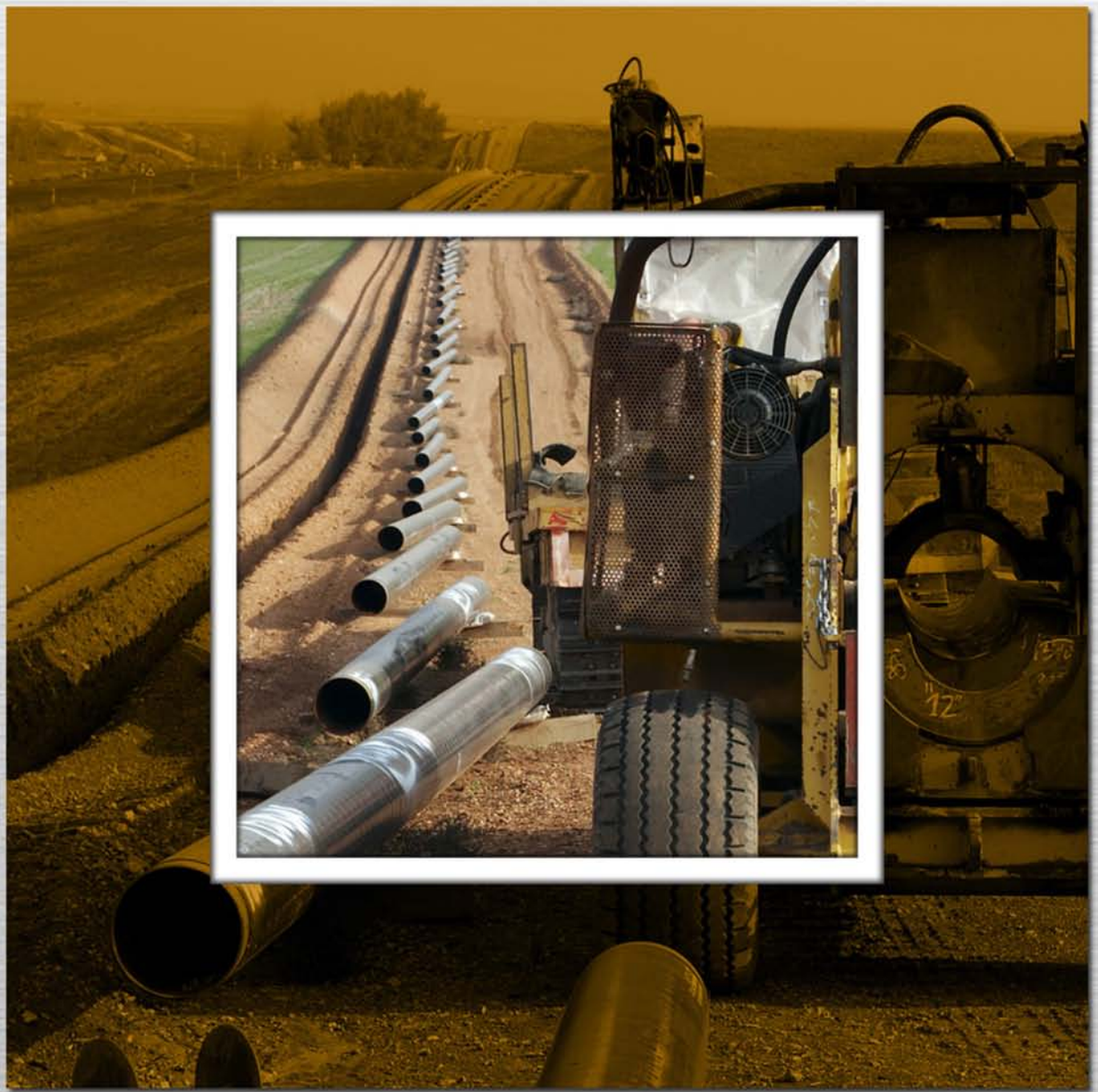
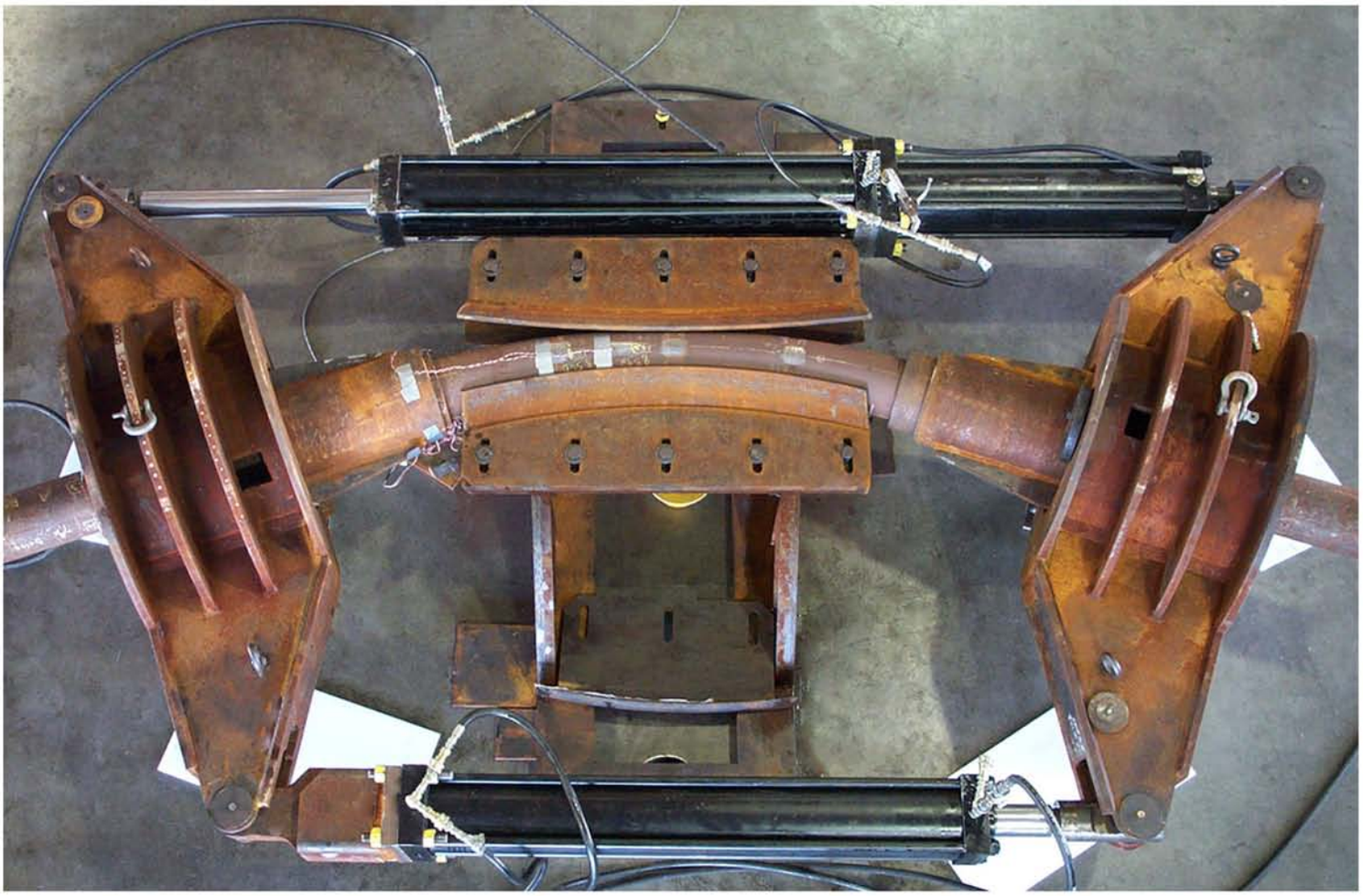
Pipeline Engineering



design • analysis • testing

STRESS ENGINEERING SERVICES INC.



A well-organized testing program can provide significant insights into the future performance of pipeline materials with existing anomalies and also gives operators the ability to assess the integrity of their pipeline system in a manner that simply cannot be achieved using an analysis-only approach.

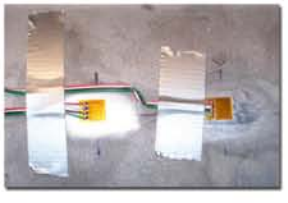
Full-Scale Testing

Full-scale testing is useful to achieve a better understanding of how pipelines respond to loading conditions that can lead to failure. A well-designed test program can validate numerical modeling efforts, thus improving the overall confidence in the analysis results. In addition, testing can provide engineers with insights on in-service behavior and threats to pipeline safety. Testing can also be a powerful tool to predict the future performance (establish reassessment intervals) of pipelines to meet integrity assessment requirements.

For more than a decade, Stress Engineering Services has been using full-scale testing methods to help pipeline companies assess the condition of their pipeline systems in support of their integrity management program. The engineers and technicians at Stress Engineering Services are leading experts in full-scale testing methods that aid in predicting the future performance of pipeline materials with anomalies such as dents, wrinkle bends, and flaws in seam welds and vintage girth welds.

Burst Testing

Increasing pressure to a test sample until it fails in order to determine the ultimate pressure capacity of the pipe sample and/or the reduction in strength associated with given anomalies.



Pressure Cycle Fatigue Testing

Performing a fatigue test using cyclic pressure to introduce cumulative damage to simulate future service before performing a burst test or determining the fatigue life of a particular anomaly. This is a useful technique for forecasting how a pipeline might perform at some future date.

Bend Testing

The application of bending loads to simulate a variety of pipeline conditions such as thermal buckling, land movement, and pipe/soil interaction. In addition to bending loads, the tests can simultaneously include the effects of internal pressure and axial tension or compression.

Simulated Damage Creation

The process of simulating pipe damage in the test laboratory instead of using actual damaged pipe materials from the field. In addition to excessive loads, anomalies are often simulated during testing including corrosion, plain dents, wrinkles, and mechanical damage.

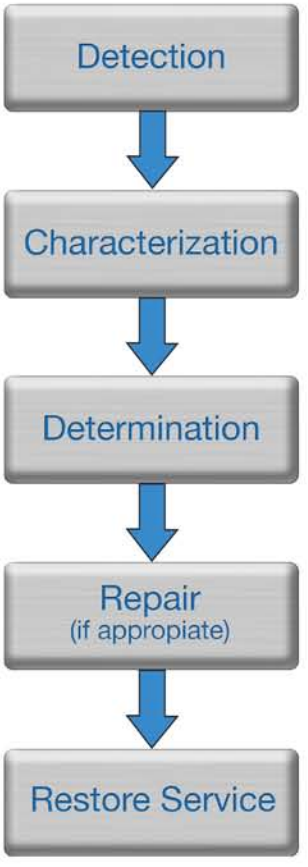
One of the most critical elements to consider when assessing pipeline damage is the classification of the anomaly. Some of the major anomaly classifications that typically arise when assessing pipeline damage include plain dents, constrained dents, gouges, mechanical damage, and wrinkles.

Damage Assessment

Knowing how to assess the types of damages that occur in pipelines is often challenging, especially considering the potential for failures. Additionally, operators are often hesitant to shut down operation or remove lines from service unless absolutely necessary. For this reason, Stress Engineering Services is frequently called upon to work with operators to assess the extent of pipeline damage.

Our damage-assessment approach is built on our experience from 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 methodology that permits the continued safe operation of their pipeline systems.

Anomaly classification is one of the most critical elements for assessing pipeline damage. It is the starting point that leads to a better understanding of the damage, characterization of the behavior, and predictability of the response. Although a wealth of information exists for a wide range of anomalies, it is often difficult to organize that information so that it is useful. The pipeline engineers at Stress Engineering Services possess the knowledge and expertise to review existing documentation to determine exactly what information is required to conduct an informed assessment.



Finding the Damage
inspection technology

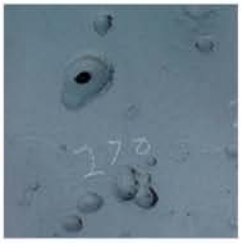
Assessing the Severity
experience, opeating history, testing, and analysis

Defining Acceptability (rank damage if required)
evaluation relative to codes, standards, and government regulations

Repairing the Damage (if required)
use available technology to determine the best repair options

Continue Operation
restore service once integrity has been re-established

Pipelines and piping frequently suffers from metal loss that threatens their integrity and serviceability. Multiple repair options exist for straight sections of pipe; however, the repair options for pipe fittings such as elbows and tees are typically limited to composite repair systems, or section replacement.



Composite Repair

Stress Engineering Services is the world leader in assessing the use of composite materials to reinforce pipelines, risers, and piping systems for the oil and gas industry. We have evaluated more composite repair systems than any organization in the world, which uniquely positions us to understand the competing technologies that comprise this important sector of the energy industry.

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. Although the majority of composite materials research has 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 plays in validating the performance of composite repair systems. Since 1994, evaluating composite repair systems has been an integral part of our services, and we are committed to continue building upon 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 in a safe manner.

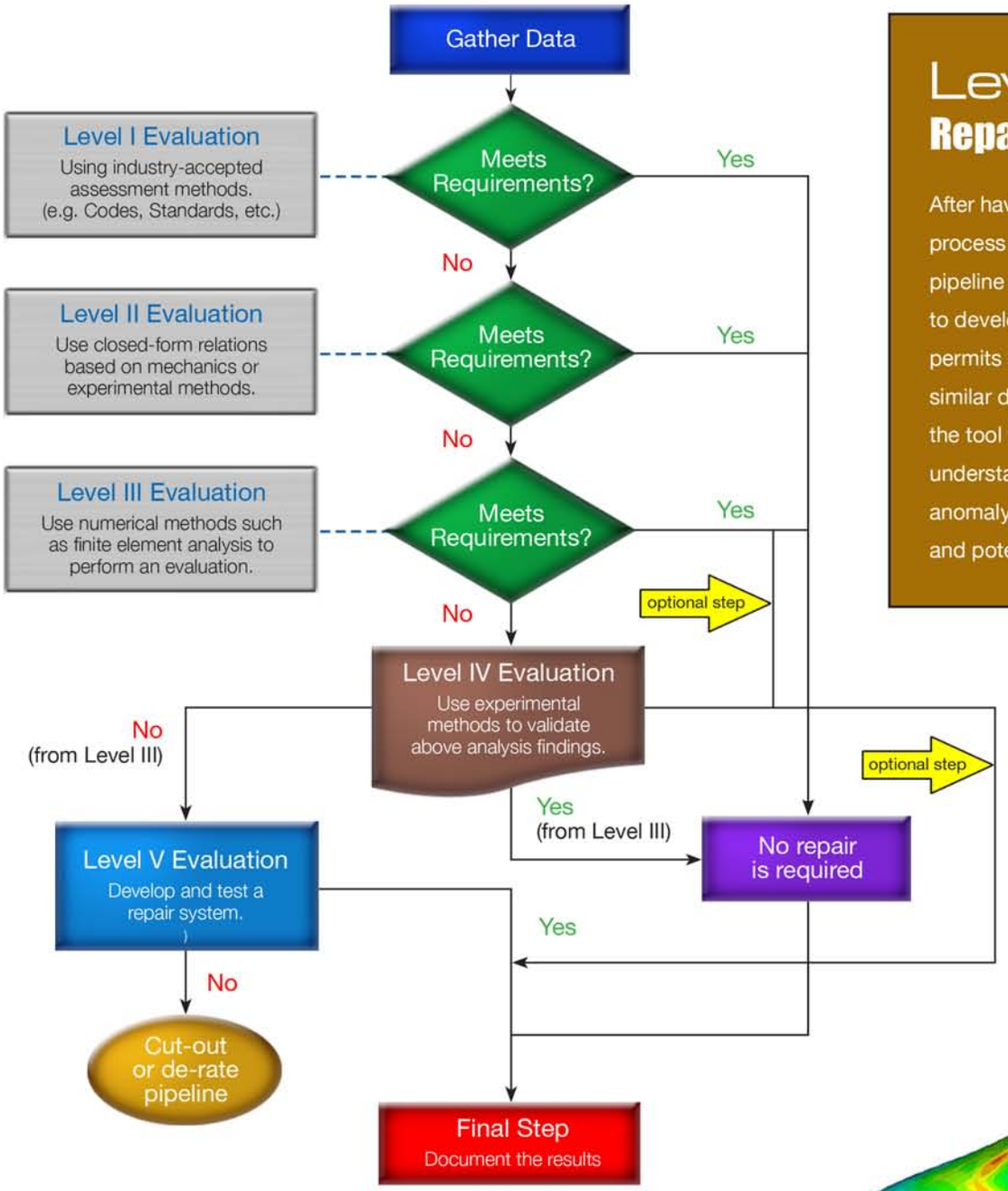
At Stress Engineering Services, our engineers work with pipeline operators and composite-material manufacturers to actively identify issues and test the wide range of pipeline repair methods within the industry with the goal of providing the most reliable solutions to solve difficult problems.

Failure Analysis

Pipeline failures are not only costly and disruptive to operations, they can cause extensive property damage and severely affect human lives. In other words, if the potential for failure is high or the consequence of failure is significant, then failure is not an option.

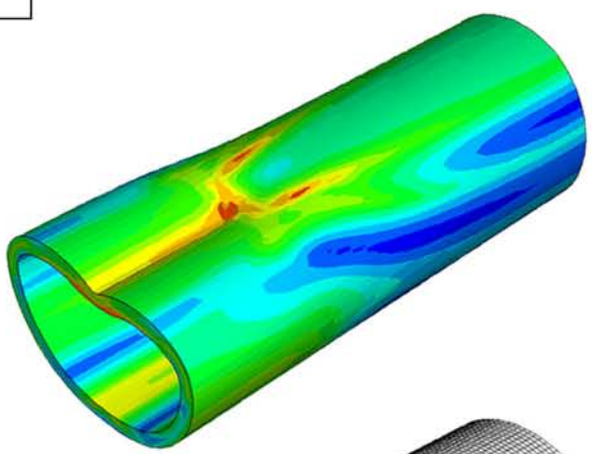
Our focus is on providing operators with an in-depth analysis of the damage mechanisms and root causes of failures so they can effectively assess the integrity of their pipeline systems. Furthermore, we specialize in identifying the mechanisms that can cause systematic pipeline failures, such as defective girth and seam welds, corrosion, stress corrosion cracking, dents, and wrinkle bends.

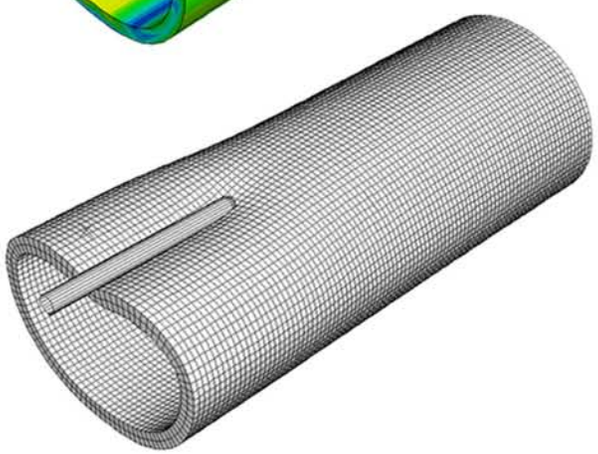
At Stress Engineering Services we realize that solving technically-challenging problems often requires a multi-discipline approach. We utilize our vast industry experience and skill sets to expertly analyze damage mechanisms, identify the root causes of failures, assist in the prevention of future failures, and provide operators with the most reliable solutions.



Level 5
Repair Assessment

After having completed the five step process in evaluating a specific pipeline anomaly, the objective is to develop an assessment tool that permits a general evaluation of similar defects. In order to do this, the tool creator must have a firm understanding of the respective anomaly including critical variables and potential modes of failure.





Engineering-Based Integrity Management

Establishing adequate pipeline integrity requires identifying specific threats, understanding their relationship to the condition of the pipeline, and establishing appropriate measures to ensure integrity. The pipeline industry has relied on many 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 assist the pipeline industry in their integrity management efforts, Stress Engineering Services has developed the Engineering-Based Integrity Management Program (EB-IMP®). The backbone of this initiative is the API 579/ASME FFS-1 Fitness for Service document; however, Stress Engineering has gone beyond the traditional API 579/ASME FFS-1 three-level assessment process to develop two additional steps that include assessment by experimental methods and development of repair techniques.

The EB-IMP® methodology is an outgrowth of Stress Engineering's work for pipeline companies over the past 20 years in evaluating anomalies that include dents and mechanical damage using finite element analysis and full-scale testing. Additionally, Stress has led industry's charge to evaluate composite repair technology for pipelines. This repair technology serves as the foundation for the EB-IMP's Level V repair assessment.

Computer Modeling & Simulation

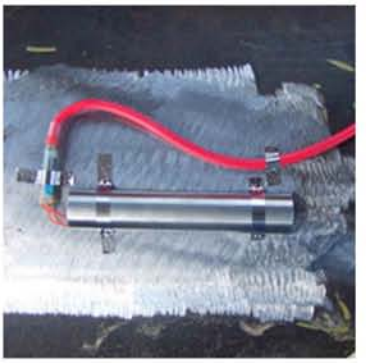
Finite Element Analysis

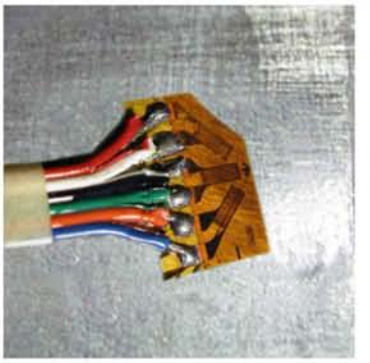
Finite element analysis (FEA) is a valuable technique for analyzing mechanical components and systems. The finite element method is a useful tool for predicting and evaluating component responses to loading and providing key information as to how it will perform in service.

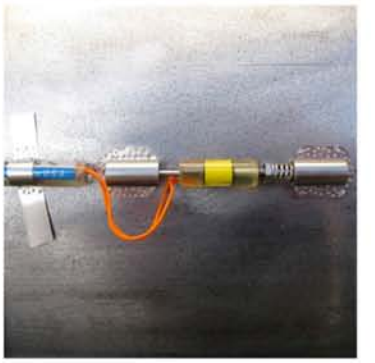
When coupled with data from in-line inspection tools, FEA offers a powerful means for assessing pipeline anomalies. Finite element analysis is an effective method for evaluating the strength and fatigue life of anomalies. In addition, FEA can incorporate the inclusion of soil into an assessment thus providing an accurate depiction of how the system will perform under pressure and/or thermal loads.

Pipe-Soil Modeling

Buried pipelines are an integral part of our national infrastructure. It is sometimes necessary to evaluate the behavior of pipeline systems by considering the interaction that takes place between the pipeline and surrounding soil. Stress Engineering has numerically modeled the behavior of pipelines using pipe-soil interaction elements to better understand variations in loading conditions. Vibrating wire strain gages have also been installed on actual pipelines to measure the displacement, and induced strains, of pipelines in soil over extended periods of time.







Vibrating wire strain gages are often used to monitor pipelines in remote environments and for measuring over extended periods of time.

Measurement & Monitoring

Achieving superior data measurements requires having the knowledge on how to properly install measurement tool installation without interfering with measured signals, what to filter out of the measured signals, what to evaluate further, and how to effectively interpret the data. For over 30 years we have been leading the way in the installation and use of strain gages, the development of advanced instrumentation monitoring and data acquisition systems, and a host of other technologies specifically designed for pipeline integrity.

Remote Monitoring

In the field or in the laboratory, our engineers and technicians use the most advanced data acquisition systems and installation techniques to accurately monitor and collect data on a variety of equipment, components, devices, and processes. We also provide a wide range of remote monitoring and measurement solutions including cellular phone / satellite monitoring and real-time posting of data on a secured website.

Materials Engineering

Solving and understanding materials problems and mechanical challenges requires exceptional skills and a multi-disciplinary approach. Our diverse materials experience, advanced techniques in metallurgy, along with our laboratory testing and scanning electronic microscopy capabilities translates to an unsurpassed level of materials engineering knowledge. These abilities allow us to provide clients with the reliable solutions they need when making pipeline, piping systems, and integrity management decisions.

Our independent materials testing laboratories are equipped with state-of-the-art equipment for a wide range of material-testing methods including static tensile, compression, fatigue, chemistry, impact, environmental-related loading, creep, and relaxation. In addition, we offer a wide range of custom testing procedures designed to accurately define failure modes and assist in dependable material selection.

Harsh Environment Testing

Our materials testing facilities host a full-service fatigue and fracture laboratory for materials testing in sour (H_2S), high-pressure/high-temperature, low temperature, CO_2, nitrogen, methane, and other extreme environments. In addition, we provide materials characterization and selection assistance for equipment used in harsh environments, as well as full-scale equipment assessments. The laboratories feature digitally controlled, servo-hydraulic material test frames with capabilities ranging from 22 to 150 kip for both standard and non-standard tests.

- Sour Service Testing
- Fracture Toughness Testing
- Small-Scale Component / Assembly Characterization
- Component Testing
- Cyclic Fatigue and Fracture Testing
- Tensile and Compression Testing

Stress Engineering Services is 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 delivering 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 listening to the client's needs to effectively assess their problem, and unite 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 materials engineering, metallurgy, testing, fitness-for-service, risk and feasibility assessments, floating production systems, riser design and analysis, pipeline engineering, mechanical design, fluid and fracture mechanics, process technology, product design and development, subsea engineering, data acquisition, instrumentation, and more.

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