

The petroleum pipeline industry has undertaken a voluntary environmental performance tracking initiative, 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 will improve performance, thus demonstrating the industry's firm commitment to safety and environmental protection by its results.

This is one of a series of fact sheets about the Pipeline Performance Tracking System, "PPTS," its evolution and its lessons.

PPTS OPERATOR ADVISORY: REFINED PRODUCT RELEASES REQUIRE NEW STRATEGIES FOR CONTINUED IMPROVEMENT

Refined Product Pipeline Releases, 1999-2004

This Advisory is one in a series covering each of the main commodity types recorded in PPTS, refined products, crude oil and highly volatile liquids (HVL). It covers the release performance, including human safety and environmental consequences, the top causes of releases, and significant role of equipment failures and operator error.

Using the principle that risk is a function of frequency *and* consequences, this Advisory evaluates the incidents and system characteristics according to the frequency and the relative consequence. Thus, high frequency events, even those with low consequence, may present the same environmental, health and safety risk as the low frequency/high consequence events. In addition, high frequency/low consequence events may be precursors to large (high consequence) events.

The location of pipeline releases is an important factor in assessing risk. Spills occurring on the right-of-way, for example, tend to be larger and to have a greater impact on the surrounding community, on its environment, and potentially, on its public safety. In contrast, spills inside the facility fence tend to be smaller, and have lower impacts on the surrounding community, but may put employees and contractors at risk.

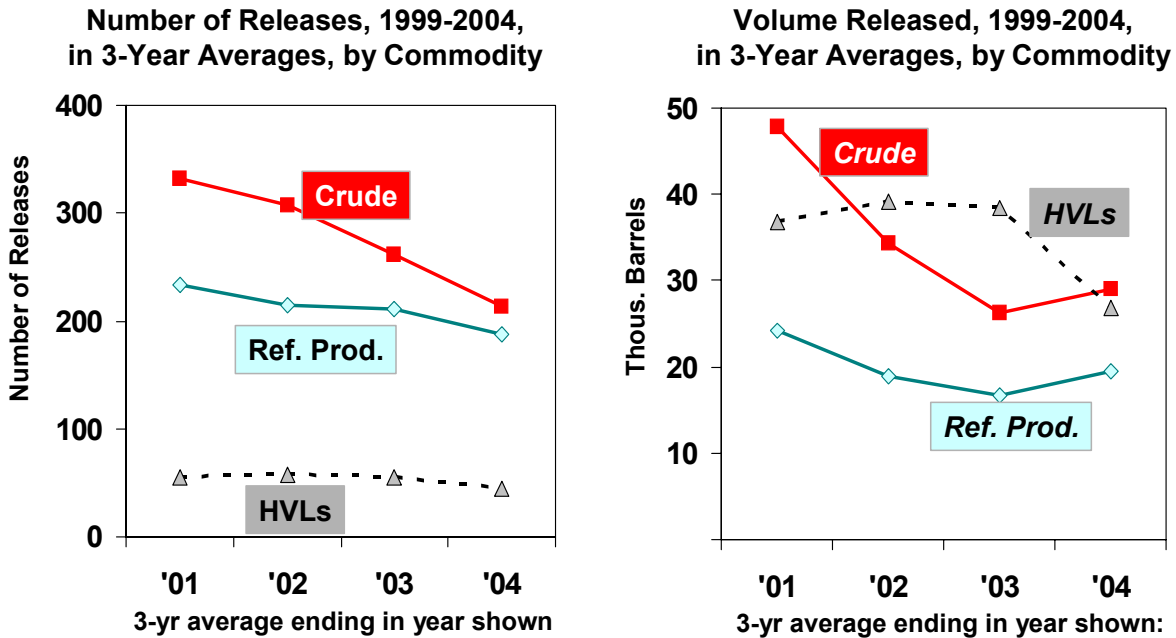
Refined Products Releases Fell 20%; Rate of Progress Has Slowed

Releases from refined products systems account for 40% of the number of incidents occurring on all commodity systems over the 1999-2004 period. As shown in the graph on the left on the next page, refined product incidents fell from an average of 233 over the 1999-2001 period to an average of 188 over the 2002-2004 period, a 19% decline. On a year-to-year basis, the decline was twice as large, 37%, from the 1999 high to the 2004 low. (The graphs use 3-year averages to smooth out the sharp spikes that may occur year-to-year.) As illustrated below, these refined product releases account for only 24% of total volume released in the same period. Refined product volumes were consistently the lowest of each of the three main commodities (the others are crude oil and HVLs such as propane).

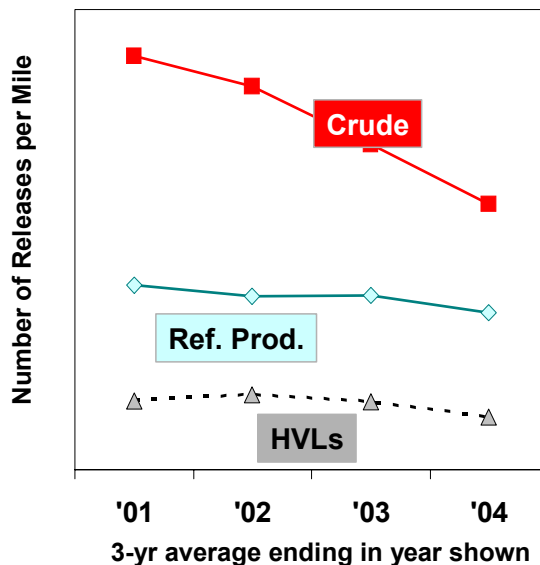
While PPTS operators represent about 85% of the U.S. oil pipeline mileage, a comparison of the absolute number of incidents by commodity does not tell the complete story. The commodities have different amounts of mileage. For instance, Refined Products mileage is about 50% higher than Crude Oil and 40% higher than HVL. Therefore, it is useful to put the record in further context by calculating the record on a per mile basis. (See graph¹, next page.) The record of the refined products systems is even better, relative to crude oil, on a normalized (per mile) basis.

¹ The graph showing the spills per mile intentionally does not include a scale on the y-axis. Performance per mile is available to PPTS participants only.

However, the crude oil record *improved* at a far higher rate over the period. This is clearly due to the unique role of corrosion in the crude oil systems, where the incident rate was high, and could be improved with intensive integrity management programs that smart pig and repair the lines.



Pattern of Releases Reported to PPTS, 1999-2004, per Mile, by Commodity



In light of the apparent plateau in the spill performance for refined product systems, it is possible that the strategies to move to the next, lower level (such as that currently experienced by HVL lines) are fundamentally different from those historically employed. They may involve new technology, innovative practices or a mix of other tactics.

Bigger Releases Drive the Volume. Smaller Releases Drive the Number

The absolute number of refined products incidents reported annually has fallen from 261 in 1999 to 164 in 2004, a 37% decline, with the majority of the decline coming in small releases, those less than 5 barrels. Small releases account for 69% of all spill events, but only less than 1% of volume. In contrast, the number of large releases, those greater than 50 barrels, has stayed relatively constant. Large releases (≥ 50 barrels) account for 13% of number of incidents, but 96% of volume. Thus, operators must continue to focus on reducing both large and small spills. However, to reduce the environmental and public safety consequences attached to oil pipeline incidents, operators must particularly focus on the circumstances surrounding these large releases.

In addition, of all 1,264 incidents involving refined products systems over the period, there are 58 that are 500 barrels or larger. These releases account for about 5% of the number, but accounted for 80% of total volume released (106 of 132 thousand barrels). Based on the *number* of incidents, the leading causes of incidents involving the release of 500 barrels or more are third party damage (TPD), corrosion, and pipe/tank material/seam failures. Based on the *volume spilled*, the leading causes of incidents involving the release of 500 barrels or more were corrosion, TPD, and “other.” These very large events – often headliners – carry the heaviest consequence in terms of public safety (death, injury, fire, explosion, and evacuations), environmental impact (impacts to water and other natural resources), and, importantly, public trust.

Refined Products Pipelines Pose a Greater Risk to Public and to Operator Safety

Out of 1,264 refined product incidents from 1999 to 2004, there were 32 incidents that resulted in some type of public safety impact such as evacuation, fire, injury, death or any combination thereof. 16 of the 32 incidents – half of them -- were evacuation only and of those 16 evacuations, 4 were precautionary only. Eight of the 32 involved only a fire. The other eight involved some combination of events.

Over this period, five refined product incidents resulted in a total of 8 deaths and 14 injuries, the highest totals among the three commodity categories. Two of these incidents caused all 8 deaths and 11 of the injuries, all of whom were non-pipeline-operator personnel. Both incidents were caused by third party damage on the pipeline right-of-way. Also, in each of these incidents, the spilled volume was greater than 500 barrels and caught fire. The three other incidents each injured one person either working for or contracted to the pipeline operator; all three occurred within pipeline facilities.

These data suggest that the general public is most at risk of death or injury from large spills caused by third party damage while pipeline workers encounter the greatest safety risk inside or near pipeline facilities.

Pipe versus Facilities: Location, Location, Location

For refined products, the majority of spills (62%) occur inside the facility fence from piping or equipment. These releases, however, accounted for just 13% of the volume spilled. Spills occurring on the onshore pipe right-of-way account for 28% of the total number, and 72% of the volume, reflecting the fact that these right-of-way releases tend to be larger than those inside facilities. Two-thirds of the incidents involving a release of 50 barrels or more, for example, come from onshore pipe. They are also higher consequence, as discussed in more detail below. These two system locations, then, account for 90% of the incidents and 85% of the volume released. (Spills from refined product tanks and other parts of the system accounted for the rest.)

Environmental Consequences: Larger Incidents on the Right-of-Way

When assessing the environmental consequence of releases, the PPTS comparison is usually limited to spills of 5 barrels or more, or incidents involving death, injury, fire or explosion, because PPTS participants provide vastly more detail on these “Long Form” releases for all aspects of the PPTS questionnaire. For environmental consequence information, the comparison is further limited to 2000 onward; after the first year of PPTS, 1999, it became apparent that certain clarifications to the consequence questions on the form were necessary.

As discussed below, both spill size and system location are important in describing environmental consequences: large spills and onshore pipe spills have consequences more frequently, as shown in the table below. These characteristics underscore the importance of careful risk-ranking in addressing spill prevention.

The PPTS report form captures water impacts (surface water, groundwater, ocean, drinking water and the special subset of drinking water sources classified as “unusually sensitive areas,” as well as the shutdown of water intakes for surface water and groundwater wells), ecology impacts (vegetation, fish, birds, other ecology), and impacts to soils.² It also records information on remediation activities.

As shown in the table, 85% of the 316 “Long Form” refined product releases have no ecology impacts as recorded in PPTS. The opposite side of the same coin, of course, is that 15% of refined product releases do have ecology impacts. The table further illustrates that the impacts occur more frequently with large spills (21% for spills of 50 barrels or more), and more frequently still with large releases from onshore pipe (30%). In general, impacts to ecology are low inside facilities (5% of incidents); this is by design, because facilities are constructed to control and mitigate the impacts of any release. The ecology impacts most frequently involve vegetation (35, or 11%, of the “Long Form” incidents over the 2000-2004 period), but seldom fish, birds or other ecology resources. For instance just 4 refined product incidents had an impact on birds over the 2000-2004 period.

Environmental Consequences of “Long Form” [*] Refined Product Releases, 2000-2004								
			Impacted Ecology?		Impacted Water?		Impacted Soils?	
Location	Spill Size	Number	No	Yes	No	Yes	No	Yes
All System Parts	<50 Bbls	187	90%	10%	80%	20%	23%	77%
	>=50 Bbls	129	79%	21%	64%	36%	16%	84%
	Total	316	85%	15%	73%	27%	20%	80%
Onshore Pipe	<50 Bbls	57	81%	19%	72%	28%	18%	82%
	>=50 Bbls	86	70%	30%	57%	43%	12%	88%
	Total	143	74%	26%	63%	37%	14%	86%
All Other System Parts	<50 Bbls	130	94%	6%	83%	17%	25%	75%
	>=50 Bbls	43	98%	2%	77%	23%	26%	74%
	Total	173	95%	5%	82%	18%	25%	75%

“Long Form” includes releases of 5 barrels or more, or involving death, injury, fire, or explosion. The “Long Form” includes extensive detail not available for smaller spills.

² The PPTS report form does not capture air emissions.

The pattern with water impacts is similar, but impact to water is more common than impact to ecology. Overall, 27% of the 316 releases involved an impact to water. The frequency grows to 36% for releases of 50 barrels or more, and to 43% for large releases from onshore pipe. Again, the facility impact is low because of where the facility is, and because parts of many facilities, by design, have containment systems to protect the environment. Surface water is most commonly impacted, 19% of the total incidents, and 29% of large releases along the right-of-way. Groundwater is the second-ranked type of water impact. Drinking water was impacted in just 3 incidents over the 5 year period, all of them large spills, and all of them occurring on the right-of-way. No incident impacted a drinking water source classified as “unusually sensitive.” Likewise, few incidents necessitated the shutdown of an intake for surface water (3) or a groundwater well (2), neither of which is necessarily related to drinking water.

Soils impact is quite common in refined product incidents, particularly those occurring along the right-of-way (86%). Even inside facilities, 75% of incidents involve an impact to soils.

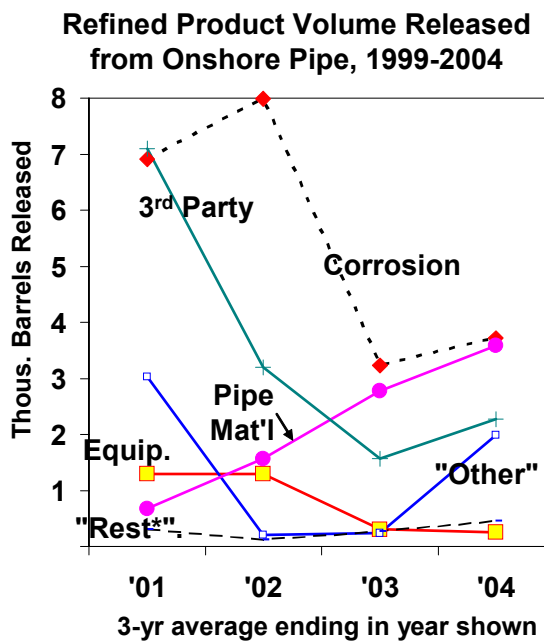
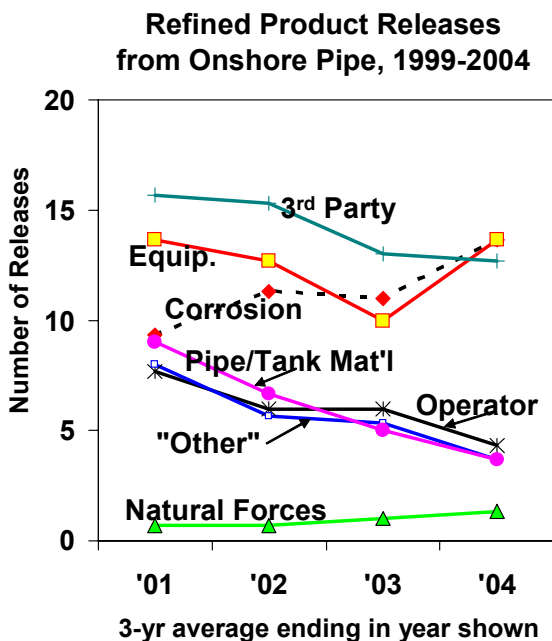
For Long Form releases, PPTS requests information on all corrective actions taken. Corrective actions taken or required were determined on a case-by-case basis and were taken for a majority of the releases with any reported impacts. Actions can range from excavation and haul-off to long-term onsite remediation activities such as pump-and-treat systems.

Refined Product Releases from Onshore Pipe Have Been Low throughout the Period, but the Trends Point to Challenges for Operators.

For onshore pipe, the top three causes over the period are third party damage (24%), equipment/non-pipe (23%) and corrosion (20%). The top three causes of releases based on the volume released are corrosion (34%), third party (30%) and at a distant third, “other” (16%).

The shares are just one part of the story. Trends in causes are instructive, and relate back to the very low number of incidents in refined product systems. An increase of even one, two or five incidents *nationwide* can shift the apparent record. For instance, in the 1999-2004 period, not even 20 incidents have been attributed to a single cause in any year. In the later period, 2002-04, there are four causes, including operator error and pipe/tank material/seam, which did not record more than 6 failures in a year. Thus even one incident makes an appreciable difference in the year-to-year pattern.

Even with the low absolute numbers, the trends point to some challenges for operators. For instance, the trend in the number of corrosion-related spills has actually been upward (see further discussion below). The corrosion-related volume has declined substantially, but partly because one 13K barrel spill in 2001 skews the data in the early period. Excluding that spill’s volume, the volume reflected in the 3-year averages has risen. Another challenge is the fact that while incidents involving pipe/tank material/seam failures have declined steadily – there were fewer than 5 in each year from 2002-2004 – the volume has shown an upward trend. Better news for operators is that incidents caused by operator error have declined both in number and in volume. The number of incidents involving equipment-related failures has shown an uneven year-to-year pattern, but the volumes have declined steadily. Thus, risk-ranking would suggest that these failures may not be the highest priority.



Third Party Damage and Corrosion Pose a Triple Threat for Releases from Onshore Pipe: Number, Volume and Consequences.

The fact that third party damage is a leading cause of the number of releases as well as a major contributor to the volume released indicates there is additional work to be done to mitigate this risk. Nearly half of the onshore pipe releases of 50 barrels or more involved third party damage. Corrosion, also, contributes significantly to both the number and the volume released. One-quarter of all onshore pipeline spills of 50 barrels or more involved corrosion. Thus, these volumes are not due to just a few isolated large incidents. Furthermore, TPD was involved in all of the fatalities and most of the injuries that occurred on refined products pipelines. Thus, the industry’s focus on these incidents remains justified.

The pattern for corrosion-related releases bears particular mention. While corrosion spills are relatively infrequent, their number has shown a slow upward trend, albeit from a small base. As noted above, refined products pipelines have had a low incident rate throughout the period. Their operators began using internal inspection prior to the 2001 regulation on managing integrity in high consequence areas. Still, the absence of a downward trend suggests that the operators must ask what they should do differently. Is there a limit to the improvement that is attainable with current technology and practices? Using the simple corollary that you can’t expect to get different results if you continue to do the same thing, operators should consider whether research and development of new technology should be deployed and/or that the industry needs to change practices to reduce corrosion spills further. (See box on “ILI: A Complex Process.”)

ILI: A Complex Process

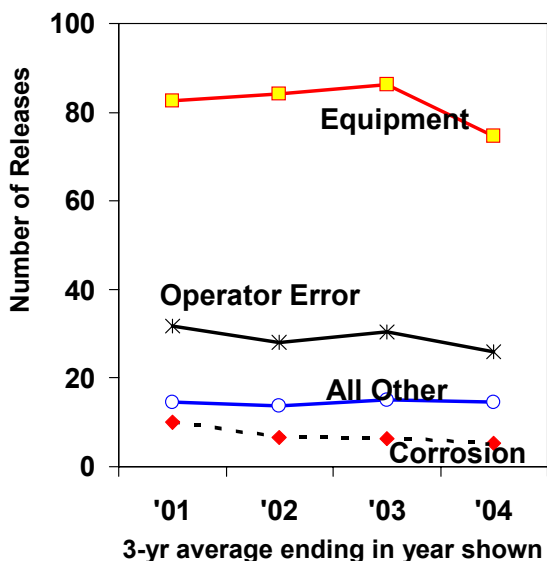
While ILI is a useful tool to reduce spill events, external corrosion is still a factor on internally inspected lines. Of the external corrosion-related spills from 1999-2004, more than half – 20 incidents – occurred on segments that had been smart pigged with a tool designed to find external corrosion, and 15 of the 20 – almost 40% of the external corrosion total – had been smart pigged with such a tool within the previous 5 years. This suggests that operators should examine each step of the process for using ILI tools to find where improvements can be made.

Four selective seam or seam-related corrosion incidents contributed to over half of the total volume of all corrosion releases. However, seam-related failures overall are low in frequency but because the failure mechanism is usually by rupture rather than leak, they tend to be large.

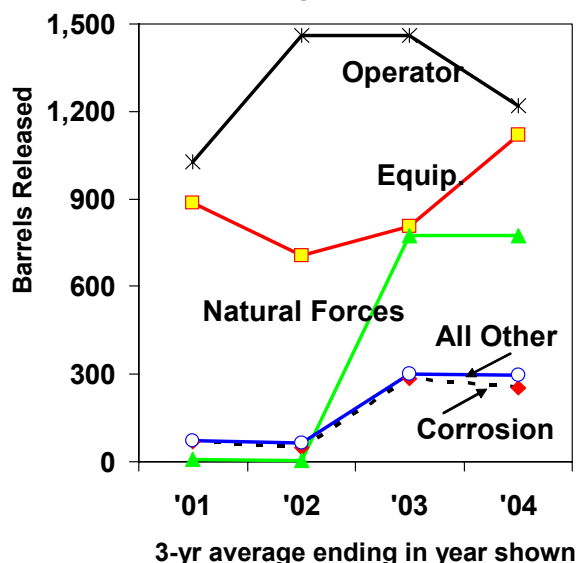
Releases Caused by Equipment and Operator Error Represent the Greatest Opportunities for Improvement at Facilities

The causes of onshore pipe spills are different from the causes of spills inside facilities, so strategies to mitigate risk must be different. In facilities piping, equipment and non-pipe failures cause 61% of the incidents. Trailing at a distant second is operator error, which causes 22% of the incidents. Corrosion-related releases are a small share of facilities piping releases. The category “all other” causes is a combination of pipe/tank material/seam, natural forces, third party damage, and the submittals that were classified as “other” cause. In recent years, each of these causes had fewer than 10 releases attributable to them annually.

Number of Refined Product Releases from Facilities Piping & Equip., 1999-2004



Volume of Refined Product Releases from Facilities Piping & Equip., 1999-2004



The converse of the point made earlier – onshore pipe has a higher share of large releases – is that facilities piping has a higher share of small releases. The total volume released from facilities piping over the 1999-2004 period is equal to about one-sixth the volume that was released from onshore pipe, while the number of incidents for facilities piping is more than twice the number of incidents for onshore pipe. Average spill size for facilities piping is 22 barrels, and for onshore pipe, 269 barrels; 80% of facilities piping releases are smaller than 5 barrels, and only 5% are 50 barrels or larger. The small spill size is particularly prevalent with equipment failures, where their volume accounts for just 34% of the volumes released in facilities. Facilities piping releases result in relatively low environmental and public safety consequences. Still, rare large releases may provide important lessons for spill prevention. In addition, risk management principles dictate that high frequency/low consequence events can present a high overall risk that could be addressed through preventive and mitigative measures.

Another motivation for pipeline operators to address equipment failures in facilities is increased productivity. Equipment releases most commonly involve valves and pumps. Pump equipment

is critical for the operation of any pipeline yet has a disproportionate rate of releases when compared to the number of valves in a typical facility.

Inside facilities, there were 7 internal and external corrosion releases. The largest release, at 725 barrels, was caused by internal corrosion. Internal corrosion releases inside facilities are likely due to low- or no-flow piping that creates a corrosive environment.

Considerations for Operators

The data presented above demonstrate that the frequency of refined product releases is low, but has fallen only modestly in recent years. While some elements have shown marked improvement, others have not. To move off the performance plateau and toward the goal of zero spills, therefore, operators of refined products systems may need to look to new strategies or to apply current strategies in a different manner. Among the considerations for operators:

- ❖ To protect the public, address the issues surrounding high volume, high consequence releases. The very large events carry the heaviest consequence in terms of public safety, environmental impact, and public trust.
- ❖ Continue to focus efforts on prevention of releases from onshore pipe, as these tend to be large, and tend to have the highest consequences.
- ❖ Investigate all failures thoroughly to understand the root causes and implement measures to prevent recurrence in other parts of the system.
- ❖ Evaluate the operator’s total process for using ILI technology and integrating its data. Is the choice of tools sound? Is the data interpretation robust? Are the dig criteria matching the results found in the ditch? Is the dig finding each target on the dig list? Is the data integration effective?
- ❖ Integrate the evaluation of the ILI process into root cause analysis.
- ❖ Consider whether there is a need for new technology or new practices, or both.
- ❖ Evaluate whether operations practices employed in HVL transport could improve the performance of refined products systems.



For additional information on PPTS and its lessons for the oil pipeline industry, please see www.api.org/ppts/. Click on the “documents” link in the left frame to see other Operator Advisories. Of particular interest for refined products operators will be the following:

Title	Date	Number
PPTS Operator Advisory: Overview of Incidents Occurring on Facilities Piping and Equipment	June 2005	2005-3
PPTS Operator Advisory: Facilities Piping and Equipment: Focus on Items Involved and Causes of Incidents	June 2005	2005-4
PPTS Advisory for Operators: Integrating ILI Use and Lessons	March 2003	2003-2