Pipeline Engineering

design | analysis | testing

STRESS ENGINEERING SERVICES INC.®
an employee-owned company

Defect Characterization and Assessments

Dent Strain and Remaining Life Assessments

Proper assessment of the types of damage that occur in pipelines is often challenging, especially considering the potential for a failure occurring. Additionally, operators are often hesitant to shut down operation or remove lines from service unless determined to be absolutely necessary. For this reason, we are frequently enlisted by operators to assess the extent and relative risk of pipeline damage.

Our damage-assessment approach is built on our experience from numerous prior evaluations and draws heavily from resources involving finite element methods as well as a database integrating years of full-scale pipeline testing. Our goal is to help pipeline operators better position themselves to appropriately respond to pipeline damage using a sound methodology that permits the continued safe operation of their pipeline systems.

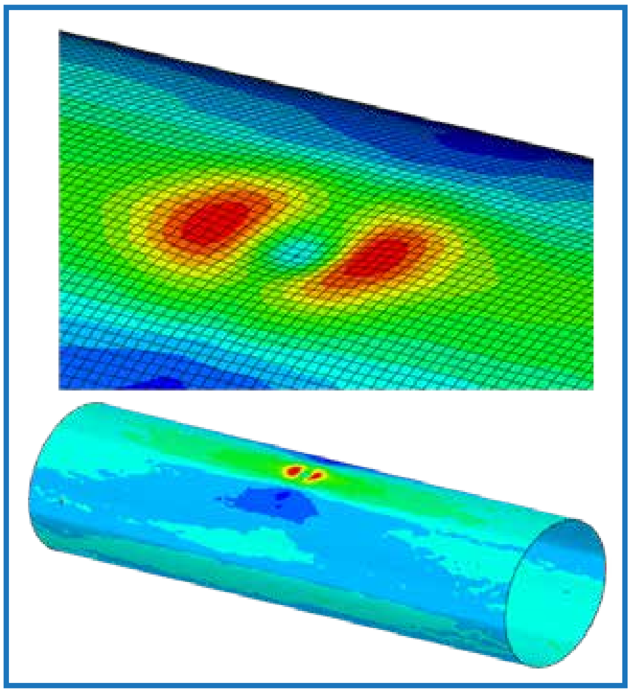
Evaluating Interacting Defects including Metal Loss and API 579 Analysis

We use testing, analysis, state-of-the-art technology, and a collective integrated approach to help pipeline companies assess threat interaction in their pipeline systems in support of their integrity-management programs. Our engineers and technicians are leading experts in predicting the future performance of potentially interacting threats along the pipeline, including combinations of anomalies such as dents, wrinkle bends, and flaws in seam welds and vintage girth welds.

Anomaly Assessment to Comply with Applicable Codes and Regulatory Requirements

The pipeline industry has used years of research and experience to develop a set of tools to perform qualitative analyses of pipeline integrity. With the implementation of the Integrity Management Program (IMP) by the Pipeline and Hazardous Material Safety Administration (PHMSA), the analysis methods and results must be defendable and well documented.

To address these requirements, we have combined existing knowledge, analytical techniques, testing, and engineering to create a systematic method for assessing damage to pipelines and generating results.



Integrity Assessment for Crack-Like Flaws according to API 579 and Ln-Sec Methods

At Stress Engineering Services, we take into account the current recommended fracture mechanics model, operational history of the line, and future conditions to perform a comprehensive assessment that addresses both strain and fatigue.

Pressure Cycle Analysis for Crack-Like Flaws including Crack Growth Assessment

Over time, a pipeline will experience some amount of pressure cycling whose impact needs to be addressed. Performing a pressure cycle analysis requires both a rainflow counter and a fatigue calculator, which is composed of a crack-growth model and a failure algorithm. By utilizing these tools and their extensive analytical expertise, our engineers can perform a pressure cycle analysis for each pipeline segment and determine the remaining life for each flaw within that segment.

Pipeline Integrity Threat Assessments

Engineering-Based Approach to Pipeline Threat Management

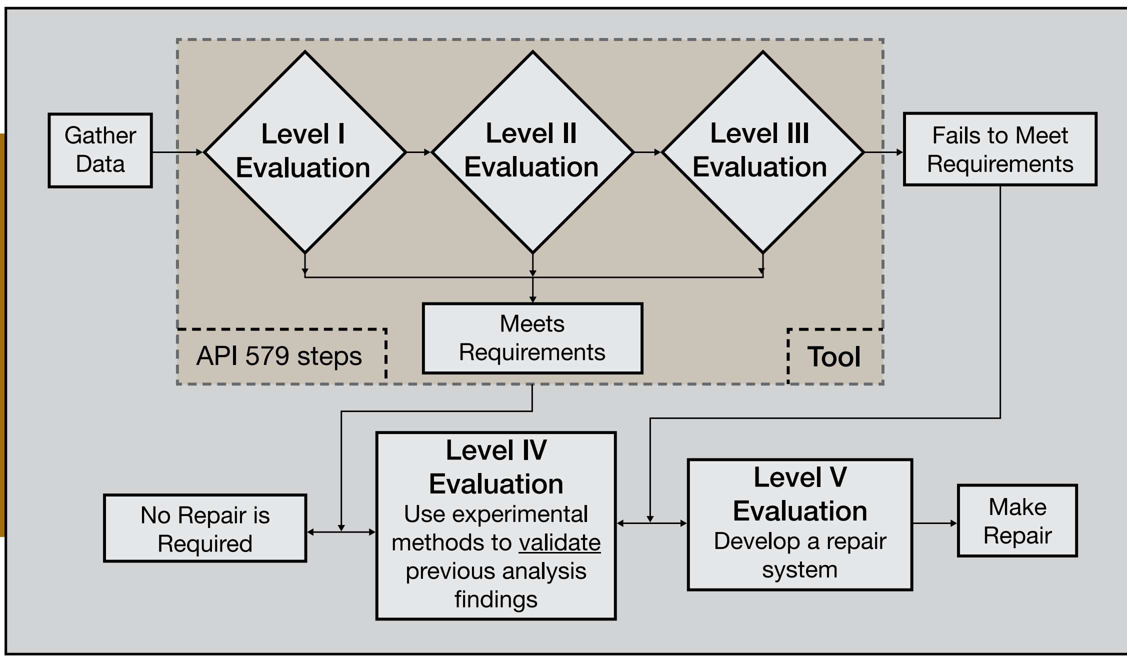
To assist the pipeline industry in its integrity management efforts, we have developed the Engineering-Based Integrity Management Program® (EB-IMP®). While the foundation of this initiative is the API 579/ASME FFS-1 Fitness for Service standard, the EB-IMP goes beyond the traditional API 579/ASME FFS-1 three-level assessment process to incorporate two additional steps that include assessment by experimental methods and development of repair techniques.

The EB-IMP methodology is an extension of Stress Engineering's work for pipeline companies in evaluating anomalies such as dents and mechanical damage using finite element analysis (FEA) and full-scale testing. Additionally, we have led industry's efforts to evaluate composite repair technologies for pipelines. These repair technologies serve as the basis for the EB-IMP's Level 5 repair assessment. Pipeline companies all around the world have used our EB-IMP process, and we believe that it gives operators confidence to safely operate their pipelines based on a thorough understanding of anomalies.

Develop Operating Criteria by Testing Defect or Condition Performance

Stress Engineering Services evaluates pipeline threats and failures to determine the safe limits of prospective operations for our clients. We analyze dents, cracks, and other pipeline threats to ensure the upmost safety. In addition, we identify roadblocks to long-term operation and help ensure that they are accounted for before installation or repair.

We thoroughly assess each situation by defining its parameters and safety factors while incorporating between stress points. We use



Flowchart showing steps of the EB-IMP®

advanced FEA and computer modeling, materials engineering, burst testing, field instrumentation, and monitoring to help our clients guard against catastrophic failure and to maintain mechanical integrity.

Build Criteria by Comparing Finite Element Results with Lab Tests

The results of the engineering and FEA analyses can be confirmed via a qualified testing program. Depending on the desired outcome, testing can involve either pipe material removed from service or newly constructed pipe. Our testing approach for evaluating mechanical integrity is extremely powerful and provides pipeline operators a means to quantify integrity concerns not possible using only standard assessment methods.

As the leader in pipeline testing, we are able to provide important insights to the pipeline's performance when subjected to actual operating conditions.

Validate Non-excavation and Prioritized Maintenance Activity

The impact of excavation damage on pipeline safety and the environment can far outweigh the potential benefits. A discriminant assessment of pipeline integrity threats allows the operator to reduce risk and develop a comprehensive solution. We have developed processes to prioritize pipeline flaws that maximize pipeline integrity and assure appropriate action for each threat.

Assess Composite and Steel Repairs for Use on Nonstandard Defects

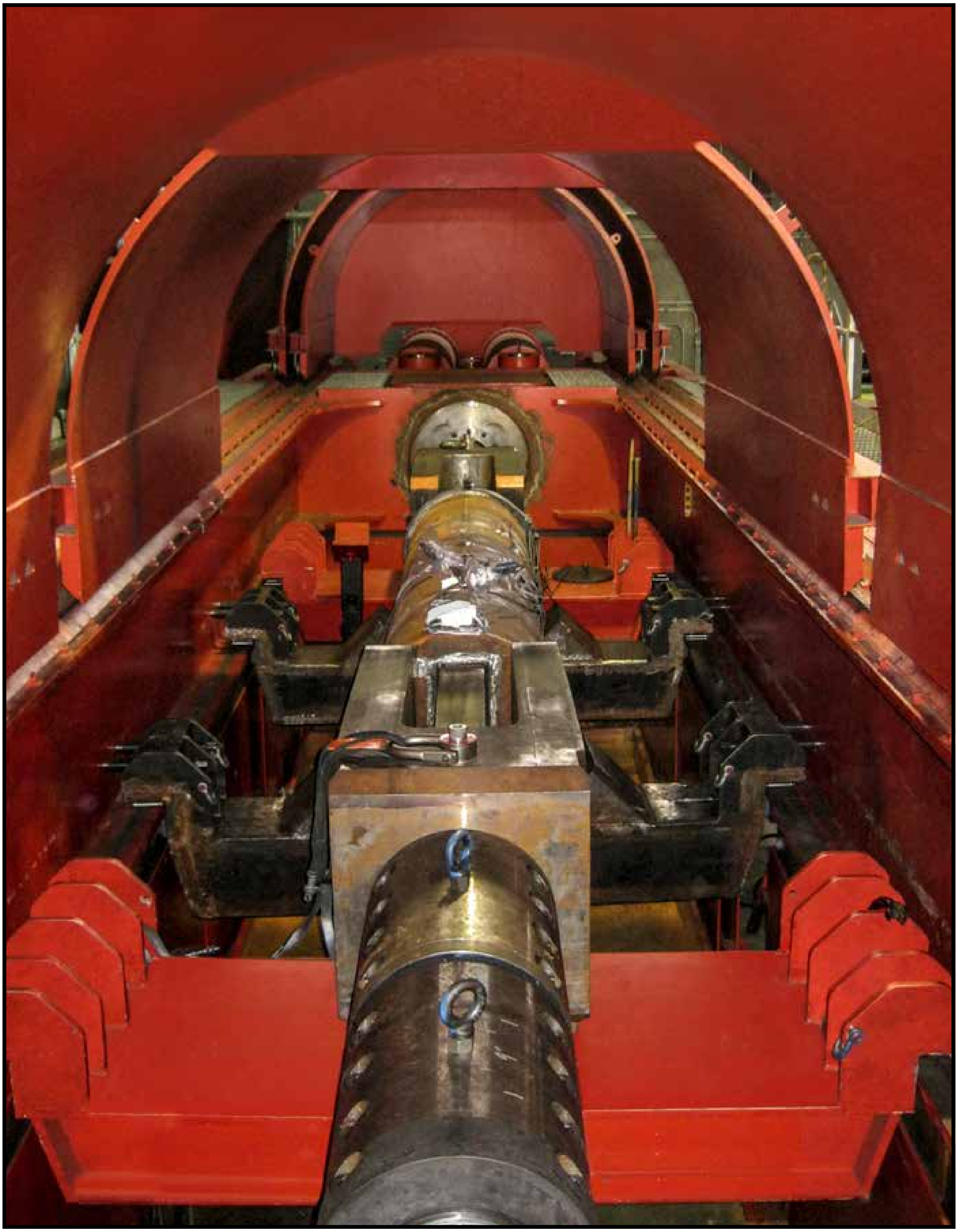
Composite materials have primarily been used for repairing corroded pipelines with the goal of restoring strength to damaged sections. However, composite materials have also been used to successfully repair dents, wrinkle bends, induction bends, vintage girth welds, and pipe fittings including elbows and tees. In addition, although the majority of composite materials research has been focused on repairing onshore pipelines, numerous studies have been conducted on assessing the repair and reinforcement of offshore risers and pipelines.

We recognize the role that engineering testing and analyses play in validating the performance of composite repair systems. We have evaluated more composite repair systems than any other organization in the world, and we are committed to continue building this valuable knowledge base. Our primary focus is on applying our vast experience and resources to integrate innovative applications of new materials to repair and reinforce risers and pipelines safely.

Subsea Engineering and Structural Integrity

Subsea pipelines and flowlines are periodically subject to threats that can drastically affect the integrity of the pipeline and possibly cause failure. Knowing how to assess these types of damage is often challenging, especially considering the potential for product release. Also, operators are hesitant to shut down operation or remove lines from service unless deemed absolutely necessary.

Using our technological skills, field expertise, and advanced analytical capabilities, we work with operators to assess the extent of pipeline damage and develop viable solutions. In addition, we assist clients with various repair activities, including the design of subsea pig launchers, diverless ancillary equipment such as pipe lift frames, pipe-indexing bases, and hydraulic clamp installation aids.



Full-Scale Testing and in-Situ Monitoring

Stress Engineering Services utilizes full-scale testing as both an assessment and predictive tool to support the integrity management programs of pipeline operators around the world. Our engineers and technicians are leading experts in using full-scale testing methods to evaluate all types of pipeline anomalies including dents, cracks, defects in seam welds and vintage girth welds, and wrinkles.

Full-scale testing of pipeline components and materials provides engineers with insights regarding the in-service behavior of their assets, including potential failure conditions. Our test programs not only highlight threats to pipeline integrity, but also give opportunities for evaluating remediation techniques and establishing reassessment intervals.

These testing techniques can be especially valuable when combined with numerical modeling and in-situ monitoring data. Validation of finite element modeling through full-scale testing enables future design efforts to more accurately simulate the service conditions experienced by the asset.

In addition to full-scale testing, in-situ monitoring is a valuable tool for assessing integrity of a pipeline. In-situ monitoring allows the external loading conditions such as ground movement affecting the pipe to be measured. These results can then be used to supplement numerical analysis and full-scale testing efforts or make decisions about remediation. In-situ monitoring can be conducted on-site or set-up to remotely transmit data.

Burst Testing

Determines the ultimate pressure capacity of the sample by increasing internal pressure until failure occurs. The addition of strain gages located at areas of interest on the sample can provide valuable information on stress concentrations due to defects, crack opening due to internal pressure, or the level of reinforcement provided by threat mitigation techniques.

Pressure Cycle Fatigue Testing

Introduces cumulative damage to simulate future service. Can be used as a determination of fatigue life for a particular anomaly or combined with operational protocols such as future hydrotests. This is a useful technique for forecasting how a pipeline might perform at some future date.

External Load Testing

Application of external loads to simulate a variety of scenarios such as thermal buckling, land movement, and pipe/soil interaction. These can include combined loading scenarios with bending, internal pressure and axial tension or compression.

Simulated Damage Creation

The process of simulating pipe damage in the test laboratory rather than using actual defective pipe materials from the field. Fabricated defects are often used during testing to represent corrosion, dents, wrinkles, or mechanical damage.

Facility Assessments and Fluid Mechanics

We provide comprehensive analysis and testing assistance to solve vibration issues in pipelines and piping associated equipment.

Vibrations and transients can occur in pipelines and facilities piping that can result in high stresses or fatigue. A common cause of vibrations in pipelines and piping systems is periodic forcing from equipment such as pumps and compressors. These vibrations can cause high noise levels and lead to fatigue damage and piping failure.

We employ a combination of measurements and modeling to analyze the source or potential for vibrations, and to predict the pipe vibration amplitudes and stresses.

Computational Modeling of Fluid Transients and Water Hammer

While many piping systems operate in a steady state manner, all experience transients at least occasionally, due to startups, shutdowns, and changes in demand. Transients can result in high and/or low pressures in the pipeline. Such transient pressures are more often problematic in liquid service than gas due to the higher densities.

Shock resulting from the sudden change in velocity of a fluid is commonly referred to as "water hammer", though a more general term is "hydraulic shock". Shocks can occur due to either starting or stopping the motion of a column of fluid.

Vortex Induced Vibration Assessments and Exposed Pipeline Spans

Managing pipelines having unintended free spans requires an engineering assessment of the current conditions as well as ongoing monitoring, since continued erosion can further increase the span length. In addition, spans carry a significant risk of failure from static loading, vortex-induced vibration (VIV), potential debris impact, and/or buckling.

Our engineers use both analytical methods and finite element methods to evaluate pipeline spans. The benefit of the analytical methods is that they use relatively simple inputs and that they can be applied to a large number of spans on the same pipeline so that you can do one calculation to apply to a number spans. Therefore, it can be used as a screening method to see which of your pipelines spans needs further evaluation.

Pipe Stress Calculation and Monitoring for Blasting and Construction Activities

In order to increase capacity, operators are often required to add pipelines to existing rights-of-way, often close to or between existing pipelines. In these cases, overly-conservative blasting criteria can result in significant expenses and delays. It is important for operators to develop blasting criteria that do not overly restrict activities while staying within risk tolerance limits.

At Stress Engineering Services we have performed a variety of blasting and construction related testing programs to measure the strains and then expertly analyzed the validity and conservatism of standard blasting stress models for these conditions. We can assist with developing blasting plans as well as instrumenting and monitoring pipe stresses during blasting.

We can also provide assistance with analyzing and monitoring stresses associated with construction activities such as road crossings, equipment loading, and pile driving in the vicinity of a pipeline.

Small Bore Branch Connection Vibration Assessment and Analysis

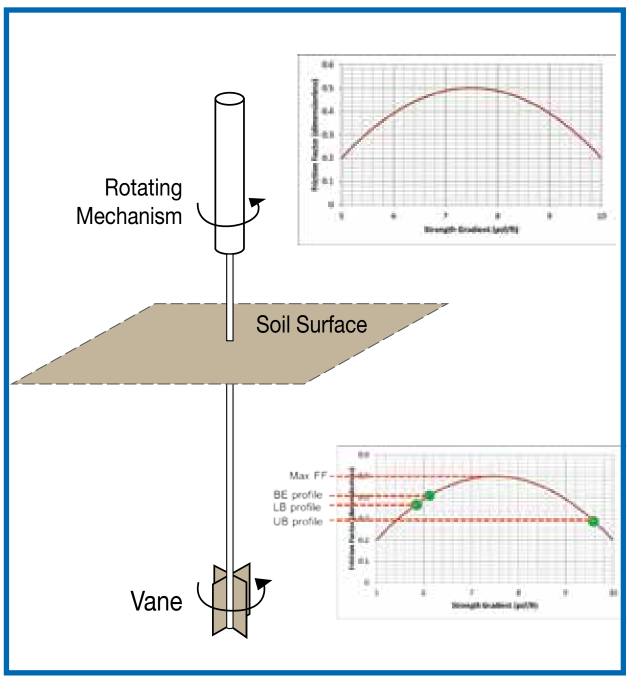
Vibrations of small-bore connections (SBC) branching from large diameter piping or vessels are a common problem. These vibrations are often associated with branch piping that is 2 inches in diameter or smaller and typically occur near pumps, compressors, or valves.

Another common cause of failures at SBCs is shell mode vibrations of the main pipe. Unlike bending modes, shell modes involve deformation of the cross-section of the piping. Our engineers have experience with both measuring and modeling shell mode vibrations.

External Loading and Geohazards

Geotechnical hazards threaten pipelines across the US and around the world. Modeling, identifying, mitigating, and monitoring hazard-prone areas can save millions of dollars in repair, replacement, and lost service. Stress Engineering Services offers geotechnical assessments by experienced professional engineers to assist pipeline operators in proactively preventing geotechnical-related failures. In addition, our integrated approach of using geotechnical data to complement IMU data, metallurgical analyses, and finite element analyses has assisted pipeline operators in returning pipelines to full service.

- Pipe Stress at Road and Railroad Crossings
- Blasting Stresses
- Ground Movement
- Strain Based Design Validation Testing



Metallurgical Failure and Vintage Materials Analysis

Utilizing a multidisciplinary approach to detect root causes of pipeline failures and provide the resources to better manage identified threats.

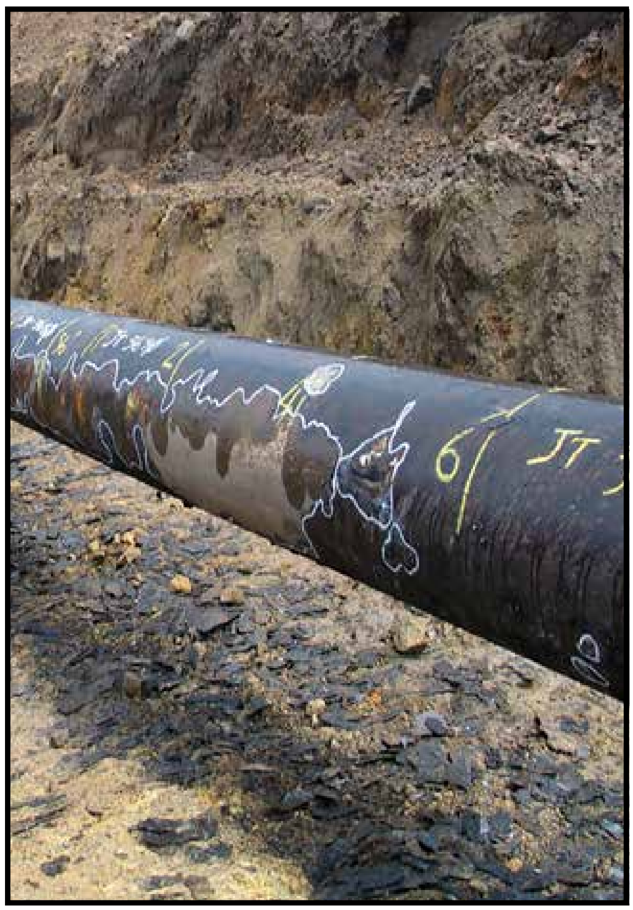
Unfortunately, pipeline failures are bound to occur from time to time. Comprehensive analysis of each pipeline failure is critically important to operators and the pipeline industry as a whole. The primary aim of these efforts is identifying the metallurgical cause of the failure, with the work often being performed by metallurgists to determine and fully document the root cause(s) of the incident.

At Stress Engineering Services, we realize that solving technically challenging problems often requires a multidiscipline effort involving metallurgists, mechanical/structural engineers, testing engineers, and field personnel. We utilize our vast industry experience and skill sets to expertly analyze damage mechanisms that can cause systemic pipeline failures, such as defective girth and seam welds, corrosion, stress corrosion cracking, dents, and wrinkle bends.

Vintage Materials Analysis

The methods that were used to construct the pipeline must also be carefully considered when determining the cause of a failure. Vintage pipelines (older than 50 years) were typically constructed using construction processes and practices different from those used today. Those practices regularly induced various types of systemic defects in pipelines. Examples of historical construction practices that may cause integrity concerns include low-quality girth welds, dents, arc strikes, and wrinkle bends.

Our engineers and metallurgists have been assisting pipeline operators around the world by helping them evaluate threats associated with systemic anomalies throughout their pipelines to make them safer for the future.



Stress Engineering Services a leader in providing proven engineering services and solutions for a broad range of industries worldwide. Always at technology's leading edge, we set the standard in technical excellence by providing clients with the right answers - on time.

This commitment to excellence is the cornerstone of our business. It stems from our belief that there's more to providing quality service than just producing results. It's about having the most advanced technology and equipment along with a team of highly qualified engineering experts with years of applied industry experience and a wide array of engineering disciplinary skills. More importantly, it's about really listening to the client's needs to effectively assess their problem, and combining the right skills and resources to solve their problem in the time they need it.

Since 1972, we have been servicing the needs of clients who require special, in-depth technical knowledge in the areas of testing, materials engineering, metallurgy, floating systems, pipeline engineering, fitness for service, risk assessment, mechanical design, fluid and fracture mechanics, process technology, instrumentation, product design and development, subsea engineering, finite element analysis, and more.

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