



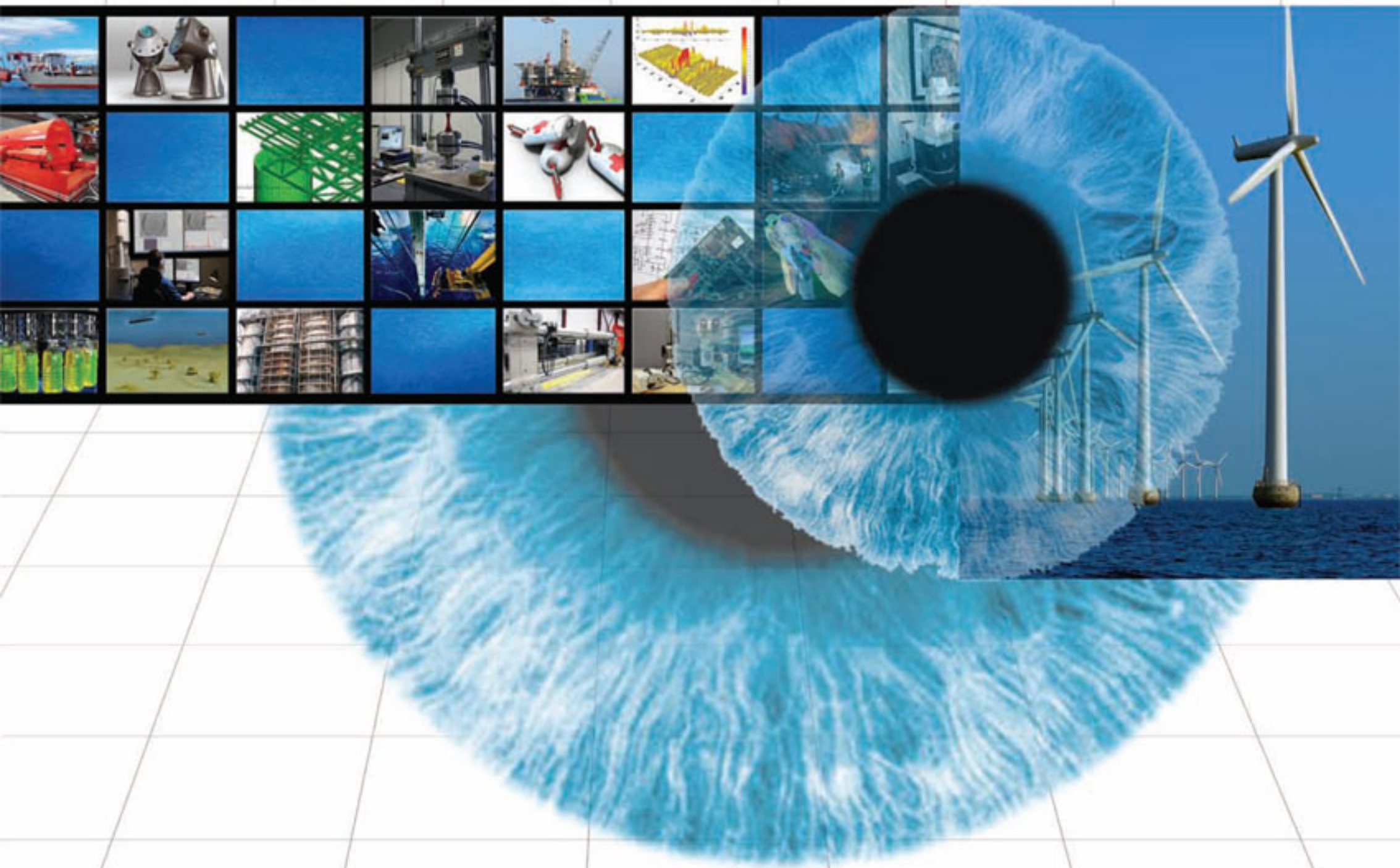
STRESS

talk²⁰¹⁰

a STRESS ENGINEERING SERVICES, INC. publication

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tomorrow's visions



TODAY



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Stress Engineering Services, Inc.
13800 Westfair East Drive
Houston, Texas 77041-1205

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The *right* people delivering the *right* answers at the *right* time!



The year 2009 was a challenging year for the industry, our clients, and Stress Engineering Services, Inc. Despite this, we helped 715 clients, and enjoyed strong sales. Early in 2010 we were notified that we had received the #1 Award as "The Best

Place to Work in Texas" from the Texas Association of Business and the Society for Human Resource Management (for medium-size companies). We are very proud of this honor.

Clients call us when they are having a problem or are doing something new. Our clients value us because we value and retain highly skilled technical people who are able to help them solve unusual problems. Our 179 engineers have an average of 15 years of experience, and two-thirds of them have advanced degrees in engineering.

Clients expect the right answer on time. Wrong answers or late answers don't help them, and they won't pay for them very long, particularly when they are paying \$500,000 a day for an offshore drilling rig.

This translates into tremendous pressure on our employees, who are our most important asset. How do we make and keep our people happy?

1. By getting the right people "on the bus." We put prospective employees through an exhaustive process where they are interviewed by six or more people, make a group presentation, take personality and intelligence tests, and undergo a thorough background check.
2. By training them.

3. By paying them well. Stress is a 100% employee-owned company. All our profits go to employees either directly or through our ESOP.
4. By tending to their needs. We have a high-deductible health insurance plan that costs \$25 for employees and ½ the cost for families. Stress deposits the entire deductible in each employee's HSA. Last year, we had no increase in premiums.
5. By respecting them and making them a part of something bigger than themselves. Employees gave \$65,000 to United Way, and support an MS 150 Bike Team, a Kohman Race team, and several other charities. Most of these activities were initiated by our employees. We do 360-degree peer evaluations every year. You can't be rude to a fellow employee at Stress for very long. Bad spirit is contagious, and so is good spirit. We are blessed with good spirit at Stress.
6. By keeping a flat organizational structure with an open-door policy to management. The Stress culture is truly like a family.

These efforts result in a very low turnover at Stress. In the last three years, we have hired 97 people and had only 2.6% turnover last year. This translates into lower finding and training costs, better work, and happy customers.

The "Law of the Farm" is alive and well. You really do reap what you sow as a company. I believe these are the reasons we won this award. Thanks to all the employees at Stress who make this happen, and thanks to all our clients who make it possible.

Regards,

A handwritten signature in black ink, appearing to read "Joe R. Fowler".

Joe R. Fowler, Ph.D., P.E.
President
Stress Engineering Services, Inc.

Integrity Management of Deepwater Floating and Subsea Systems

Common Sense or Uncommon Sense?

by: J. T. von Aschwege, P.E.

What is Integrity Management?

Integrity Management (IM), particularly as it applies to deepwater floating and subsea systems, is the relatively recent product of a long history of engineering efforts to keep things from leaking, breaking, blowing up, burning down, falling down, falling off, or (one of the worst things that can happen from the perspective of a floating systems engineer) sinking! IM requires both a depth and breadth of understanding and experience among its practitioners, coupled with a strong management commitment to implement it properly through good times and bad. Ultimately, when you get into the details, IM is clearly the common-sense thing to do.

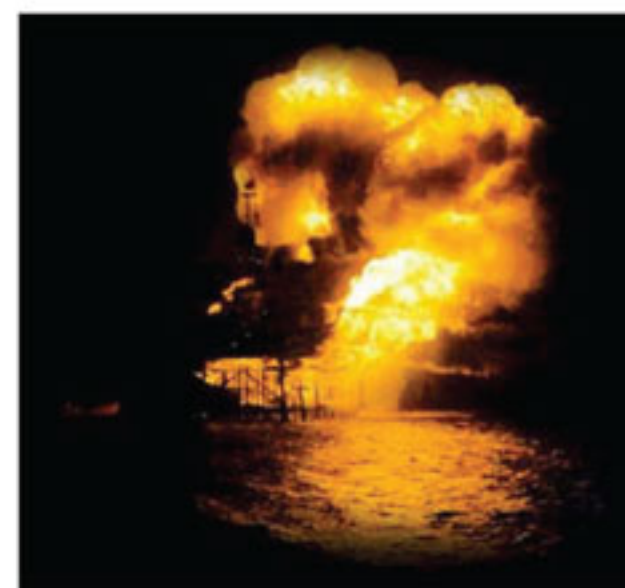
IM now fully encompasses concepts and processes such as Risk-Based Inspection, Reliability-Centered Maintenance, Process Safety, Corrosion Management, Mechanical

Integrity Management, Asset Integrity Management, and probably many other related and overlapping phrases and concepts. These are more of the "hands-on" topics that deal with fixing your hardware before it "fixes" you, your career, and your company.

If you ask ten experts, you will hear ten different answers to the question, "What is IM?" This is because it is an evolving concept, and it has evolved differently in different parts of the world. Generally speaking, the application of IM is more advanced in the downstream refining and chemical businesses. In the offshore world, it evolved much more rapidly in the North Sea after 1988. The turning point was the Piper Alpha platform disaster that year, which resulted in 167 deaths, dozens of injuries, and the total loss of the offshore facility. A two-year investigation into this disaster was docu-

mented in the "Lord Cullen Report, Public Inquiry into the Piper Alpha Disaster," 1990, by HMSO.

In the offshore Gulf of Mexico, accidents have occurred as well, but nothing of the devastating magnitude of Piper Alpha. It can be argued that the slower uptake of many IM principles in the Gulf of Mexico is largely a result of having avoided major disasters, combined with a continually improving offshore



Piper Alpha Incident - July, 1988

industry safety record, as reported by the Minerals Management Service (MMS). In other words, "Why fix it if it ain't broken?"

On the other hand, deepwater systems in the Gulf of Mexico are becoming more and more complex. From a simple external viewpoint, it is now difficult to see the difference between the topsides of a large deepwater fixed or floating platform in the Gulf of Mexico and the topsides of an offshore facility in the North Sea. Additional hazards and potential consequences exist because of the greater complexity of deepwater floating systems, which

"Why fix it if it ain't broken?"

are dominated by dynamic forces and responses. Deepwater subsea systems are becoming more complex too, producing from wells at ever-higher pressures and temperatures, and requiring more sophisticated metal alloys and welding techniques. Even though the probability of bad consequences may be extremely low, the cost of those consequences can be extremely high—much higher than in the days when 1000 ft was considered deep water. If the new Gulf of Mexico deepwater floating systems are not managed with the required level of care, then it will be only a matter of time until something goes wrong, and you receive that dreaded telephone call in the middle of the night.

What's Happening Lately with Integrity Management in the Gulf of Mexico?

For companies wanting to develop a comprehensive IM program from scratch, or just wanting to enhance or expand what they already have in place, API has provided some help. API RP 75, "Recommended Practice for Development of a Safety and Environmental Management Program for Offshore Operations and Facilities," provides an excellent overall framework, as well as individual building blocks (or "elements") for a formal and comprehensive IM program.

The more traditional IM activities have focused on hardware – inspection, testing, monitoring, maintenance, and repair – with a view toward identifying and mitigating small problems before they become big problems. As the industry has gained experience, various additional, people-related processes have been pulled under the umbrella of IM. As outlined in API RP 75, these include areas such as Hazard

Analysis, Management of Change, Operating Procedures, Safe Work Practices, Training, Emergency Response and Control, Investigation of Incidents, and that task dreaded by many engineers: Documentation and Record Keeping. In the big picture, all of these areas must be addressed carefully to ensure the long-term integrity of deepwater floating and subsea facilities.



Recently, the MMS proposed a new rule that would require offshore operators to develop at least some



of the components of a formal IM program. As published in the Federal Register, Volume 74, No. 115, on June 17, 2009, "The MMS proposes to require operators to develop and implement a Safety and Environmental Management System to address oil and gas operations in the Outer Continental Shelf. The Safety and Environmental Management System would consist of four elements- Hazards Analysis, Management of Change, Operating Procedures, and Mechanical Integrity—that, until now, have not been covered in our regulations." These elements represent only four of the 12 elements described in API RP 75. Having received public comments, including comments from the offshore industry, the MMS is expected to issue a final rule which will be a revision of their proposed rule. The timing of the rule is not certain, but may be in late 2010.

What is the Value of Integrity Management?

The value of IM is extremely easy to assess *after* your company has experienced a major disaster. It doesn't take long to discover that *if* you had an IM program in place before the disaster, and *if* it had been rigorously implemented, then that last disaster *would not* have occurred. The value of IM for your company at that point is equal to the cost of the disaster that you did not avoid. That cost would often pay for implementing a comprehensive IM program throughout your company for many years.

It is regrettable that a major disaster is often required to motivate individuals, organizations, and regulators to do something different to prevent a similar occurrence in the future.

That's what happened after Piper Alpha, and unfortunately, it is a recurring scenario in all types of activities.

A much more challenging goal is to assess the value of IM *before* your company experiences a major accident or disaster, and then convince decision-makers that it makes sense to implement it. Here are some ideas to consider to assess the value of IM—the value of what could be avoided:

Loss of Life

The human cost associated with those people who lost their lives, their families (including long-term impacts on life prospects for their children), and their friends.

Environmental Damage

The actual, often undeterminable (other than in court) cost of damage to the environment, or as a minimum, the cost of cleaning it up.

Cost of Litigation

The cost of litigating damages, and paying for awards, particularly if there is loss of life or serious environmental damage.

Social Reputation

The indirect cost of having your company's name, and possibly yours, plastered in the headlines continually, with the potential for being excluded from doing future business in some communities.

Business Reputation

The indirect cost of being excessively scrutinized by regulators and citizen groups, of being excluded from joint ventures with other companies, and of potentially losing your "license to operate" in some areas.

Cost of Repairing or Replacing a Facility

The cost of repairing or replacing a facility, or its components, to return it to production; replacement cost can often be significantly higher than the original cost.

Cost of Disruption to Business Activities

The cost of employees' time and efforts to restore an existing facility to an acceptable operating condition, which simply returns it to a previous status and does not grow the company; the value of new projects that must be deferred because the resources – people and money – are diverted into restoration work.

Employee Morale

The indirect and immeasurable cost of decreased employee morale, resulting in decreased productivity, and potentially increased attrition.

Depending on the probability of a bad consequence occurring and the cost of the bad consequence (incidents, accidents, or serious disasters), the ultimate value of an IM program can theoretically be calculated. For deepwater developments, because of their extremely high costs and requirement for extremely high revenues for economic justification, the cost consequences of failure are tremendous. Multiply these cost consequences by the *improvement*, or *decrease*, in probabilities of failure resulting from a well-implemented IM program, and you have calculated the value.

After all potential consequences are considered, IM makes good sense. But perhaps those companies who are doing it well, and who recognize the value of IM, are really exhibiting very *uncommon* sense. 

tom.vonaschwege@stress.com

Predicting Structural Performance of Flexible Polymer Films and Thin Rigid Plastics for Biaxial Loading

by: Clinton A. Haynes, Diana Papania, and Douglas L. Marriott, Ph.D.

Introduction

Stress Engineering Services (Stress) conducts a variety of tests on plastic packaging to evaluate its structural response under various manufacturing, shipping, and handling loads. Most “real-world” forces and the resulting stresses that act on both rigid plastic packaging and mono- and multi-layer films are multi-axial. The sources of these forces are ubiquitous in the world of product performance: pressurization from elevation change, drop loading, assembly and tension in a web, to name a few.

Unfortunately, package and product designers typically only have uniaxial stress vs. strain data available to them because of the difficulty and cost of generating biaxial data. Since ductility can be greatly reduced in biaxial tension, compared with uniaxial tension, the consequence of this situation is that the limiting ductility of the material used in the design of products and packages in use is non-conservative. Product designers, therefore, do not have the data they need to develop product and package designs that will survive the most critical load cases.

The need for material data that are more representative of the life limiting load cases has been and remains a growing problem. Manufacturers’ increased focus on both reduced material usage and improved

sustainability demands greater performance with less material. Also, as computational methods such as non-linear finite element analysis work their way into the mainstream of product and package development, multi-axial data are needed to predict failure. Package, product, and process designers cannot meet these challenges without having the data required to accurately quantify the performance of the materials they are using.

To address this requirement, Stress has developed a test method to measure biaxial material properties for polymer films and relatively thin

rigid plastics at high strain rates, such as those experienced during drop impact.

Practical Biaxial Test Fixture

A high-strain-rate biaxial inflation test fixture developed by Stress is shown in Figure 1. A fast-response laser position sensor [1] is used to measure the height of a clamped specimen [3]. Several clamps of various opening sizes and shapes can be used to obtain varying strain rates and multi-axial stress states. A clear protective barrier [2] is used to protect the laser from the high-pressure air stream released after the test specimen bursts [4].

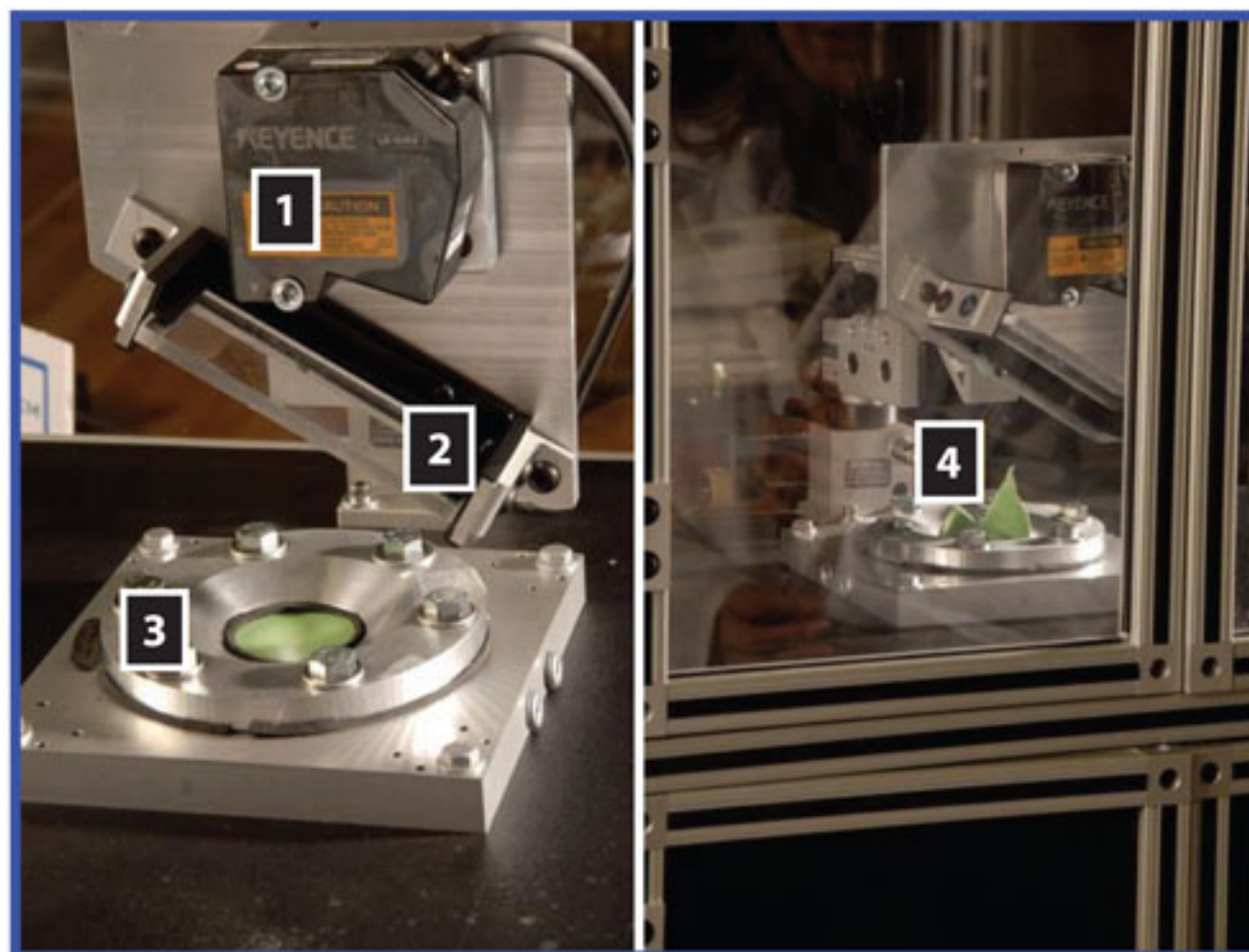


Figure 1: Biaxial Test Fixture

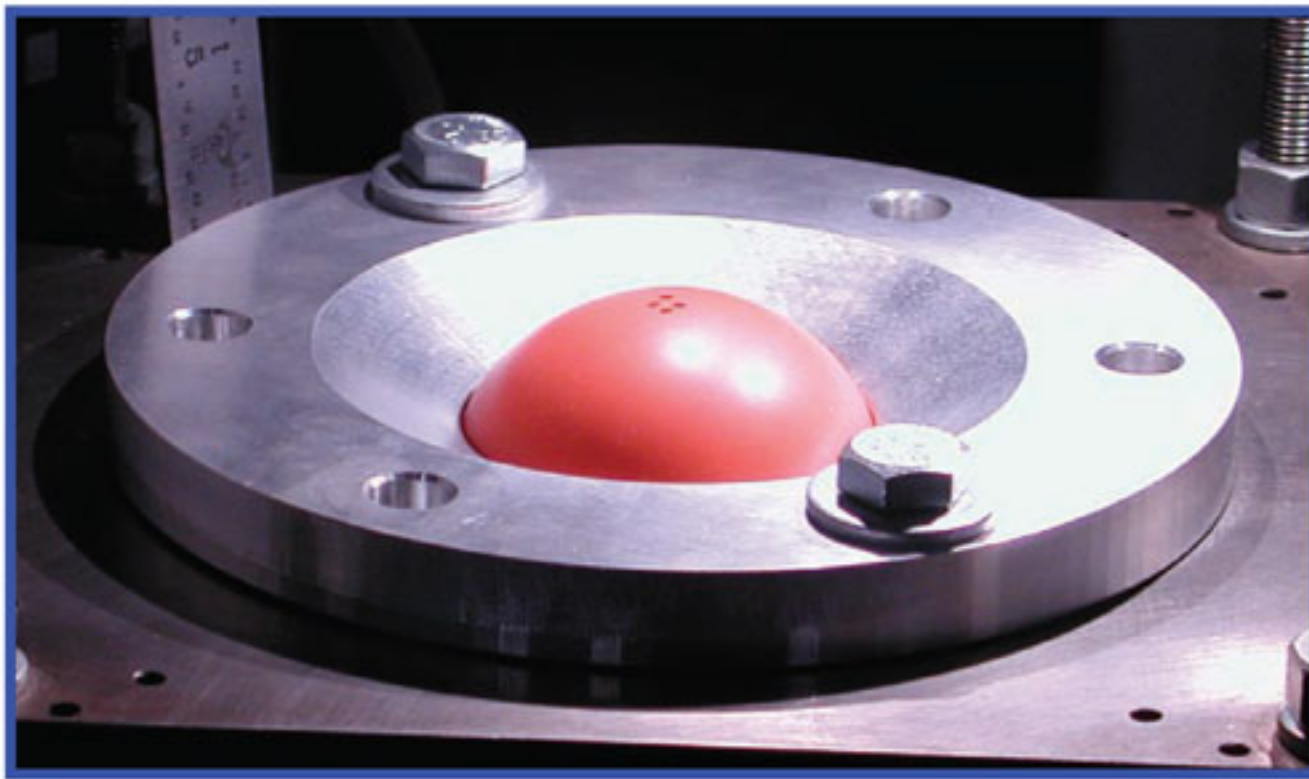


Figure 2: The "bubble" that develops in the test specimen prior to its rupture

High-pressure plumbing and a fast-acting solenoid connect the gas source to the test fixture. Pressure sensors are installed under the specimen and in the upstream piping. A solenoid is connected to a trigger signal through a timed relay circuit. When the solenoid is activated, high-pressure gas quickly inflates the specimen to failure within a few milliseconds. The upstream pressure sensor triggers the data-acquisition system, which records signals from the laser and pressure sensors at high sampling rates.

Data Analysis and Results

True stress vs. true strain is obtained from the test data. Figure 3 shows a comparison between the modulus and ductility at fracture of the multi-layer film used on a beverage pouch (Figure 4). The blue curves are based on a uniaxial tensile test conducted at 2 inches per minute. These are the only data typically available to a package designer. The red and pink curves in Figure 3 are based on a biaxial test conducted at a high strain rate. The biaxial data are more representative of the performance-limiting material

response of the pouch material, with a ductility of only about 14% before fracture. Although instability occurs even in uniaxial tension at about 30%, the material continues to draw, absorbing considerable energy in a way that is not available in biaxial tension. If the package structure is being designed to survive a drop load, the performance is limited by biaxial stress, not uniaxial stress.



Figure 4: Multi-layer film package

For orthotropic materials, such as polyesters, the inflation may not be spherical, which will introduce error in the calculated failure strain. The magnitude of the error depends on the difference in strength in the orthogonal directions. However,

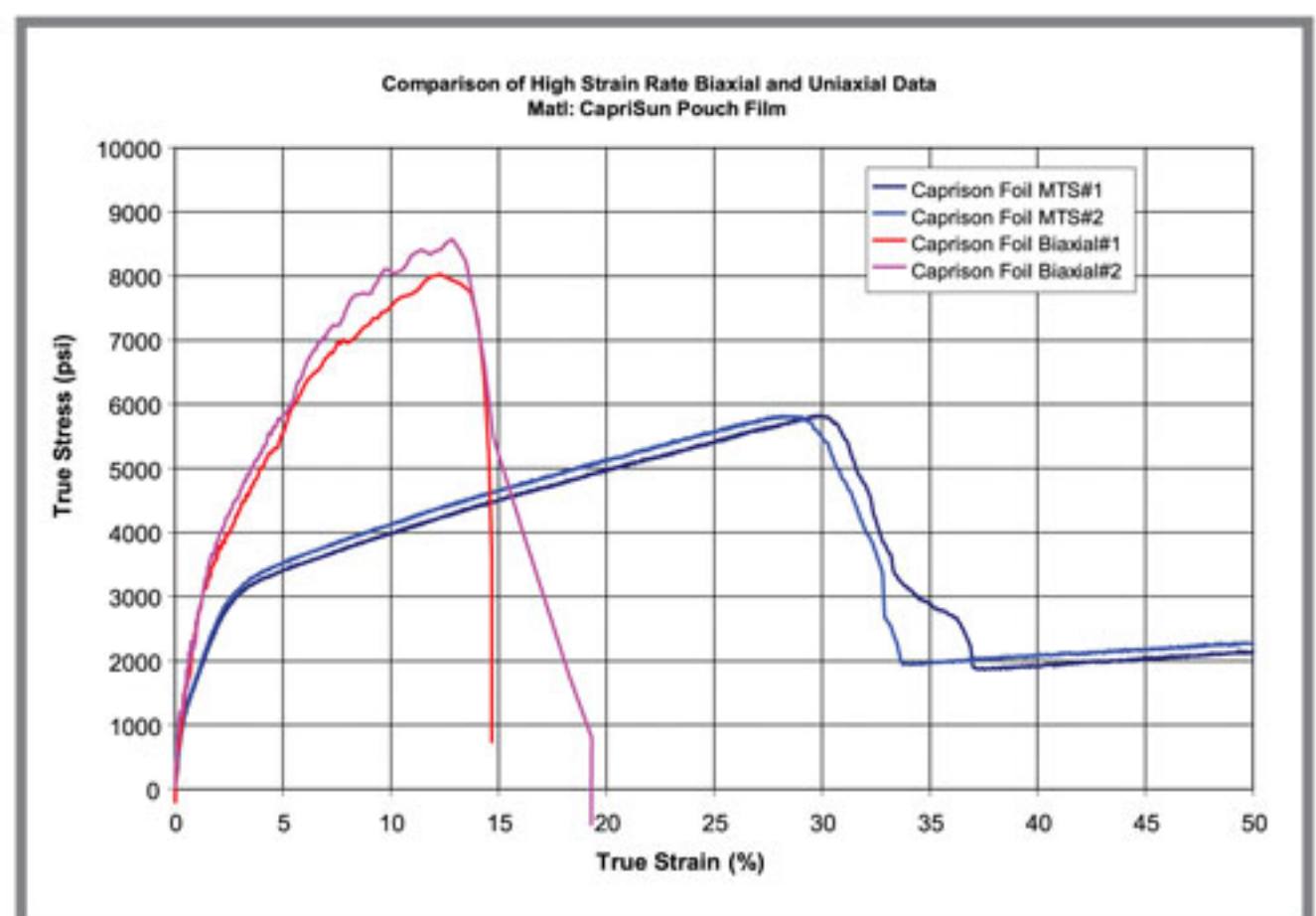


Figure 3: Comparison of biaxial and uniaxial test data

Figure 5: Flexible packaging for consumer products



based on practical experience to date, the error is relatively small. (Stress is currently investigating this behavior.)

Application

One example of packaging where biaxial data are uniquely valuable is in the analysis of drop loading for fluid- or solids-filled flexible pouches, such as the types shown in Figure 5. Non-linear finite element methods have been used to predict the performance of a package subject to drop loading.

To predict the failure of the package, it is necessary to characterize the failure of the material when subjected to high-strain-rate biaxial loading. Figure 6 depicts a finite element model of a fluid-filled pouch. The model of the pouch is dropped onto a rigid surface and the structural response of the package calculated. The material behavior of the composite film has been established via biaxial tests and included in the predictive finite element model.

Figure 7 shows the progression of the deformation and ultimate failure

of the material after being dropped. For this type of loading situation, the failure of the composite film is governed by the biaxial stress state.

Conclusions

Biaxial stress is frequently the life-limiting stress state for a wide range of plastic products and packages when in use. Uniaxial stress/strain data typically overstate the ductility of a material and are inadequate for judging material performance when the stress state is biaxial.



Figure 6: Finite element model of a fluid-filled flexible pouch

By using Stress's biaxial inflation test system described here to obtain biaxial stress/ strain data for films and thin rigid plastics, important strain-to-failure information is available for screening candidate materials and as input data for predictive structural simulation of packages, products, and processes. 

clint.haynes@stress.com
diana.papania@stress.com
doug.marriott@stress.com

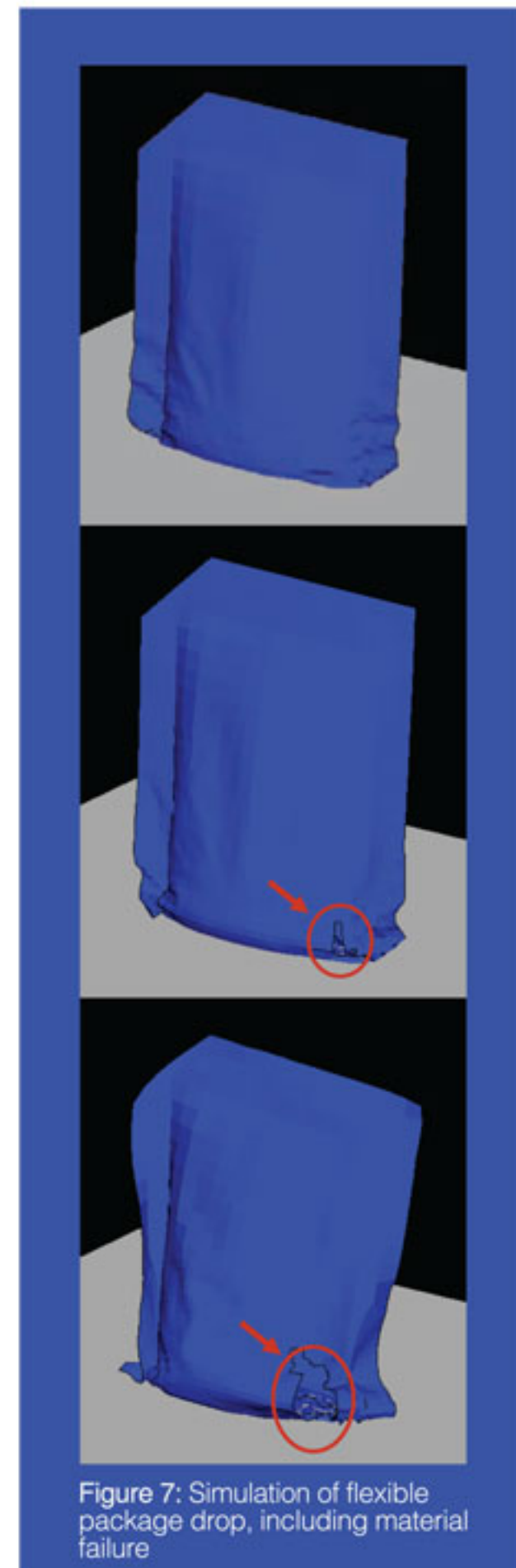


Figure 7: Simulation of flexible package drop, including material failure

Elements of an Engineering-Based Integrity Management Program

by: Dr. Chris Alexander

Establishing pipeline integrity requires identifying specific threats, understanding their relationship to the condition of the pipeline, and establishing what mitigative measures are appropriate to assure integrity. The pipeline industry has relied on many years of research and experience in its development 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 defensible and documented.

This article discusses how existing knowledge, analytical techniques, along with testing and engineering rigor can be combined to develop a systematic method for assessing damage to pipelines. At the heart of this effort is the development of field-friendly tools that permit operators to quickly respond to any threat once it has been identified. To assist industry in this effort, Stress Engineering Services (Stress) has developed what we call the Engineering-Based Integrity Management Program (EB-IMP). The backbone of this initiative is the API 579 Fitness for Service document; however, Stress has gone beyond the traditional API 579 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 our work for pipeline companies over the past 15 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 Level 5 repair assessment.

Figure 1 shows the fundamental elements of the EB-IMP process based on three activities:

- Identify the integrity concern
- Develop engineering-based solutions
- Remediate the pipeline if required

Although a significant body of pipeline research data is available, the challenge that exists for industry is to compile this information in a format that can be deployed for making integrity management decisions. There are also times when research data does not exist for a specific anomaly and pipeline companies must fill in the gaps by conducting their own studies that employ either analysis or experimental methods.

The following is a brief description of each of the five EB-IMP assessment levels.

Level I Analysis – Basic

The Level I effort involves the most basic form of an analysis that is possible. Typically, this includes performing an assessment based on consensus-based codes or standards (e.g., referencing the original construction codes such as ASME B31.8 for gas pipelines and ASME B31.4 for liquid pipelines).

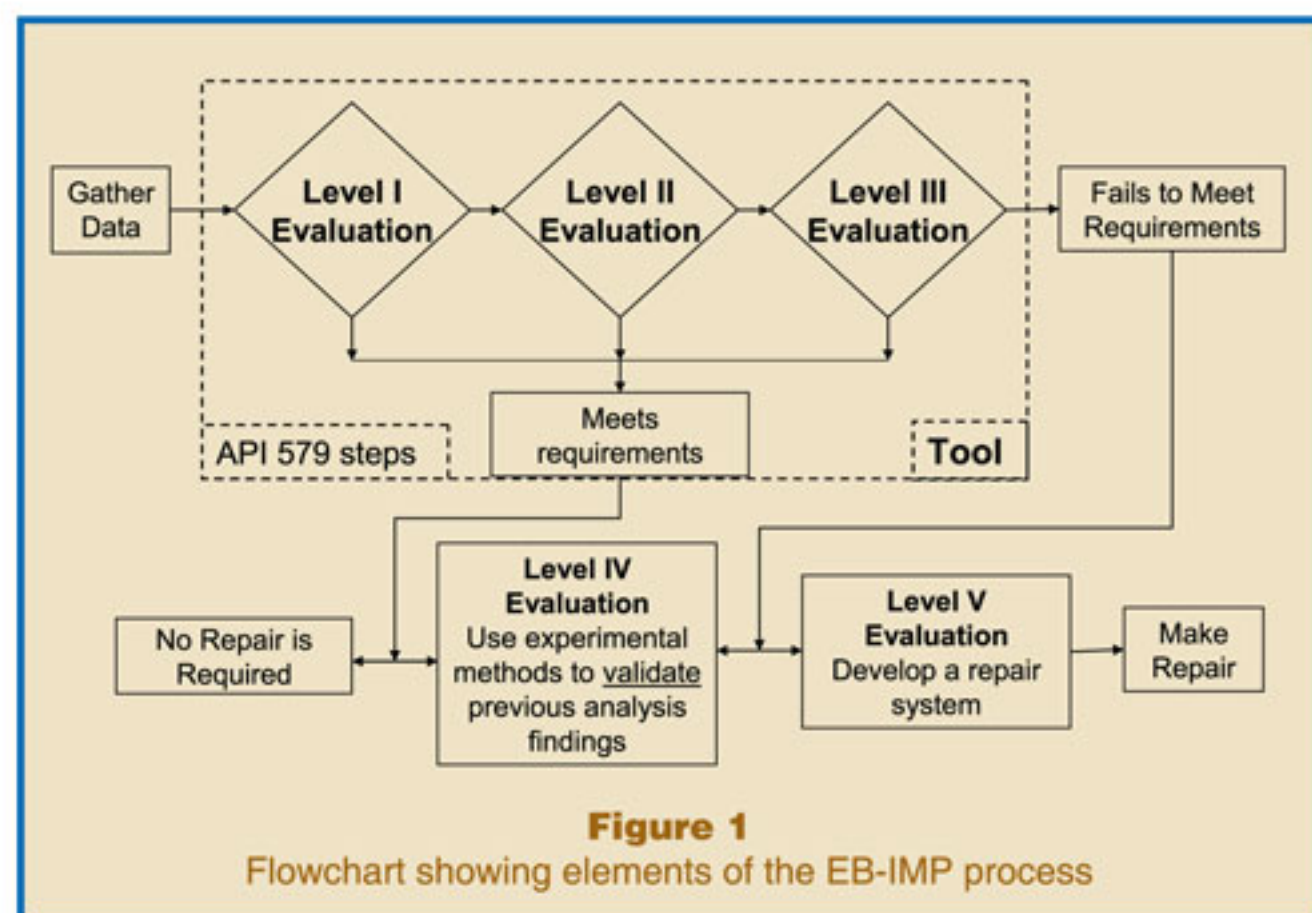


Figure 1
Flowchart showing elements of the EB-IMP process

Level II Analysis – Detailed

The analysis associated with a Level II analysis requires more detailed information than for a Level I assessment. The efforts are more complicated and the results are less conservative than those calculated using Level I methods. A Level II analysis typically includes calculations based on closed-form solutions such as those contained in API 579 or other engineering resources. This work is typically performed by an engineer experienced in pipeline design and operation.

Level III Analysis – Numerical (Finite Element Analysis)

When the Level I and II analyses indicate that either the operating pressure must be re-rated or that a repair is necessary, it is appropriate to perform a Level III assessment. Numerical methods such as finite element analysis are the basis for a typical Level III assessment. The level of rigor associated with this effort is significant when compared to calculations completed for a Level I or Level II assessment, although the reward for completing a Level III analysis is a reduction in the safety margin associated with the previous two levels and a greater understanding about the actual load capacity of the pipeline or component.

Level IV - Testing

The results of the engineering and FEA analyses can be confirmed via a testing program. Testing can involve either pipe material removed from service or pristine pipe, depending on the desired outcome of the study. For example, if a pipeline company is interested in the performance of vintage girth welds subject to cyclic pressure service, it would be prudent to remove girth welds from the field and test them. The testing approach

for evaluating mechanical integrity is extremely powerful and provides pipeline operators with a means for quantifying integrity concerns not possible using the assessments per Levels I, II, or III.

Level V - Repair Solution Design

Remediation of common integrity threats can be accomplished using accepted repair procedures, and these methods are, for the most part, well-suited and conservative. The Level V approach is used to develop a repair procedure to meet the specific needs of each situation. These tailored-repair solutions offer safe, cost-effective solutions in lieu of the one-size-fits-all cut-out method of repair. The design for the repair is typically evaluated using experimental methods, although the repair can also be modeled using numerical methods such as FEA to evaluate suitability.

Examples of EB-IMP

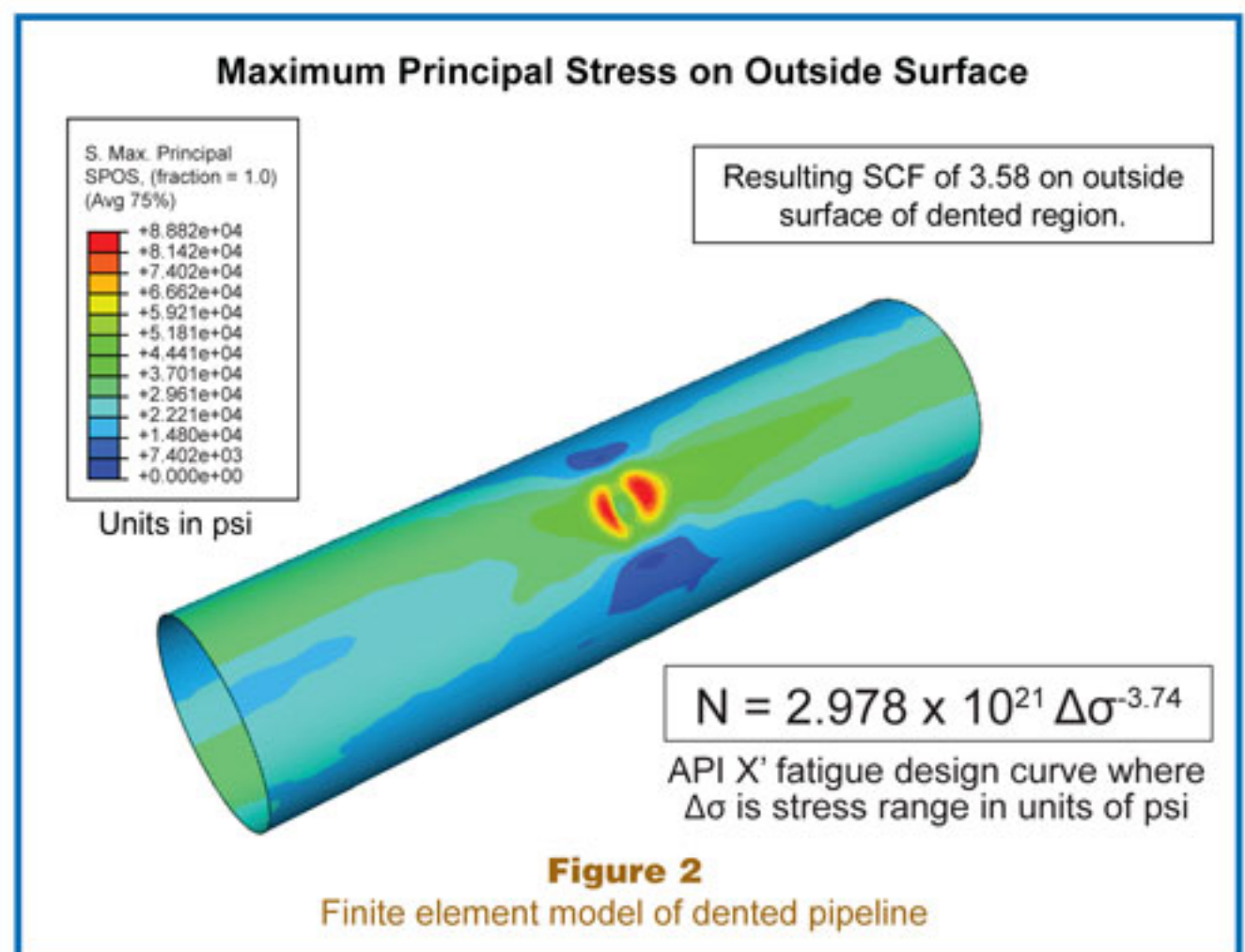
Two examples of the EB-IMP initiative are included below. The first details

an assessment where the severity of a dent in a liquid pipeline was quantified using data from an in-line geometric inspection tool. The second example includes results from a testing program used to evaluate the ability of a composite repair system to restore integrity to a high-pressure transmission pipeline having corrosion up to 75% of the pipe's nominal wall thickness.

Example #1:

Dent Damage Assessment

In-line inspection (ILI) tools can collect geometry data on dented pipelines that can be used to build FEA models to calculate local stresses. Using these stresses, an integrity assessment is made by evaluating loading such as cyclic pressures on the pipeline in question. In this example, ILI geometry data were collected on a dented pipeline and stresses in the dent were calculated (Figure 2). For this particular pipeline, the resulting dent stress concentration factor was 3.58. Using actual pressure history data



from the pipeline, Stress estimated the remaining life of this pipeline to be 55 years.

Example #2:

Composite Repair Assessment

Composite materials are routinely used to repair damaged pipelines. One of the greatest challenges for composite repair systems is restoring the integrity to pipelines subjected to frequent pressure cycles where significant levels of corrosion are present (e.g., on the order of 75% of the pipe's nominal wall thickness). Stress performed testing on an E-glass/epoxy system used to repair a 12.75-inch x 0.375-inch, Grade X42 pipe having a corrosion depth of 75%. Two tests were performed that included a burst test and a pressure cycle test. Figure 3 shows the test set-up, while Figure 4 plots the strains recorded during the burst pressure test. The strains beneath the repair were within acceptable levels and the failure occurred outside of the repaired region. Additionally, the fatigue pressure

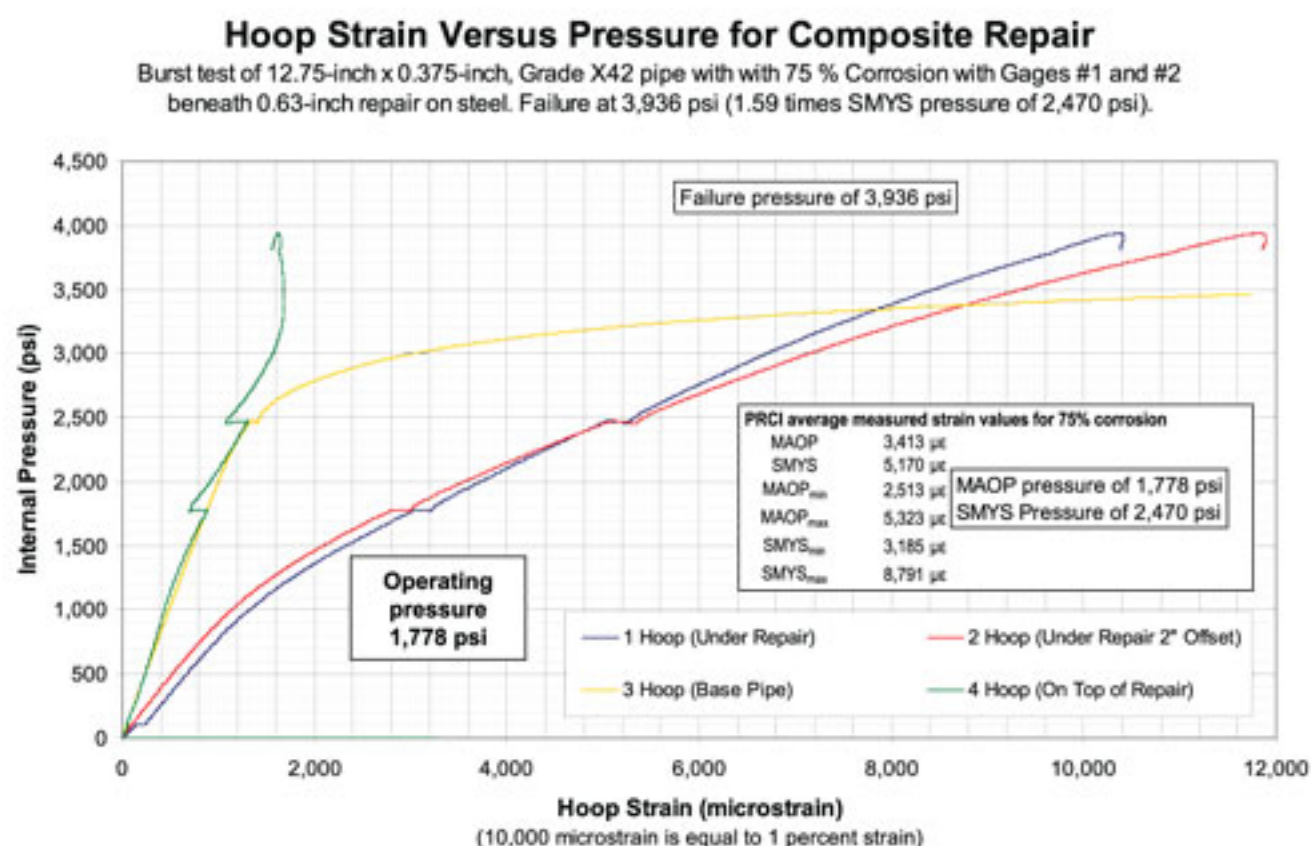


Figure 4
Strain measured during burst test of 75% corrosion sample

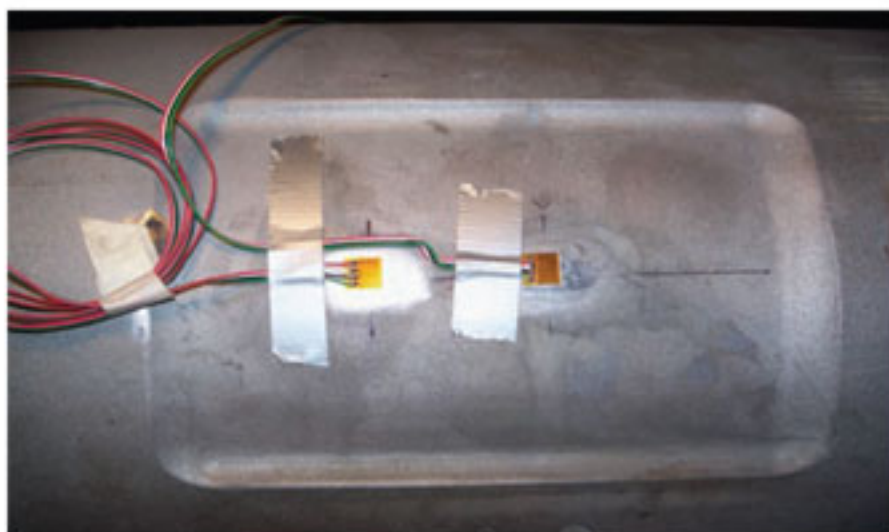
sample was cycled between 36 and 72% SMYS and failed after 260,000 cycles had been applied. These test results clearly demonstrate that this particular repair could meet the integrity requirements of a pipeline having significant corrosion that was subjected to an aggressive cyclic pressure condition.

Stress has used the EB-IMP process to assist more than 10 transmission pipeline companies over the past two years. The methods we employ are based on fundamental engineering techniques that have been used by pipeline professionals for many years. The uniqueness of Stress's approach is the integration of actual pipeline data, coupled with analysis and testing efforts, to generate a tailor-suited engineering-based process that addresses specific threats to pipeline integrity. The result of this effort is that the EB-IMP process can address single critical integrity threats, or the process can be used to develop a general-purpose tool to address a range of threats found at several locations across a pipeline system.

Contact Stress to put the EB-IMP to work for your pipeline company, or other engineered applications requiring mechanical integrity assessments. 



Location of strain gages installed on the test sample



Photograph of strain gages installed in the machined corrosion region

Figure 3
Test sample details for 75% corrosion sample

chris.alexander@stress.com
ron.scrivner@stress.com

Well Screens

MEETING THE ISO DEMANDS

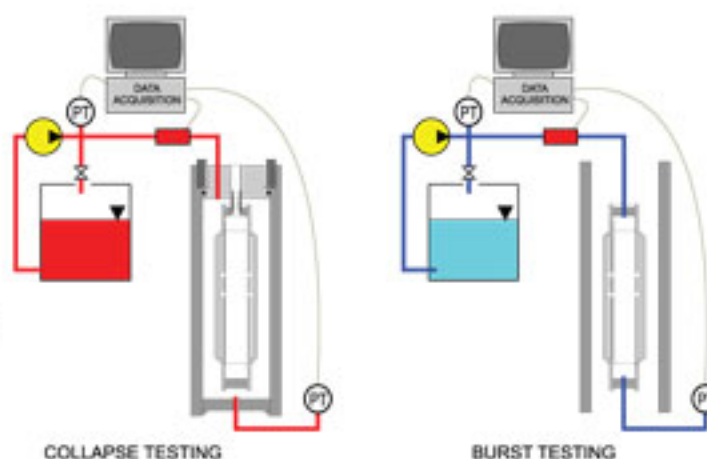
by: Eric Gage

Well screens are used in down-hole applications to filter particulate matter out of produced fluids. They are typically stainless steel or more exotic materials wrapped over base pipe perforated with hundreds of holes. During use, as more and more particles are filtered out, the screens build a "cake" on their exterior, restricting flow or plugging the screen completely. A back-flush or acid wash may be used to clear blockage, but these techniques require subjecting the screens to abnormal pressures.

The question then arises regarding how much external or internal pressure the screen material can tolerate before the screens fail. Failure opens an area for sand or other unwanted fluids to enter the production string.

Mohr Engineering Division (Mohr) has been performing burst and collapse tests on well screens for over a decade. The process is simple—a plugging "pill" is used to

bridge across the filtration slots or holes in the screen media. This plugging agent is a water-based gel with a distribution of particle sizes. These are typically comprised of calcium carbonate ranging in size from 50 microns up to 1000 microns (1 mm). These pills are designed to fit each specific screen geometry such that the largest particles fill the gaps, and then smaller particles fill voids around these larger particles, eventually creating a seal.



With the release of the new ISO TC 67/SC 4 Specification in 2009, much of the current manufacturers' data has been rendered obsolete, necessitating retesting of many products. The new specification requires the following:

- All samples must be prepared to Q1 quality grade.
- Minimum length of a sample screen is 7.8 ft (2.4 m).
- Annular clearance between screen OD and ID of the collapse chamber is 0.98 in. (25 mm).

- Maximum plugging pill flow rate is 10 gpm (0.038 m³/min) during testing.
- Flow rate must be measured and recorded.
- Plugging pills must be comprised of very specific ratios of small, medium and large particles.

Mohr currently provides the capacity to collapse 10-ft screens constructed on base pipes up to 6½-in. OD, and at external pressures up to 7500 psi. Another vessel was purpose-built to test 30-ft screens on base pipes up to 5-in. OD. Mohr has performed many other custom tests as manufacturers have sought to satisfy a range of exotic requests from their clients. These have included:

- Sand erosion through isolated orifices
- Measurement of pressure differential through a full length screen over its full flow range (0–380 gpm)
- Sand pack-off testing

Mohr is now developing a more automated and efficient facility to perform standardized screen burst and collapse testing. We will continue to provide custom tests and equipment to meet the extraordinary needs of our clients. For the moment, the main focus is to provide the most efficient process to retest all existing screen designs so that they comply with the recently released ISO Specification. 

eric.gage@mohreng.com



a focus on POWER

by: Joe Frey P.E., Shannon Read, and Greg Garic, P.E.

High Temperature Creep Testing Facility

A new high temperature testing facility at Stress Engineering Services in Cincinnati, Ohio is scheduled to come on-line in early 2010. This facility will allow testing across the full spectrum of engineering applications, from ambient to temperatures up to 1000°C on materials of virtually any description.

This new lab will provide a resource to support work directed at risk and remaining life assessment, fitness-for-service (FFS) evaluations, vessel re-rates, and experimental verification of design procedures.

Currently this lab contains more than 50 conventional tensile creep machines, several electro-hydraulic test rigs suitable for subcomponent and cyclic testing, as well as two 100,000-lb creep machines

designed for creep testing of weldments. Related to FFS, the lab will also serve as a center for exploring and developing innovative methods for creep evaluation of service-exposed components. This will include methods of extracting samples from components in the field, use of subminiature specimens, and practical implementation of in-situ methods for both destructive and nondestructive testing.

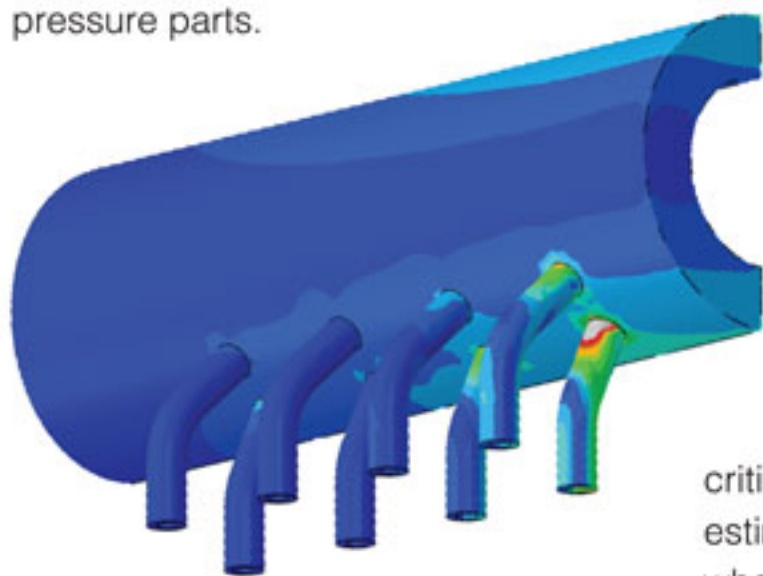
Stress Engineering's experience with high temperature engineering, testing and analysis extends back to the early 1960s. This early work is described in the 1st edition of Design for Creep, co-authored by Dr. Doug Marriott (Staff Consultant at Stress) and published in 1971 at the beginning of the development of elevated-temperature applications in nuclear power plants. In subsequent years, Stress Engineering has built on this understanding of creep behavior while helping clients worldwide deal with remaining life issues on a broad range of high-temperature service equipment.



In 2008 Stress launched the "Elevated Temperature Component Evaluation Program," which combines component performance analysis with experimental verification and supporting material testing. This includes but is not limited to conventional creep testing. The program also includes testing of subcomponents (such as welds), as well as innovative and unconventional material testing aimed at assessing creep performance of materials as found in-situ in components.

High Temperature Cyclic Service

Running utility boilers for unusual cyclic conditions places new demands on boiler operators, requiring new and pro-active measures to manage the risk of equipment failure. Described below are aspects of the problem for boiler pressure parts.



Unusual (non-design) loading on headers can lead to cracking in terminal tube welds. This can be the result of side-to-side (gas-temperature variation) or local (flow-induced) tube temperature differentials. Consequences can go beyond terminal weld failures; a recent case illustrates this point.

A header borescope inspection was recommended after the repair of

terminal tube welds. Preliminary evidence of characteristic circumferential cracking was found at several tube penetrations, consistent with cyclic axial stress. Thermocouples were installed on terminal tubes to identify the source of thermal stress. The header damage was judged to be non-critical unless temperature data indicated more severe loading than suspected from the data. Based on these findings, a program of monitoring and inspection was initiated.

Knowledge of risks leads to rational and defensible decisions. The ability to compare risks of failure means that decisions for inspection, repair, down-rating, etc. have a solid basis. This is important when attempting to understand the meaning of "exceeding minimum rupture life."

A probabilistic definition of acceptable risk may be used to define inspection intervals which decrease over time, and which can be justified in terms of the risk of failure between inspections. The process is dynamic and should be updated after changes occur. For each

critical component or assembly, the estimate of risk needs to be updated when new data become available. This ensures that any unforeseen event such as an over-temperature can be assessed quickly and efficiently.

Application of API 579-1 / ASME FFS-1

Evaluating a flaw in pressure-retaining equipment and subsequently allowing that flaw to remain in service is a fairly new approach in the power industry. The recent adoption of API 579-1 by ASME

resulted in a dual name for the document: API 579-1/ASME FFS-1. This also opened the door for the use of evaluation techniques for detecting flaws such as cracks, thinning, and creep. Following are two examples of Stress's application of this document in the power industry in 2009.

Lower Headers Cracking: Part XX Crack Growth

Lower headers for a coal-fired boiler configured in a four-sided rectangle cracked at the corners consistent with outward bowing of the side headers. These cracks were discovered at the end of a planned outage, and the utility wanted to return the unit to service on schedule. Repair of the cracks would have delayed startup.

Stress performed a level 3 FFS-1 evaluation using API 579-1/ASME FFS-1. The results indicated that the cracks would not propagate through wall prior to the next scheduled maintenance outage. Based on this information, the unit was returned to service on schedule, thereby avoiding a costly delay.

Weldolet Creep Damage: Part XX Creep Evaluation

The weld between a 6-in. pipe and a 26 by 6-in. weldolet on a main steam pipe failed, causing an unscheduled outage just four weeks prior to a scheduled maintenance outage. The weldolet was constructed of carbon steel and had reportedly been in service for 207,000 hours at 1005°F and 2600 psi! Slight swelling was found, but no advanced graphitization was present. The utility wanted to return to service as soon as possible and delay replacing the weldolet until the originally scheduled maintenance outage.

Stress performed a level 3 creep evaluation and determined that a reduction of 20°F in the operating temperature combined with a properly sized replacement weld would allow the weldolet to be returned safely to service for the four-week period. As an added precaution, Stress also recommended and provided continuous acoustic-emission (AE) monitoring of the old weldolet and new weld.

The AE monitoring was set up with a trigger-notification feature that would call Stress in the event of a predetermined increase in acoustic signal. Based on Stress's recommendations, the utility was able to successfully operate the unit until the scheduled maintenance outage. The weldolet was replaced during the outage.

EPRI Projects

Stress offers design and field installation of any measurement device that a utility may require. Following are two examples of field instrumentation that was designed, installed,

and remotely monitored by Stress as part of projects sponsored by the Electric Power Research Institute (EPRI).

Strain Gage Hanger Rod Clamps

Stress designed a clamp that could be installed on pipe-support rods by rope access and used to measure the change in load of a constant support, or the total load on a support. Installation by rope access eliminates the need for scaffolding and reduces the cost. The change in load from the hot position to the cold position for a constant spring pipe support is supposed to be zero. This monitoring tool provides a low cost and convenient way to determine if a support is functioning properly.

If the pipe support rod is unloaded prior to installing the strain gage clamp, the actual load on the support can be determined. The actual load can also be used to more accurately perform both an as-found creep stress analysis and a creep stress analysis. A creep stress analysis is

used to determine the remaining life of a piping system that operates in creep service, such as main steam and hot reheat.

Strain Gages on ID Surface of Steam Drum

Another project conducted by Stress for EPRI included installation of strain gages on the inside surface of a steam drum near the troublesome downcomer connection. Cables for three strain gages and one thermocouple were routed through the wall of the steam drum using a high pressure seal. Strain measurements for both a cold and a warm startup were recorded and reported to EPRI and the utility. The project successfully illustrated the potential applications of strain gages in harsh environments. Measurements such as these could be used to calculate remaining fatigue life for various operating modes. 

joe.frey@stress.com
shannon.read@stress.com
greg.garic@stress.com



Fatigue Testing of Weld-Overlay Repair of Coke Drums

by: Mahmud Samman, Ph.D., P.E.

Coke drums are refinery vessels that operate under extreme cyclic mechanical and thermal loads. These transient loads cause bulges to form. With time, bulges can become severe enough to initiate and propagate cracks, which can result in leaks and fires.

Many techniques are employed to repair bulge-induced cracks. The traditional gouging and welding of cracks has limited life and is ineffective in stopping bulges from further deterioration. Long-term repair is normally conducted using one of the following techniques:

1. Window replacement: A rectangular window is cut from the bulged area and replaced with a new plate. Typically, the mismatch between new and old material properties and residual fit-up stresses cause cracks to form at the corners of the window in about one to two years.
2. Can replacement: An entire cylinder (can) eliminates corners and therefore lasts longer than window replacement. Again, material mismatch and residual fit-up stresses encourage formation of cracks at the interface within two to five years.

Both of these techniques are expensive, disruptive to plant operations, and only last for a relatively short period of time. Eventually, repeated

cracking around these repaired areas forces operators to replace drums even if the bulges are limited to a relatively small area of the drum.

Recent developments in machine-controlled weld-overlay technology have made possible the treatment of large areas of coke drums with a consistent and high-quality deposit process. So far, this weld repair technique has been used as a temporary reinforcement of bulged areas until drum replacement takes place. Because it is a relatively new technology, there is not enough of a track record to establish its long-term performance. In addition, since the



fatigue resistance of weld deposits is highly dependent on the quality of the welding process, many questions need to be answered before this methodology can be relied upon for long-term repair.

Stress Engineering Services (Stress) is now conducting a fatigue test program to examine the long-term performance of automated weld-overlay repairs. The primary objective of this program is to quantify the improvement in the fatigue life of weld-overlay repaired bulges in coke drums. The secondary objective is to assess the impact of weld procedure details and surface finish on the fatigue life of repaired bulges.

The significance of this test program is potentially profound. If weld-overlay repair can be demonstrated as a viable long-term repair methodology for bulging coke drums, operating companies can potentially save substantial costs by eliminating or postponing lengthy shutdowns associated with replacement of coke drums.

To simulate the performance of the overlay technique on actual deteriorated coke drums, Stress is conducting tests on samples from a plate salvaged from a retired drum. The 27-ft diameter drum was constructed of C-1/2Mo with 410SS clad, and was repaired using a can replacement. The drum was later retired after bulging and cracking became too frequent to operate the drum cost-effectively.

This ongoing test program was originally funded solely by Suncor Energy of Fort McMurray, Alberta, Canada, one of the heaviest users of delayed cokers in the world. Encouraged by the initial test results, Suncor has agreed to expand the program into a joint-industry project (JIP). The JIP will provide the following added benefits:

- Increase in the scope of work of the program by reducing the per company cost.
- Incorporate a wider experience base.
- Develop an industry consensus Best Practice for drum repair that can be recognized by regulatory agencies as "Generally-Accepted Good Engineering Practice." 

mms@stress.com

TESTING...1 – 2 – 3

LARGE or SMALL; HOT or COLD; in HARSH ENVIRONMENTS...
STRESS PROVIDES TESTING SOLUTIONS

by: Randy Long, P.E.

Problems come in all sizes; and the severity of the problem is not a function of the size of the component involved. Which is more critical: the small endoscopic surgical device used by doctors on a patient or the huge Gulf of Mexico offshore floating facilities producing energy for our country? Stress understands that both are critical to the lives of people and that both must be safe and reliable. An important part of assuring safety and reliability of critical components is testing to verify their ability to survive all expected service loads and environmental conditions. Stress strives to provide testing solutions for the most difficult problems, no matter the size of the components involved or the industry served.



Stress has been actively expanding its testing capabilities for several years. Recent and in-progress efforts include:

- Purchase of 92 acres of land in Waller (near Houston) and building a 25,500 ft² test facility that includes a *large* shielded test pit, several cased test holes, and a *large* outside storage and test area.
- Startup of a materials lab test facility in Waller including H₂S / harsh environment test capabilities and MTS static and fatigue test machines with capacities from 1,000 to 1,000,000 lb.
- Purchase and commissioning of materials-testing equipment in Cincinnati including 50 creep-testing machines along with other materials-characterization test machines including high-frequency (up to 100 Hz) fatigue machines, multi-axis fatigue machines, high-temperature test ovens, and controlled environment chambers.
- Addition of two new 3.3 million lb load frames in Houston to better serve the testing needs of the oil and gas industry.

Past testing efforts have encompassed a variety of conditions including:

LARGE

Stress manages the Deepwater Response to Underwater Pipeline Emergencies (DW RUPE) project, a joint effort by multiple oil companies to provide ready access to emergency deepwater subsea pipeline repair equipment. We recently completed purchasing most of the

equipment needed to repair or replace damaged pipe in a pipeline in deep water (2500 ft+). As part of this effort, Stress performed a System Integration Test (SIT) where a 600 ft section of 12.75-in. diameter pipe was set up to simulate a subsea pipeline section. Equipment from various manufacturers was used together to simulate repair and replacement activities on portions of the pipeline.

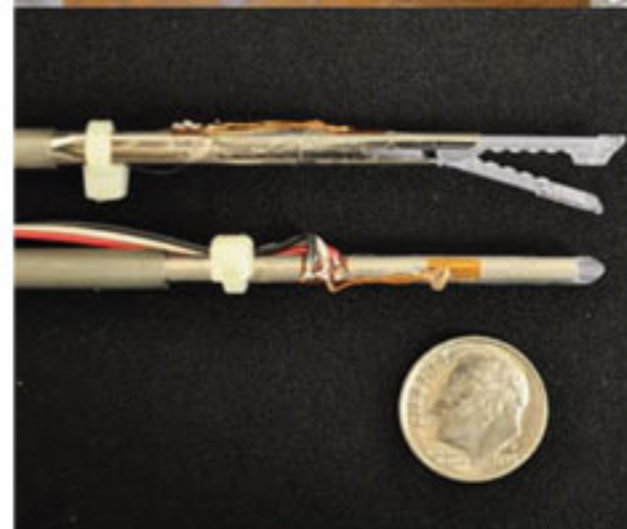
Tests of large samples have been completed in our Waller test pit, which is 10 ft deep, 8 ft wide, and 50 ft long. It also includes a cased hole extending an additional 40 ft below the pit bottom. Numerous full-scale burst tests of large-diameter pipe have been performed in the pit, along with other large pressurized components.

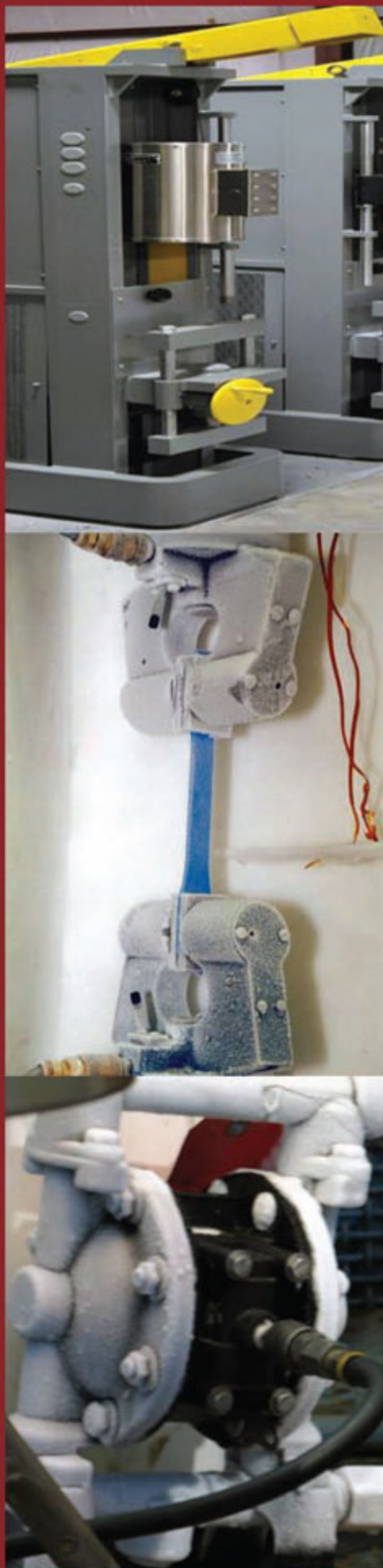
SMALL

Stress' Cincinnati office has tested many small and unusual components used in medical-devices and the consumer products industries. The breadth of application is amazing—from instrumenting a surgical device with 0.098-inch strain gages to characterize its performance when used in animal studies to measuring the dynamic response of a compound hunting bow to evaluate the effectiveness of different damping accessories.

HOT

Stress has tested full-scale threaded pipe connectors in temperatures exceeding 1000°F and routinely performs full ISO 13679 and other protocol connector tests with elevated temperatures of 600°F and higher. Heating methods include resistance strip heaters and induction heating of either the sample or a surrounding carbon-steel pipe. The





method selected is based on the required temperature, sample size and the material being tested.

One of the challenges in performing connection testing at elevated temperatures is quantifying or characterizing the material properties. These properties at the elevated temperature are crucial to calculate the maximum loads used in the connection evaluation. The Waller facility now has these capabilities in-house to support all types of tubular testing.

Stress also has several dozen creep-testing machines capable of testing at temperatures of up to 2200°F (using an oven over the sample) and similar configurations for high-temperature tensile testing.

COLD

We have completed a range of tests of oilfield pipe at low temperatures. For one unusual protocol, fluid at -40°F was circulated through the test specimen to initiate a phase change in the fluid in the external annulus with the goal of quantifying the resulting impact on the inner pipe. This setup required placement of a pipe within a pipe with a sealed annulus to simulate actual well conditions. Sealed thermocouple ports allowed measurement of the annulus fluid temperature along the full length of the specimen. Reproducing the actual downhole environment during the phase change was very challenging, but was completed successfully in Stress's test lab.

Cryogenic testing of tensile coupons and full-scale sections of piping has also been performed, with temperatures as low as -320°F.



HARSH ENVIRONMENT

H₂S testing is the latest development in harsh-environment testing at Stress. The Waller lab will add this capability in the first quarter of 2010. The facility alarm and safety monitoring system will be state-of-the-art, with flexibility to allow us to tackle difficult test environments safely. MTS machines are already running tests on site, and are being outfitted for safe containment and delivery of the H₂S test environment to the test sample.

THE FUTURE

Stress believes that testing is an important step required to provide a safe and reliable product, no matter what the application. We will continue to add equipment and develop new capabilities to serve our clients', whatever the application. 

randy.long@stress.com



Subsea Water Injection System: Field Architecture for Flexible Well Locations

by: Scott K. Beall, P.E. and John C. MacNeill, P.E.

In the early engineering phases of a subsea development, various forms of enhanced oil recovery methods are typically considered for use later in the field's development. Oil reservoirs eventually lose their "drive" as reservoir pressure decreases, resulting in production decline. Without a stimulus to drive the remaining oil, many barrels will be left in the ground. Pressurized treated water can be injected below the oil reservoir to force some of the remaining oil out of the formation. This approach is known as a water-injection system.

A client with a Gulf of Mexico (GOM) production field located in 4000+ ft water depth requested that Stress Subsea, Inc. (SSI) perform a study to determine the best seabed arrangement for adding a water-injection system to the field. The study objective was to evaluate risk areas such as procurement schedules, installation methods and schedules, construction factors, and cost. The client would choose the architectural design using the conclusions from SSI's study.

Moving Target

Early in the project, potential locations for injection wells are estimated based on seismic data. The reservoir characteristics become better understood as oil is produced. As a result, the injection well "top-hole" drilling coordinates are continually optimized to maximize the recoverable oil from a reservoir. The goal is to position the

injection wells at strategic reservoir locations.

Because of the need to optimize well locations based on the latest information, the water-injection flowline route can be affected. What may have been an optimized route at the beginning of the development could change and challenge the installation constraints. Eventually, the field architecture needs to be determined so that materials (i.e., pipe) and equipment can be procured. These materials can take up to one year to acquire.

Design Concept

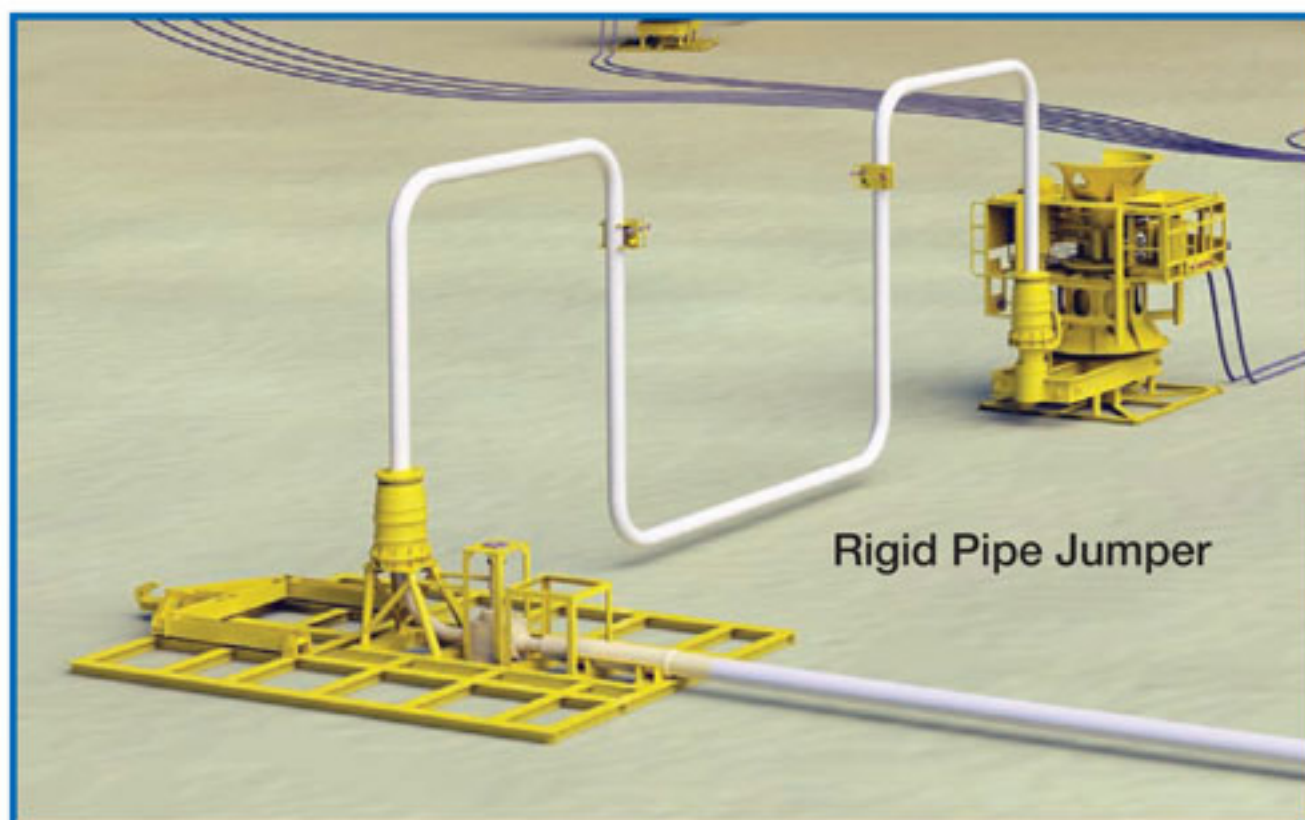
The starting point of SSI's study was to design a route to lay the water-injection flowline along the seabed so that it will be located within 50 ft of the planned injection well. At each of the well locations, the flowline will have an in-line tee and connector. The injection

wells will eventually be connected to the flowline by means of a rigid pipe jumper.

This type of field architecture design utilizing rigid jumpers is common in the GOM. Precise measurements (metrology) are acquired at the seabed to determine the distance and attitude (pitch and roll) between the two connection points on the subsea equipment. This information is conveyed to the jumper fabricator who then constructs the jumper to the required dimensions. Upon completion of fabrication and testing, the jumper is sent offshore for installation.

Flexibility

One of the major constraints of using rigid pipe jumpers is that the maximum horizontal length between the connection points is limited. Length limitations are related to transportation and handling logistics. Rigid jumpers



are normally fabricated onshore, so inland barge access to the yard is required. There are challenges with transferring the jumper from an inland barge to an offshore barge, and to the installation vessel. Each transfer poses a safety risk to personnel, as well as a risk of damage to the equipment.

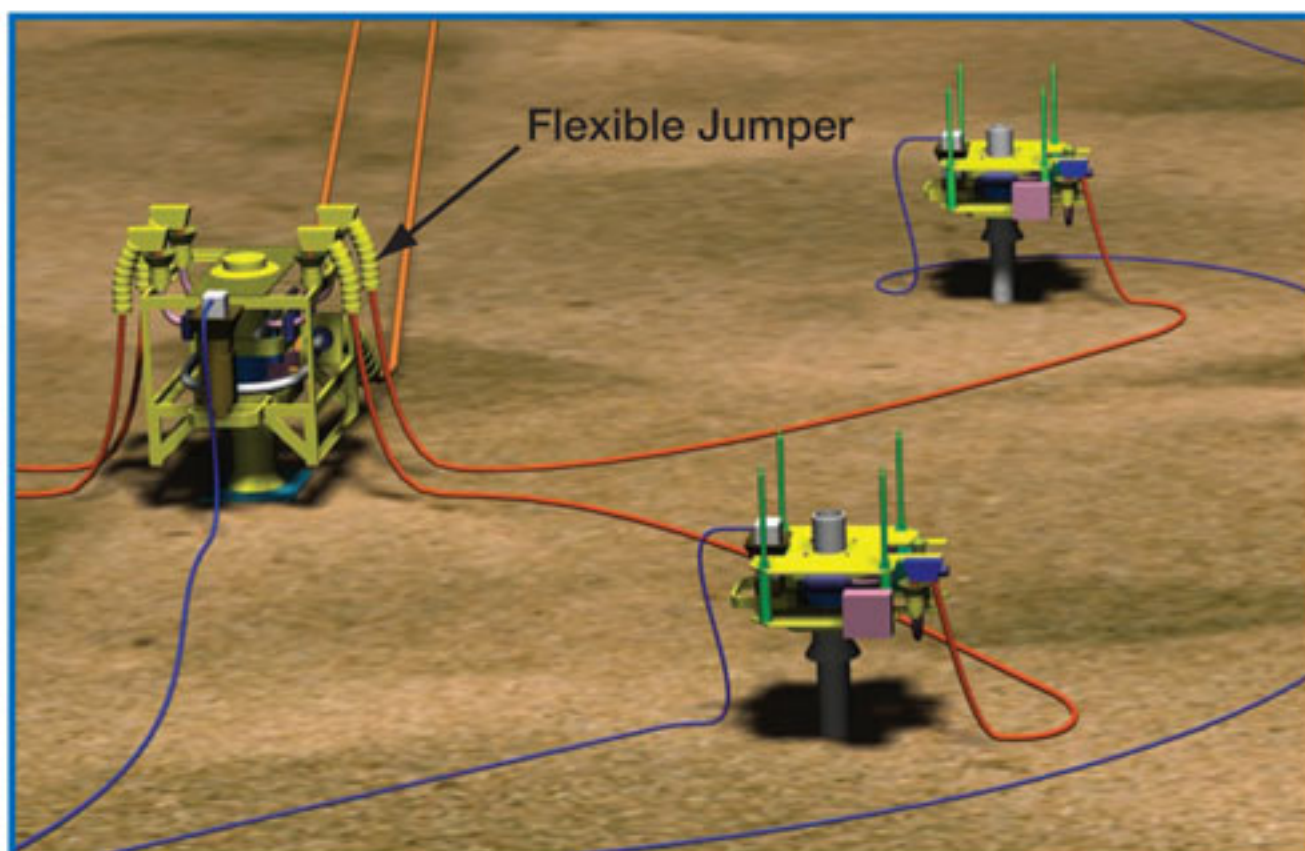
Jumper length is typically limited to 100 ft. Since well locations are likely to change during the project, there is a risk that a well may be offset from the tee by a distance that is not practical for jumper fabrication and handling.

One way to design flexibility into the field architecture is to determine the flowline routing based on the initial well locations and then establish a drilling target area for each location. For example, a well top-hole location could be anywhere within a radius of 500 ft from the flowline in-line tee. Since an offset this large is not practical for rigid pipe jumpers, flexible pipe jumpers could be used to compensate for the offset distance.

Flexible pipe is constructed of several concentric layers of steel and polymers. Each layer is designed to provide a characteristic required for pipe strength and pressure/content containment. This type of pipe is used worldwide in applications where some pipe movement is required, such as a Floating Production Storage Offloading (FPSO) vessel, or when seabed architecture needs flexibility for installation.

Field Design

The study by SSI considered various combinations of flowline routes and subsea architecture. In all cases, flexible pipe was planned for the well jumpers. Different equipment configurations were reviewed (e.g., one hub



versus two hubs for in-line tees), and lengths of the flexible pipe jumpers were varied (e.g., from 100 ft to 5000 ft). Key parameters were considered for all of the design cases, including procurement schedules, flowline and jumper installation methods and schedules, construction factors, and cost. After reviewing the study results, the client selected the final architecture. Flexible pipe well jumpers 1000 ft in length were specified. The flowline route was chosen such that the in-line tees would be installed within 500 ft of the proposed well top-hole locations. A drill center radius of 1000 ft was established and centered on the in-line sled location. This defined a target area for well placement and provides flexibility for adjusting the well top-hole location as the field data mature.

Conclusion

The study concluded that the use of flexible jumpers provides flexibility for top-hole drilling locations and allows the drilling program to be removed from the project critical path with respect to well placement. Placement of the flowline and in-line sleds does not depend on being located close to

the well top-hole locations, as is the case with rigid jumpers. The top-hole locations can be adjusted within the drilling target. This allows reservoir engineers to gather additional data over time and refine target locations.

Flexible jumpers eliminate the need for a separate survey crew to perform precise metrology for the hub locations. The flowline post-installation survey data are precise enough to be used to generate the jumper hub offset, and thus the final jumper length. Since flexible pipe is hydrostatically pressure tested as part of the manufacturing process, a finished product can be completed without knowing the final well top-hole location. This advantage lowers the risk to the installation schedule.

Use of flexible pipe jumpers allows flexibility in the architectural design of a water-injection system by allowing changes to be made during development construction without affecting the equipment that has been procured. This provides a great tool in the subsea architect's tool kit. 

scott.beall@stress-subsea.com
john.macneill@stress-subsea.com

Deepwater Insulated Flowlines Become a **Hot** Test Item

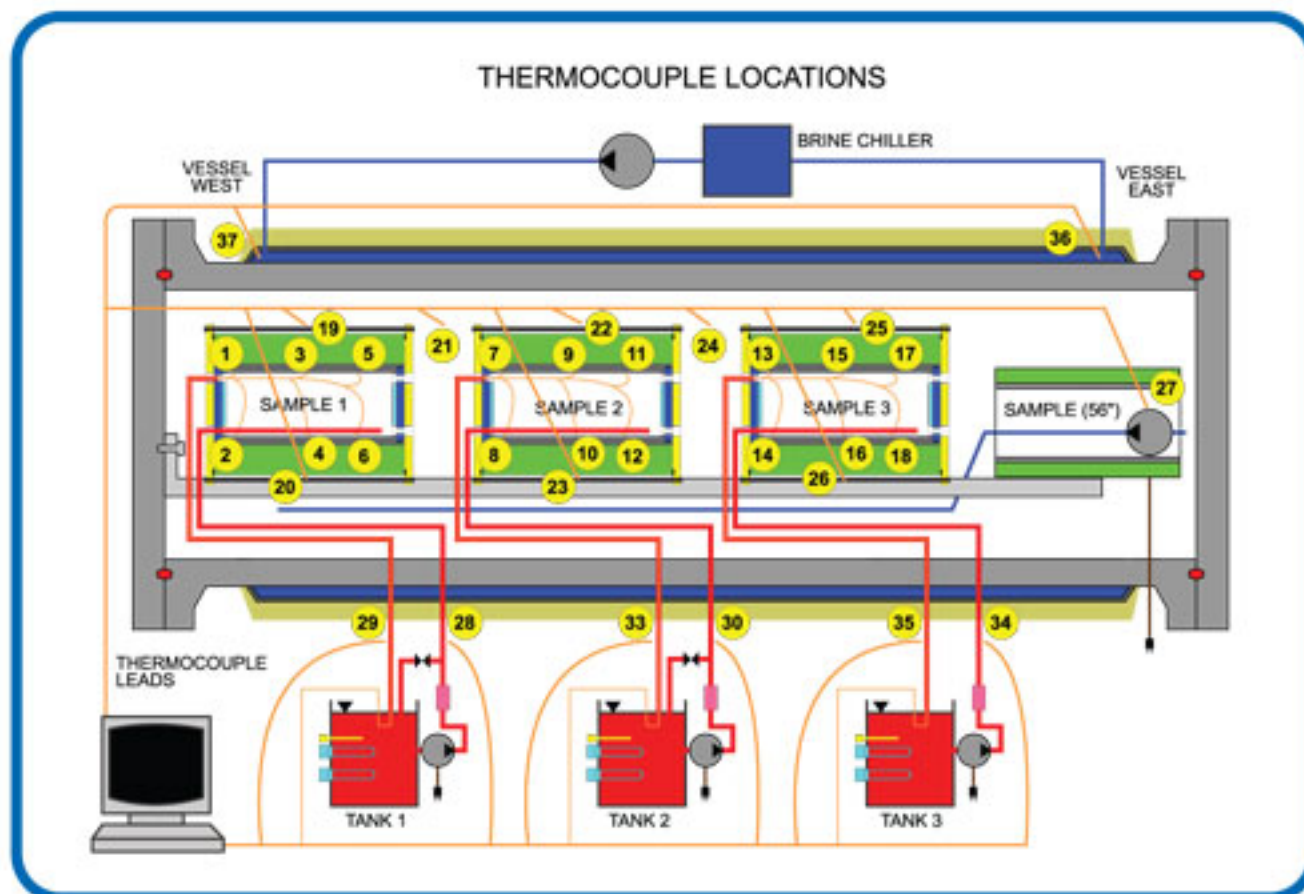
by: Eric Gage

As subsea wells go deeper, subsea flow systems must be adapted to deeper waters to support them, and the associated flow lines must overcome harsher conditions. Hot well fluids are flow long distances from the wells to production facilities. Preventing these fluids from cooling has become a more and more challenging industry requirement. Over-cooling can cause paraffin to drop out of these fluids or lead to hydrate formation, both of which can choke or plug flow lines. To combat this problem, insulation manufacturers are constantly developing new pressure-resistant coatings.



Stress Engineering Services has purpose-built a 22-in. ID x 20-ft long pressure vessel and testing system designed to evaluate performance of deepwater insulation systems. Insulated pipe samples are tested at Stress using one of two methods for heating the pipe interior while the exterior is chilled with cold water:

1. **Hot oil circulation with external heaters**
2. **Individual resistive heaters inside each sample**



This system was recently tested under extreme conditions: an internal temperature of 275°F, external temperature of 36°F, and external pressure up to 3700 psi. An elaborate array of internal and external thermocouples continually records temperatures throughout the vessel. Data from these sensors are then used to determine the properties of a manufacturer's insulation.

Stress performs calculations based on temperatures and sample geometry to determine heat-transfer coefficients for continuous pipe lengths coated with the same insulation. These methods are:

1. **Cool-down method:** Samples are allowed to stabilize at the target temperature. Heaters are turned off and temperatures are allowed to fall naturally. A logarithmic decay is then fit to the data to determine a K value.

2. **Steady-state method:** Samples are allowed to stabilize at the target temperature. The electric energy required to maintain the samples at the target temperature is monitored and used to calculate the heat flow from the system.

Both calculation methods are typically combined into a single 28-day Simulated Service Test. Sample geometry is chosen so that all end effects can be removed from the heat-transfer equation. Empirical data are all that is necessary to determine an "infinite length" pipe sample insulation value.

In the end, manufacturers are provided with defined thermal properties of their insulation under external pressure and at specific temperatures. 

eric.gage@mohreng.com

Equipment Vibration Problems:

tools and techniques used to solve difficult and unusual vibration problems

by:

Lyle Breaux, P.E.

Eric Luther, P.E.

Scot McNeill, Ph.D., P.E.

The most common equipment vibration problems are often solved in industry without the use of specialty engineering resources. Routine vibration problems—from machinery imbalance and misalignment to simple cases of noise and resonance—are often addressed at the plant level without help from consultants. On the other hand, some encounter noise and vibration problems that require a more in-depth approach—one that involves a combination of computer simulation, specialty field measurements, and/or advanced data analysis techniques. When these more difficult and challenging

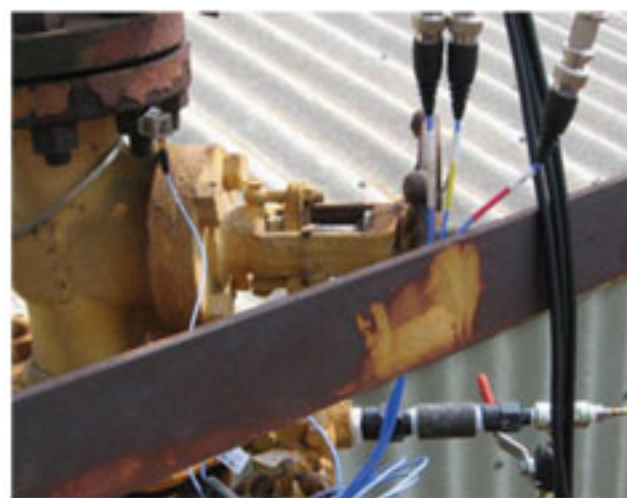


Figure 1:
Compressor piping vibration problem. Field measurement using triaxial accelerometer and dynamic pressure sensors

dynamics problems arise, they call on Stress Engineering Services (Stress) for expert consulting and field services.

Field Vibration Surveys – Portable Data Acquisition

Most field vibration troubleshooting starts with basic data collection via portable, hand-held signal analyzers that are easily moved around multiple locations in the vicinity of a vibration problem. Data are typically acquired as a “snapshot in time” of a vibration signal, although modern portable analyzers can also be used as a digital tape recorder, enabling long-term and/or transient data capture. Even complicated multi-channel vibration monitoring jobs often start with a field survey to identify the best locations for mounting sensors. A field vibration survey with portable data acquisition is the simplest and fastest technique available for troubleshooting problems in the field.

Field Vibration Monitoring – Multi-Channel Acquisition

For some difficult vibration problems, long-term monitoring with multi-channel data acquisition emerges as a very powerful tool. This is certainly the case for complicated flow-induced vibration in which the

vibration characteristics are intimately related to process conditions. A variety of sensor types are often used together—from strain gages and accelerometers to microphones and pressure sensors. Long-term monitoring allows our engineers to identify causal relationships between vibration characteristics and plant operating conditions. Taken together, this information often points to the source of a complex vibration problem.

Experimental Modal Analysis (EMA)

EMA is often referred to simply as impact or shaker testing, and is used by Stress engineers in troubleshooting problems and for calibrating computer models. This is a traditional structural dynamics testing method that involves controlled loads applied to the test structure, and the analysis of the vibration (output) signals along with the measured loading (input) signals. The controlled loads are applied using shakers or impact hammers. This type of testing yields the three fundamental vibration parameters of all machines and structures: natural frequencies, mode shapes, and damping.



Figure 2:
Impact testing of a large valve system using a modal sledge hammer.

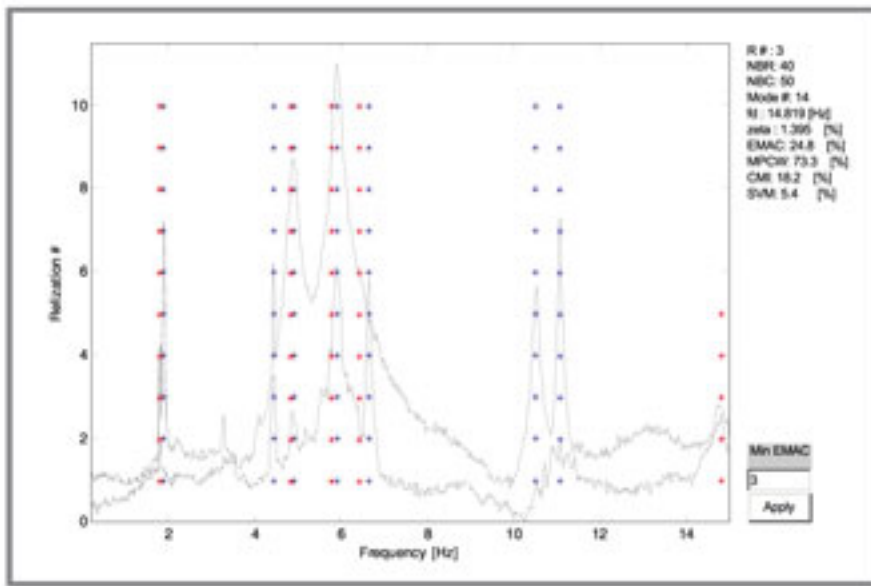


Figure 3: Consistency diagram used during OMA to identify modal parameters.

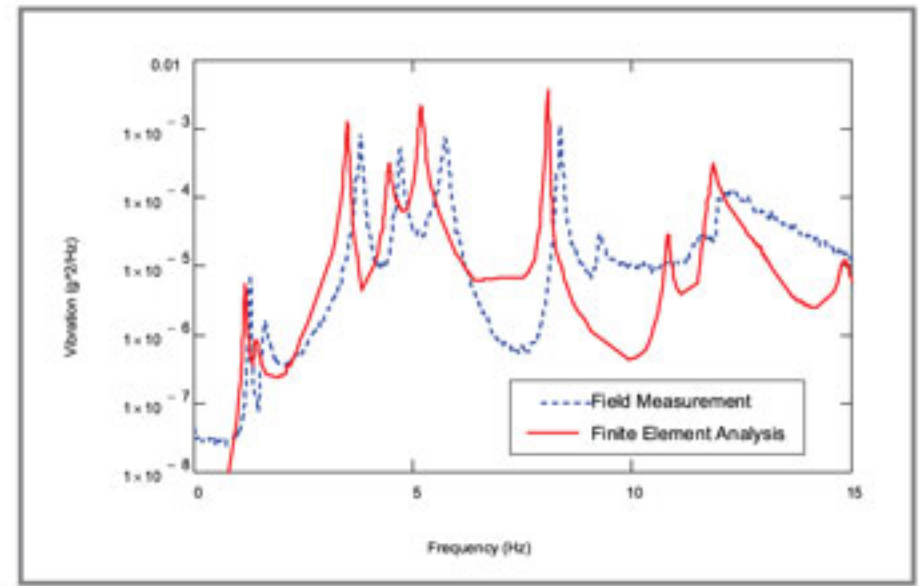


Figure 4: Comparison of a calibrated FE model with field vibration data.

Operational Modal Analysis (OMA)

There are scenarios when traditional structural dynamics testing cannot be performed, for example, the equipment cannot be shut down, background noise levels are too high, and impact hammers are not practical or accessible, to name a few. The technique known as OMA may provide an alternative to traditional structural testing in such cases. Multiple vibration sensors are used to measure the system's normal operating vibration. Computer algorithms process the cross-correlation between the various measured signals; the result is the same natural frequencies, mode shapes, and damping, just like in EMA described above. This powerful technique is particularly well-suited for process flow-induced vibration and civil/structural vibration—situations that are dominated by random vibration signals.

Advanced Data Analysis

Troubleshooting and solving complex vibration problems often require data analysis that goes beyond simply looking at time waveforms and frequency spectra. Our engineers use advanced data analysis and signal-processing techniques to

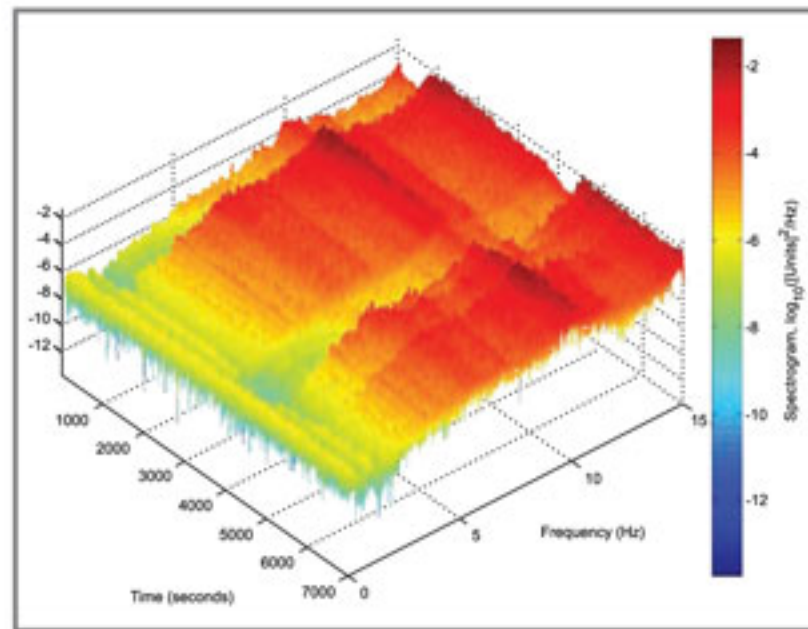


Figure 5: Spectrogram of non-stationary random vibration

reveal the features, patterns, and nuances in measured data that aid in understanding complicated dynamics problems. Stress' expertise in system dynamics ensures that state-of-the-art analysis capabilities are at the client's disposal, from structural integrity monitoring and damage detection, to system identification using random output-only data.

Computer Simulation

Computational tools such as finite element analysis (FEA) and computational fluid dynamics (CFD) are utilized for all types of problems that Stress encounters, including those in vibration and acoustics. When the results from computer models must be accurate to within a specified tolerance, Stress engineers use actual vibration and acoustic mea-

surements from the field to fine-tune and calibrate models. Computer models calibrated to field measurements take much of the guesswork out of FEA to better simulate real-world behavior. The dynamics of structural and machine components can be simulated under different scenarios or loading conditions that are impossible to measure in the field, or to verify solutions to vibration problems before costly modifications are implemented. 

lyle.breaux@stress.com

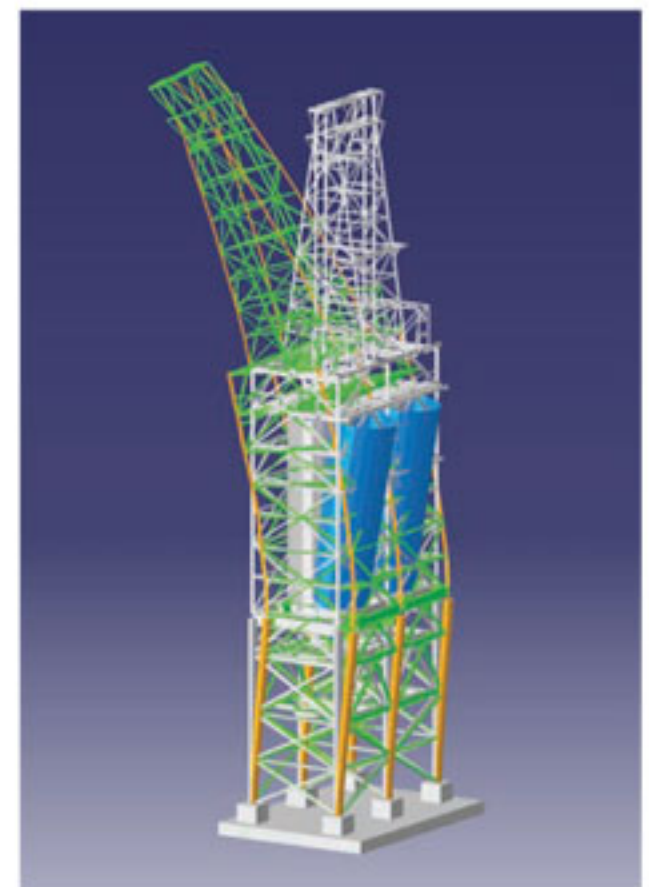
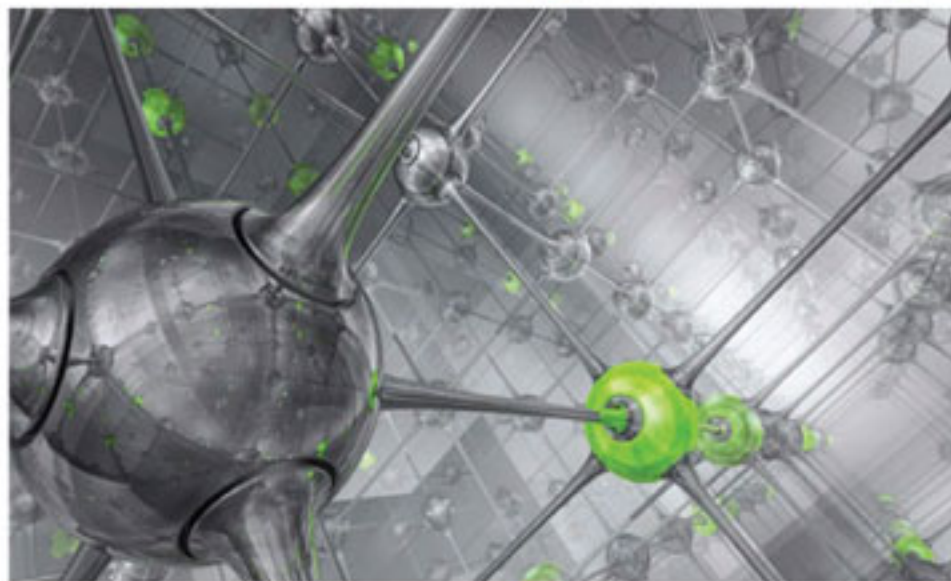


Figure 6: Dynamic FEA result showing one mode shape of a refinery Coke Drum structure.

Indra's Net:

by: David Parrott

The Power of Integrated Design



"They say there is a vast net containing everything, everywhere, and a multifaceted diamond is caught at each nexus point in the net. Like a sparkling hologram, each diamond reflects every other diamond. Looking at one, you see the entire net throughout space and across all time. If you shake one piece of the net, all other parts tremble; each is codependent on the others..."

Joel Speerstra

This is Indra's Net — a compelling illustration of the effect of change in a complex system. A modern consumer product is such a system; its parts, function and purpose are so interconnected and complex that a discreet change at the design level reverberates system-wide. Like an orchestra without a conductor, the development of modern consumer products invariably happens in silos, with little or no communication between the players (e.g., engineering, design, and marketing). The resulting product is often a dissonant patchwork of short-term fixes and

half solutions lacking elegance, integration, or even simple function.

The challenge of designing a product within a web of interconnected constraints can be overwhelming if the orchestrator cannot see beyond a single node (e.g., the concerns of his own department). Guided by the broadened perspective of 30 years of product development experience, the integrated Industrial Design (ID) practice at Stress Engineering Services (SES) can anticipate and direct the intricacies of a complex design process to produce products of extraordinary elegance and ultimately, heightened profitability.

The Changing Face of Design

Designers are artists whose skills are tempered by the real-world constraints of marketability and mass production. Traditionally, ID is the profession concerned with the aesthetic and usability of a product. However, the complexity of modern product design has forced good designers to expand their knowledge

beyond the realm of aesthetics alone. Their increased experience allows them to inductively access a vast body of knowledge from which to distill innovative solutions.

They have a principal skill that describes the vertical leg of the T — they're mechanical engineers or industrial designers. But they are so empathetic that they can branch out into other skills, such as anthropology, and do them as well. They are able to explore insights from many different perspectives and recognize patterns of behavior that point to a universal human need.

The "vertical leg" of SES ID and the primary tool of ID is communication. From brainstorming to the support of intellectual property, the illustrative skills of SES ID form the connective tissue that integrates all the expertise of SES toward a single, unified goal. The "horizontal leg" of our practice can tap into 30 years of expertise in every aspect of product development, testing, and engineering.

What is Good Design?

Can a design be "good" if it is beautiful but doesn't function? Of course... We call that art, and the truism, "beauty is in the eye of the beholder," illustrates its subjective nature. In a marketplace of objective constraints (e.g., manufacturability, cost, reliability, marketability, etc.), artistic subjectivity is misplaced. While art can ignore and exceed all constraints, the greater challenge of design is that it must embrace them on many levels.. Great art must be beautiful or meaningful, but a great product must excel on all three levels of design: form, function and meaning and in such a way that each buttresses the other.

Form

The form of a design is what is immediately perceived by the senses—how a product looks, sounds, tastes, smells, and feels. Beyond that, an object's visceral attributes— aesthetics—must communicate, in the language of form, both its function and meaning.

Function

A design's function describes how well it fulfills a prescribed purpose. How does it feel in use? Is it durable? Is it efficient? Is it reliable? These are all concerns of the functional level of design. To make a product's function obvious, intuitive, and ultimately elegant, functional attributes must be celebrated within the aesthetic of a design.

Meaning

Faced with the challenges of cost and manufacturing, the generation of meaning can seem esoteric, yet it is by far the most important and reliable predictor of product success. Meaning of a product is associated with the feelings it generates in a user and others. What does the product say about its owner? How does it reflect his ideas or ideals? A product that generates no emotional bond with its user will always remain a commodity; it is incapable of generating desire.

"Each of the three levels of design plays its part in shaping your experience. Each is as important as the others, but each requires a different approach by the designer."

Donald Norman

Author of Emotional Design:

Why We Love (or Hate) Everyday Things

A product that excels in one or two levels of design may be successful, but only a product that embraces all three levels of design can be great.

What is Different about Industrial Design at SES?

The role of most design firms remains relegated to the area of aesthetics and is easily marginalized because of its artistic, and therefore subjective, nature. The work of these firms is styling, not design. To convert a work of styling into a salable product necessitates a patchwork of compromises and quick fixes. The result is invariably disappointing - an inelegant product that is over budget, behind schedule and ultimately unsuccessful.

Only by melding design every aspect of the development process can designers rapidly conceive and refine feasible concepts to avoid the high cost of developing and, predictably, abandoning aesthetics-driven concepts of marginal value.

Traditional design firms stumble over the complex interconnections of Indra's Net. At SES, we are incorporating the tools of ID into our already robust engineering practice to create an integrated design service, capable not only of understanding these connections, but of harnessing them to predict and streamline the product-development process.

The SES design process saves development time, cuts cost, and yields elegant, reliable and profitable products. Where will you take your next project? 

david.parrott@stress.com

www.stress.com

Houston Office Expands Materials Laboratory

Stress Engineering Services is pleased to announce the expansion of our Metallurgical Laboratory facility in Houston. The new 4,000 ft² space has dedicated areas for macro-photography, metallography, chemical etching, and hardness. The versatile space allows for custom configurations to conduct inspections ranging from microelectronics to structural fire damage assessments. Our state-of-the-art electron microscope provides imaging of large samples up to 100,000X, semi-quantitative chemical analysis, and phase identification using an electron backscatter diffraction system. A conference room within the lab allows group meetings and simultaneous, remote monitoring of the electron microscope image and output. There are additional, semi-private areas for visitors with internet access. With over 68,500 square feet of full-scale test laboratories and load frames up to 10 million pounds, Stress is uniquely equipped to support independent third party inspections.

kim.fesner@stress.com

www.stress.com



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SERVICES INC.**

an employee-owned company

HOUSTON
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513.336.6701

NEW ORLEANS
504.889.8440

BATON ROUGE
225.769.9772

MOHR ENGINEERING
281.469.2177

STRESS SUBSEA
281.890.8441

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713.590.6599

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