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.

This is one of a series of Advisories about the Pipeline Performance Tracking System (PPTS), its evolution and its lessons.

PPTS Advisory for Operators:

A Look at Operator Error or Other Incorrect Operation

A Continued Worker Safety Issue

Operator error accounted for 14% of all incidents and 10% of the spill volume reported to the Pipeline Performance Tracking System from 1999 to 2006. While the data indicate that operator error incidents tend to be smaller in volume and less common than other categories, the consequences can be serious:

- ❖ Operator error is the leading category for harm to company employees and the sole cause for harm to contract workers.

- ❖ Operator error incidents account for 77% of all incidents resulting in an injury to a pipeline worker and 66% of all incidents resulting in a fatality of a pipeline worker.

- ❖ Seven of the operator error incidents resulted in 2 fatalities and 10 injuries.

Incidents related to operator error are often directly under the operating company's control. While operator error incidents are caused by an individual's actions, the individual's performance of these tasks is often a reflection of the operating company's culture, policies, and procedures. When appropriate, operating companies should delve deeper, using root cause analysis during incident investigations to uncover underlying drivers that can lead to operator error incidents.

Considerations for Operators

- ❖ Reduce or eliminate situations that provide an opportunity for operator (human) error to cause a failure throughout the pipeline lifecycle: design, construction, operations, maintenance, and deactivation.

- ❖ Consider cultural, policy, and procedural factors that may contribute to incidents involving operator error (*e.g.* management of change, quality assurance/quality control, employee training and experience, selection and use of contractors, etc.).

- ❖ Plan for the changing work force: as experienced personnel retire or move on and are replaced by less experienced personnel, the opportunity for operator error could increase without appropriate training for these personnel.

- ❖ Analyze abnormal events and releases using root cause analysis methods to expose possible operator errors.

- ❖ Communicate lessons learned from incident investigations and periodic reviews of operations and maintenance practices and procedures throughout the organization to maximize opportunities for learning.

- ❖ Plan particularly carefully for unusual operations and one-time events. Develop and review detailed work plans with subject matter experts through a Process Hazard

Analysis, HAZOP, or management of change process to help reduce the risk of unfamiliar situations.
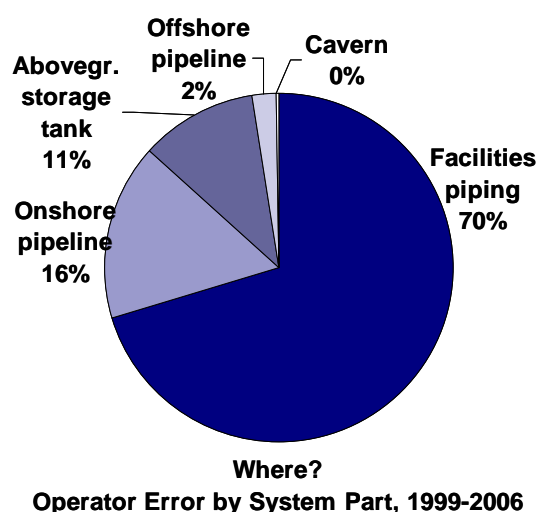
Operator Error Basics

Who & What
As used in PPTS, operator error refers to actions of an individual. This includes everything from accidental spills associated with removing a smart pig to mistakes made due to lack of experience or training to poor decisions by control room operators. It also includes incidents resulting from actions by company employees or contract employees during excavation, sometimes called first- and second-party damage.

Location
Operator error releases overwhelmingly take place in facilities piping. Seventy percent (70%) of all operator error incidents take place in facilities piping and another 11% involve storage tanks while only 16% affect onshore pipelines (the right-of-way or ROW).

The distinction is important because releases along the ROW impact the public more directly through pollution, inconvenience, strains on the infrastructure, and even the potential for bodily harm. The good news is that not only is the share of releases that occur along the ROW relatively low, but also that the number of releases due to operator error along the ROW has shown more sustained declines than the overall operator error record.

**Where?
Operator Error by System Part, 1999-2006**

Size
Operator error releases tend to be very small. Seventy-five percent (75%) of these incidents result in a spill of less than 10 barrels and the median spill size is just over 1 barrel.

Commodity
Operator error accounts for a larger share of refined products releases (19%) and a smaller share of HVL releases (6%) than would be expected from the 14% overall share of incidents. Operator error accounts for 11% of crude oil releases, which is in line with the overall share.

Operator Error – A Trend to Reverse

From 1999 to 2006, 530 incidents, or 14% of all incidents, were reported as operator error. Overall, operator error incidents have averaged 66 incidents per year ranging from a high of 121 incidents in 1999 to a low of 37 incidents in 2004. Since the low in 2004, the number of operator error incidents has been on the rise, with 45 in 2005 and 62 in 2006. There has also been an increase in the percentage share of operator error incidents compared to other causes and in 2006 the percentage share returned to the same share as 1999 -- 18%, up from a low of 10%.

In facilities, operator error incidents have declined significantly in only 2 years, and in 2006 were at about the same level (45 incidents) as they were in 2000 and 2001. Along the ROW, in

contrast, the number of operator error releases has declined by 53% between the 1999-2001 average and the 2004-2006 average. Furthermore, there was a decline in each successive period. Thus, while continued improvement along the right-of-way is imperative, the real focus of efforts to eliminate operator error incidents is facilities piping.

Operator Error Detail from the Long Form: What happened, Who was Involved

Until 2007, releases of less than 5 barrels or releases that did not involve a death, injury, fire, or explosion were reported on the "short form," which provided very limited information to PPTS. The detailed information – equipment involved, consequences, etc. – was only required on larger and more consequential incidents. This was changed in 2007 and now operators provide full detail on all incidents.

Of the 530 operator error incidents, 180 qualified for the "long form." For operator error incidents specifically, the long form asks what type of failure occurred and whether a direct employee or a contractor was involved.

Of these 180 incidents, 59% involved a direct employee of the operating company and 24% involved contractors (8% didn't know). The remaining 9% involved tank overfill incidents that, under old navigation in the PPTS system, did not include asking the "who" question.

Of the incidents involving direct employees, 41% were reported as "other human error." There is a further discussion of these incidents later in this advisory. "Valve left or placed in the wrong position" also accounted for 41% of incidents involving direct employees.

The involvement of a direct employee versus a contractor is a reflection of the task being performed and where it is performed. Of the incidents involving contractors, 50% were reported as excavation damage, and of the incidents along the ROW, 55% involved contract employees. This is consistent with the fact that excavation along the ROW routinely involves contract crews.

> **From 530 to 180:**
> **Characteristics of Higher**
> **Consequence Incidents**
>
> When looking only at the incidents that required the long form, over 70% of the incidents get dropped out of the data set and the distribution of incident location and commodity changes. The facilities percentage share is decreased from 70% to 60% and the ROW (onshore pipeline) share increases to 23% from 16%. On the commodity side, about 1/3 of the crude oil and refined product releases qualified for the long form while over 70% of the HVL releases qualified for the long form! This shows that many of the facility releases were less consequential, while more of the ROW incidents had greater consequences. And while there are not many HVL operator error releases, the majority of them have greater consequences.

Overwhelmingly, valves are the item involved in operator error incidents. This makes sense since a majority of the reports list "valve left or placed in the wrong position" as the mode of failure.

For all of the points mentioned above, see the graphs on the next page.
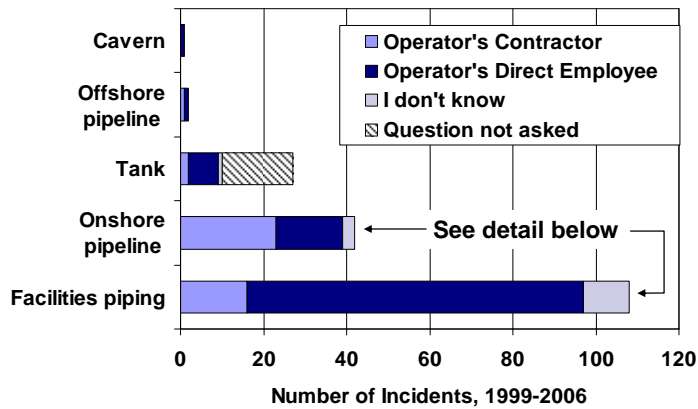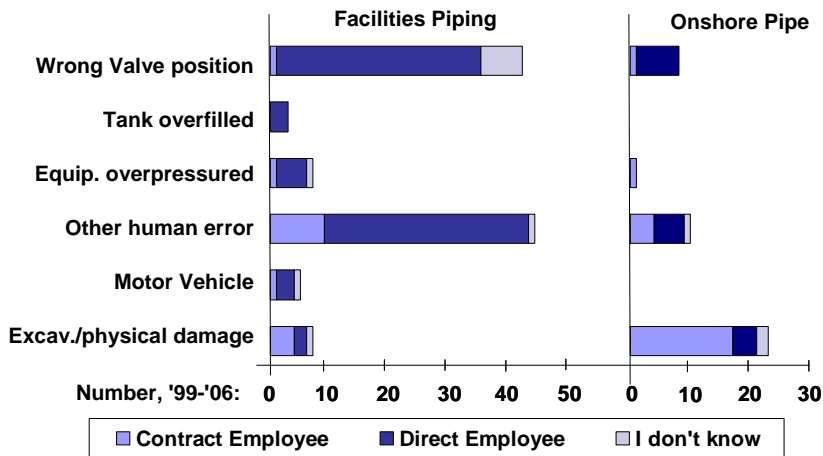
High Consequence Operator Error Releases

Operator error incidents tend to be small facility releases; however, a small share of the incidents was greater than 2,000 barrels and 2 were over 10,000 barrels.

Operator error also causes the majority of operator or contractor injuries and fatalities. Since PPTS began collecting data in 1999, 7 incidents attributed to operator error have resulted in 2 fatalities and 10 injuries. Both fatalities and 6 of the 10 injuries were contract personnel working for the pipeline company; the remaining 4 injuries were direct employees.

Where Did It Go Wrong; Who Was Involved

Legend:
- Operator's Contractor
- Operator's Direct Employee
- I don't know
- Question not asked

Categories (top to bottom): Cavern, Offshore pipeline, Tank, Onshore pipeline, Facilities piping

See detail below

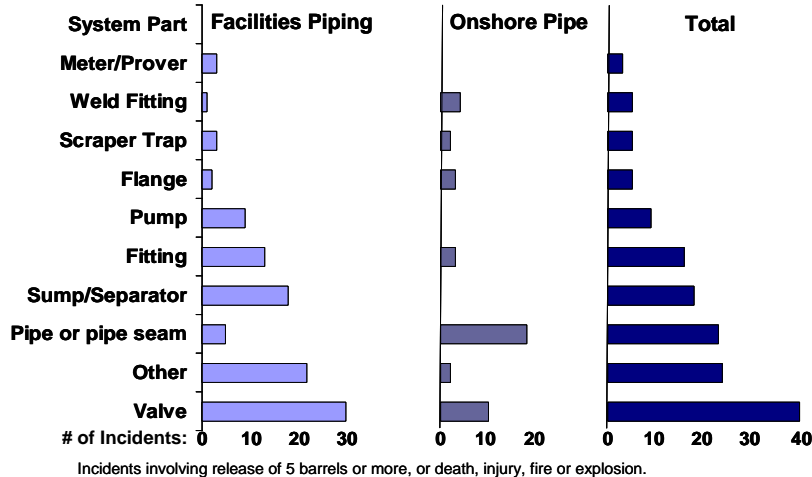**Number of Incidents, 1999-2006**

Incidents involving release of 5 barrels or more, or death, injury, fire or explosion.

Detail for Facilities Piping and Onshore Pipe: What Happened; Where; Who

Facilities Piping — **Onshore Pipe**

Categories (top to bottom): Wrong Valve position, Tank overfilled, Equip. overpressured, Other human error, Motor Vehicle, Excav./physical damage

Number, '99-'06:

Legend:
- Contract Employee
- Direct Employee
- I don't know

Incidents involving release of 5 barrels or more, or death, injury, fire or explosion.
Excludes incidents occurring on aboveground storage tanks, caverns and offshore pipe..

What Equipment; Where

System Part — **Facilities Piping** — **Onshore Pipe** — **Total**

Categories (top to bottom): Meter/Prover, Weld Fitting, Scraper Trap, Flange, Pump, Fitting, Sump/Separator, Pipe or pipe seam, Other, Valve

# of Incidents:

Incidents involving release of 5 barrels or more, or death, injury, fire or explosion.
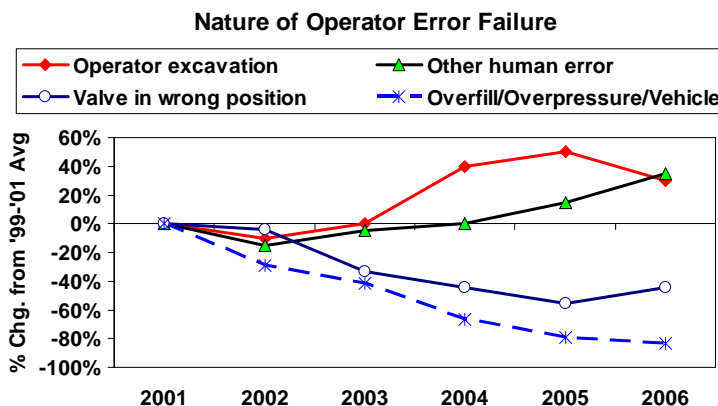
The 2 fatalities occurred during 2 different incidents on the right-of-way of HVL systems. Each of the 2 fatality incidents was associated with a release of less than 5 barrels. So, small releases, especially small HVL releases, can be VERY serious. It is critical that people working on HVL pipeline systems understand the unique physical characteristics of HVLs, how the different commodities act during and after a release, and, therefore, safe handling practices for them.

A Word on Contractors and Serious Operator Error Incidents

Of the 7 operator error incidents involving injuries or fatalities, 5 (72%) were caused by the actions of contract employees. Three of these 5 incidents took place on the right-of-way and 2 took place in facilities. A few different things could account for this disproportionate representation of contractor involvement in serious incidents. Contractors are often used for project-related work where more unusual or one-time operations are done. Also, contractors might not be as familiar with the assets as the operators, which could lead to wrong assumptions or mistakes. Contractor safety management should be an important part of any work involving contract employees. In particular, contractors used regularly for routine maintenance are different from contractors used for project work. Companies might consider handling the different types of contractors in different ways.

Two Modes of Failure to Explore

While progress has been made in some categories of operator error, there is room for improvement. This chart shows all the choices (modes) for describing Operator Error and the percentage change above or below the 1999-2001 average. The modes of failure of motor vehicle, overpressured equipment, and tank overfills have fallen by about 80% from the earliest period to the most recent periods. In fact, there have been no motor vehicle incidents since 2003 involving

Nature of Operator Error Failure

Uses 3-year averages ending in year shown. Includes incidents of 5 barrels or more, or involving death, injury, fire or explosion.

any of the long-form criteria. "Valve left or placed in the wrong position," the second-ranked category leading to operator error releases, ended the period with more than a 40% decline from the first 3-year average.

The two categories of "other human error" and "operator excavation" still happen with more frequency than they did when PPTS started to collect data (35 and 30% more often, respectively). To be fair, the category of "operator excavation" has shown improvements in 2005 and 2006 that are not obvious in the 3-year average, which is used in the charts. Still, there is room for improvement when the operator or operator's contractor is excavating around the pipeline. The recommendations in the PPTS Operator Advisory on excavation damage (in preparation) are a good place to start in developing ways to tackle the operator excavation mode of failure. In contrast to operator excavation, which has recently been improving, the 3-year average masks further year-to-year increases in the category "other human error," which accounted for 50% of the operator error incidents filed on the long form in both 2005 and 2006. The increase in the category of "other human error" is difficult to evaluate and develop recommendations for since it

encompasses such a wide range of failure modes and the Data Mining Team (DMT) is formulating a resolution to this as discussed in the next section. Understanding "other human error" is important because both of the fatalities and 9 of the 10 injuries were ascribed to "other human error." The other injury involved "operator excavation."

Root Cause Analysis

Among operator error incidents, "other human error" has become the leading operator error subcategory reported, and as seen the graph on the previous page (Nature of Operator Error Failure), its numbers have increased. (The 3-year averages mask improvement in the record for "operator excavation" and deterioration in the record for "other human error.") It is possible that the increase is due to companies changing their incident investigation procedures and placing more emphasis on getting to root causes of incidents (see inset box). A recent survey of PPTS member companies provided some information that points to improved incident analysis leading to more incidents identified as "operator error." Of the 40 PPTS operators, 20 responded to the survey. All of the respondent companies conduct root cause analysis for at least some of their release incidents. Sixty percent (60%) of respondents have actually reclassified incidents as "operator error" based on the results of a root cause analysis. The majority of companies have implemented their current incident investigation programs in the past 10 years with 75% making modifications and improvements in the past 3 years. The timing of the recent modifications approximately coincides with the increase in the use of "other human error." While there may be other factors involved, it is clear that improved investigations can account for some of the increase in this failure mode.

More rigorous incident investigations could identify causes such as "inadequate procedures," "failure to follow procedures," or "equipment not installed properly," subcategories not available in the PPTS reporting structure. The Data Mining Team is formulating additional questions that will make it easier to report these incidents, thus providing additional opportunities to learn from them.

> **Root Cause Analysis**
>
> When looking at an incident, often the "cause" that jumps out first is the proximate cause – the thing that happened at the time of the failure – not really the ultimate or "root" cause of the incident. Root Cause Analysis is a process that tries to get to underlying factors and causes with the idea that fixing the "root causes" will be more effective in the long term than "treating symptoms."
>
> There are several methods of root cause analysis. The "5 Whys" technique simply asks why an event happened and then why the precursor event happened, etc. Usually 5 rounds of why is enough to get to an underlying problem. There are also many commercially available root cause analysis techniques, including Tripod Beta Incident Analysis and the Apollo process.

Operator Error as a Contributing Cause / Contributing Causes to Operator Error

Operator Error is a very sensitive topic because it involves the actions of an individual. It is much easier to blame a faulty piece of equipment than an individual. During a root cause analysis though, operator error is often found to be the cause. Release events can often be traced to the actions of an individual somewhere in the life cycle of the pipeline. For example, there might have been a gasket failure. However, if a 10" gasket was used on a 12" flange, is that equipment failure? It is up to each operator to classify its own incidents, but in the drive toward zero spills,

an in-depth look at every incident might be necessary to identify and address real problems instead of addressing what might just be symptoms of the real problems.

With an even deeper look, there are often contributing causes that lead to operator error. These contributing causes are often company culture, faulty procedures, or certain policies that drive individuals to act the way they do, factors that themselves are operator errors at a different level of the company. To address operator error incidents, operating companies might have to look at some of these underlying causes.

Operator Qualification

As stated in the Final Rule issued by PHMSA on August 27, 1999, the objective of the Pipeline and Hazardous Materials Safety Administration's Operator Qualification (OQ) Rule (49 CFR Part 195 Subpart G) is "to reduce the risk of accidents on pipeline facilities attributable to human error" and "to provide an additional level of safety." OQ programs specifically address qualification for a specific task and for reacting to abnormal conditions that can arise during that task. Thus, OQ strives to eliminate a lack of training and qualification as a cause of operator error. There was a 50% drop in operator incidents from 1999 to 2000 (121 to 64). However, the number of incidents has hovered in the 60s for most years since then so it is hard to draw any OQ-based conclusions from this. Current incident reporting does not require any information on whether tasks that led to the incident were "covered tasks" or if individuals were qualified under the provisions of the rule. Furthermore, the form does not list "improper training" or anything similar as a reporting choice. Thus, there is no hard data to assess the role of the OQ program in incidents classified as operator error. The next revision of the PPTS reporting form will have some questions concerning OQ in the Operator Error path. These questions will be developed in collaboration with the Operator Qualification Committee.

> *NOTE: The "Considerations for Operators" contained 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.*

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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.