Leak Detection & Computational Pipeline Monitoring (CPM)

Alberto Hernandez
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- Leak detection systems are used by pipeline operators to protect the public and the environment from consequences of a pipeline failure. These systems can do this by automatically alerting the operator when a leak occurs, so that appropriate actions can be taken to minimize spill volume and duration.

- There are many different leak detection methods. Some simply compare "metered out" product volumes with "metered in" volumes. Others utilize complex computational monitoring systems that simultaneously monitor numerous operating conditions. Other methods fall somewhere between these two examples in their level of complexity.

- All Hazardous Liquids pipelines require an effective leak detection system (195.444)

- Compliance Deadlines:
    - -Pre-Oct 1, 2019, Pipelines: Comply by Oct. 1, 2024
    - -On/after Oct. 1, 2019, Pipelines: Comply by Oct. 1, 2020.

- Evaluation Factors: length and size of the pipeline, type of product carried, the swiftness of leak detection, location of nearest response personnel, and leak history.

- Leak detection methods vary from the complex instrumentation and computer analysis of computational pipeline monitoring (CPM) systems, to simpler instrumentation and calculations.

- Volume balance "meter out" versus "meter in".

- Mass balance "meter out" versus "meter in".

- Simple "Rate-of-Change".

- Combination "Rate-of-Change".

- Computational Pipeline Monitoring. (CPM)

- Effective leak detection requires precise location identification

- Methods for Location accuracy:

  -CPM: uses pressure/flow data to pinpoint leaks

  -Geospatial integration: GPS and mapping for real time leak coordinates

  -Acoustic/Fiber-optic sensors: Detect leak sounds or vibrations along pipelines.

- HCA prioritize rapids, accurate location.

- Sensitivity determines smallest detectable leak size (§195.444).
- Factors affecting sensitivity:
- Pipeline characteristics (diameter, length, product type).
- Sensor technology (e.g., pressure sensors, infrared, AI-driven analytics).
- Hybrid systems improve sensitivity by combining methods (e.g., CPM + acoustic).
- Regular testing and calibration ensure optimal performance.

Computational Pipeline Monitoring Systems

- CPM systems must comply with APR RP 1130

- **Requirements:**

  -Design Per Section 4.2

  -Operating, maintaining, testing, record keeping, and dispatcher training of the system.

- It is a leak detection method that employs numerous monitored variables, and a sophisticated computer model to identify upsets or potential leaks.

- Monitored inputs include operating parameters for temperature, pressure, flow and density, and include equipment inputs such as pump start/stop and valve open/close signals.

- The data from all sensors is compared against a baseline model for values that differ from the modeled case indicating a potential leak.

- The goal is to ensure the safe and efficient operation of the pipeline and to detect potential leaks or other issues before they may become major problems.

Why is CPM Important?

- Faster leak detection

- Reduces environmental and safety risks

- Supports pipeline integrity

CPM Requirements in the Code

- §195.134: New pipelines must have leak detection system

- §195.444: Existing pipelines in HCAs must have effective leak detection system

- CPM is not the only method

CPM Limitations and Considerations

- Data quality impacts performance

- Can produce false alarms or missed leaks

- Requires regular testing and tuning

Common types of externally based systems or devices are:

- Fiber optic hydrocarbon sensing cables.

- Dielectric hydrocarbon sensing cables.

- Acoustic emissions detectors.

- Hydrocarbon (vapor) sensors (including those with vapor pick-up tubes).

Types of CPM Technologies

- Statistical Volume Balance (SVB)

- Mass/Volume Balance

- Real-Time Transient Model (RTTM)

- Pressure Point Analysis (PPA)

- Each has specific advantages and limitations

CPM System Performance Metrics

- **Sensitivity:** Smallest detectable leak rate

- **Reliability:** Frequency of false alarms

- **Accuracy:** Detection location and volume

- **Robustness:** Response to noise, missing or bad data

Operational and Maintenance Practices

- Continuous monitoring and tuning

- Data quality and calibration

- Routine testing and validation

- Alarm response protocols and documentation

- FAQ-7. Do I need to have a computational pipeline monitoring (CPM) leak detection system over all of my pipelines?

- FAQ 7.1 Is patrolling alone a sufficient leak detection system per § 195.444?

Region 4/7 Team Lead Alberto Hernandez

Alberto.Hernandez@rrc.texas.gov

512-318-0110