Enterprise Products

An Operator Perspective
Hazardous Liquids (HL) Pipeline Leak Detection

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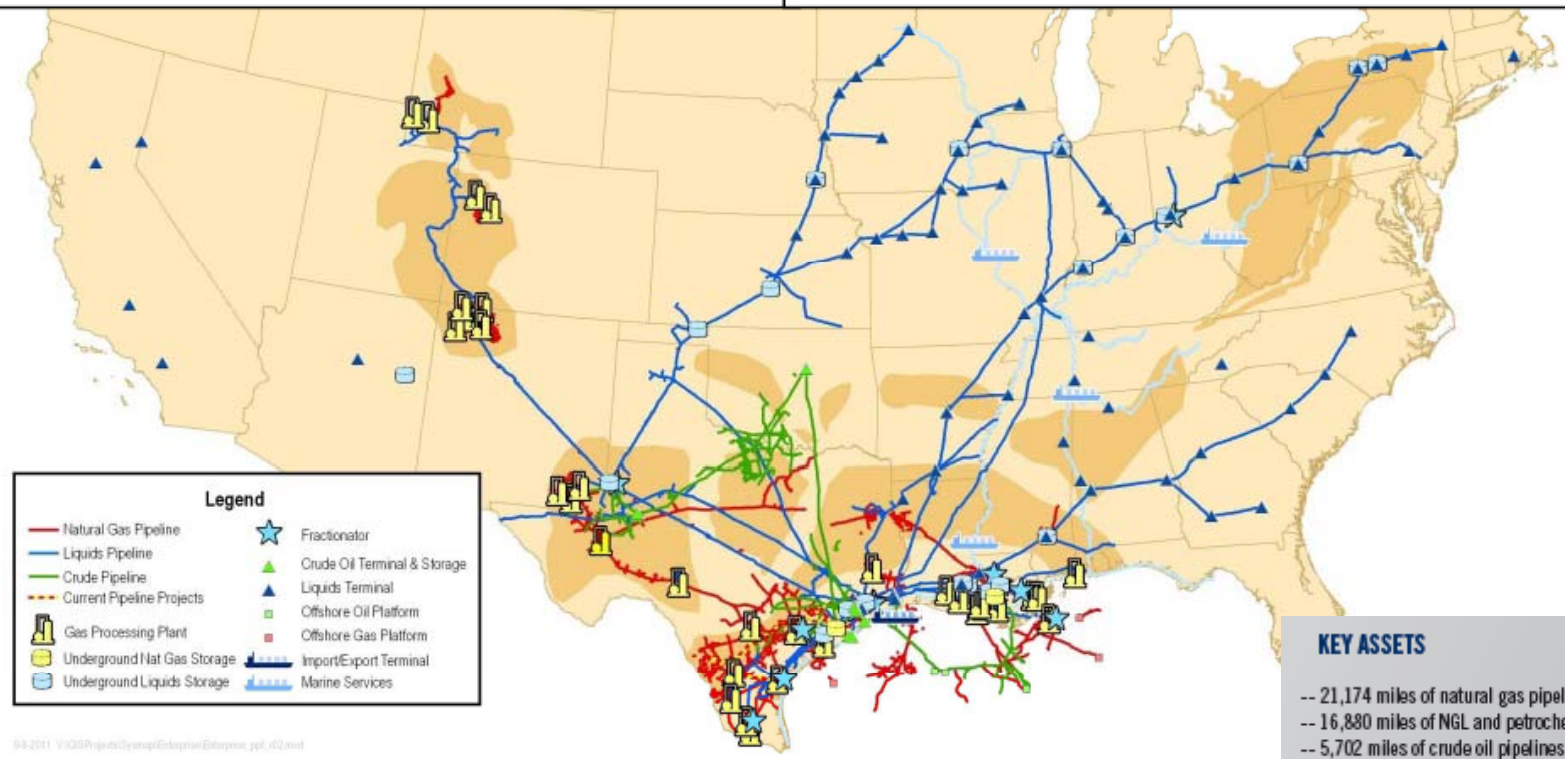
Enterprise Products

Major Asset Overview

- 50,600 miles of natural gas, NGL, crude oil, refined products and petrochemical pipelines
- 190 MMBbls of NGL, refined products and crude oil & 14 Bcf of natural gas storage capacity
- 24 natural gas processing plants
- 20 NGL & Propylene fractionators
- 6 offshore hub platforms
- NGL import / export terminals
- Butane isomerization complex; octane enhancement facility; high-purity isobutylene facility



KEY ASSETS

-- 21,174 miles of natural gas pipelines
-- 16,880 miles of NGL and petrochemical pipelines
-- 5,702 miles of crude oil pipelines
-- 6,451 miles of refined products pipelines

Leak Detection System (LDS) changes due to HL Integrity Mgmt Program (IMP) Rule

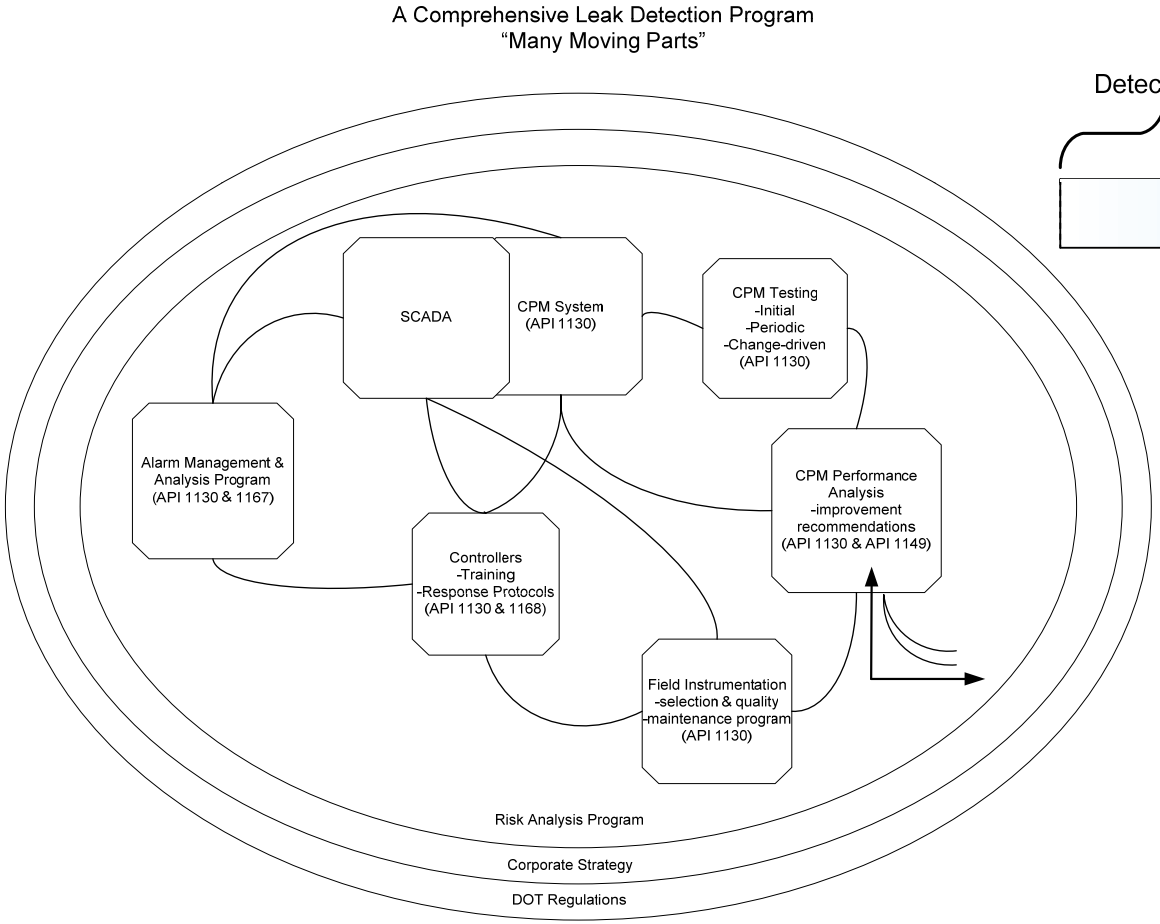
- General comments about the Enterprise Leak Detection Program
  - Program is all encompassing for all DOT regulated HL pipelines operated by Enterprise Products
  - Program has a baseline level of leak detection on all regulated pipelines, regardless of High Consequence Area (HCA) impact
  - Pipelines with a higher risk level have enhanced levels of leak detection
  - Program is risk driven in that more resources and tighter constraints are applied to higher risk pipelines
  - Continual review and process improvement program is in place to update LDS program on existing and new pipelines
  - CPM systems/processes comply with API 1130

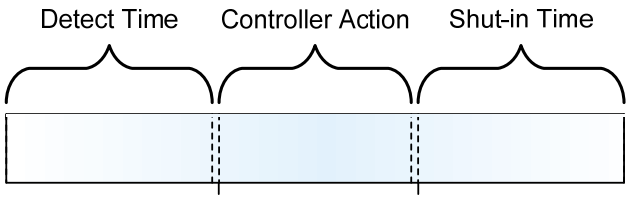
Layers of Redundancy

- LDS Layers of Redundancy in use today
  - Aerial Patrols (all)
  - Field automation devices – low suction pressure cutoff or high amperage cutoff on pumps
  - 24x7x365 Controller Monitoring of LDS & Alarms
    - Pressure/flow monitoring with alarming (all)
    - Baseline CPM system - volume-based over/short algorithm with alarming (all)
    - Enhanced CPM - pressure compensated over/short algorithm with alarming (where warranted)
    - Higher fidelity CPM system layered on top of baseline CPM system (where warranted)
    - Overlapping segments in place (where warranted)
    - Multiple time periods used for over/short calculations within same line segment (most)
  - Eyes of operations staff (partial)
  - Eyes of public through public awareness program (partial)
- Layers of Redundancy are used where warranted by risk ranking and complexity of operation

Shut-in Time Improvement

- Shut-in time is a function of much more than the LDS
- All these moving parts need to work in conjunction to provide optimal shut-in time





CAPEX/OPEX cost on existing vs. new pipelines

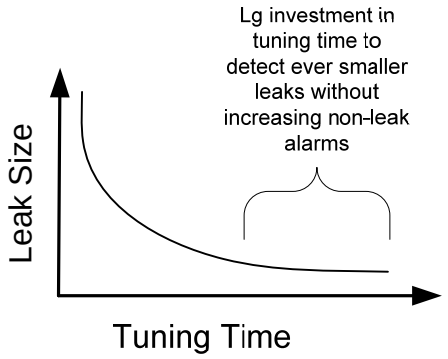
- Much higher costs are incurred to install metering/instrument on existing lines vs. new pipelines
  - Limitations of space, both in terms of land and piping
  - Mobilization costs
  - Need to retrofit power & communications as well
  - Maintenance costs may also be impacted by retrofit limitations
  - Older lines especially, were not designed with leak detection instrumentation in mind, therefore retrofit costs are higher
  - One major challenge is how to install low cost, accurate measurement for leak detection on short existing pipelines (laterals or stub lines)

CAPEX/OPEX cost on existing vs. new pipelines-II

- External LDS – special case – Distributed Temperature Sensing (DTS) Cables
  - Evaluated for use on Natural Gas Liquids (NGL) pipelines
  - Seemed very promising in lab testing for rapid leak detection and leak location identification
  - Retrofit installation issues, increased pipeline risk, and maintenance issues caused industry to focus on field testing alternate technology
    - company standards about digging near a pipeline,
    - 3rd party pipeline crossing where we would need to involve another company in the excavation, and
    - road crossings which are frequent on our existing lines in populated areas

False positive/negatives with LDS

- False alarms are a major consideration with installation and operation of LDS
  - Balancing act is used to minimize non-leak alarms and keep sensitivity low
  - False positives
    - Max allowable number per time is used in setting alarm thresholds
    - False positives are monitored and targeted for reduction if they exceed maximum targets
  - False negatives
    - Layers of redundancy strategy is used to address
  - **Tuning to reduce false alarms and keep sensitivity low is a labor intensive, pipeline-by-pipeline effort, no one-size-fits-all solution is available**



- LDS alarms are 1 indication to controller of a problem, controller has additional tools at his/her disposal
  - Pressure indications
  - Knowledge of recent operational activities
  - Knowledge of recent operational status of all equipment in LDS
  - Field operations personnel
  - Situational awareness and experience to address the circumstances
  - Reports from operations personnel, emergency responders and the public

Human Factors Impact LDS

- Controller trust is significant part of success of LDS
  - False alarm rate is number 1 factor in their mind
- Ways to improve controller trust in system
  - Controller involvement in testing
  - Operational procedures addressing specifics of LDS
  - Feedback from controllers to leak detection group
  - Training and frequent interaction between controllers and leak detection group
  - Defined level of support for controllers from leak detection group
- The controllers are ultimately responsible to make the call:
  - ***A Pipeline Controller has full and independent authority and responsibility to shut down and isolate pipeline systems. --Enterprise CRM Manual***
- CRM Regulation has focused industry on display and alarms management in an overall manner, benefiting the controller's ability to address Leak Detection System information

External, environmental, operating conditions impact on LDS

- **All these variations must be handled on a case-by-case basis with individual tuning for each pipeline, there is no one-size-fits-all solution**
- All variations in the environment or operating conditions make leak detection performance much more difficult to achieve
  - Variations drive increased false alarms and often reduced sensitivity levels
- Best performance numbers, quoted by vendors, are for leak detection under steady-state conditions (i.e. – non-real world operating conditions)
- Vendor answer to transient conditions is often to reduce sensitivity of LDS until transient passes
- Additional instrumentation and LDS tuning is possible to address impact of transients.
  - Difficult to forecast all transients in advance
  - Difficult to retrofit all needed instrumentation on existing pipelines

Following, piloting new technologies

- PRCI (Pipeline Research Council International)
  - Enterprise is a major supporter of PRCI initiative: “Small LD on Liquids Pipelines”
    - Enterprise has been Team Lead on project since 2010
    - Effort in place to field test several vendors equipment in 2012
  - Enterprise is participating as a team member on a current PRCI project to update API 1149
    - API 1149 – addresses impact of uncertainties on LDS performance
    - Update will address more products and pipeline conditions

- Internal testing
  - Running test on 1 vendor’s LD technology for use on short (lateral) pipelines (Rarefaction Wave Technology)
    - Capital allocated to project = $400K, much more spent in internal labor and vendor engineering time, resulted in pilot evaluation only
    - Final results not available yet, preliminary results look like vendor has overcommitted
  - Completed test on metering system to facilitate quicker deployment and more segmentation
    - Capital allocated to project = $150K, with much more spent in internal labor and vendor engineering time, resulted in pilot evaluation only
    - Final results indicate clamp-on ultrasonic meters only work in a very limited set of real-world conditions
      - Non-batched lines, non-varying product density, and flowing at near constant rates

Summary

- Enterprise believes LDS are valuable in safely operating HL pipelines
  - LDS is successfully being used to detect, locate and mitigate pipeline releases above a minimum threshold level
  - Risk-based programmatic approach is working to focus resources on critical areas
  - CPM tools today allow for 2-35% leak detection under most conditions
    - <5% is still very labor intensive to achieve and subject to vagaries of environmental and operating conditions, potentially driving non-leak alarms which undermine controller confidence
  - Challenges remain to improve LDS, being actively pursued through research & testing initiatives
    - Controller confidence through tight management of non-leak alarms is #1 challenge
    - LDS installation is very much a pipeline-by-pipeline process with large variability in tools to achieve a goal
    - LDS operation is a complex, multi-discipline process which all must be managed to achieve maximum results
    - System effectiveness is ambiguous in today's LDS – no industry agreement on definition of effectiveness parameters
      - All these measures are interrelated and must be analyzed for various states of pipeline conditions: Percent of flow, Time to detect, Acceptable level of non-leak alarms
      - Layers of redundancy provide an overall complicating factor in measuring effectiveness