PASSIVE DEVICE TECHNOLOGY
THE TREND AWAY FROM RELIANCE UPON VALVING SYSTEMS
TO ADDRESS TRANSFER LINE FAILURE

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Abstract

Since the landmark incident in Sanford, North Carolina to the more recent tragedy in Riverview, Michigan, reliance upon excess flow valve technology to stop the potentially catastrophic consequences of hose and line failure has been eroding. Through legislation requiring "passive device" technology to formal warnings against this reliance issued by all of the major regulatory agencies in the United States to special permits that provide regulatory relief for users of passive device technologies, a growing trend has commenced towards eliminating this over-reliance upon excess flow valves in the event of transfer line failure. The basis of our paper is to identify this trend, explain its genesis and provide an understanding of the benefits to safety, cost and regulatory compliance through the growing trend and regulatorily encouraged use of passive devices for line and hose failures.

Introduction

For more than a decade, safety concerns have been proliferating throughout industry – none more so than the LPG industry. Incidents have spawned greater concerns over "weak links" in the safety chain of LPG transfer systems. Incidents have caused countless millions of dollars and claimed many lives. On September 8, 1996, in Sanford, North Carolina, during delivery of propane to a bulk storage facility by an MC 331 bulk transport, more than 35,000 gallons of propane were released. The discharge hose separated from its hose coupling at the delivery end of the hose. Most of the transport's 9,800 gallons of propane and more than 30,000 gallons from the storage tanks were released. If this quantity of released propane ignited, local authorities estimated that about 125 emergency response personnel could have been injured or killed.

This incident as well as many more in other petrochemical industries all point to a fundamental flaw in the fluid transfer system - over reliance on the excess flow valve. This recognition spawned a landmark Rulemaking issued by the United States DOT-RSPA in which they declared formally that excess flow valves are not reliable to address hose failures and new technology must be developed and identified to provide a greater degree of safety and reliability. Thus the term, **passive technology** was defined as shutdown equipment that has the capability to shut off the flow of product without human intervention within 20 seconds of an unintentional release caused by complete separation of a delivery hose. This definition and requirement thereby changed the safety landscape. This rulemaking marked the first, of several important, steps that have since been taken to require alternative means to address the consequences of transfer line failure by relying upon systems other than excess flow valves.

Excess Flow Valve Technology and The related problems of Over Reliance

An excess flow valve is, typically, a metallic device inserted into the interior piping of a tank car, just below the valve(s) used to load and unload the car. In the event that the valves are sheared off in a railroad accident, there will be a sudden rush of product out the opening thus created. With nothing to impede the flow of fluid product, the excess flow valve will move toward the opening and seat, thus sealing off the opening. In response to concerns that the then-current regulatory provision for excess flow valves might be ambiguous, in 1985 the DOT published a notice of proposed rulemaking to amend the tank car specifications by adopting what is now the contemporary standard. Proponents of the clarification stated that tank-mounted excess flow valves are not intended to substitute for adequate excess flow equipment in plant loading systems. ``The only use of such valves is for protection against loss of lading due to shearing of external closure during transit.'' \1\

The hazardous materials regulations (HMR) are quite clear that excess flow valves are limited in purpose and scope: An excess flow valve as referred to in this specification, is a device which closes automatically against the outward flow of the contents of the tank in case the external closure valve is broken off or removed during transit \2\

Excess flow valves, by their nature, must encounter a high-volume, surging flow of product to be activated. If that were not the case, they might function in unintended situations, such as when a tank car is being unloaded with the aid of a strong pump. As designed, essentially any apparatus attached to the outside of the external closure valve will create sufficient internal friction (whether hose or pipe) that the flow of product will not be sufficient to activate the excess flow valve. Excess flow valves, by both design and regulation, are intended to function only when the external closure valve is sheared, broken off, or otherwise removed during transit. These devices may also function as a back-up flow control device during tank car loading or unloading activities.

Despite these clear and obvious functional limitations, in the perceived absence of newer passive device technology, industry has placed great reliance on these types of valves to address a scenario that they are not designed for – line/hose failure. (See NTSB Report in which, six of nine companies surveyed rely on tank car excess flow valves as a method of stopping or limiting a leak in the transfer equipment.).

In the face of this limitation and over reliance, what would the regulatory bodies do when the next major incident occurs?

Rulemaking HM-225 and 49 CFR 173.315

New regulations **HM-225A** in effect since July 1, 1999, imposed new requirements on operators of cargo tanks used to transport liquefied compressed gases and new procedures for unloading liquefied compressed gases from cargo tanks. The new regulations seek to prevent unintentional releases during unloading of liquefied compressed gases, assure prompt identification of unintentional releases, and reduce the consequences of unintentional releases. Specific provisions include: New inspection, maintenance, and testing requirements for cargo tank discharge systems. Revised unloading requirements for liquefied compressed gases, including revised attendance requirements. New requirements for emergency discharge control equipment, such as passive systems that will shut down unloading without human intervention and remote control devices that enable an attendant to stop the unloading process at a distance from the vehicle.

The new requirements for emergency discharge control equipment on cargo tanks used to transport liquefied compressed gases are keyed to the degree of risk associated with the transportation of specific liquefied compressed gases. The regulation **49 CFR 173.315** specifies two types of emergency discharge control equipment - **Passive Shut-down Equipment**. Passive shutdown equipment must shut off the flow of product without human intervention within 20 seconds of an unintentional release caused by complete separation of a delivery hose.

This landmark legislation marked the first time that any regulatory body not only identified the risks associated with excess flow valve reliance but further regulated against their use in lieu of other technology. Since this regulation went into effect several systems have been developed and no recorded incidents have occurred.

These same standards were adopted in Canada. **Safety standard CSA B620** has been revised to introduce off-truck remote or **passive** emergency discharge control systems for highway tanks or portable tanks during the unloading of liquefied compressed gases. This applies to highway tanks and portable tanks of the type TC 331 and TC 51, respectively that are used to transport for example, liquefied petroleum gases (LPG) or anhydrous ammonia, the most common of these gases transported.

The standard calls for new highway tanks or portable tanks to be equipped with these emergency discharge control systems by January 1, 2003. The standard also includes a five-year retrofit period for the installation of these off-truck remote or **passive** systems on existing tanks consistent with the five-year pressure re-inspection date. This retrofit period will begin January 1, 2005, and will end December 31, 2010. The emergency shutdown systems are also subject to test procedures.

The remote capability introduced in CSA B620 enables operators attending the unloading operation to shut off the flow of product when away from the motor vehicle during delivery. These remote systems are associated with TC 331 tanks that are in metered delivery service, more commonly referred to as Bobtail units. The **passive** emergency discharge control equipment (sometimes referred to as a **Smart Hose**) is designed to shut down unloading operations without human intervention. These **passive** systems are found on larger trailer type units.

Post-Rulemaking
Riverview Michigan Accident and The NTSB's Conclusions

About 3:45 a.m., eastern daylight time, on July 14, 2001, in Riverview, Michigan, a pipe attached to a fitting on the unloading line of a railroad tank car fractured and separated, causing the release of methyl mercaptan, a poisonous and flammable gas. About 4:09 a.m., shortly after the Riverview Fire Department chief arrived on scene, the methyl mercaptan ignited, engulfing the tank car in flames and sending a fireball about 200 feet into the air. Fire damage to cargo transfer hoses on an adjacent tank car resulted in the release of chlorine, a poisonous gas that is also an oxidizer. The fire was extinguished about 9:30 a.m. three plant employees were killed in the accident. There were several other injuries; most of the injured were treated for respiratory symptoms and released. About 2,000 residents were evacuated from their homes for about 10 hours. Two tank cars, railroad track, and plant equipment (including hoses and fittings) were damaged in the fire. /3/

The Safety Board determined that the probable cause of the accident was a fractured cargo transfer pipe that resulted from (1) the failure to adequately inspect and maintain cargo transfer equipment, and (2) inadequate Federal oversight of unloading operations involving hazardous materials. Contributing to the accident was reliance on a tank car excess flow valve to close in the event of a leak from cargo transfer equipment.

Both OSHA and the Environmental Protection Agency (EPA) have required companies to develop and document safety plans for their facility that included safeguards intended to reduce the risk and consequences of catastrophic releases of hazardous materials. This facilities risk management plan (mandated by the EPA) and process hazard analysis (mandated by OSHA) included an accident scenario that involved the failure of a flexible hose on the unloading apparatus for a methyl mercaptan tank car - a scenario similar to this accident. Under both plans, the facility indicated that the release of methyl mercaptan would be stopped by the automatic closure of the tank car's excess flow valve. Further, the filed risk management plans explicitly noted that excess flow valves on the tank car would activate in the event of a pipeline or unloading hose rupture. **<u>However, when the transfer pipe/hose failed on July 14, 2001, the excess flow valve on the tank car did not close and stop the release of the methyl mercaptan.</u>**

Calculations made by Safety Board engineers and parties to the investigation indicated that the flow rate of methyl mercaptan through the broken transfer piping was insufficient to cause the excess flow valve to close. Excess flow valves are designed to close and stop the release of product from the tank car in the event a tank car valve or fitting is broken or sheared off during transit. Attaching cargo transfer apparatus to a tank car can change product release rates and flow rate characteristics and can prevent the excess flow valve from closing in the event of an emergency. As noted by the Chlorine Institute in its *Chlorine Manual Pamphlet 57 and* by the Safety Board in its investigation of a July 30, 1983, accident at a facility in Baton Rouge, Louisiana, *"tank car excess flow valves are not designed to act as an emergency shutoff device during cargo transfer". /4/*

To determine whether reliance upon tank car excess flow valves as safety mechanisms during transfer operations is not restricted to the aforementioned incidents it is a broader problem, Safety Board investigators interviewed a sampling of domestic chemical companies. Interviews with personnel responsible for company safety plans revealed that six of nine companies surveyed rely on tank car excess flow valves as a method of stopping or limiting a leak in the transfer equipment. Only one company reported having remotely operated shutoff valves on the unloading piping just outside the tank car dome. (The other two companies did not respond to the Safety Board's inquiry.) Although the Safety Board's sampling was limited, the results suggest that the **inappropriate use of tank car excess flow valves may be a widespread practice in industry.**

As a result of its investigation of the previous accident, the National Transportation Safety Board therefore made the following safety recommendation to the Occupational Safety and Health Administration*: "Assist the U.S. Department of Transportation in developing safety requirements that apply to the loading and unloading of railroad tank cars, highway cargo tanks, and other bulk containers that address personal protection requirements, emergency shutdown measures (passive device technology), and the inspection and maintenance of cargo transfer equipment".*

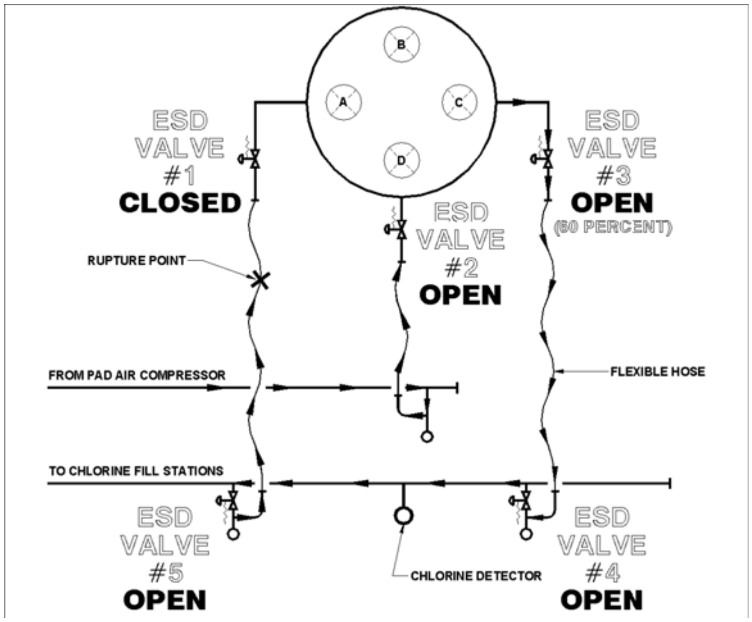
The Continued Consequences of Over Reliance on Excess Flow Valves

A chlorine repacking plant receives 4 railcars contained nearly 250,000 lbs of chlorine to be repacked into cylinders and other distribution. After 59 days, a hose wrongfully identified as a chlorine hose catastrophically failed spilling 48,000 pounds of Chlorine over 3 ½ hours. The root cause in addition to the hose failure is that backup systems (ESD'S) as well as Excess Flow Valves (EFV's) failed to work. /5/

Below is the section of the hose that failed after three workers on break heard a loud "pop", which clearly was this hose failing. The hose was made of stainless steel not suitable for Chlorine uses, although it was identified as hastelloy by the manufacturer, a material that is suitable for Chlorine usage. There is no visual difference between stainless steel and hastelloy, therefore the chlorine repackagers employees relied upon the manufacturers representation that they were indeed shipped the correct hose. Moreover, the facility relied upon the four valves (ESDs and Excess Flow Valves) in case of this precise type of error.

Ruptured chlorine transfer hose with its Teflon inner layer exposed;
when the hose burst it ejected pieces of Teflon as well as other components of the hose.

The illustration below shows the positions of all valves and hoses as it relates to this incident. Determining the actual positioning of the five ESD valves at tank car station #3 led the United States Chemical Safety Board's investigators to conclude that the chlorine flowed through the partially opened ESD valve #3, to the attached intact liquid CTH line, into the plant side piping, and back through the ruptured hose (see arrows denoting product path). Closing tank car valve A did not stop the release because valve C continued to supply chlorine through the intact liquid CTH line. Even if these events replayed themselves the product flowing through the building, because of the failure of the ESD's would have been stopped had known passive device technology been employed on the hoses. The pressure of the product itself would have kept the plunger/valve sealed and limited loss of product to what was in the hose, likely below the RQ (reportable quantity).



CSB investigators concluded that it is all but impossible to determine all possible routes of escape for hazardous materials or the infinite numbers of LPHC (Low Probability/High Consequence) scenarios. It is however abundantly clear that the hose is the weakest link in the chain and that devices, training and other precautions have proven to be inadequate in combating hose failures. In most reports of hazardous material release incidents we submit that one constant seems to be that employees may not follow regulations, rules and precautions that management, organizations and agencies have mandated and reasonably assume are being followed. Moreover, the valving technology that relies upon excess flow principles has been vastly over relied upon to address these incidents and governmental regulatory bodies have taken notice through he issuance of warnings and landmark Special permits encouraging the use of the passive device system mandated in 49 CFR 173.315.

Regulators Begin their Proliferation of Passive Device Technology Benefits

A Special Permit (previously referred to as an Exemption to Regulation) is temporary regulatory relief from one or more regulations given to a person or class of persons subject to the regulations, or who intend to engage in an activity that would make them subject to the regulations. (b) A Special Permit provides the person or class of persons with relief from the regulations for up to two years, and may be renewed. (c) Special Permits may only be granted from one or more of the requirements contained in the certain sections of the various regulations. To apply for such a Permit, the applying party must identify how they would ensure that they could achieve a level a safety that is **equivalent to, or greater than, the level of safety that would be obtained by complying with the regulation.** Thus the issuance f such a permit indicates that the regulatory body considers the procedure or technology to be of a greater safety value than the regulations promulgate. This is precisely the conclusion that the United States Federal Railroad Administration reached when they issued the landmark Special Permit 12325-SP. (See attached FRA Analysis)

Exemption/Special Permit 12325-N provides that the use of a Smart-Hose Technologies hose assembly will exempt the user from 49 CFR 173-177-Railcar Unloading Attendance Requirements. This regulation normally provides that rail tank car unloading operations must be performed by a reliable person who has been properly instructed in unloading hazardous materials and attended by the unloader until unloading is completed. Section 177.834 requires that a cargo tank motor vehicle be attended by a qualified person (usually the driver) at all times while it is to ensure the safe loading or unloading of hazardous materials being loaded or unloaded. The purpose of the attendance requirement in section 174.67 is to ensure the safe loading or unloading of hazardous materials and that, in the event of an emergency; such processes can be quickly halted. The Permit provides that the attendance requirements in the above regulations are relaxed if the rail car operator is using a Smart-Hose hose assembly.

The loading and unloading of tank cars requires the driver to stand and monitor the discharge of gas and fluids from the vehicle. The DOT recognized that this monitoring does not always occur particularly in the cold wintertime when the driver may retreat from the cold to their vehicles. Air Liquide, a current user of the Smart-Hose passive device technology effectively petitioned the DOT to create a Special Permit 13484 to provide for relaxed attendance requirements for MC 330, MC 331 and 338 cargo tankers for division 2.2 gases.

Warnings are Issued

Nearly two years after the National Transportation Board made its recommendations; all major regulatory bodies in the United States issued warnings. In April of 2004, the United States Environmental Protection Agency issued the following warning: "Notify all facilities that are required to submit risk management plans to the **Environmental Protection Agency** that tank car excess flow valves cannot be relied upon to stop leaks that occur during tank car loading and unloading operations and that those companies that have included reliance on such valves in their risk management plans should instead identify and implement other measures that will stop the uncontrolled release of product in the event of a transfer line[hose] failure during tank car loading or unloading."

In, September 2003, the **United States Department of Transportation – Federal Railroad Administration** issued the following warning: FRA is issuing Safety Advisory 2003-02 advising all persons involved in loading and unloading products from railroad tank cars that they cannot rely on internal excess flow valves to stop the flow of product except under the limited conditions for which these valves were designed and installed.

As early as 1980 **OSHA had issued warnings** indicating that in Anhydrous Ammonia service, it is emphasized that the system is not adequately protected without devices designed specifically to protect the system in case of rupture of the applicator tank liquid withdrawal hose. It is strongly stressed that excess-flow valves or other protective devices installed in bulk storage tank feed hose outlet lines are not designed to protect the system in case of an applicator tank withdrawal hose rupture. These devices are required to protect the lines that they serve and are designed specifically for this purpose only. For example, a manufacturer of anhydrous ammonia equipment advised that an excess flow valve installed in a bulk storage tank hose outlet (designed to accommodate a one-inch fill hose that is 15 feet in length) will be spring-loaded to trip should the hose be severed at any point along the 15 foot length of the hose; however, it is doubtful that adequate protection would be provided beyond the 15 foot point. Thus in the case of the applicator tank equipped with the combination valve, the hose outlet excess flow valve provides protection of the system from the bulk tank to the applicator fill/withdrawal valve with doubtful effectiveness in protecting the system beyond this point. It should be noted that the applicator tank involved in the accident was provided with a 3/4 inch liquid withdrawal hose. A reduction in the diameter of the hose line on the applicator tank further reduces the possibility of the bulk tank hose outlet excess flow valve tripping in case of severance of the applicator tank withdrawal hose -- especially in view of the fact that excess flow valves function on the basis of gallons per minute (GPM) flow rates and pressure differentials, i.e., a sudden drop of pressure in the line.

The preceding discussion has been limited to liquid lines and the filling of an applicator tank from a bulk storage tank. However, the same principles apply when filling the applicator tank from a nurse tank. In addition, it is equally important that protective devices be installed in the vapor lines to protect the system in case of vapor line rupture. It should also be noted that the bulk tank that was used to fill the applicator tank involved in the accident was not provided with an excess flow valve on the one-inch hose outlet on the bulk tank.

HM-223 - the Jurisdiction and Perspective Changes

Under the newly enacted Rulemaking (98-4952), otherwise known as HM-223, RSPA clarified the applicability of the Hazardous Materials Regulations (HMR) to specific functions and activities, including hazardous materials loading and unloading operations and storage of hazardous materials during transportation. They also listed in the HMR pre-transportation functions to which the HMR apply. They stated that pre-transportation functions are functions performed to prepare hazardous materials for transportation in commerce by persons who offer a hazardous material for transportation or cause a hazardous material to be transported. They determined that transportation functions are functions performed as part of the actual movement of hazardous materials in commerce, including loading, unloading, and storage of hazardous materials that is incidental to that movement. For purposes of applicability of the HMR, they concluded that ``transportation in commerce'' begins when a carrier takes possession of a hazardous material and continues until the carrier delivers the package containing the hazardous material to its destination as indicated on shipping papers or other shipping documentation. Thus, in promulgating this rule, they effectively transferred the regulatory oversight of loading and unloading railcars to the Occupational Safety & Health Administration ("OSHA") and, to a lesser extent, the Environmental Protection Agency.

The direction that has been recommended by the National Transportation Safety Board and promulgated through warnings by the Environmental Protection Agency, the Department of Transportation- Federal Railroad Administration and the US-Department of Labor's Occupational Safety and Health Administration is away from over reliance on excess flow valves towards the regulatorily established Passive Device technology.

Conclusion

Given the numerous, detailed and accurate warnings from manufacturers, advocacy groups, government agencies and from accidents themselves, it is not reasonable for anyone be they industry or agency to be surprised when the next hose bursts and an EFV fails to stop the catastrophic consequences. These warnings are advice to beware to professionals charged with the safety of facilities, communities and individuals and are intended to be actionable.

The "passive device" addresses directly the deficiencies of the excess flow device. These deficiencies are not an indictment of the EFV device, the device behaves exactly as designed when used and installed properly. Rather, where the fault lies is in the properties and attributes that industry affixes to these devices to do a job for which they were not designed. The EFV is designed to trigger at a preset flow rate exceeding normal operation and contemplating the "shearing off" of valves or other catastrophic hardware event. In the event off a transfer line failure, in truth the EFV does not fail it simply works as designed, as the flow through a transfer line is likely within the parameters of normal operation and a rate at which the EFV set to accept.

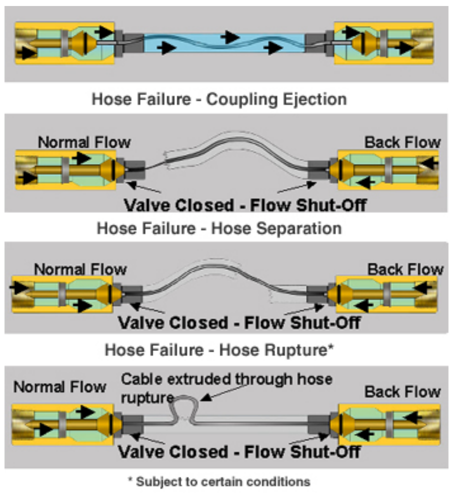
The "passive device" is designed to shut off the flow of product in both directions in the transfer hose in the event of a failure between the couplings. This device provides safety at flow levels that are common in instances that sometimes are not. While the EFV triggers at only high rates a "passive device" will trigger in incidents not only at high and low rates but even when a system is on standby (Festus) making the device not only complimentary but redundant to the EFV. When the next transfer lines fails and the call goes to the responsible party rather than wondering if they have dodged a bullet with an EFV the first question will be, "What did the hose do?"

A proven solution is at hand and industry and government are moving inexorably towards adaptation of passive device technology. The aforementioned warnings are not intended to provide cover to those that ignore them, as they are now so widely known. The fact is that given this knowledge and "best practice" the consequences to those who do take notice and action are likely severe. What is that solution?

The ***Smart-Hose^tm^ technology*** is a proven hose technology designed to counteract the hazardous effect of hose rupture or failure during fluid or gaseous transfer operations. All **Smart-Hose^tm^** designs, **Smart-Hose^tm^ I**, **Smart-Hose^tm^ I** with breakaway, and **Smart-Hose^tm^ III** utilize the unique, patented and patent pending design eliminating the potential for disaster through the use of an internal cable connected to specially designed, normally unseated valve "wedges or plungers" located on each end of the cable.

In the event of hose separation, stretching to the point of an unsafe condition or coupling-to-hose separation, the valve "wedges or plungers" are released and instantly seat **stopping the flow in both directions.**

Smart-Hose[tm] **Technologies** manufactures a patented safety hose assembly that bi-directionally stops the flow of fluids or gas in the case of catastrophic hose failure for **all** high pressure, liquid and gaseous hose applications including Rubber, Teflon, Metal that can be combined with all flanges connections welded or threaded, Cam-lok, Air fittings, Brass fittings, Boss Ground Joints, Shank fittings, Plastic fittings, all Valves, Tank Truck fittings, Swivel Joints, Pipe and Welding fittings.



Through the use of Passive Device Technology, sanctioned and in some cases mandated, the LPG industry can provide a level of safety for our operators, a level of compliance increasingly mandated and further confidence to our customers that safety does count and we embrace it.

Acknowledgment

We want to thank the various nongovernmental organizations that have supported this effort. We appreciate the contributions by the National Transportation Safety Board, the United States Chemical Safety Board, The United States Department of Transportation, The United States Environmental Protection Agency and The United States Department of Labor – OSHA. We further appreciate the World LP Gas Association for engaging us to research and develop a comprehensive paper on the impact of excess flow valve technology on the LP gas industry.

References

\1\ Docket HM-166W, NPRM at 53 FR at 36418, September 19, 1988; Final Rule adopting the amendment as proposed, 54 FR 38790, September 20, 1989.

\2\ 49 CFR 179.100-13(d).

National Transportation Safety Board, *Hazardous Materials Release From Railroad Tank Car With Subsequent Fire at Riverside, Michigan, July 14, 2001*. Hazardous Materials Accident Report NTSB/HZM-02/01 (Washington, D.C.: NTSB, 2002).

\3\ National Transportation Safety Board, *Safety Recommendation,* Norman Minetta, July 16, 2002.

\4\ The Chlorine Institute, Pamphlet 57, Emergency Shut-Off Systems for Bulk transfer of Chlorine, Edition 3, October 1997 section 3.1.

\5\ The Chemical Safety Board, Investigation Report Chlorine Release, DPC Enterprises, May 2003, incident Festus, Missouri August 14, 2002

[2] National Transportation Safety Board, *Vinyl Chloride Monomer Release From a Railroad Tank Car and Fire, Formosa Plastics Corporation Plant, Baton Rouge, Louisiana, July 30, 1983,* Hazardous Material Accident Report NTSB/HZM-85/08 (Washington, D.C.: NTSB, 1985).

Although excess flow valves are routinely used as safety mechanisms in the piping systems of fixed facilities, those excess flow valves are designed and constructed for specific piping systems and the properties of the material flowing through the pipe.

Correspondence dated July 16, 2002, from Marion C. Blakely, Chairman, NTSB, to Allan Rutter, Administrator, FRA, summarizing the Board's investigation, including a public hearing, of this incident.