PPTS OPERATOR ADVISORY:
NEW FINDINGS ON RELEASES FROM FACILITIES PIPING

Executive Summary

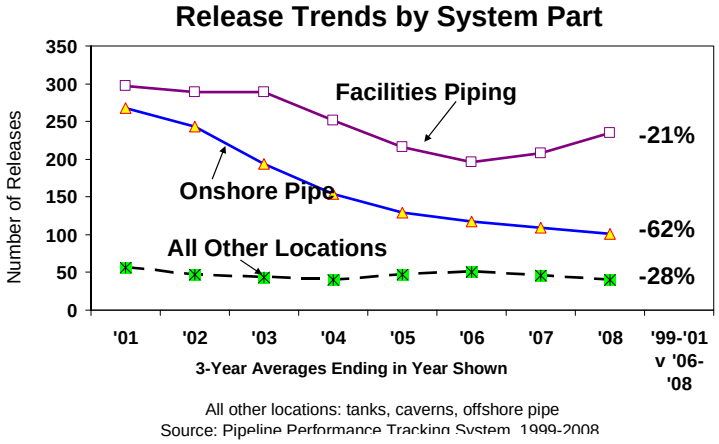
Facility releases account for more than half of the incidents in the hazardous liquids industry's Pipeline Performance Tracking System (PPTS). They are generally low consequence -- usually small in volume and contained on site. Each operator should consider the frequency and consequences of releases in its own facilities to determine its own course of action. Integrity management can be more complex for facilities than for mainline pipe on the Right-of-Way (ROW) due to the different functions the facilities serve and to the variation of equipment in service. Advancing previous work on this issue, the Operations Technical Committee (OTC) conducted a limited survey to clarify the causes and possible prevention strategies for certain facility releases. Operators of 57% of the mileage recorded in PPTS responded to the survey, which covered 6 distinct areas of concern: Dead Legs, Drain Lines, Relief Lines, Tubing/Small Diameter Piping, Valve Vault Design, and Facilities Inspection Practices. The survey captured operations practices as well as release information.

- About half of the 180 reported incidents involved tubing and small piping. Improper installation was one of the largest causes of these releases, and was the largest area of concern. Vibration was also a frequently reported cause. Minimizing the use of tubing and careful, quality installation of required tubing are essential to improving facility integrity.
- Almost half of the 180 incidents reported involved a fitting, not the pipe itself. Two thirds of incidents in both the tubing/small piping and the relief line category failed at the fitting. Thus, quality installation and periodic inspection of fittings can be important. This finding led PPTS and PHMSA to amend their accident forms to clarify when a fitting was involved, allowing tracking of this issue.
- Internal corrosion continues to be a problem in facilities, especially for tubing and small piping, dead legs, drain lines and relief lines, and particularly for crude operators. Water in a free state or in contact with certain transported commodities contributes to corrosion. In addition, microbial-induced corrosion (MIC) occurs at the interface between contaminants (sludge) and the transported product.
- Flushing low flow lines seems like a simple fix, but implementation takes more analysis. It is essential to understand the corrosion mechanism that may be at work. MIC must be monitored. Biocides and corrosion inhibitors may be required and their effectiveness confirmed. Each operator should determine the appropriate interval for flushing and examine other practices to use in tandem with flushing.
- Water also causes issues due to expansion in freezing conditions; so avoid potential water traps.
- Operators conduct facility inspections with great variability. Not all operators follow a documented protocol clarifying where and what inspectors should inspect. According to subject matter experts, the adherence to more standardized, comprehensive and documented inspections may be beneficial.
- Beyond inspection, facility integrity should cover design, operations and maintenance.
- Subject matter experts have contributed additional Considerations for Operators on page 9.

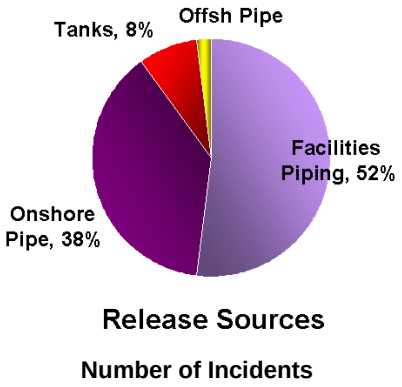
One lesson spans all of the findings: an operator can not learn from data that have not been collected. Operators should give thoughtful consideration to collecting data that goes beyond regulatory reporting. The incident record should include the specific component involved, as well as identify primary and root causes and human factors that can be addressed through training and education.

Overview

Facility releases continue to be a concern to pipeline operators. Recent release trends indicate that limited progress has been made in consistently reducing the number of releases inside facilities. While released volume is small compared to other types of releases, these incidents continue to represent a majority of the total.



The Operations Technical Committee was tasked with advancing previous work of the Performance Excellence Team and the Data Mining Team (DMT). The OTC/DMT Work Group decided to conduct a survey of PPTS participants to gain insight from details not contained in the current PPTS database.



PPTS Operator Advisories such as 2003-5, 2005-3, 2005-4 (www.api.org/ppts) and published studies such as PRCI Report *"Pipeline Facility Incident Data Review and Statistical Analysis"*[1] have focused on facilities as a primary target for performance improvement and identified broad areas of interest for further review. The data available in PPTS, however, did not have the necessary detail to support definitive conclusions on some aspects of these releases. Since facilities contain diverse equipment used for dissimilar functions – pumps, valves, meters, pipe, tubing, sumps, etc -- the goal was to divide facilities into smaller areas and explore detailed data for selected areas of interest.

This survey focused on 6 target areas; 4 from the Pipe category and 1 from Non-Pipe Components or Equipment, and 1 from inspection practices (not physical assets). The survey provided data that yielded some definitive conclusions and in addition reinforced some previously identified areas of concern.

The next area of interest in understanding releases from facilities piping and equipment will be failures involving pumps.

Survey Design and Response

The target areas for the survey were selected based on a combination of PPTS release data and experience of the OTC subject matter experts. For example, the PPTS data show "pipe or pipe seam" as the item type with the highest number of facility releases, but the data do not specify the function of different types of pipe, each of which would have different integrity issues. (Accident data filed with Pipeline and Hazardous Materials Safety Administration on a Form 7000-1 have similar gaps.) The Work Group's surveys collected data on practices and releases over the past 5-year period. The goal was to drill down to learn more about a selected subset of incidents that occur on a subset of equipment. The surveys specifically addressed:

- Tubing/Small Piping,
- Drain Lines,

[1] Prepared for Pipeline Research Council International by Kiefner & Associates and Allegro Energy Consulting, PR-218-08350; KAI Report # 08-123; December 2008.

- Dead Legs,
- Relief Lines,
- Valve Vaults and
- Inspection Practices for Facilities Piping and Equipment.

The surveys themselves are contained in the first file embedded below ("Facilities Survey for Advisory.xls 1"). They cover the use of selected practices appropriate to the specific survey target. The compiled results of the operators' practices for each module of the survey are available in the second embedded file ("Survey Practices for Advisory.xls 2").

Facilities survey for Advisory.xls

Survey Practices for Advisory.xls

The surveys also collected release-by-release information on the component's material and type (neither of which are covered in PPTS), and the PPTS Survey ID, if any, for access to the complete PPTS record. The inspection practices survey focused on the comprehensiveness, frequency, and technology employed for facilities inspections.

All of the OTC members (22 operators) were asked to complete each of the 6 surveys. A total of 11 operators participated. The survey respondents represent:

- 57% of PPTS mileage;
- 57% of PPTS pump stations;
- 41% of PPTS meter stations; and
- 60% of PPTS mileage that "could affect" an HCA.[2]

In addition, this survey included significant assets and facilities located in Canada which had the same integrity programs as those applied in the continental United States.

Respondents represent a mix of system types such as large diameter long distance lines versus smaller diameter shorter lines; and some that operate both. Transported commodities include crude oil, refined products and HVLs, with most operators transporting more than one commodity.

The facilities survey respondents gave details on 180 releases over the 2003-2007 period. About half of these incidents were also reported to PPTS. (Some of the releases were not reported to PPTS because they were below PPTS reporting thresholds or took place in Canada.) See Table 1 below.

[2] 49 CFR Part 195 requires hazardous liquids pipeline operators to classify each pipeline segment as one that "could affect" a defined high consequence area (HCA) or not. The HCAs include high population areas, other populated areas, commercially navigable waterways, "unusually sensitive areas" for drinking water or ecology.

Table 1 -- 2003-2007 Releases Reported on Facilities Survey		
Section	**Total Releases**	**Share by Section**
Dead Leg Piping	29	16.1%
Drain Lines	40	22.2%
Relief Lines	17	9.4%
Tubing and Small Piping	93	51.7%
Valve Vault Design	1	0.6%
Grand Total	180	100.0%
Source: Special survey of releases in facilities, 2003-2007. (Because there was only 1 incident relating to valve vault design, this category is not covered further in this Advisory.)		

Tubing and Small Diameter Piping Results

Tubing/small piping accounted for the largest number of incidents by far, at 93 of the 180, or 52% of the incidents identified in the survey. Two-thirds of these incidents involved a fitting and one-third the tubing or piping itself.

Tubing/small piping: 52% of the survey incidents, 2/3 of which involved the fitting…

For the purposes of this survey, the questionnaire on "Tubing and Small Diameter Piping" addressed piping used for instrumentation and small thermal relief connections: small diameter piping, tubing and threaded fittings (2" and less). Some highlights of the responses on the characteristics of this pipe and related practices:

- 9 of 11 respondents have written standards for material, pressure rating, installation and maintenance of these assets;
- Only 3 respondents depended on one manufacturer alone, one because of the quality of manufacture, one because of reliable installation and training support, and one because it was armor jacketed with steel fittings;
- 10 out of 11 respondents did not use any external coating or other protection; the 11th respondent uses the armor jacketed material;
- Inspection programs varied widely. No given type of program among those in the survey was used (or not used) by more than 64% (7 out of 11) of respondents. This may create an opportunity for practice sharing. The survey asked about the following programs [read each result as # out of 11 respondents]: inoperative instruments still connected/pressurized (no program=7); unused connections plugged/blinded off (yes, a program=7); differential movement causing strain (no program=6); non-conforming pipe material (yes, a program=6); proper supports (yes, a program=7); excessive length (yes, a program=6); excessive vibration (yes, a program=7);
- All respondents used tubing and small piping for sample collection, monitoring (pressure, temperature, e.g.), and pump seal flushing. Some respondents also used it for other purposes such as drain lines and relief piping.
- Respondents were asked their biggest problem (not their only problem) with respect to tubing/small piping. The largest number cited improper installation (5), followed by excess

Quality control during installation is critical to improving tubing/small piping performance…

vibration (2), corrosion (1), and outside force damage (1). Other available choices (but not selected by any operator) were freezing, mismatched equipment/materials and "other." Two operators did not provide an answer to the question.

Improper installation and vibration were not only identified by operators as their biggest problem, they were also key contributors to the releases submitted to the survey, together contributing to more than 1/3 of the incidents (40% of the incidents involving a fitting, and a lower share of those involving the piping itself). Many of these fittings are designed for "easy installation," but it is still possible to install them improperly if procedures are not followed. Additionally, care must be taken to ensure the piping is designed and installed in a manner that is not susceptible to vibration (e.g. unsupported lengths, heavy fittings on small piping, etc.) Most piping suppliers have installation best practices that should be considered during installation. Quality control during the installation of tubing and small piping is critical to improving performance in this area. Also important for failures involving the fitting were equipment failure (19%) and freezing (11%). For incidents involving piping/tubing, other important causes are corrosion (27%) and equipment failure (23%).

Drain Piping Results

The drain piping section of the survey had questions regarding design of drain lines and maintenance practices as well as questions about releases from drain lines. Ten of the 11 survey respondents completed the section on drain piping. All of the 10 responders use carbon steel for drain lines and slope the lines to prevent low spots. Six of the 10 use butt weld connections, three use threaded connections and one uses socket welds. Most operators that responded do not internally coat drain lines as a general practice. Threaded connections below grade are not allowed by 70% of respondents.

Almost half of the drain line releases occurred on the body of the pipe, not the fitting or connector.

Freezing (above ground) and internal corrosion (below ground) were the main contributing factors

There were 40 releases from drain lines reported on the survey. One release was from an HVL line, 18 were from crude lines and 21 were from refined products lines. Freezing and internal corrosion were the main contributing factors to the releases, with 10 and 9 releases respectively. Location of drain piping above- (21 incidents) or below- grade (16 incidents) showed a clear pattern with respect to the contributing factor: lines above ground had all of the freezing incidents while most of the internal corrosion incidents occurred on lines below grade. Unlike tubing and small piping where most of the releases occurred on the fitting, almost half of the drain line releases (18) occurred on the body of the pipe. There were 11 incidents at fittings and 7 more at connectors.

Mitigation of problems in drain lines will depend on the location and configuration of the lines. Aboveground lines need to be configured to prevent water traps or have water drained from the lines. Belowground lines should be monitored for internal corrosion. One typical mitigation technique is flushing of the line. Of the 40 drain line releases, 31 or 75% took place on piping that saw flow at least once a year. Because information is limited, so must our conclusions be: the only thing we can conclude is that flow at least annually – alone – does not seem to stop releases. Each operator will thus need to determine the appropriate interval for flushing and to examine other prevention practices.

Dead Leg Results

85% of dead leg incidents result from internal corrosion; 90% of these in crude oil systems

The definition of a dead leg for the purpose of this survey was: a line with no flow, low flow, or intermittent or occasional flow. Relief lines that would channel pressure from a mainline to a vessel in an overpressure situation would still be a relief line but it also could be considered a type of dead leg due to intermittent flow. The same could be true of drain lines. It is assumed for the purpose of this survey that the dead legs are not also relief lines or drain lines. There are characteristics in common, however, so a later section discusses some issues and mitigation strategies for these low flow/no flow lines.

Respondents to the survey indicated that 85% of dead leg incidents over the period from 2003-2007 were caused by internal corrosion. Five of eleven operators completing the survey reported dead leg incidents.

In 92% of incidents, the dead leg did not see flow at least annually

Dead leg piping accounted for approximately 16% or 29 of the incidents identified in the survey. Of these incidents, crude oil was the commodity in 26 (90%) of the incidents and refined product was the commodity in 1 (3%). No commodity was reported in the remaining 2 (7%) incidents. Of the 24 incidents where the frequency of flow was reported, 22 or 92% occurred on dead legs that did not see flow at least annually. (No information on the frequency of flow was reported in 5 incidents.) In one incident reported on this survey, the operator sampled the contents for MIC; this involved a segment that had not previously been identified as a dead leg. Among the incidents involving a previously identified dead leg, MIC sampling of the contents was not conducted.

- All 11 operators in this survey were actively trying to **identify idle/abandoned lines** that still contain product.
- **Periodic flushing** activities are performed on dead leg piping by 3 of 11 operating companies.
- The majority of operators perform **visual inspections (9 of 11) and NDT inspections (6 of 11) of above ground piping**.
- Half of the operators (5 of 10) reported performing **NDT inspections of below ground piping** with 1 operator not reporting below ground dead legs.
- Once a line is deemed a dead leg, 3 of 11 operators have a program that requires the **product to be removed** from the piping.

Relief Lines Results

Relief lines represented the fewest number of releases of any of the piping groups at 9%. One-third of the leaks were related to corrosion and another one-third were leaks from the relief valve itself. All but one of the corrosion leaks were internal corrosion, which was not a surprise given the typically stagnant nature of the product in this type of piping. One of the questions in the survey asked operators about flushing these lines. Very few operators regularly flush their relief lines (2 of 11) and while the data is not available to support a conclusion on the success of flushing, one of the operators that flushed their lines also experienced a leak. This indicates flushing is not necessarily the answer, but many subject matter experts would concur that it makes sense to perform a flushing activity more frequently than once per year (see Drain Piping Results). Ultimately, each operator needs to evaluate its system to determine the need for internal corrosion mitigation activities.

All but one of the relief line corrosion leaks were internal corrosion

The releases due to failure of the valve itself indicate additional attention to the valve may also be warranted. It was not possible to tell from the survey results if the valves involved in these releases were

subject to inspections by regulation or not. Regardless of regulatory requirements, operators are advised to include inspection of these valves as part of their integrity programs. (These incidents include those where the valve does not open or close on command, or opens or closes without a command. They do not include incidents where an individual might place or leave a valve in the wrong position.)

Low Flow and No Flow Lines in Perspective

Dead legs, drain lines and relief lines have a common denominator: the problems that come with limited, sporadic flow or no flow at all. Some of the strategies to manage the integrity of these lines are also common among them. Not all operators have dead legs and some may be in the process of eliminating them, because experience has demonstrated that they are susceptible to internal corrosion, particularly in crude oil service, and should be considered high risk. Operators should consider draining and isolating crude oil system dead legs that serve no further process purpose. A phase-out plan for systematically removing these dead legs could be developed. Importantly, however, drain lines and relief lines may also be essentially dead legs much of the time.

Table 2 –
Facility Inspections Survey Summary

Inspections of:	Respondents Performing
Alarms/Shutdown Systems	82%
Aboveground Piping	64%
Loading Arms/Hoses	64%
Small Piping/Connections	55%
Underground Piping	45%
Valves	36%
Pump/Seal Flush Systems	27%
Traps	18%
Sumps	9%

In the absence of a dead leg removal (drain and isolation) plan, flushing dead legs can reduce the internal corrosion threat. Ideally, dead legs should be flushed with fluids that contain biocide to inhibit microbial growth. Flushing dead legs with un-treated fluids can reduce the threat of corrosion by removing deposits and preventing microbial bio-films from becoming established. Caution should be exercised, however, as flushing can replenish the nutrient supply, which can exacerbate microbial growth. This should be taken into consideration when deciding upon a mitigation strategy. Unless removed, dead legs in all commodity types should be inspected at a prescribed interval appropriate to the corrosion risk. Inspections should be targeted at locations where water and deposits can collect, which allow microbial activity to develop (dependent upon the orientation and configuration of the pipe work).

Inspection Practices for Facility Piping and Equipment

The purpose of the facility inspection portion of the survey was to identify common operator inspection practices, and the breadth, depth and frequency of those practices. The questions also covered the technology employed.

The survey results indicate a wide variety of inspections practices are currently in place for facility piping and equipment within industry. The wide variety may be attributed to not only the varied regulatory requirements, but individual company standards and practices as well as practices resulting from past incidents. Table 2 (right top) is a survey summary of the percent of respondents performing inspections on various facility components and equipment. The release data in Table 1 suggest that facility inspection programs should give additional consideration to small piping, connections and underground piping. About one-half of the survey respondents are not performing any formal program inspections on these specific items. As expected, inspection techniques varied across operators but included pressure testing, guided wave ultrasonics (UT), Non-Destructive Testing (NDT), visual and other techniques.

Tubing/small piping accounted for 52% of the incidents, but only half of the respondents perform periodic inspections of them.

For above ground assets, the most common cause for drain line failures was damage from freezing. However, not all of the respondents include a winterization program/checklist in their facility inspection program. This indicates that a frequent, yet preventable cause of facility releases might be addressed by putting a Standard Operating Procedure (SOP) or checklist in place.

50% of respondents utilize a checklist for the periodic walkarounds

As the industry transitions to a less experienced workforce, it is critical to have well-documented operation, inspection and maintenance procedures. The survey indicated 82% of respondents have documented inspection and maintenance procedures for critical equipment and 72% of respondents indicate local operating instructions for equipment are available. However, only 46% of the respondents indicated facility drawings such as P&IDs, area classification, utilities, etc., including those for non-regulated facilities, were up to date. Finally, only 50% of respondents utilize a checklist for the periodic walkarounds performed by facility personnel.

46% of respondents have updated facility drawings.

In summary, there are many factors that influence spill performance at facilities. This limited survey has identified several improvement opportunities. Integrity testing and inspection alone will not ensure acceptable spill performance. Other considerations such as design and installation standards, operating and maintenance procedures, and employee knowledge and skill should be incorporated in the overall facility integrity program.

Facility Assessments in Perspective

While an integrity-related facility assessment focuses on potential release sources, a fully integrated program should encompass the entire functional and operational roles of a facility. It should include more than the consideration of integrity related equipment, components, and systems that have the potential risk of product release. While the use of integrity assessments alone may satisfy government requirements, it falls short of providing an overall picture of the current performance of the facility. A more thorough facility assessment should include a review of the equipment and components required for operation of the facility beyond integrity compliance. Considerations for safety, risk, reliability, maintenance, design, and equipment life, to name a few, should be included in the overall facility assessment. A well designed and structured predictive maintenance and assessment (audit) process is recommended to ensure adherence to the agreed upon processes.

This PPTS Operator Advisory examined some facility components' operational systems that contribute to failures at facilities. Facilities are unique to company designs and culture, construction era, technology, maintenance philosophies, function and the like. Therefore, the assessment of any facility should be adapted to the facility age and design.

Considerations for Operators

The facility assets discussed in this PPTS Operator Advisory present a number of challenges for integrity management. A release prevention strategy should evaluate risk avoidance where the items are designed away entirely, and risk management where threats such as the presence of water, vibration, and installation errors are mitigated. The opportunities for release prevention may be different for existing facilities relative to new facilities or those being significantly renovated. Some considerations for operators include:

- Where possible, eliminate the need for tubing through the use of electrical transducers or sensors. Where tubing/small piping is absolutely necessary, care should be taken to ensure proper installation and inspection according to manufacturer's recommendations. Configuration of the tubing should be designed to eliminate long runs, reduce or prevent vibration, and allow for periodic inspection.

- Although tubing and small diameter piping accounted for approximately 52% of the survey incidents, only half of the respondents perform periodic inspections. Inspection of tubing/small piping, especially at the fittings, for correct installation, tightness, and excessive vibration should be considered as part of a facility integrity program.
- Water can be a problem in drain lines – in fact, in any lines with limited, sporadic flow. Work to eliminate accumulations of water in the design of drain lines. For existing above ground lines, freeze protection should be considered. Injection of biocide and/or corrosion inhibitors should be considered for lines with potentially corrosive product. Experience says threaded connections are most at risk from freezing and corrosion.
- For dead legs, the first step, particularly in crude systems, is to identify them. If possible, reconfigure piping to effect removal of a dead leg. If it is not possible to remove the dead leg, it may be necessary to take a series of steps such as draining the segment, isolating it from other piping, flushing/treating it in a carefully designed program that considers different corrosion mechanisms and appropriate intervals for treatment, and finally, inspecting the identified dead leg at defined intervals using an internal inspection technique such as UT checks of low spots, guided wave ultrasonic inspection, or intelligent pig tools.
- For relief lines, where limited, sporadic flow is again an issue, operators may need to flush the line periodically. They may also consider some type of internal inspection of the line, or external UT of the line walls, especially when potentially corrosive products have been in the line. In addition, operators need to test and inspect relief valves to assure that they are working properly.
- Operators should carefully develop a facility inspection program that goes beyond regulatory compliance and includes design, maintenance, operation and other relevant considerations as well. Operators should perform periodic walkarounds of the their facilities. A standardized checklist for these walkarounds should be used not only to document the inspection but also to ensure facility personnel are focused on identifying relevant issues to prevent and/or mitigate facilty incidents.
- Operators should consider developing internal incident reporting procedures that collect and document specific details on items involved in failures and should strive to conduct thorough investigations to determine primary and root causes beyond the results or symptoms of failures.

The hazardous liquids pipeline industry undertook a voluntary environmental performance tracking initiative in 1999, recording detailed information about spills and releases, their causes and consequences.

The pipeline members of the American Petroleum Institute and the Association of Oil Pipe Lines believe that tracking and learning from spills improves performance, and demonstrates the industry's firm commitment to safety and environmental protection by its results.

This is one in a series of Advisories based on the Pipeline Performance Tracking System, "PPTS."

NOTE: The "Considerations for Operators" in this document represent the experience of a limited number of subject matter experts from a variety of liquids pipelines operators. They were not developed under the process prescribed by the American National Standards Institute and do not represent a Standard or a Recommended Practice of the API or its member companies.

Find this and other Advisories drawn from the hazardous liquid industry's Pipeline Performance Tracking System at www.api.org/ppts.