.C. 60110 Congress directed DOT to issue regulations requiring operators to notify customers in writing about EFV availability, the safety benefits derived from installation, and costs associated with installation, maintenance and replacement. Amendment 192-83[55] fulfilled this requirement and Section 192.383 was published on February 3, 1998 and was to take effect on February 3, 1999.

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[51] 55 FR 52188
[52] 58 FR 21524
[53] 61 FR 31459
[54] 62 FR 2619 and 63 FR 37504
[55] 63 FR 5471

Section 9 of the Pipes Act of 2006 required the Secretary (DOT) to prescribe minimum standards for Integrity Management Programs for distribution pipelines within one year of enactment. The bill requires minimum standards to include criteria for requiring operators of natural gas distribution systems to install excess flow valves on single family residential service lines that are installed after the date of enactment and to report to the Secretary annually on the number of excess flow valves installed under this requirement.

On June 5, 2008, PHMSA issued an Advisory Bulletin ADB-08-04[56] encouraging gas distribution pipeline operators to install EFVs on newly installed or replaced service lines that meet the requirements of the Pipes Act of 2006. The requirements of Section 9 of the Pipes Act of 2006 were to be effective as of June 1, 2008. Due to the complexity of the enforcement regulations, the Distribution Integrity Management Program's (DIMP) implementation has been delayed.

The NPRM for DIMP was published in the Federal Register on June 25, 2008.[57] The rule was issued on December 3, 2009.[58] DIMP requires operators of gas distribution pipeline systems to develop and implement Integrity Management Programs for gas distribution systems. In conjunction with the DIMP rulemaking, the installation of EFVs on newly installed and replaced service lines serving one single family residence is now required. The installation of EFVs on newly installed and replaced service lines for other classes of service would be one of the potential mitigative measures to be considered during implementation of DIMP. When DIMP is finalized, Section 192.383 of the CFR will be repealed.

[56] 73 FR 32077
[57] 73 FR 36015
[58] 74 FR 63934

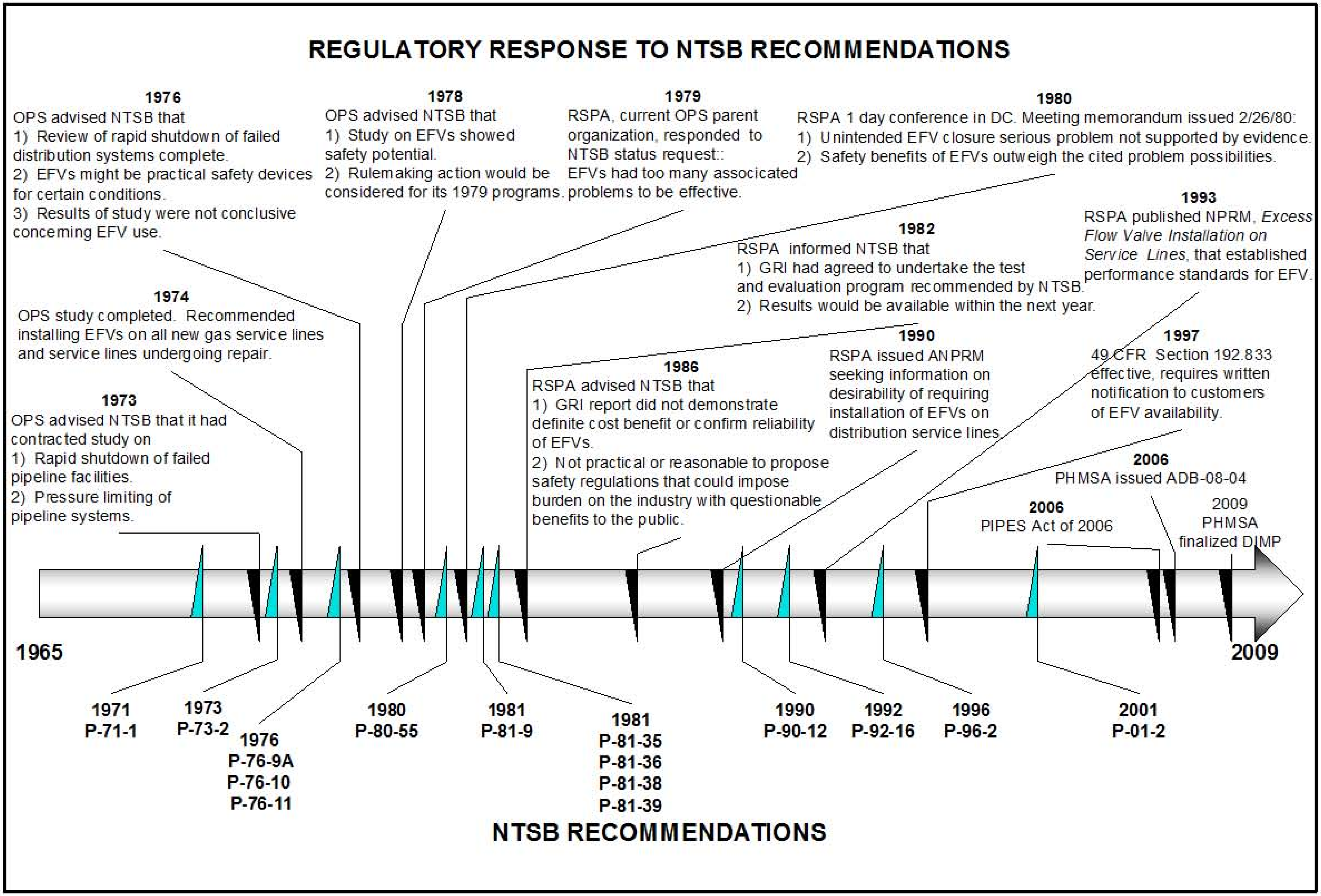

REGULATORY RESPONSE TO NTSB RECOMMENDATIONS
1976
OPS advised NTSB that
1) Review of rapid shutdown of failed distribution systems complete.
2) EFVs might be practical safety devices for certain conditions.
3) Results of study were not conclusive concerning EFV use.
1978
OPS advised NTSB that
1) Study on EFVs showed safety potential.
2) Rulemaking action would be considered for its 1979 programs.
1979
RSPA, current OPS parent organization, responded to NTSB status request::
EFVs had too many associated problems to be effective.
1980
RSPA 1 day conference in DC. Meeting memorandum issued 2/26/80:
1) Unintended EFV closure serious problem not supported by evidence.
2) Safety benefits of EFVs outweigh the cited problem possibilities.
1993
RSPA published NPRM, *Excess Flow Valve Installation on Service Lines*, that established performance standards for EFV.
1982
RSPA informed NTSB that
1) GRI had agreed to undertake the test and evaluation program recommended by NTSB.
2) Results would be available within the next year.
1974
OPS study completed. Recommended installing EFVs on all new gas service lines and service lines undergoing repair.
1990
RSPA issued ANPRM seeking information on desirability of requiring installation of EFVs on distribution service lines.
1997
49 CFR Section 192.833 effective, requires written notification to customers of EFV availability.
1986
RSPA advised NTSB that
1) GRI report did not demonstrate definite cost benefit or confirm reliability of EFVs.
2) Not practical or reasonable to propose safety regulations that could impose burden on the industry with questionable benefits to the public.
1973
OPS advised NTSB that it had contracted study on
1) Rapid shutdown of failed pipeline facilities.
2) Pressure limiting of pipeline systems.
2006
PHMSA issued ADB-08-04
2006
PIPES Act of 2006
2009
PHMSA
finalized DIMP
1965
2009
1971
P-71-1
1973
P-73-2
1976
P-76-9A
P-76-10
P-76-11
1980
P-80-55
1981
P-81-9
1981
P-81-35
P-81-36
P-81-38
P-81-39
1990
P-90-12
1992
P-92-16
1996
P-96-2
2001
P-01-2
NTSB RECOMMENDATIONS

Figure B.1 - Chronology and Timeline of PHMSA's Regulatory Responses to NTSB Recommendations

APPENDIX C. SUMMARY OF EFVS AVAILABLE FROM MAJOR VENDORS

C.1 DOMESTIC VENDORS

Specifications for off-the-shelf EFVs that meet the three technical standards, MSS SP-115, ASTM F1802 and ASTM F2138, offered by vendors in the United States are presented below. It is expected that the specifications of these products encompass the majority of vendor designs. The companies listed below also manufacturer application specific EFVs.

C.1.1 UMAC

UMAC has installed EFVs on single family residences, multi-family residences and on some commercial facilities and is in the process of designing a 10,000 SCFH EFV. UMAC reports that 25.6 billion cubic feet of gas was saved in 2002 by EFVs. This reduced methane release into the atmosphere and saved utilities lost gas revenue. The company has been manufacturing EFVs since 1975 with an estimated 5 million being sold.

Table C.1.1.1 - UMAC EFV Specifications

Model	Minimum Trip (SCFH) @ 10psi	Size (Inches)	Range of Inlet Pressures (psi)	Customer Flow (SCFH) @10 psi Inlet	ΔP @10psi Inlet
300	450	¾IPS -2 IPS	5-1000	275	.2
350	400	½ CTS, ½ IPS & ¾ CTS	5-150	275	.75
400	400	¾ IPS - , 2IPS	10-1000	275	1.38
550	550	½ CTS, ½ IPS & ¾ CTS	5-150	275	.53
700	700	¾ IPS – 2 IPS	5-1000	425	.15
800	800	½ CTS	10-150	630	1.88
1100	1100	¾ IPS – 2 IPS	5-1000	800	.3
1800	2000	¾ IPS – 2 IPS	5-1000	1000	.44
2600	2600	¾ IPS – 2 IPS	10-1000	1400	.9
5500	5500	1 ¼ IPS -2 IPS	10-150	4000	1.3

C.1.2 LYALL

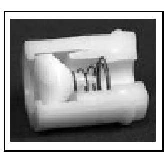
The LYCO® EFV is primarily for 3/4 IPS through 1 IPS "stick" applications and the LYCO® EFV I, Magnum series is designed for 1/2 CTS residential service line applications, though many carrier options are available for adapting to other service sizes. As can be seen in Table C.1.2.1, Lyall has a recommended maximum connect flow close to the minimum trip flow of the EFV.

Table C.1.2.1 - Lyall EFV Specifications. This table was created using the vendor's EFV Calculator for gas at 0.60 sg with inlet pressure of 10 psig at 60°F.

Model	Minimum Trip Flow (SCFH)	Size	Recommended Maximum Flow (SCFH)	Line Length Protected at 10 psig (ft)
375	375	½ CTS	368	198
400	400	½ CTS	392	198
450	450	½ CTS	441	199
775	775	½ CTS	760	52
350	350	¾ IPS	343	5110
475	475	¾ IPS	466	2939
775	775	¾ IPS	760	1219
1200	1200	¾ IPS	1176	555
350	385	1" IPS	377	12644
475	525	1" IPS	514	7242
775	855	1" IPS	838	3008
1200	1325	1" IPS	1299	1367

C.1.3 DRESSER[59]

This information was obtained from Dresser 's web site[60].

PIPE	PRODUCT	STYLE NO.	CONFIGURATIONS	SIZES	PSI RATING
Steel & PE Applications		Style 480, 481 & 488 EFV's	Excess Flow Valves- Available in a variety of mechanical and fusion carrier fittings	1/2", 3/4", 1" CTS and IPS New 1/2" CTS Ultra-Low	5-1,000 psig

C.1.4 ELSTER PERFECTION

All information for Elster Perfection was taken from their web site[61]. No information was requested from Elster Perfection. The following specifications were obtained:

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[59] Dan Manion, Director Sales and Marketing, PHMSA Public Meeting, Dresser Excess Flow Valves, Overview, June 23, 2009.
[60] www.dresser.com/documents/Piping Specialties/Gas_Product_Selection_Guide.pdf/ and http://www.dresser.com/documents/PipingSpecialties/EFV_Intro_brochure.pdf

- Trip flow rates of 400, 600, 800, 1100 and 1800 SCFH at 10 psig
- Minimum inlet pressure 5 psig
- Depending on model, sizes from ½ " CTS to 2" IPS

[61] http://www.elster-perfection.com/en/natural_excess_flow_valves.html

APPENDIX D. GAS DISTRIBUTION SERVICE LINE DATA

D.1 U.S. SERVICE LINES BY MATERIAL AND LINE DIAMETER

EFVs are commercially available for pipe diameters of up to 2 inches. As can be seen in the table below, this includes 97% of steel and 99% of plastic service lines currently installed. Some vendors report manufacturing EFVs larger than 2" IPS.

Table D.1.1 – U.S. service lines by material and line diameter. Data source is the 2009 Annual Reports submitted to PHMSA.

Material	Size Unknown	<=1"	>1", <= 2"	>2", <= 4"	>4", <= 8"	>8"	Total	Percent <= 2"
Steel	449,190	14,609,353	5,317,084	158,984	15,414	935	20,550,960	96.96%
Ductile Iron	0	703	10	2	314	43	1,072	66.51%
Copper	66	686,198	395,019	557	12	0	1,081,852	99.94%
Cast/ Wrought Iron	4	10,410	13,603	448	216	19	24,700	97.22%
PVC	2,351	147,759	28,739	145	3	0	178,997	98.60%
PE	991,579	37,387,696	3,938,361	103,870	10,342	757	42,432,605	97.39%
ABS	7	4,021	5,352	1,067	0	0	10,447	89.72%
Other	319,752	705,402	64,691	354	74	2	1,090,275	70.63%
Total	1,762,949	53,551,542	9,762,859	265,427	26,375	1,756	65,370,908	96.85%

D.2 SERVICE LINE INCIDENTS BY SYSTEM PRESSURE

Little information is available on line pressures in distribution systems. Several operators report operating at approximately 7"-10"wc. These are primarily old systems in cities in the northeast, east and south which were installed prior to the 1950s. Data collected for DIMP indicates new services are being installed in distribution systems that operate at 10 psig and above.

Table D.2.1 depicts the line pressure at the time of all 2004-2009 gas distribution incidents. 84% of all incidents occurred at operating pressures between 10 and 200 psig, conditions for which an EFV is commercially available.

Table D.2.1 – Line pressure at the time of 2004-2009 Gas Distribution incidents

Pressure Range psig	Number of Incidents In Pressure Range	Percent of All 2004-2009 Incidents
NO DATA	53	5.8%
0.01 - 5	49	5.4%
>5, <10	18	2.0%
>=10, <=20	106	11.6%
>20- <=30	84	9.2%
>30, <=40	82	9.0%
>40, <=50	151	16.5%
>50, <=60	245	26.8%
>60, <=100	51	5.6%
>100, <=200	45	4.9%
>200, <=1000	29	3.2%
>1000	1	0.1%
Total	914	100.0%