AMPP

INSTITUTE OF CORROSION

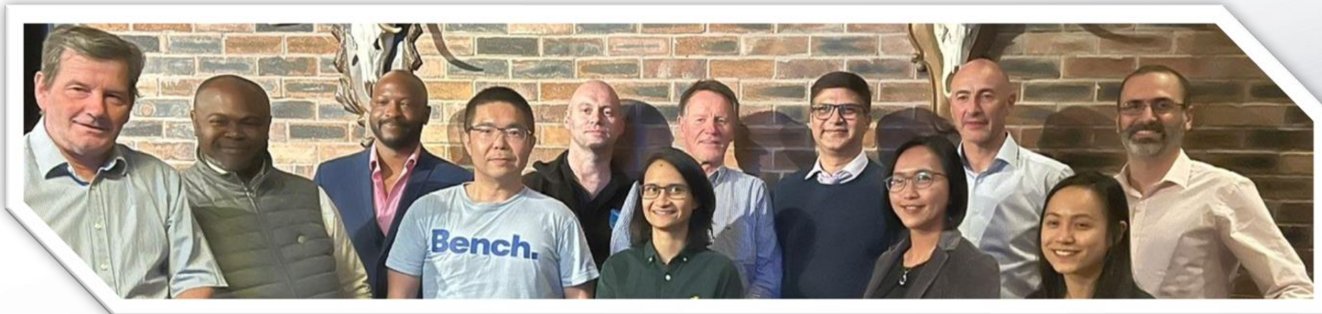
JOINT EVENT

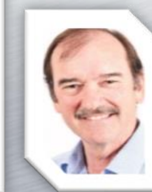
ICORR ABERDEEN BRANCH & AMPP May 2024 Webinar

Topic: Proportional hazard values for different pipeline coating types, used over the timeline from 1900s till now

by Susan Jacob – One Gas (USA)

2023/24 Aberdeen Branch Committee





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Next Branch Programme

ICORR Technical Event

Metallographic Replication of In-Service Plant by IRIS NDT

+ AGM

25/06/2024 at 6 pm

INSTITUTE OF CORROSION

Our speaker for Today is:

Susan Jacob is a Senior Pipeline Engineer in Asset Management for One Gas (Natural Gas Distribution, USA) where she has worked for over 5 years covering Oklahoma, Kansas, and Texas.

Susan previously worked with ConocoPhillips (Aberdeen, UK) for over 6 years as an Integrity Engineer. She completed Masters in Subsea Engineering the University of Aberdeen in 2016.

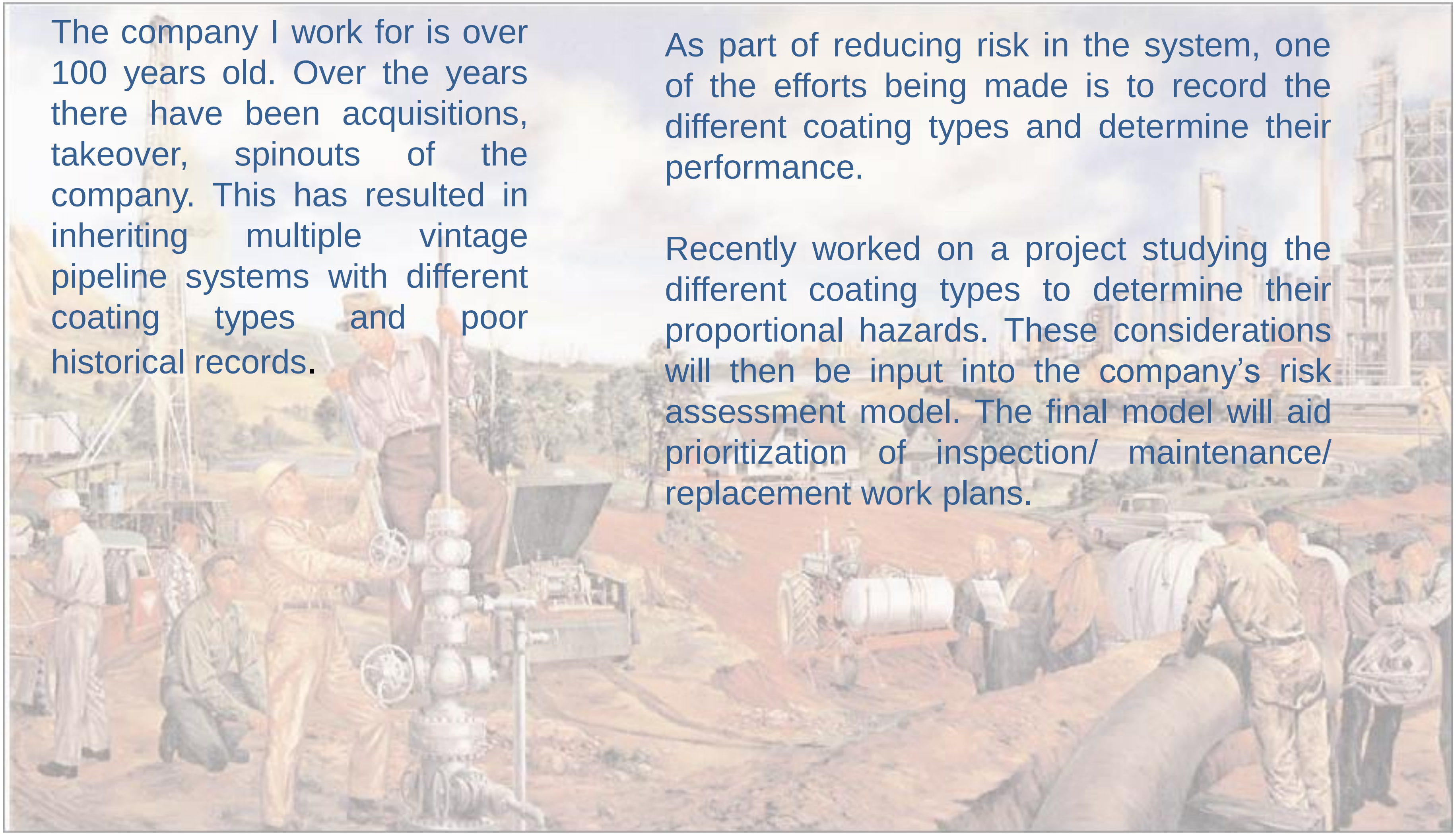
Susan loves working with people from different cultures. Outside work, she loves exploring new places and going rustic camping with her family.

Synopsis

The company I work for is over 100 years old. Over the years there have been acquisitions, takeover, spinouts of the company. This has resulted in inheriting multiple vintage pipeline systems with different coating types and poor historical records.

As part of reducing risk in the system, one of the efforts being made is to record the different coating types and determine their performance.

Recently worked on a project studying the different coating types to determine their proportional hazards. These considerations will then be input into the company's risk assessment model. The final model will aid prioritization of inspection/ maintenance/ replacement work plans.



Tulsa-airport-panorama-of-petroleum

Topics & Contents

- History and Evolution of Coatings
- Pipeline Coatings timeline
- PHMSA v/s HSE UK
- Failure Analysis & Risk Methodologies
- Threat Considerations
- Inherent Risk

- Recorded Threats by PHMSA 2010-2020
- Incidents due to External Corrosion Threat
- Weibull's Proportional Hazardous Model
- Corrosion Threat Base Likelihood model
- Coating Performance Ranking
- Unique Coating type
- Coating Performance Research

History and Evolution of Factory Applied and Field Applied Coatings

1859 - Use of metallic pipe, mainly Wrought iron, for oil transportation started soon after the drilling of the first commercial oil well by "Colonel" Edwin Drake in Titusville, PA.

1920s - Some operators began to coat the pipe as it was being laid in the ditch, in an attempt to protect it from corrosion. The idea was to place a barrier between the pipe and the corrosive conditions in the soil, hence the term "the barrier principle**.**"

1943 - NACE was established by 11 corrosion engineers in response to high levels of corrosion failures reported on pipelines.

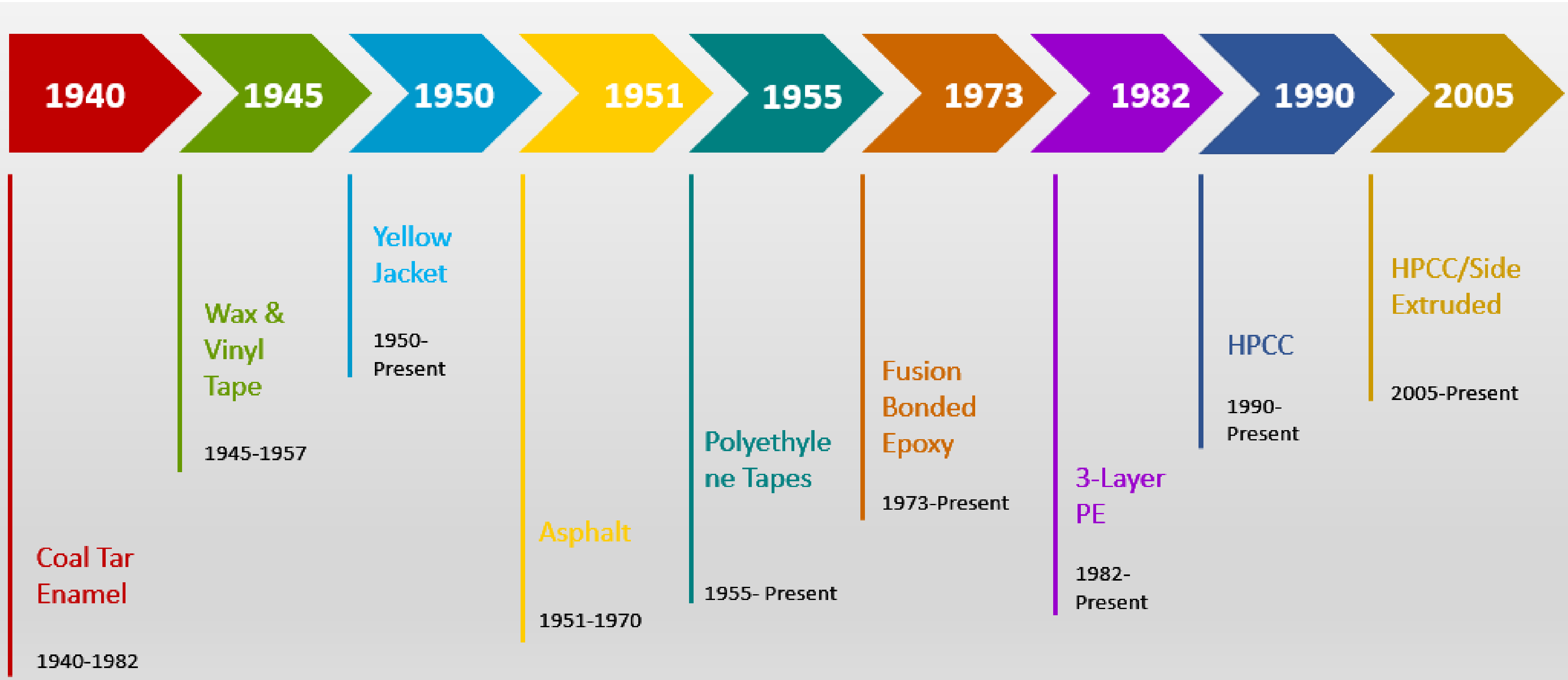
1930s-1950s - Over-the-ditch application of enamels and asphalts during construction continued up to the 1950s

1950s - The first plant-applied, extruded polyethylene mainline systems were developed

Late 1950s to Early 1960s - Liquid-based epoxy coatings (coal tars & asphalts) to polyolefin materials (polyethylene or polypropylene), Fusion Bonded Epoxies. These powder coatings were used either as standalone systems or as part of multi-layer system—which really gave birth to the three-layer PP and three-layer PE systems**.**

1960s - Saw the birth of mainline coating systems. FBE also provided excellent flexibility properties, this was an answer to the failures of many previous materials due to handling and bending of the pipe spools during pipelay and subsequent cracking of the system

Example of Pipeline Coatings timeline from Shaw's Pipe timeline (previously Brederoshaw now Shawcor)



Cited from:
Pipeline Coatings - Y Frank Cheng & Richard Norsworthy

Pipeline and Hazardous Materials Safety Administration (PHMSA)

The United States Department of Transportation Agency responsible for developing and enforcing regulations related to the safe, reliable, and environmentally sound transportation of energy and other hazardous materials.

HSE is the UK's national regulator for workplace health and safety covering a wide range of industries including agriculture.

Compared with HSE, though similar, PHMSA is a <u>federal</u> regulatory body solely dedicated to safety and regulations of pipelines on a national level

In addition, to PHMSA, there are <u>state-leve</u>l regulatory bodies such as, the

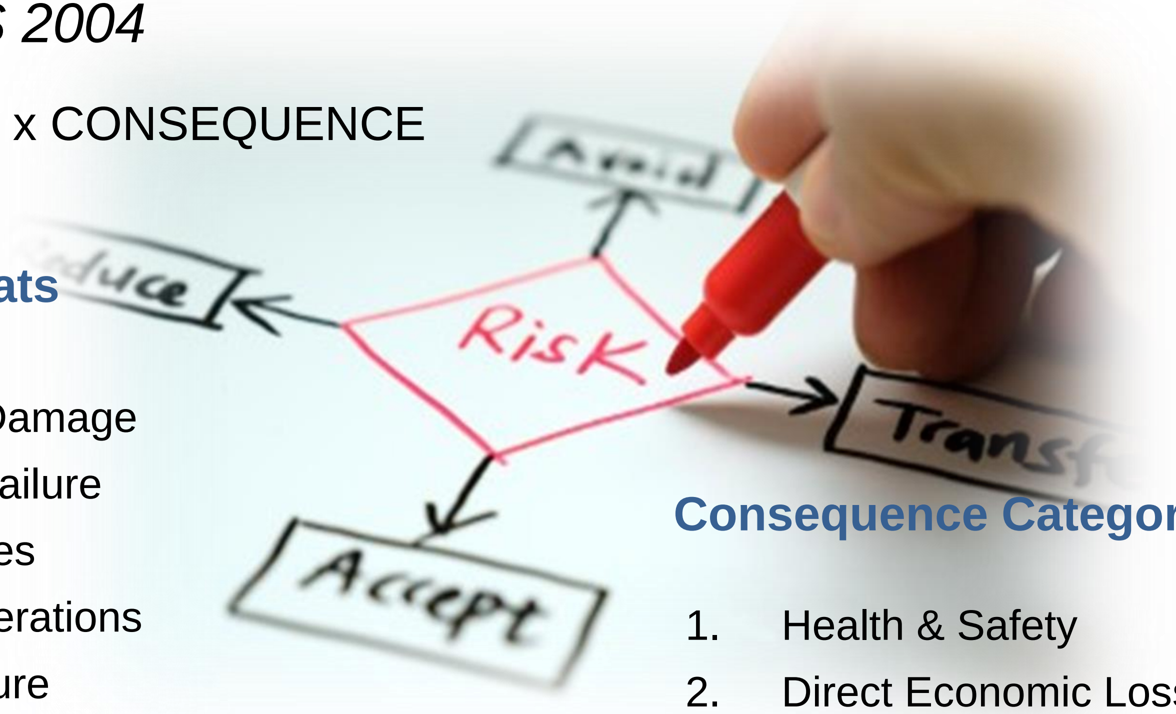
- Oklahoma Corporation Commission (OCC),
- Kansas Corporation Commission (KCC),
- Texas Railroad Commission (TRRC), etc.

U.S. Department of Transportation
Pipeline and Hazardous Materials Safety Administration

Failure Analysis & Risk Methodologies

"Risk is the mathematical product of the likelihood (probability) and the consequence of events that result from a failure."
ASME B31.8S 2004

RISK = THREAT x CONSEQUENCE



8 PHMSA Threats

1. Corrosion
2. Excavation Damage
3. Equipment Failure
4. Natural Forces
5. Incorrect Operations
6. Material Failure
7. Other Outside Forces
8. Other Causes

Consequence Categories

1. Health & Safety
2. Direct Economic Loss
3. Regulatory Impacts
4. Environmental Impacts
5. Corporate Image/Reputation

3 Categories of Threat Considerations

Threat Considerations

Time-Independent (Random) Threats:

These threats do not change significantly over time and are often unpredictable.

- External Corrosion
- Internal Corrosion
- Manufacturing and Construction Defects
- Equipment Failure

Time-Dependent Threats:

These threats tend to grow over time and require ongoing monitoring.

- Stress Corrosion Cracking
- Fatigue Cracking
- Hydrogen-Induced Cracking
- Environmental Stress Cracking

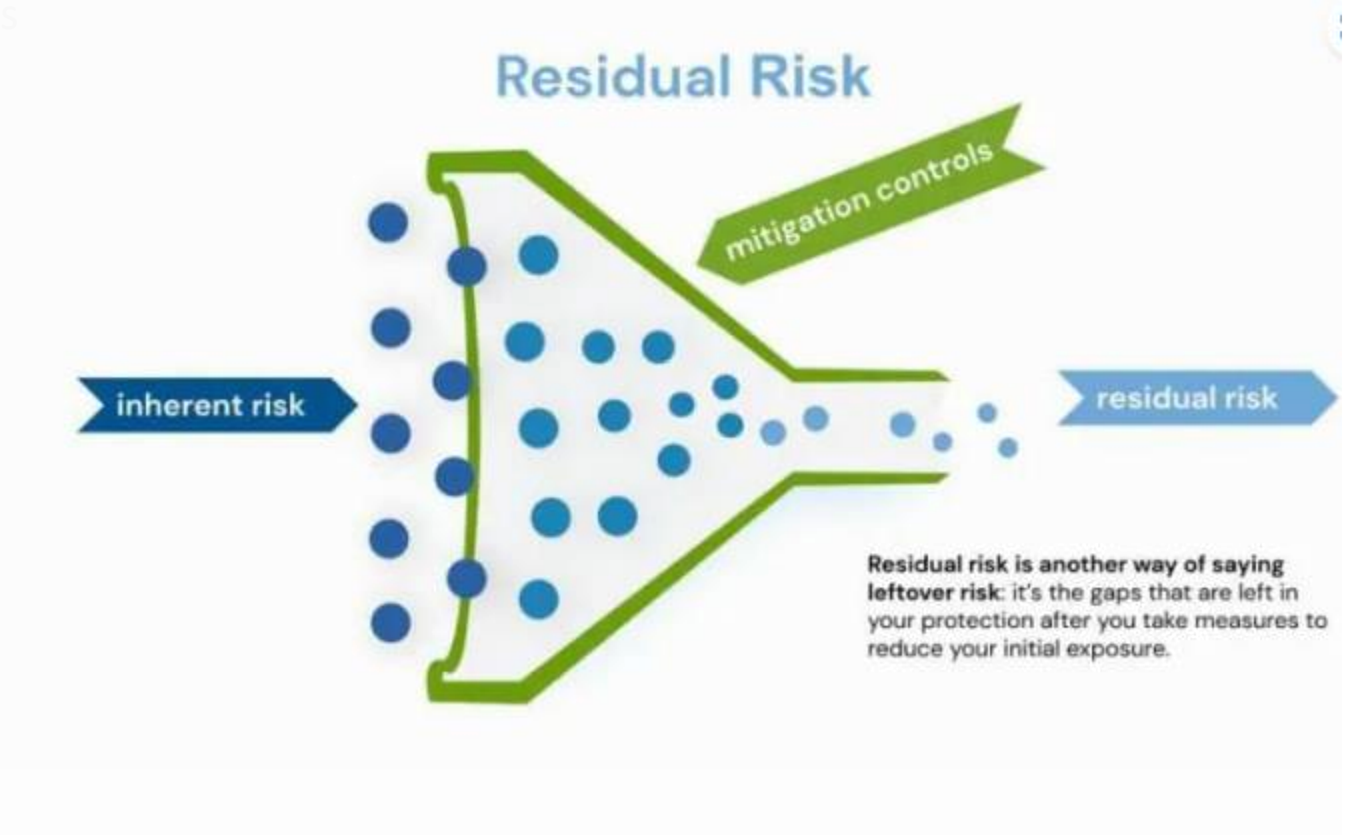
Resident Threats:

These threats do not grow over time but may act when influenced by other conditions or failure mechanisms.

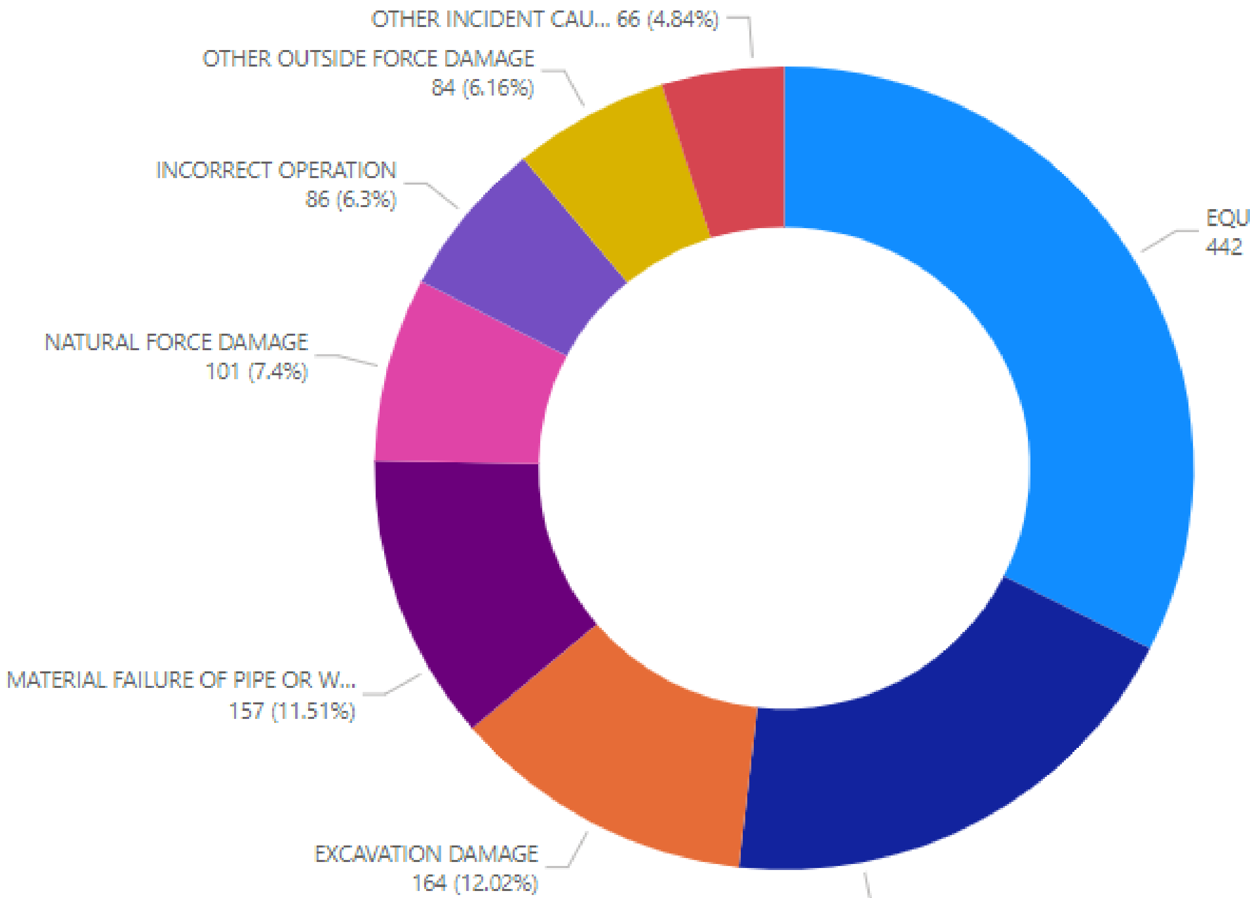
- Mechanical Damage
- Geotechnical Hazards
- Natural Forces (Earth Movement)

Inherent Risk

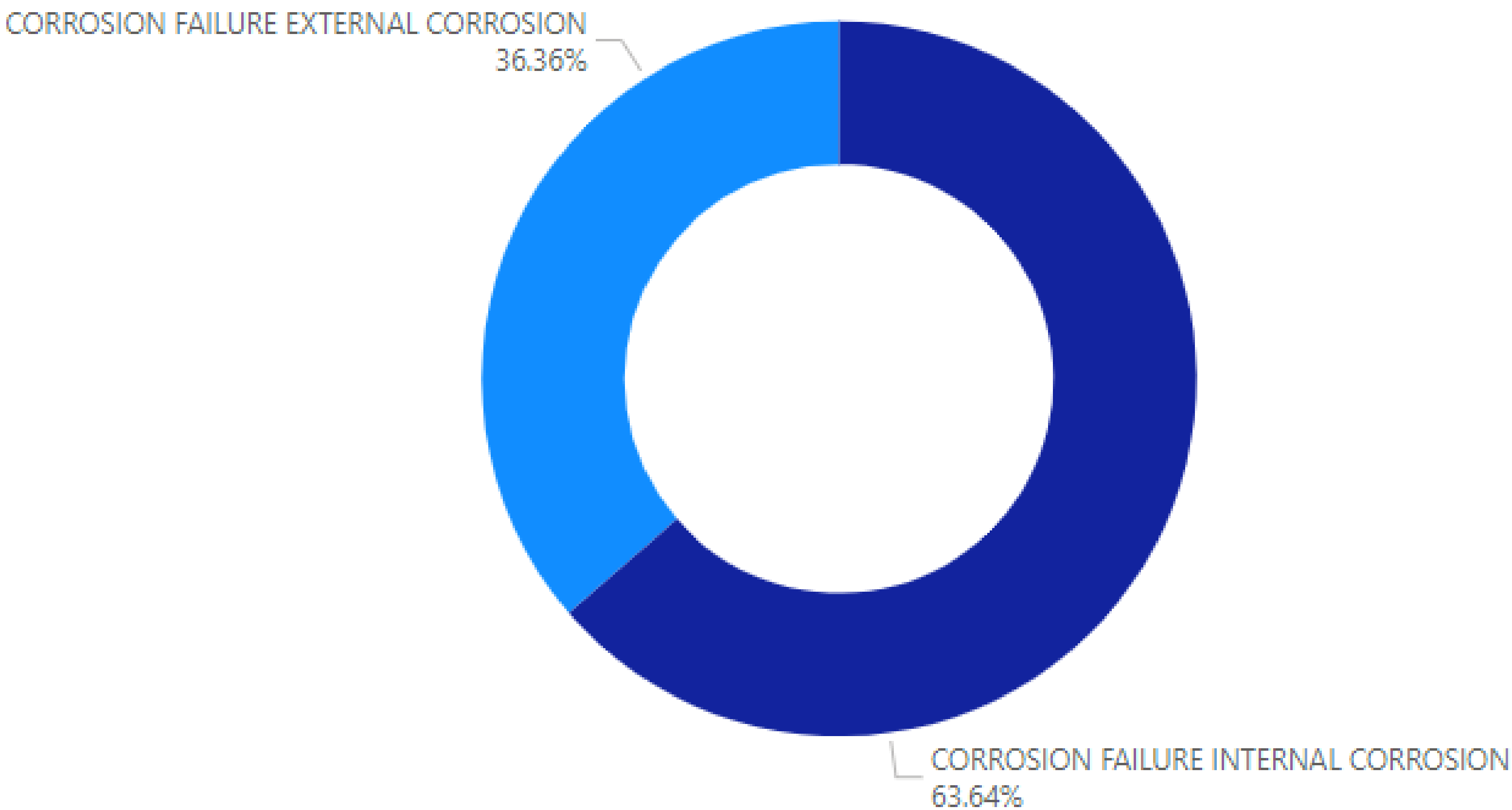
Inherent Risk in a system can be considered as addition of mitigatable risk and residual risk. Some of the threats that can be mitigated with controls in place are corrosion, equipment failure, material/joint failure, other causes. While the non-mitigatable risks contributors may be excavation damage, incorrect operations, other outside forces and natural force



Recorded Threats by PHMSA 2010-2020



Incidents due to external corrosion threat



Weibulls proportional hazardous model - Probabilistic Mechanistic Risk Model

$$h(t) = \frac{\beta}{\eta}\left(\frac{t-t_0}{\eta}\right)^{\beta-1} \cdot \exp\left(\bar{x} \cdot \bar{y}\right)$$

Defines baseline failure rate for entire asset population

Adjust baseline failure rate specific factors

h(t) = the failure/hazard rate – the likelihood that the asset will fail at age t given that it has not yet failed
t = the age of the asset
β = Beta, the shape parameter of the distribution
Describes whether the hazard rate increases or decreases with time
η = Eta, the scale parameter of the distribution
Describes the magnitude of the hazard rate
t_o= the time after which failures start to be observed
For some assets, failures don't begin after a certain time period has passed

Corrosion Threat Base Likelihood Model

$$h(t) = \frac{\beta}{\eta}\left(\frac{t-t_0}{\eta}\right)^{\beta-1} \cdot \exp\left(\bar{x} \cdot \bar{y}\right)$$

Expanding the above model to consider corrosion threat:

h(t)=(Asset Age Factor)*(Asset Size Factor)*(Coating Factor)*(Leak History Factor)

Coating Performance Ranking

Coating	Application	Performance Priority
FBE Dual Coated	Factory	1
FBE	Factory	2
Polyethylene Coating	Factory	3
Coaltar Enamel	Factory	4
Liquid Epoxy	Field	5
Wax Tape	Field	6
Polyethylene tapes	Factory	7
Biturine	Factory	8
Coaltar	Factory	9
Asphalt	Factory	10

Susan Jacob

A unique pipe coating system not commonly available but still in the system

Biturine
Install Date Range: 1930s

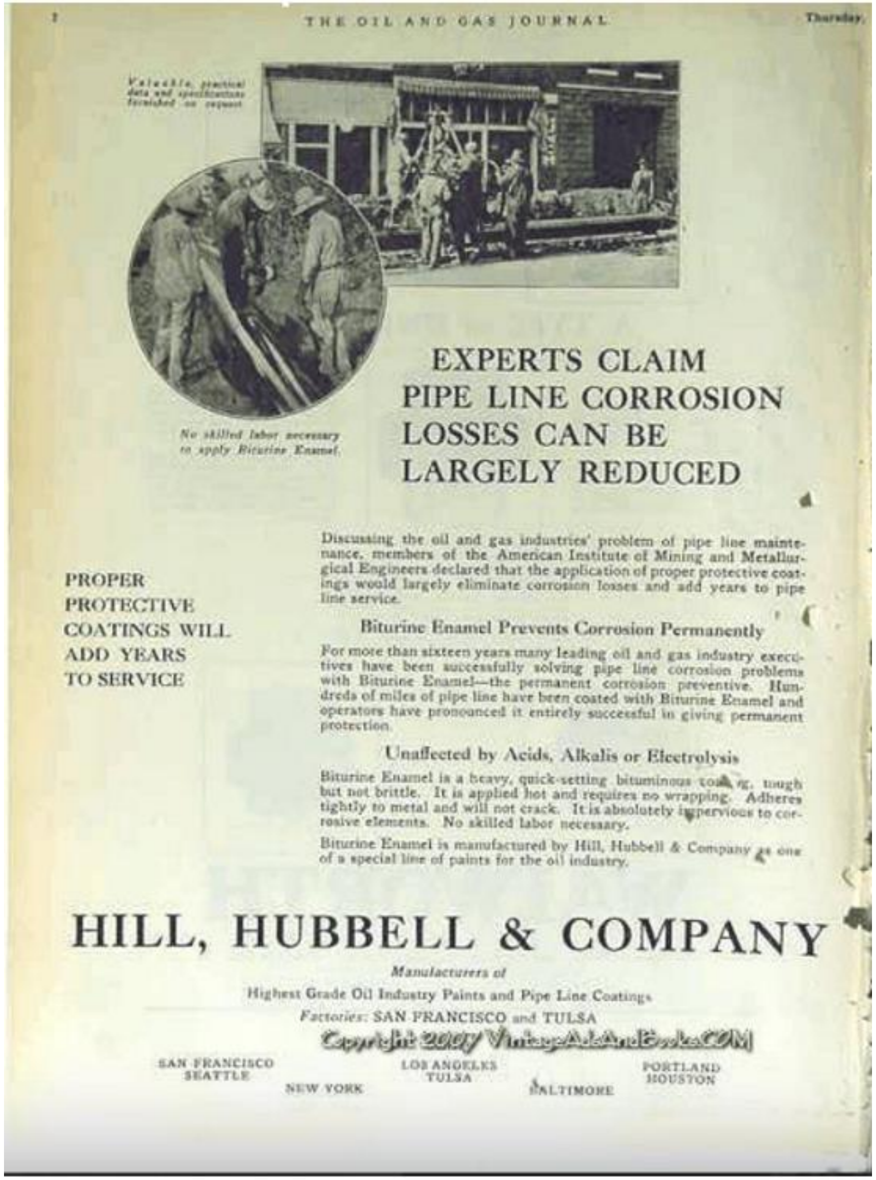
Chemical Composition: Factory application **c**onsists of primer followed by two coats of biturine enamel (coal-tar-asphalt), spiral wrap (asbestos felt), flood coat of enamel and kraft paper (machine wrapped). Heavy, quick-setting bituminous coating, tough but not brittle. Heavy, quick-setting bituminous coating, tough but not brittle. Hot application and requires no wrapping.

Type: Field Applied & Factory Applied

Uses: Promoted as a mechanically applied coating and wrapped pipe designed to meet rough handling during transportation and installation.

Advantages: Protective coating against moisture, alkalis, acids, and all other corrosive agents.

Disadvantages: Health & air quality concerns



2 THE OIL AND GAS JOURNAL Thursday,

Valuable, practical data and specifications furnished on request

No skilled labor necessary to apply Biturine Enamel.

EXPERTS CLAIM PIPE LINE CORROSION LOSSES CAN BE LARGELY REDUCED

PROPER PROTECTIVE COATINGS WILL ADD YEARS TO SERVICE

Discussing the oil and gas industries' problem of pipe line maintenance, members of the American Institute of Mining and Metallurgical Engineers declared that the application of proper protective coatings would largely eliminate corrosion losses and add years to pipe line service.

Biturine Enamel Prevents Corrosion Permanently

For more than sixteen years many leading oil and gas industry executives have been successfully solving pipe line corrosion problems with Biturine Enamel—the permanent corrosion preventive. Hundreds of miles of pipe line have been coated with Biturine Enamel and operators have pronounced it entirely successful in giving permanent protection.

Unaffected by Acids, Alkalis or Electrolysis

Biturine Enamel is a heavy, quick-setting bituminous coating, tough but not brittle. It is applied hot and requires no wrapping. Adheres tightly to metal and will not crack. It is absolutely impervious to corrosive elements. No skilled labor necessary.

Biturine Enamel is manufactured by Hill, Hubbell & Company as one of a special line of paints for the oil industry.

HILL, HUBBELL & COMPANY

Manufacturers of

Highest Grade Oil Industry Paints and Pipe Line Coatings

Factories: SAN FRANCISCO and TULSA

SAN FRANCISCO SEATTLE NEW YORK LOS ANGELES TULSA BALTIMORE PORTLAND HOUSTON

Coatings Performance Research

Comparison of performance between the various coating types has been a challenge. Lab test comparisons are available for the more recent ones compared to vintage coating.

Ideally, it is recommended by Frank Cheng & Richard Norsworthy (Pipeline Coatings) that the best way to determine if a coating system may provide satisfactory service under the variable conditions anticipated during coating application, installation, and service, an attempt should be made to replicate the conditions in the laboratory, accelerate them, if possible (to provide for differentiation between candidate systems), and to establish a ranking prioritization between candidate systems.

As this method has not been possible, efforts have been made by referring to the standards for external coating materials and applications. In addition to this, have compared different coating candidates in our system based on leak history, age of asset, cathodic protection.

THANK YOU

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