

Interacting Threats to Pipeline Integrity – Defined and Explained

Purpose

This document is intended to outline the management of interacting threats to pipeline integrity. Key areas presented are:

- An explanation of an interacting threat condition
- Typical scenarios in which an interacting condition can exist
- Best Practices used by pipeline operators to manage and mitigate these conditions

Introduction

A key component in managing pipeline safety is threat identification. Nine primary threat conditions are identified in the ASME B31.8S standard. These nine individual threats fall into three separate threat categories:

- Time-Dependent Threats (threats tending to grow over time)
 - Internal Corrosion
 - External Corrosion
 - Stress Corrosion Cracking
- Resident Threats (threats that do not grow over time; instead they tend to act when influenced by another condition or failure mechanism)
 - Manufacturing
 - Fabrication/Construction
 - Equipment
- Time-Independent Threats (not influenced by time)
 - Human Error
 - Excavation Damage
 - Earth Movement, Outside Force or Weather

Pipeline operators use various methods and programs to prevent, detect and mitigate and/or inspect for individual threats. Additionally, there may be circumstances when two or more threats can occur coincidentally and independently of each other. These “coincident threats” result in a likelihood of failure greater than that due to either threat individually or merely the superposition of the threats.

Interactive Threats – Defined

Interactive threats are the coincidence of two or more threats in a pipe segment, the result of which is more damaging than either of the individual threats themselves. An example could be where the likelihood of two threats, working independently together, is greater than the likelihood of either threat independently. An example of such an interaction is earth movement exacerbating construction-related imperfections such as wrinkle-bends or certain vintages of girth welds. Either of these two conditions, absent the other, may not be a significant threat to pipeline safety. However, when they are both present in the same location, the resulting condition could be a concern.

Other Examples of Interacting Threats

Each pipeline system is different and may contain a unique set of threat conditions related to location and environment in which the pipeline is located. For example, pipeline systems located near fault zones have a high susceptibility to earthquakes. Operators are aware of many of these location-specific threats, and they should be incorporated into the threat-interaction analysis. There also are time-independent and time-dependent threats that may interact with resident threats on most pipelines. Examples include:

- Wall loss due to external corrosion and/or internal corrosion can begin at locations that have manufacturing imperfections or have had previous mechanical damage
- Flooding with construction defects
- External corrosion and latent third party damage

Every operator needs to evaluate its specific system to identify and prioritize all threats that could interact.

Coexisting Threats

There are many cases in which threats could coexist. When these threat conditions exist but are not synergistically interacting, it should not be considered an interactive threat but should be properly characterized and managed. Many examples of coexisting threats are managed effectively, such as internal and external corrosion. These situations are typically addressed using existing risk assessment models, and additional analysis is not required.

Fatigue

The role of fatigue in natural gas pipelines - from both internal and external forces - has been studied extensively. Pressure cycling, sometimes misidentified as an interacting threat and potentially leading to fatigue, is an operating condition that must be considered when evaluating the severity of a single threat. Research has shown that gas pipelines do not experience the frequency or magnitude of internal pressure changes as pipelines that transport incompressible fluids because of the compressible characteristics of natural gas. However, there are circumstances when pressure cycling and other forces can act upon resident subcritical imperfections in natural gas pipelines and potentially lead to fatigue. For example:

- Pipelines that experience relatively high and frequent pressure cycles – specifically those locations without a historical pressure test in excess of normal operating pressure
- Facilities that experience a high magnitude of vibration
- Above-ground facilities such as spans that are subject to cyclical external loading such as vortex shedding and thermal expansion

Every operator should evaluate its system to determine if it has pipeline segments susceptible to fatigue. It may be possible that time-dependent growth is occurring. In order to manage systems safely, pipeline operators should be proactive, update facility records after pipeline inspections, and integrate data from operating pressure history.

Methodologies for Evaluating Interactive Threats

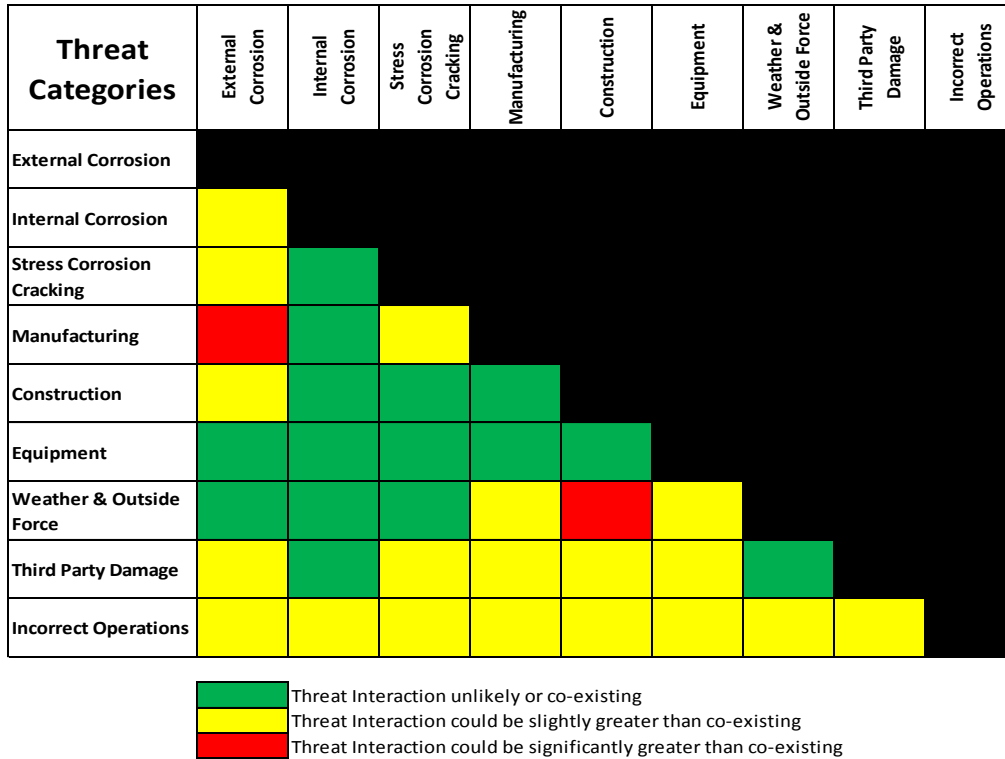
Evaluating and documenting interactive threats can be done in a variety of ways – from using a simple matrix, to obtaining subject matter expert (SME) input, to using complex algorithms. One of the more common solutions is using a matrix to compare threats that the operator has determined to be potentially interactive.

A matrix can be used to outline the relationship between different pairings of threats and detail the ways in which each particular active combination is managed. Not all boxes in the matrix would include guidance, as many combinations of threats are not inherently interactive. A simple representation of this method is shown in Figure 1.

A matrix also can be used to help quantify the synergistic effect in common threat interactions. Each operator's approach to developing a matrix may be different based on historical threats and how they have been observed to potentially interact in different parts of its system. To capture interactive synergies, many operators use this type of matrix to apply "multiplier" factors to individual threat scores where the interaction is expected to exist.

Interactive Threat Pairing

Figure 1



Another way of addressing potential threat interactions is to analyze and evaluate, generally through probabilistic or deterministic models, the coincident location of resident features (subcritical imperfections) that are acted upon by failure mechanisms, which can compound or magnify the original reduced resistance. This methodology couples the likelihood of a failure mechanism (or combination of failure mechanisms) being active and occurring at a resident feature location. A simple representation of this method is shown in Figure 2.

Figure 2

Threat Categories	Manufacturing	Construction & Fabrication	Equipment
External Corrosion	Red	Yellow	Green
Internal Corrosion	Green	Green	Green
Stress Corrosion Cracking	Yellow	Green	Green
Third Party Damage	Yellow	Yellow	Yellow
Weather & Outside Force	Yellow	Red	Yellow
Incorrect Operations	Yellow	Yellow	Yellow

The methods used to identify interacting threats on their system all rely upon the integration of available data to determine conditions or combinations of conditions that may present a threat to pipeline safety.

All these methods are valid and provide information to the operator on possible interactions. From this information, operators can select assessment methods as well as preventive and mitigative measures that address the threats and interactions.

Regulatory Requirements for Interactive Threats

The term “interactive threat” does not appear in 49 CFR 192. Interactive threats and fatigue were first specified in the original 2001 ASME B31.8S document and remain in the 2004 version, which is currently incorporated by reference into 49 CFR 192. The imperative to “consider” interactive threats is clear; however the ASME document does not provide specific guidance on models and methodologies. Efforts to better address this are detailed below.

Path Forward

INGAA member companies recognize that the above methodologies have inherent limitations. For instance, the matrices currently lend themselves to only two threat interactions occurring simultaneously. In addition, any interactive threat analysis requires significant and accurate data that is not always available. As a result, INGAA member companies are pursuing the next evolution of threat-interaction models and methodologies in keeping with its guiding principles of continuous improvement and zero incidents.

Two industry studies currently are underway. The Gas Technology Institute (GTI) and Kiefner & Associates will independently produce interactive-threat reports and guidance. INGAA member companies are involved and support these efforts to better understand how threats can interact and to develop methodologies to evaluate and mitigate these interacting effects.

