Emergency Flow Restriction Device (EFRD)

Adequacy Evaluation

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Regulatory Overview

The U.S. DOT Hazardous Liquid Pipeline Integrity Management rule (CFR 195.452) requires operators to:

- Identify where pipeline releases could potentially affect **High Consequence Areas (HCAs)**.
- Meet prescriptive requirements for periodic **Inspection and Repair**.
- Conduct Risk Analyses to evaluate the need for additional **Preventive & Mitigative Measures**, to prevent and/or mitigate the impact of a release to HCAs.
- An **Emergency Flow Restriction Device (EFRD)** is a special class of Preventive & Mitigative Measure identified in the regulation.
High Consequence Areas (HCAs)

For Hazardous Liquid Pipelines...

- High Population Areas.
- Other Populated Areas.
- Unusually Sensitive Areas:
  - Ecological
  - Drinking Water
- Commercially Navigable Waterways.
What is an EFRD?

An **Emergency Flow Restriction Device (EFRD)** is defined as either a **Check Valve** or **Remote Control Valve**.

A **Check Valve** automatically prevents backflow when the pipeline shuts down.

A **Manual Gate Valve** can be converted into a **Remote Control Valve** by adding a **Motor Operator** and **SCADA Controls** to enable timely remote closure (e.g. from a pipeline control center).
EFRD Adequacy Evaluation

Chevron Pipe Line Company (CPL) uses various GIS toolsets to evaluate the adequacy of Emergency Flow Restriction Devices (EFRDs).
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Again, EFRDs are valves and remote controls which mitigate the impact of a catastrophic rupture to HCAs.
Release Modeling

In order to measure the impact of a release to HCAs, the release volume and it’s transport over land and water must be modeled relative to HCAs.

CPL uses a GIS based process for Pipeline Release, Overland Flow and Hydrographic Transport (PROFHT) modeling.
Release Modeling

In order to measure the impact of a release to HCAs, the release volume and it’s transport over land and water must be modeled relative to HCAs.

CPL uses a GIS based process for Pipeline Release, Overland Flow and Hydrographic Transport (PROFHT) modeling.

An understanding of pipeline drain down volume is a critical input to this release modeling process.
Modeling Drain Down Volume

- Release Locations
  - Model release every 100 ft.

- Failure Mechanism & Size
  - Third Party damage – full rupture.
  - Worst Case Discharge (WCD).

- Operating Conditions
  - Flow Rate.
  - Leak Detection & Response.

- Design Factors
  - Pipe diameter.
  - Valve type & spacing.
Overland Flow, Hydrographic Transport

**Channelized Flow**
- Based on “Rain Drop” Tool.
  - Flow accumulation + flow direction ➔ least cost path.
  - Product fluxes include evaporation, infiltration, adhesion

**Lateral Spread**
- Stepwise processing of “flat” areas.
  - Least cost flow surface to define time/distance intervals.
  - Tracks flow velocity, flow depth, product loss

**Hydrographic Transport**
- Relies on NHD dataset to determine stream network.
  - Product is transported downstream or as a radial surface plume in lakes
  - Transport distance is governed by stream velocity, product loss, and remaining response time
After the release modeling is complete, an **EFRD Advisor** application uses GIS to provide an interactive viewing and modeling environment to facilitate the evaluation of potential EFRD improvements.
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This application employs an EFRD Index as a measure of change in consequence relative to a baseline analysis.
Understanding Release Consequence

Before attempting to gauge the effect of placing a new valve, or reducing closure time on an existing valve, we must understand the **consequence** (negative impact) of a potential release along the pipeline.

Different releases will have different consequences, which will depend on the following factors:

- **Release volume.**
- **Number and types of HCAs impacted:**
  - Volume in;
  - Time of impact relative to Emergency Response time.
- **Product type:**
  - Some products have more severe impacts on certain HCA types than others.
Understanding A Consequence Index

A **Consequence Index** is a dimensionless quantity expressing *relative* consequence of releases within the context of a line segment.

A Consequence Index is:
- Internally consistent.
- Reproducible.
- Inherently arbitrary (e.g. parameters are adjustable).

A Consequence Index is **not**:
- Quantitative.
- Suitable for calculating absolute consequences.

A Consequence Index for a given scenario is calculated relative to a baseline analysis.
The EFRD (Consequence) Index

The **EFRD Index** is a **Consequence Index**

- The size of the release and associated HCA Impacts represent *relative* losses or costs.
  - Impact to Human Health & Safety.
  - Property Damage.
  - Environmental Damage.
  - Product Loss / Cleanup & Remediation Costs.
The EFRD (Consequence) Index Formula

\[
EFRD_{\text{Index}} = \left( 1 + \sum_{\text{HCA}\text{Hits}} \left( \frac{\text{Rem}_\text{Vol} \times \text{Rem}_\text{Time}}{\text{Drain}_\text{Vol} \times \text{Resp}_\text{Time}} \times \text{HCA}_{\text{wt}} \right)_{\text{max}} \right) \times \frac{\text{Drain}_\text{Vol}}{\text{Avg}_{\text{Drain}_\text{Vol}}} \times \frac{\text{EFRD}_\text{Vol}}{\text{Drain}_\text{Vol}} \times \text{Threat}_\text{Index}
\]

Where:

- HCA Hit = Intersection of Rupture Point, Overland Flow Path or Polygon, Hydrographic Trace Path or Plume with an HCA.
- Rem_Vol = Remaining release volume introduced into an HCA.
- Drain_Vol = Total release volume at Rupture point for baseline scenario.
- Rem_Time = Time remaining to Resp_Time when an HCA is hit.
- Resp_Time = Emergency response time.
- HCAwt = Weight factors applied by HCA and Commodity type.
- Avg_Drain_Vol = Average release volume for all modeled rupture points on the line segment being analyzed. Can optionally be replaced by a user specified threshold drain volume to allow cross segment comparison.
- EFRD_Vol = Release volume calculated at the rupture point for the EFRD scenario under consideration.
- Threat_Index = optional estimate of relative threats along the pipeline.
Perform Pipeline Release, Overland Flow and Hydrographic Transport (PROFHT) Analysis.

- **Baseline Drain Down Analysis.**
  - Considers only existing Check Valves

- **Baseline EFRD Consequence Index.**
  - Calculated from HCA Intersections.
  - Uses weighting factors for:
    - HCA Type.
    - Commodity Type.
Perform Operational Drain Down Analysis
- Considers existing Remotely Operated Valves and Manual Block Valves
- Calculate Operational EFRD Index based on Reduced Drain Volumes.

Evaluate Effectiveness of Existing EFRDs
- Compare EFRD Index between Baseline and Operational Scenario.
  - Expect to see Significant Reductions.
**EFRD Adequacy Evaluation Process**

Identify and Prioritize Potential EFRD Evaluation Segments

- Where EFRD Index remains high.
- Where there is significant potential for Drain Volume reduction

Identify Potential Valve Installations or Conversions

- Valve Conversions should be considered first.
- Consider site access and potential power sources
Example EFRD Adequacy Evaluation

- River valley location near a populated area and other HCAs
- The Operational EFRD Index remains high
- Significant potential for further drain volume reduction
Example EFRD Adequacy Evaluation

Valve Site A: Existing manual valve, 2-hour closure.

- Convert to Remote Control Valve (EFRD), 10-minute closure.
Example EFRD Adequacy Evaluation

Valve Site B: Existing manual valve, 2-hour closure.
- Convert to Remote Control Valve (EFRD), 10-minute closure.
### Example EFRD Adequacy Evaluation

#### Tabular Reports

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‘EFRD’ Adequacy Evaluation

Questions?