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Inside this issue...

STRESS ENGINEERING SERVICES INC.

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President’s Message

Our 40th Anniversary celebration in November 2012 showcased the dramatic technology changes in all our service areas since the company was founded in 1972.

We exhibited the significant progress in strain gage and instrumentation technology, software, load frame technology, and computing power. The challenges of meeting clients’ needs for safe HPHT (high-pressure, high-temperature) equipment demand this technology. We reflected on some of our successes, such as saving over one billion pounds of plastic through our advanced analysis capability applied to plastic consumer packaging.

We were pleased to welcome 37 new top-notch employees during 2012. Their training is ongoing, and they are already helping solve clients’ toughest technical challenges. We are expanding rapidly to meet strong demand for our services with both new smart, young folks and with more experienced folks who are rapidly absorbing the culture of internal co-operation of an employee-owned company.

We completed our new office and lab facility at 7030 Stress Engineering Way in Mason, Ohio and consolidated our three Cincinnati area work locations in the new facility. Our creep testing capability there is the most advanced in the country. We also completed another test facility at our Waller, Texas laboratory and are currently constructing our fourth building to meet the demand of testing HPHT well drilling and completion equipment.

As our clients have become more international, so has our work. Last year, we worked on over 200 international projects for clients in 30 countries. Our Canadian office also reported an outstanding year. The services Stress supplies in failure analysis, instrumentation, stress analysis, and integrity management are needed worldwide because no client can tolerate failures.

We thank you, our clients, for your support and friendship. We pledge to continue providing you the **“right answer on time.”**

Thanks!!

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

Real-Time Drilling Riser Fatigue Monitoring

by: Scot McNeill, Ph.D., P.E. and Daniel Kluk

In 2011, our original battery powered Subsea Vibration Data Logger (SVDL) unit was re-engineered at a client's request to provide greatly expanded capability as part of a larger system: the Riser Fatigue Monitoring System (RFMS). The RFMS was specifically developed to measure and characterize drilling riser response in real time at a deepwater well site located off the coast of Japan. The metocean environment at the site is subject to impingement from strong ocean currents, with surface speeds routinely exceeding 4 knots and occasionally exceeding 6 knots. Such strong currents make VIV a prime concern for riser-based deepwater drilling. To assess the drilling riser response in this environment, the client proposed the development of a monitoring system capable of measuring and displaying the vibration response in real time, and analyzing the recorded data to generate estimates of instantaneous and accumulated fatigue damage.

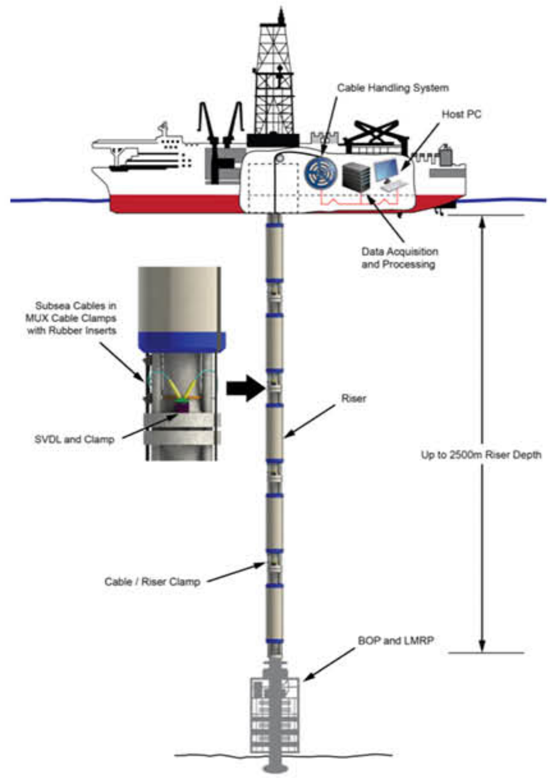

Figure 1: *RFMS system physical architecture*

The RFMS, shown schematically in Figure 1, utilizes accurate and robust vibration monitoring instrumentation at strategic locations along with information from an analytical finite element (FE) model to provide real-time stress and fatigue damage over the entire riser system. The only required online inputs are the dynamic riser response, top tension (TT), and mud weight (MW); therefore, fatigue estimates may be calculated without knowledge of the impinging currents, wave conditions, or other sources of excitation (although the fatigue response may be correlated to these data, if available).

An unprecedented level of actionable information regarding the health of the drilling riser is provided to the rig crew through the RFMS. Drilling and riser engineers receive real-time information on vibration levels, stress levels, excited modes and frequencies, and fatigue damage. Responses of the riser to changes in TT and MW can be observed in detail shortly after they occur.

The real-time data requirements of the RFMS required a redesign of the original SVDL to provide enhanced functionality. In the new embodiment, the batteries were replaced with an external power supply, and fiber-optic links were added to allow transmission of data between each SVDL and a topside data acquisition and processing unit (see Figure 2). External connectivity (via subsea fiber-optic cabling) to the topside also allowed several SVDL units to be accurately synchronized, thereby providing important phase information about structural modes.

The RFMS hardware and software were completed in the summer of 2012 and installed on the client's drilling riser during two campaigns off the coast of Japan, at 1180-meter and 1939-meter water depths. The system

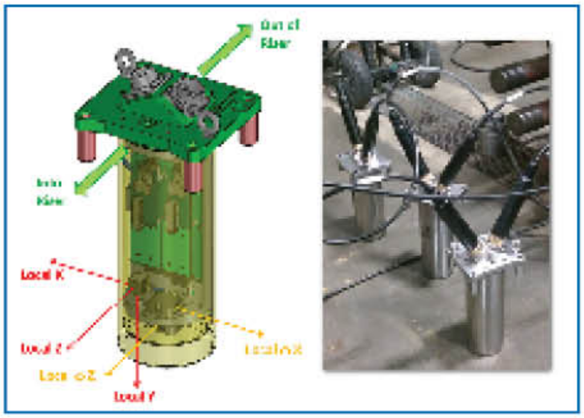

Figure 2: Modified SVDL interior arrangement (left) and actual units with subsea fiber optic cables during testing (right).

was tested at the former site in a relatively low-current environment. At the latter site, current speeds of up to 5.3 knots were encountered, with sustained currents over 4.0 knots. The data collected from the two deployments are discussed in the following paragraphs. Figure 3 shows normalized fatigue damage results generated by the RFMS in real time during the first campaign. The left window shows fatigue damage rate (top) and running cumulative fatigue damage (bottom) at desired locations in the riser. By default, only the location with the highest fatigue damage is shown. Damage at other locations can be investigated using the controls on the right side of the window. Although strong VIV did not occur during the deployment, it is

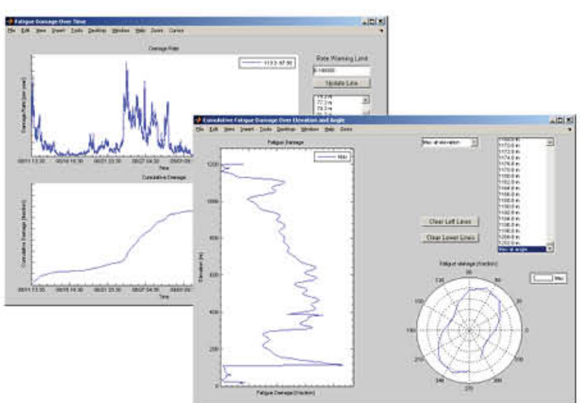

Figure 3: Normalized fatigue damage output displayed over time (left) and over the riser elevation (right) during the initial RFMS deployment.

clear that fatigue damage rates changed significantly with varying conditions.

A plot of normalized cumulative damage over riser elevation and angle is shown for the same deployment in the right window of Figure 3. By default, the maximum fatigue damage over all angles is shown at each elevation in the plot. Damage over specific angles can be added to the plot. Similarly, the maximum fatigue damage over all elevations is shown at each angle in the lower-right plot. Damage at specific elevations can be added to the plot. Discontinuities in the damage are seen where changes occur in the fatigue curve or cross-sectional properties.

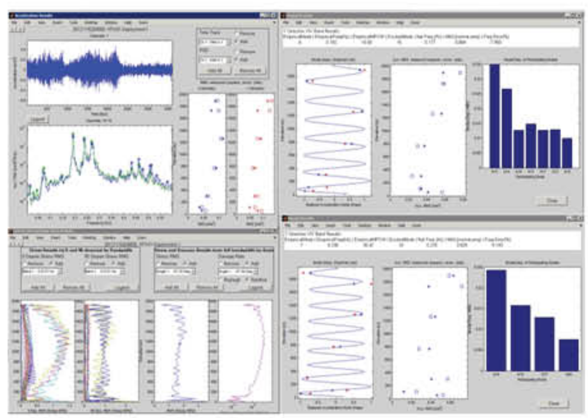

Figure 4: Fatigue estimation algorithm output with riser connected, second deployment.

During the second deployment at 1939-meter water depth, the RFMS recorded several damaging events due to the heavy currents and waves. Figure 4 shows a portion of the fatigue-damage software output for a one-hour time segment of data when fatigue damage rates are high. Fatigue damage rates and cumulative fatigue damage plots are shown on separate displays. The upper left window contains acceleration time trace and power spectra plots, along with the measured and reconstructed RMS acceleration values (in the entire bandwidth of interest) at the sensor locations. The lower-left window contains plots of RMS stress over each spectral band, centered around each spectral peak (identified with stars in the PSD plot). It can be noted

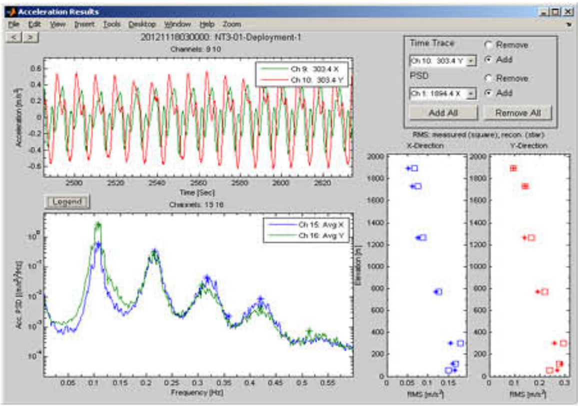

Figure 5: *Acceleration results window during a VIV event with riser disconnected*

that three bands contain high RMS stress levels. These bands correspond to the three primary peaks in the PSD plot. The two windows on the right show modal results for two of the spectral peaks and bands. Results include the measured frequency and mode shape, corresponding analytical frequency and mode shape, measured/analytical mode shape correlation, measured mode complexity (traveling wave behavior), strength of participating modes, and measured and reconstructed RMS acceleration (within the spectral band). Despite the complex, multi-mode traveling wave behavior, the software is able to accurately reconstruct the vibration response and resulting stress and fatigue damage on the riser.

Figure 5 illustrates an acceleration results window during a 1-hour time period when VIV was active for the disconnected riser case. VIV during this brief time period was fairly strong as the vessel was in transit, moving out of the high-current area. The classical hallmarks of VIV are evident in the time series and spectra. The fundamental cross-flow shedding frequency is evident as the 0.11 Hz peak. The cross-flow third harmonic is evident at 0.32 Hz. The fundamental in-line shedding frequency is evident at 0.22 Hz (double the fundamental cross-flow frequency). The in-line harmonic is evident at 0.42 Hz. The directionality becomes clearer when the data are rotated into in-line and cross-flow components as in Figure 6 (left). Figure 6 (right) shows a snapshot of SVDL acceleration data integrated to yield displacements, after removing the gravity (g*sin(θ)) component.

It is evident that the new field data provided by the SVDL and RFMS will prove increasingly useful as the design boundaries of risers, wellheads, and other subsea structures are extended, and as structural integrity management becomes a preeminent concern in deepwater drilling and production operations. Ultimately, a sufficient amount of quality field data are expected to lead to improved model validation and accuracy, and to more focused inspection and integrity-management programs.

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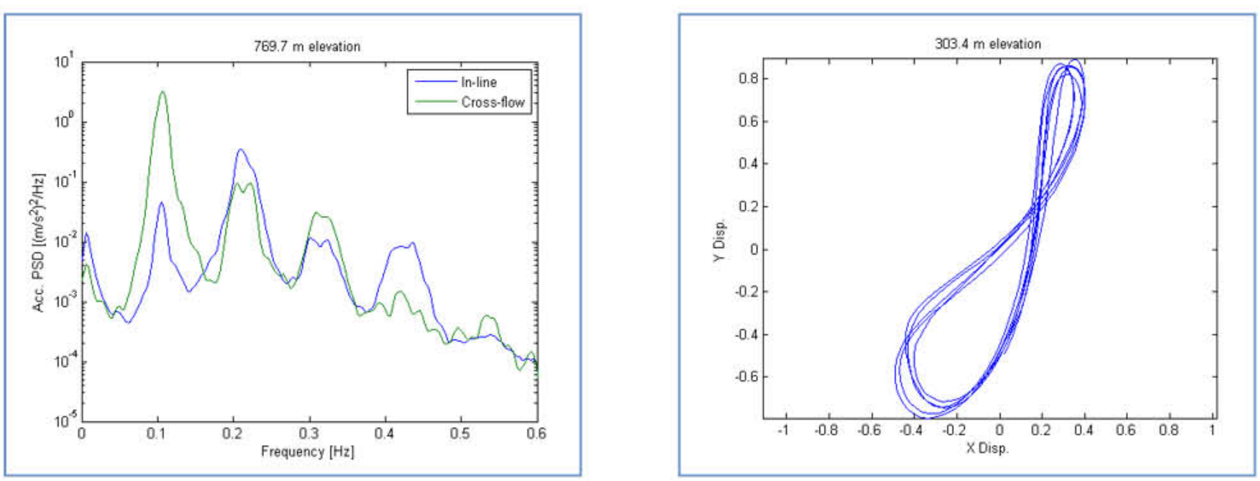

Figure 6: *PSD of rotated SVDL data at 770 m elevation (left); Normalized displacement at 303 m elevation (right).*

Stress Subsea and Floating Systems Practice Join Forces

by: Chuck Miller, P.E.

November 2012 marked the 40th anniversary of Stress Engineering Services. Only a few years after opening our doors, we began supporting the offshore Oil and Gas industry through providing component design/ analysis services and by developing one of the first computer programs specifically designed for dynamic analyses of offshore riser systems, DERP. Since those early years in the 1970s, our services provided to the offshore Oil and Gas industry have continued to grow as we have expanded to provide our clients the technical expertise they need to address their most challenging problems.

We now execute projects for offshore activities around the world. These projects range from small (one or two day) efforts to large programs that may require multiple years to execute. Some of the broad service categories we provide include:

- Design and analysis services for offshore and onshore oilfield equipment and equipment components
- Engineering services to support offshore MODU drilling operations
- Riser engineering services to support offshore drilling and production operations
- Coupled global analysis of floating drilling and production systems
- Structural engineering, global analysis, riser engineering, and metallurgical services to support operators' integrity-management programs for their floating production systems
- Testing and instrumentation services

In 2003, we made a significant step forward by broadening our services to include subsea engineering expertise through the addition of the Stress Subsea division. This addition brought to Stress Engineering Services the critical expertise and capability needed to tie all of our offshore engineering services together and to provide our clients with a more complete package of services including:

- Field Architecture Development
- Subsea Pipeline Engineering
- Deepwater Pipeline Assessment and Repair
- Subsea Engineering

Based on the successes that we've experienced with the broad set of services that we provide, we have now decided to take the next step in our advancement by placing all of our upstream services under the single banner of "Upstream Services." We are very excited about the opportunities this union presents. By integrating our floating production systems, subsea, riser design and analysis, offshore drilling, pipeline, and testing expertise into the Upstream Services Group, we are forming one of the most comprehensive upstream services portfolios in the Oil and Gas industry—all under one roof.

We believe that consolidating our upstream practice areas into a single, global entity brings great value to our clients. Together, we will be able to operate more efficiently, expand our capabilities, and deliver an even broader range of integrated solutions and services.

Most importantly, our commitment to technical excellence and superior service is now stronger than ever. Our primary focus is, and always will be, to provide the highly professional and responsive services our clients need.

chuck.miller@stress.com

Preventing Cracking Failures in PC, ABS, and PC/ABS Blends in Pharmaceutical, Medical, and Consumer Device Applications

Mark A. Bennett, P.E., Kenneth R. Waeber, P.E., Martin J. Gibler, and Clinton A. Haynes

The medical and pharmaceutical industries rely on polycarbonate (PC), acrylonitrile butadiene styrene (ABS) and blends of these materials for producing many of the devices in use today.

These materials are well known for their durability, with PC being used for many items referred to as "unbreakable" and ABS frequently used for harsh-duty items such as appliances. PC and ABS materials are also used because of their stability, which provides excellent dimensional characteristics and very good surface finish.

These characteristics notwithstanding, there are still a large number of failures involving these materials. In fact, failures occur in situations where it seems the device should be fine, based on traditional design criteria and the information provided by the material suppliers. Many years of involvement by Stress Engineering Services (SES) in diagnosing and analyzing failures has highlighted that there is a general lack of understanding among device designers, engineers, and material suppliers about the life-limiting conditions leading to these failures. In spite of the desirable properties of ABS and PC materials, small, seeming innocuous loads can have a large effect on the mechanical properties of both materials. We have found that these unexpected failures are quite often due to small, sustained loads in the device (Figure 1), typically developed upon assembly.

SES has developed methods to evaluate device designs and materials to enable predicting the life and reliability of these devices.

Figure 1: *Cracked boss in device caused by sustained strains in PC.*

Evaluation Process Summary

Investigating and evaluating the life and reliability of PC/ABS devices involves a number of different activities, each with a specific purpose, approach, and outcome. The typical process comprises a combination of stress analysis, testing, and statistical methods for life prediction. These steps are frequently modified and/or customized to most effectively address a particular situation. Life assessment typically provides the most benefit in the design phase of a device. However, if a failure is detected after a product launch, the commercial needs surrounding the failure often elevate these activities to an "urgent" or "emergency" status, necessitating compressing the process and completing multiple activities in parallel to determine the root cause(s) of the failure. Figure 2 illustrates the flow of activities associated with life prediction or failure.

Typical Scenario

Device manufacturers will typically perform verification testing, as required by the FDA and other regulatory bodies. However, this testing is usually performed

Figure 2:
Reliability Assessment Process

with samples from a very limited number of product batches. As a result, the outcome does not necessarily represent what will be experienced in actual production. In particular, this approach does not capture the full range of dimensional variability as a result of the molding process or dimensional variability over the life of the product design as tooling wears. The data from a typical verification test can be used to determine the approximate life of a component or device, but this life prediction is only applicable to devices with similar variability to those tested. Even when the life prediction is valid, most of the time it will not provide any substantial information about how to extend the life when required. Using the most common methods employed by today's device manufacturers, it is necessary to test a very large number of devices—on the order of hundreds or thousands—to document a reasonable range of variability and truly evaluate performance. It is very expensive and often impractical to test this many devices.

SES has developed a method that utilizes testing, analysis, and statistical calculations to improve the ability to accurately predict life. The method enables device manufacturers to anticipate ranges of assembly variability that result in sustained stresses/strains that cannot practically be evaluated any other way during development. This approach not only enables evaluation of the nominal device design, but also makes it possible to assess design robustness over the life of the device.

Evaluation of Product or Device

The initial step in the reliability-assessment process is to evaluate the device and components in the assembly. It is critical to fully understand the assembly and the interaction between all components. Specific aspects of the design under consideration include how the parts are manufactured, the assembly methodology, and the loading scenario. Of particular importance are whether any of the components are subjected to sustained strain during storage and the environment in which the assembly is stored and/or used. In addition, the intended usage and design life must be quantified and understood in the context of the stresses and strains in the individual components.

Finally, it is essential to decide which failure modes are to be prevented. This is typically determined by thinking through how the device is used and anticipating which of the failure modes will be affected by delayed cracking mechanisms. The information collected from the design evaluation is then used to define the initial stress analysis activity.

Initial Stress Analysis

Based on the information collected during the evaluation task, the next step in the process is to complete an initial stress analysis. These are needed to determine the approximate stress levels in the assembly as a function of dimensional variability, which are used to design experiments for evaluating the material and its effectiveness for the application.

These initial analyses are normally not highly detailed. They involve assessing local regions of the assembly to determine the stress levels present when the device is assembled, stored or used. For example, what is the stress level caused by an interference fit between parts when the device is assembled and stored? A critical aspect of these analyses is to include tolerance cases, i.e., where parts at the extremes of their dimensions are assembled. These tolerance cases will always drive failure of the device.

This task will define the stress levels that need to be evaluated in the testing phase of the life prediction.

Figure 3: *Finite element methods are often used to calculate sustained stress/strain in complex geometries.*

Accelerated Aging Test Program

The core activity in a life-prediction project is the experimental program. As mentioned previously, most companies perform extensive testing of their devices. However, it can be very difficult to capture the behavior of a production system, even in what would be considered a thorough device-testing program. Testing of complete devices can provide data on the life expectancy of the units tested, but nearly always masks the failure modes associated with ongoing manufacturing variability and poorly understood environmental effects of time-dependent degradation on material performance. The testing program described here is aimed directly at flushing out these coupled, camouflaged failure modes.

The purpose for the testing program advocated here is to define the relationship between "strain" in the components and "time to failure." Once this relationship is defined, it can be used to evaluate the outcome of predictive non-linear structural analyses and subsequently predict the life of the component or assembly. Of equal importance is that the strain/time-to-failure relationship can be utilized, in combination with analysis, to define and verify improvements to the device design that will extend the life. Rather than testing devices, this program involves experimental evaluation of the materials used to fabricate the components in the assembly. The choice to test materials is made to maintain a well-defined strain state in the test specimens, which is used to establish life-limiting failure modes of the material. This is much more difficult to accomplish if the full device is tested, since that task would require detailed metrology of each component in the assembly prior to testing, and obtaining these measurements often requires the device to be disassembled. Therefore, assessment of molded test specimens enables much greater control over the test conditions and reduces the scatter in the results. This approach to material evaluation is often adopted as a screening methodology to make the initial material selection. When used for screening early in the development process, assumed sustained stress/strain ranges are used, rather than actual measured values. This "bounding" approach typically eliminates poor candidate materials quickly and enables a ranking of potential resin systems.

A suitable testing program incorporates several key elements. These elements include placing the material specimens in a known strain state. An applied stress can also be used, but the constant-strain approach is more common. It is also necessary during testing to create failures in the specimens. Generating a failure is required for establishing the conditions at the boundary of the material performance. Knowledge of the boundary enables an assessment of the robustness of the device design. During a typical device-development schedule, it is impractical to execute a testing program that extends for the duration of the target design life. Therefore, the testing program must include means to accelerate the material-aging process. In most cases, the accelerators include increasing the strain in the test specimens above the nominal strain in the assembly and testing at elevated temperatures. Many devices are designed for operation in "hostile" environments, such as high humidly, chemical agents, solvents, and exposure to body fluids. As a result, the testing program frequently includes exposing the specimens to other accelerating agents to ensure that the interactions that may influence life are included. To generate sufficient data to develop the time/temperature/failure load relationship, the failures need to occur at several different time intervals as well as different strain levels. Therefore, a matrix of test conditions is organized and used to age the specimens. The specific conditions for this testing vary for each application. Information about the operating environment, assembly of components, and data from the initial stress analyses are used to formulate an appropriate test condition matrix.

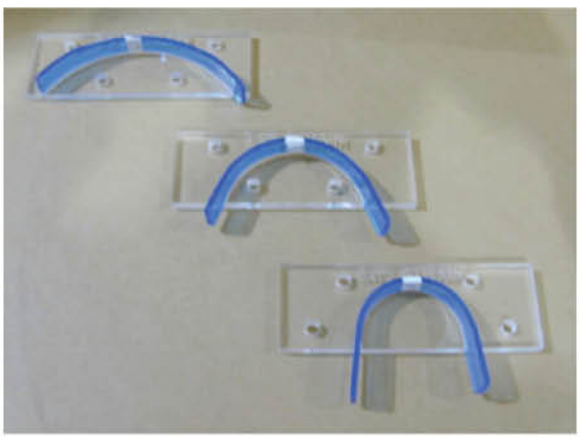

Figure 4: *Examples of one type of sustained strain fixture.*

In addition to multiple environmental and strain conditions, the test matrix will often include alternate material variations. Including alternates is a hedge against identifying a critical failure mode in the original material selected and not having a substitution identified and available. The material variations can include using resins with high melt flow rate, low melt flow rate, or evaluating several different candidate materials. The test specimens also vary from test to test. Many times, custom test procedures are developed around the available material samples, which are extracted from the specific components, regions, or features in the device.

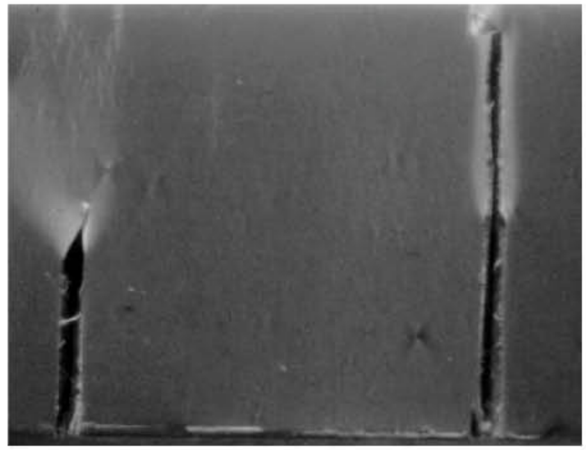

Figure 5: *Cracks in Specimen After Aging*

Once the test matrix is developed, specimens are prepared, protocols written, and the test methods verified, as required. The test program is then executed. During the testing, specimens are regularly inspected for failure using various means. Data on the time to failure are collected until the testing is terminated. In some cases, destructive testing is required to determine the effects of aging on the materials. Figures 4 and 5 show examples of failed specimens.

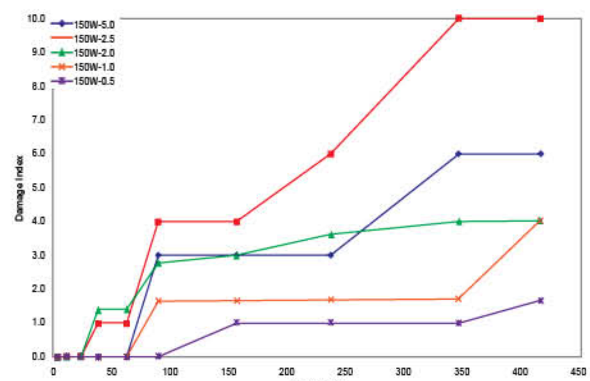

Figure 6: *Damage Index for Different Strain Levels*

The outcome of the testing program is a Damage Index for each of the factors involved. Figure 6 illustrates a sample damage index for strain effects.

The test data are processed to define a damage function for the specific material and application. The damage function is the relationship between time, temperature, stress, and the environment. An example of the damage function equation is as follows:

$$P(t,T,RH,\sigma) = t * [0.4 + 0.006RH\%] * \sigma^n * e^{\left[-Q/_{RT}\right]}$$

where t is time, T is temperature, RH is relative humidity, σ is stress, R is universal gas constant, and Q is activation energy.

Detailed Structural Analysis

The next step in the life-prediction process involves performing more thorough non-linear structural finite element analyses of the device (Figure 7). The objective is to complete a more detailed evaluation of the conditions existing in the parts once the device is assembled and operated by the end user. An essential feature of the detailed structural analysis task is to include the effects of variability including dimensions, assembly methods, temperature, and other sources.

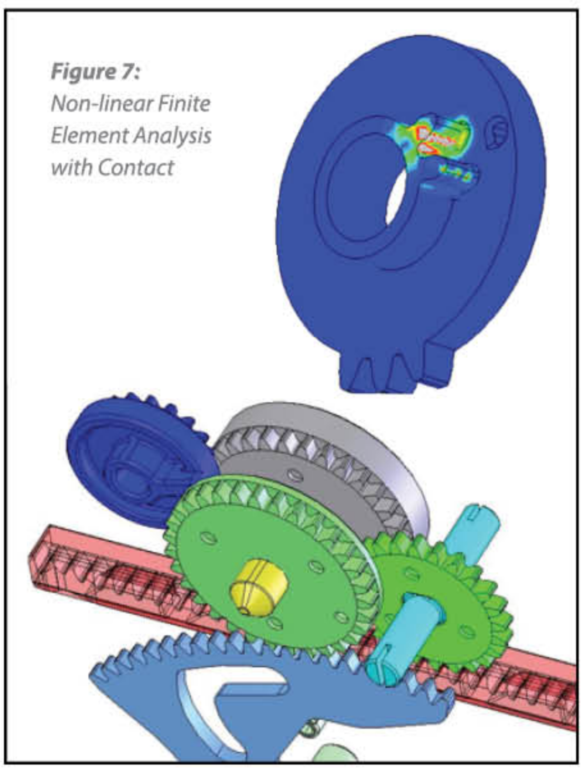

Figure 7:
Non-linear Finite Element Analysis with Contact

Because of the need to evaluate these sources of variability, multiple analysis cases are required. Very often, these cases include assembling components at their extremes of dimensional variability and/or applying different assembly forces in the analysis to represent the variability in the assembly process. For assemblies involving load-controlled conditions, the effects of creep are also included in the stress analysis. In those instances where parts slide against one another during assembly, it can be beneficial to include variability in the coefficient of friction as well.

Depending on the complexity and operation of the device, multiple analyses may be completed for various sub-assemblies, or the entire device may be evaluated in a simulation. The analyses always involve tracking the non-linear behavior of materials and contact between components, such as snap-fit and other interference-fit assemblies. In almost all cases, assembly of the device results in regions where parts are in a state of sustained strain due to the design features or tolerance stack-up.

The result of these detailed structural analyses is definition of the variable and sustained stress range in the actual device assembly. *By considering the variability in the component dimensions, assembly methods, environmental conditions, etc., the stresses across the full range of production variability can be quantified in this step.* This is the key information that enables life/reliability prediction representative of the full production population.

Life Prediction

Life prediction is a statistical calculation that considers the stress range from the detailed structural evaluation together with the damage function to arrive at the time-to-failure for a specific device. Using the expected variability of the components, assembly methods, storage and usage environment, and applied forces, calculations are performed to determine how these factors would come together and translate into the expected distribution of devices present in production. Life-prediction curves (Figure 8) and reliability curves (Figure 9) are drawn with specific confidence intervals based on the size of the testing program and the scatter in the data. Typically, increasing the number of experiments conducted can narrow the band between the confidence intervals. The stress range for this distribution of devices is then determined and used with the damage function to arrive at a distribution of expected life for the device. These methods can be applied to obtain the distribution of reliability throughout the range of device assemblies. However, in most life-prediction projects, the worst-case interference condition and nominal interference condition are used as the specific bases for reliability calculations.

Life Improvement

A significant benefit of this systematic approach to life prediction is realized when the results indicate that the device will not achieve the target life defined by the specifications or by commercial concerns. In this event, results from the detailed structural analysis can be used to develop design modifications or material alternatives targeted toward life improvement. The assembly of the device and the manner in which it carries load are clearly documented in the analysis, often leading to relatively simple solutions for life improvement. Once these potential changes are identified, they can be assessed in detail by making changes to the detailed structural analysis model and re-running the critical cases. The updated stress ranges are then used to revise the life assessment and reliability predictions to determine whether the target life can be realized with the modifications. A significant advantage of this approach is that these modifications can be evaluated computationally and do not require further testing.

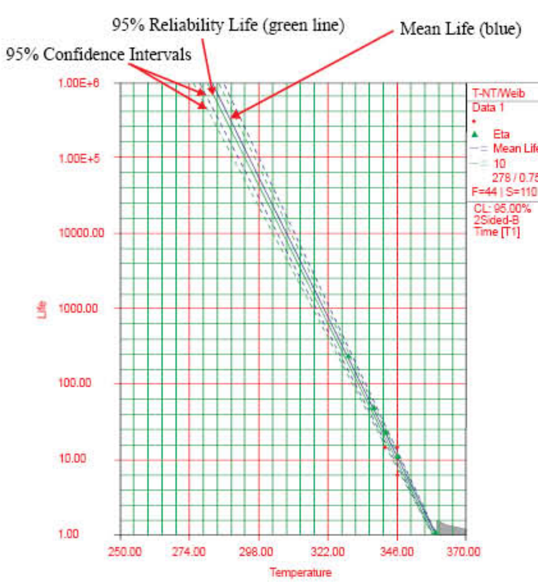

Figure 8: *Life Prediction with 95% Confidence Intervals*

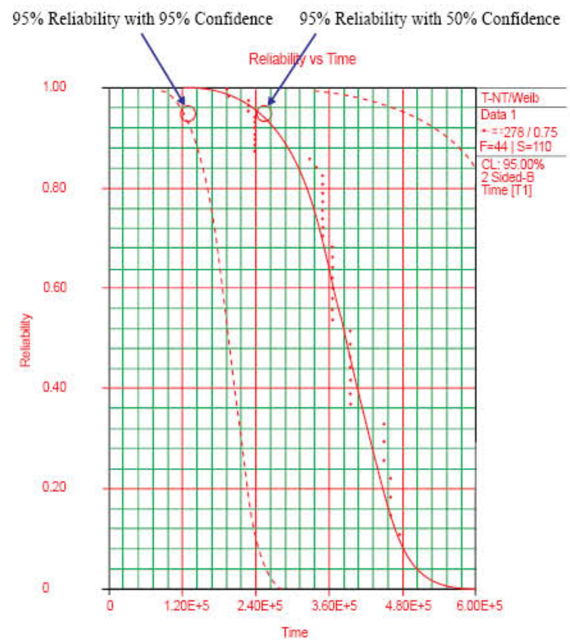

Figure 9: *Reliability Prediction with 95% Confidence Intervals*

Conclusion

The failures observed in devices made from polycarbonate, ABS, and PC/ABS blends are predictable and, therefore, preventable. The methodology developed by SES represents a significant departure from the typical evaluation approach employed by medical and pharmaceutical device manufacturers for design evaluation and life prediction. However, this methodology has proven to provide the data needed to calculate the reliability of devices over their range of variability and has been successfully utilized by SES to make reasonable life predictions for these devices.

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Building on Failure Analysis:
Managing Pipeline Threats by Learning from the Past

Dr. Chris Alexander, P.E. and Ron Scrivner

With the aging infrastructure of the US pipeline system, failures occur from time to time. Most engineering consulting firms working with pipeline companies perform failure analysis assessments. The primary aim of these efforts is identifying the metallurgical cause of failures, with the work often being performed by metallurgists to determine the root causes of the incidents.

For the past five years, Stress Engineering has taken a unique approach in working with pipeline operators who have experienced failures. We conduct failure investigations, but don't always stop there. Our approach is a multi-disciplined effort involving metallurgists, mechanical/structural engineers, testing engineers, and field personnel. While performing a failure analysis is a critical part of the work completed by Stress Engineering, we recognize the importance of working with operators to understand how to reduce pipeline threats and their impact on the future operational integrity of their transmission systems.

In this regard, Stress Engineering is assisting pipeline operators around the world by helping them evaluate threats associated with systemic anomalies throughout their pipelines. Common examples include dents, mechanical damage, seam welds, girth welds, branch connections, and wrinkle bends. To accomplish this objective, Stress Engineering employs its Engineering-Based Integrity Management Program (EB-IMP), a five-step fitness for service assessment process that includes numerical modeling, full-scale testing, and development of repair solutions.

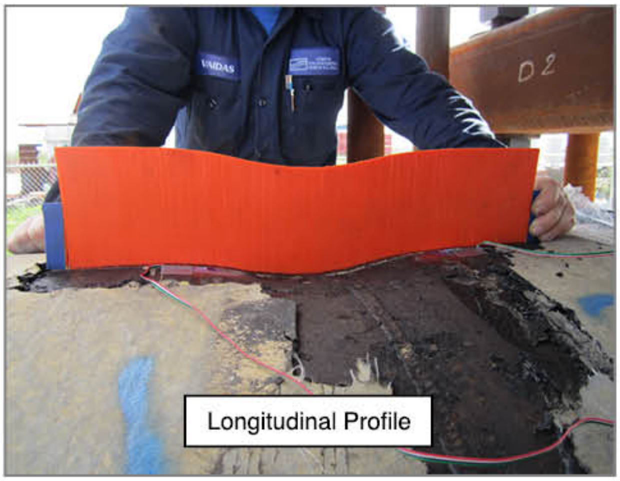
The EB-IMP process is based on the principles of API RP 579/ASME FFS-1, but also employs full-scale testing and the design of repair solutions. The goal is to provide improved confidence in predicting the future performance of pipelines. Stress Engineering is widely recognized for its expertise in evaluating composite repair systems, a key resource in the fifth step of the EB-IMP process.

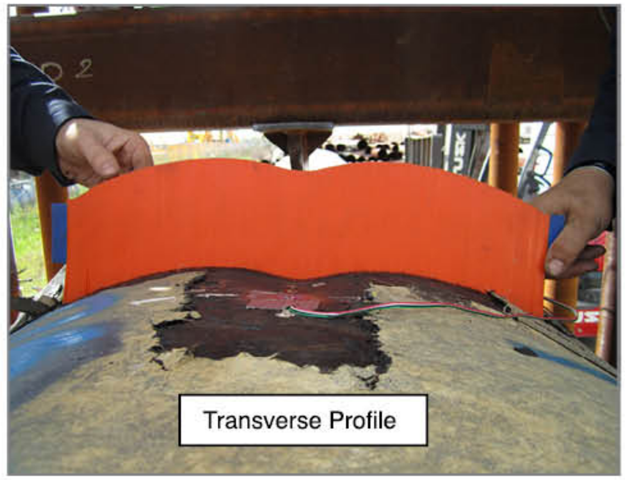
The aim of this article is to provide industry with an enhanced perspective by building on lessons learned from failure investigations and utilize insights gained by studying why pipelines fail so that future operation is not limited by the potential for future failures. While it is difficult to ensure that pipelines will never fail, it is clearly possible to learn from previous failures to reduce the likelihood of future failures. It is not enough to merely perform a failure analysis. Rather, multi-discipline firms such as Stress Engineering can provide pipeline operators with the resources and tools they need to manage identified threats.

This article describes two case studies that highlight how various elements of the EB-IMP process were used (1) to assess the behavior of dents in a transmission pipeline and (2) to validate the performance of an external clamp used to repair a dented deepwater pipeline using finite-element analysis and full-scale testing.

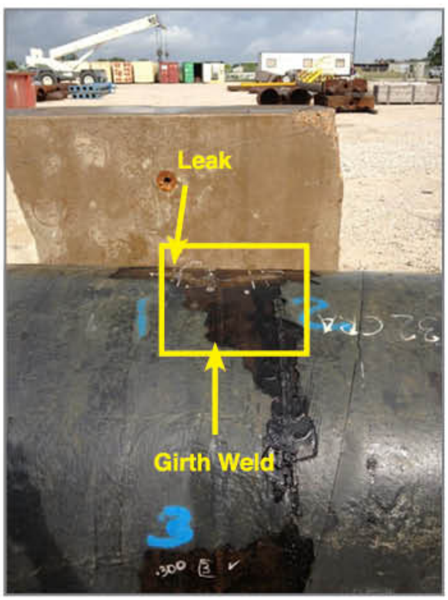
Onshore Dent Assessment

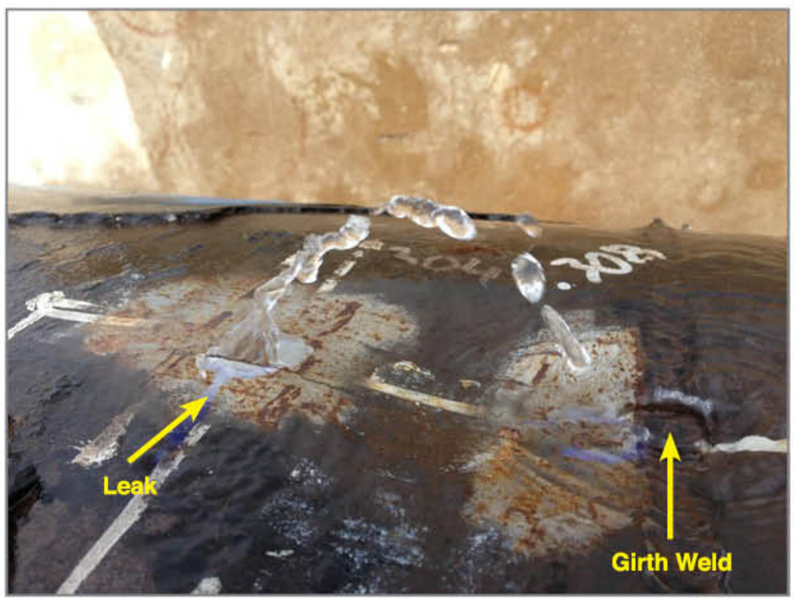
A liquid transmission pipeline operator contacted Stress Engineering after they identified multiple dents in one of their pipeline systems based on data from an in-line inspection run. One of the dents had resulted in a leak. The operator asked us to determine the relative severity of several dents, including those interacting with girth welds and seam welds. The initial effort involved finite element modeling, but eventually integrated full-scale pressure cycle fatigue testing (Step 4 of the EB-IMP process).





Validating geometry of dent created in test sample





Leak failure in dented test sample after being subjected to cyclic pressures

By the end of the study, we were able to provide the pipeline operator with an estimated remaining life based on the relative severity of a particular dent and the reduction in life based on the interaction of the dent with welds. The operator was able to continue operating the line with confidence, and was also equipped with the knowledge required to remove the more severe dents from service to ensure the long-term service of the pipeline.

Dented Subsea Pipeline

In 2005 an anchor struck a deepwater 18-inch diameter subsea pipeline. The pipeline was displaced laterally 1,200 feet, yet (thankfully) experienced no loss of pressure. Because of concerns over localized damage to a specific region of the pipeline, the operator determined to make a repair. After initially assessing the damage to the pipeline using finite element analysis, Stress Engineering conducted full-scale destructive testing that included pressure cycling to simulate 50 years of service along with burst tests. Final efforts included the design and evaluation of a subsea-deployed repair sleeve. The study included modeling the repair sleeve design accompanied by full-scale destructive testing. Strain gages were used to measure strain in the reinforced dent beneath the sleeve, which was then compared to prior results for the unrepaired dent test results. Steps 3, 4, and 5 of the EB-IMP process were used in this study.

Dent profile being measured subsea

The work in this project represents one of the more comprehensive efforts in the pipeline industry conducted to date in evaluating damage to a subsea pipeline and validating the performance of the repair. The results of the analysis and testing work provided the pipeline operator with a solid understanding of the behavior of the damage inflicted to the pipeline and what level of performance could be expected from the repaired pipeline during future operation. After the engineering analysis and testing phases of this work were completed, the deepwater pipeline was repaired and restored to full-capacity conditions.

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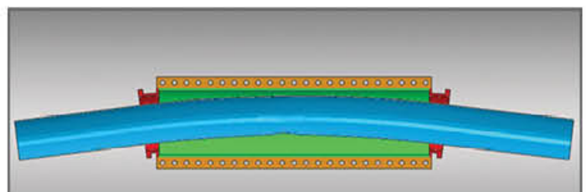
For more information on our Engineering-Based Integrity Management Program, visit www.stress.com.

Dent profile being measured subsea



Cross-section of sleeve on pipe

Sleeve-reinforced sample in test pit prior to burst

Coke Drum Fatigue Issues and Solutions

by: Richard S. Boswell, P.E.

Low-cycle fatigue failures of coke drums in severe thermal cycle service have been a problem since the coking process began. Petroleum coke was first made in the 1860s and Standard Oil of Indiana built the first delayed coker in 1929. An early API Survey in 1958 described many of the problems that refiners still face today: deformation and growth of the vessel shell, cracking of the circumferential seams, cracking of skirt attachment seams, problems created by non-symmetric flow geometries, and general frustration that pressure vessels fail in cyclic thermal service. These vessels are designed as code-compliant pressure vessels, yet their cyclic service can create weld failures with five years of duty. Repairs represent costly production outages. Replacements represent huge capital investments in addition to lost production.

The failure mode in these vessels is usually leak-before-break, and brittle cracking is sometimes observed when repairing 1.25 Cr materials after many years of service. Cracking in the cylinder is usually limited because, once the stored energy is released as either steam and hot water or hot combustible vapor, the driving force is rapidly reduced. However, fires can occur that are difficult to extinguish and threaten the structural integrity of the derricks and supporting structure.

In general, only the circumferential weld seams fail from axial stress fatigue. The vertical seams are staggered between cans, and have adequate wall thickness to resist pressure containment hoop stress. Strain gage measurements by Stress Engineering Services have demonstrated that the axial stress can exceed the hoop stress for a short duration during quench.

Cracking in the cone is a greater risk because access is difficult and the circumference is shorter. Cracking of the circumferential seam is more difficult to detect and monitor, and fires from leaking vapor can threaten the support skirt. The driving force in the cone includes the hydrostatic pressure of the vessel contents as well as thermal self-constraint. If this force is sufficient to drive an existing full circumferential crack through the wall thickness, then it is possible to completely dump the contents of the vessel, assuring a severe catastrophe. Because the consequence is great, the risk is also large.

If the skirt weld has already cracked through the full circumference and is not detected (because it is hidden under insulation), the vessel could continue to operate but may slip inside the skirt. Only friction will hold the drum vertically in place. This consequence is similar to the cone cracking.

American Petroleum Institute Subcommittee on Corrosion and Materials – API 934 Task Group / API 934-G, Coke Drum Document has requested voluntary submission of technical content to assist in creating a Recommended Practice for the Design and Operation of Fatigue Resistant Delayed Coke Drums. Stress Engineering Services is participating with technical experience input and creating the next edition of their industry survey.

Delayed coke drum service is a tortured duty life for a pressure vessel. Batch processing places the vessel in high and low thermal service extremes almost daily in many plants. The process requires a self-created high temperature environment as hot and heavy feed enters the vessel, and cracks the carbon chains into a highly volatile vapor that exits the vessel, leaving behind a high-density carbon residue that slowly fills the drum. At the end of the cycle when the drum has filled, the furnace-fed vapor is switched to another drum. The residual carbon in the drum is still very hot and must be cooled below auto-ignition temperatures by water quenching to begin emptying the drum. Thus, the severe thermal extremes of hot then cold continue as the other drum is filled.

Delayed coking upgrades the quality of the product by thermally cracking the long carbon chains to release a smaller and more valuable vapor molecule. The residue left is a function of the thermal/pressure process and ranges from a solid-like sponge coke to a loose conglomerate of small spheres referred to as "shot coke."

Low Cycle Fatigue describes failure created by a limited number of cycles exceeding the material yield strength. This is typically less than 10,000 cycles, at which point High Cycle Fatigue becomes the damage mechanism (cyclic stress significantly less than yield).

Low Cycle Fatigue is not simply a matter of how fast a vessel component or region is heated and cooled. The problem is created because of self-constraints the adjacent areas impose on each other during thermal transients. The faster and more local the transient, the more likely a severe gradient is created. Local hot areas thermally expand more than areas that are not as hot. And conversely, local cold areas thermally contract more than areas that are not as cold. This conflict of thermal expansion between adjacent materials creates stress. Because of this transient conflict, analysis of the problem is not complete with simple steady-state solution of the thermally induced stress, which often far exceeds the mechanically-induced stress.

For many decades, the inlet nozzle to the drum has been positioned at the bottom, centered vertically upward on a blind flange. This assembly must be unbolted and removed to allow the drum to empty the coke material left behind in the process. In the past 10 years, a new concept was introduced by a Stress Engineering client: employing a remotely operated slide valve. This tool significantly reduces exposure to risk of serious injury for the people who are un-heading the drum. But the conventional inlet nozzle was no longer feasible and was relocated to a horizontal position above the valve.

A similar concept had been used many years ago, and thermal fatigue cracking quickly appeared in the nozzle and cone. Side inlets today are integrally reinforced and do not experience this same cracking issue. However, the side inlet creates a non-symmetrical flow pattern in the drum that interacts with the loose shot coke, creating a new set of destructive problems.

With the return of the side-entry nozzle required for the automated un-heading valves, local channeling has become more consistent in creating a preferred side of the drum for the hot oil to flow. With one side hotter than the other, the vertical expansion of the sides is unequal, and the top of the drum moves off center into what is often described as a "banana" shape. During quenching, cooling water often favors the same hot side and aggressively cools and shortens what was previously the longer and hotter side. This effectively slams the drum quickly back to center and possibly bends the drum in the other direction.

A new tool has been introduced by a Stress Engineering client that uses a retractable horizontal nozzle to place the flow vertically upward in the center of the drum. This restores symmetrical flow and improves the likelihood that the quench water will flow upward through the center of the coke bed, rather than flowing up the inside wall of the drum and not inside the coke. Stress Engineering's strain-gage measurements are used to calculate cyclic fatigue damage. In one application measured before and after the installation of this tool, the damage was reduced by 37%, suggesting a remnant life increase of 60%. This is a significant improvement of the drum's health and safety.

Cracks are active when the local stress field can propagate the crack tip. Critical cracks will continue to grow with little additional encouragement. When should a crack be repaired? The obvious answer is before it extends through the wall and allows product to leak. Workmanship quality is an important issue in new drums as well as in old. Stress raisers from undercuts or defects can become future cracks to repair.

Understanding the problem is the first step toward a solution. The effects are well known in terms of repair and lost production time. The causes are more difficult to grasp because our knowledge of what is happening inside the drum is based on experience outside the drum through observation and measurement.

In presentations to API and various clients, Stress Engineering has shown significant results from our strain-gage and temperature measurements on the shell, as well as their variability. A short-duration, large stress is generated during quenching. This stress often exceeds the original yield of the material, and is the source of low-cycle fatigue and incremental distortion of the pressure vessel. The larger stress cycles will accelerate damage and encourage cracks to grow. Temperature measurements reveal the non-uniformity at any elevation, and how rapidly the steel is quenching. When the steel quenches quickly, the flow is not cooling the coke bed, which delays the removal of the drum contents or allows greater risk of internal fires and eruption when the top head is opened for drilling.

Many coke drums have developed bulges (permanent corrugations) during service. These do not appear suddenly. They grow in incremental amounts with each cycle until they create significant stress amplifications. While laser scanning is effective in locating bulges, it is not completely effective in assessing the impact they have on cracking, nor for predicting which bulges will ultimately crack and fail.

Stress Engineering has developed several procedures for evaluating the severity of these bulges. Bulge severity analysis uses the laser profile scan data and the drum thickness in a finite element based solution to evaluate bending stress created by the corrugation. Inspectors can also exploit this information to prioritize and plan their inspection efforts.

Stress Engineering's approach to coke drum life assessment issues is usually in partnership with the client/owner using our measurement and analysis tools and experience, the client's proprietary information and situation, and the client's technical experience and engineering support.

Typical Life Assessment Questions from owners/users include the following:

- How long will it last?
- When is the economic end of life?
- How many cycles remain?
- When will we have a through-wall crack?
- Which repair is best and when and how to repair?
- How can we extend the end of life?

Why do these questions and issues arise?

1. These drums were not originally designed/fabricated for this harsh cyclic service.
    a. Not only a pressure vessel.
2. Service conditions were not fully understood.
    a. Bulges and corrugations accelerate damage.
    b. Internal cracks develop at the circumferential weld cap/cladding/base metal interface.
    c. External cracks develop at or near the heat affected zone of the circumferential weld.
3. Consequences—Safety, Environment, and Financial—are extreme.

Stress Engineering's Integrated Approach and Service for Coke Drum Life Extension Practice is based on these sequential actions:

1. Search for bulging and evaluate it.
2. Search for cracking.
3. Repair the cracks.
4. Determine actual cyclic stress in the shell and skirt.
5. Perform structural, mechanical, and metallurgical evaluation of the drum.
6. Develop plans for Long-Term Operation, Inspection, Repair and Replacement.

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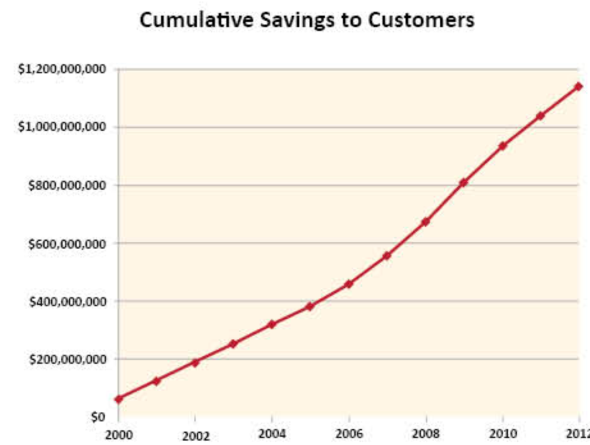
Saving Consumer Products Customers Over One Billion Dollars

by: Robert G. States

Stress Engineering Services (SES) has a long-standing history of working with customers to reduce product costs without sacrificing performance. Since 2000, we have helped our customers save over one billion dollars. The broad mix of projects, experience, and skill-sets at SES are key to our customers' significant cost savings for a range of products.

For the consumer products industry, our projects generally fall into three categories: new product development, failure remediation, and cost savings/productivity projects. Our work in failure remediation represents a significant component in our ability to help our customers implement cost savings successfully. Along with performing engineering design and analysis, we have a large internal knowledge-base for failure analysis in a variety of industries and applications. This insight into product reliability and life-cycle issues prevents SES from chasing "red herrings" in cost-savings efforts.



Note: These calculations are based on hard data provided to us by our customers.

SES Approach

Based on SES's history of implementing cost-savings projects, there are generally four areas to address to reduce costs:

1. Optimization of current systems
2. Implementation of newer technologies
3. Changes in product specifications
4. Changes in purchasing strategies

Each of these areas represents opportunities to reduce costs. Based on the typically limited knowledge for existing products, SES believes that all options should be considered at the onset of most projects.

Optimization of Current Systems

In this area, SES examines both the economics and engineering of the product. SES has developed sophisticated cost models to estimate the optimal cost for manufactured components. These tools can be used one of three ways. The first approach is to examine the optimal machine/tool sizing to deliver the lowest cost for the business needs. The second approach is to use these tools to develop "should cost" models. These data then can be turned around to be used to negotiate with component suppliers. The third approach is to set up "Monte Carlo" type options analyses to examine the effect on cost of changing materials, part designs, and assembly options.

Based on key cost drivers from the economic analysis, SES then focuses on the opportunity to re-engineer portions of the assembly. This includes considering items such as:

1. Reducing wall stock of components
2. Simplifying assemblies
3. Exploring alternative materials
4. Changing design platforms

SES possesses full engineering capabilities internally to engineer and test options. Given our long history of remediating failures in plastic components, we rely on our material failure logic models (MFLM) to first ensure that the options we recommend can be successful. Then we consider any potential downsides and ensure that we design against them.

Implementation of New Technologies

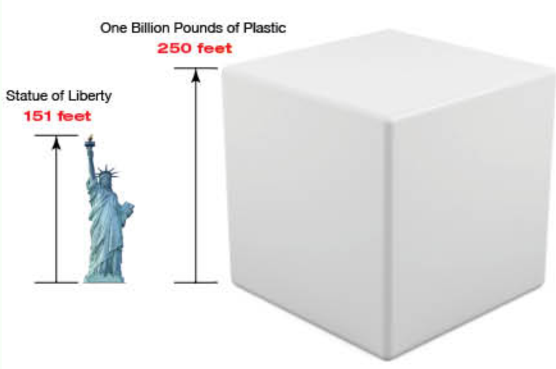
In conjunction with Optimization of Current Systems, SES can consider newer technologies that have been developed since the launching of the initial product. We often find that newer technologies exist that can lower costs and/or improve reliability. For any particular product, SES would consider the following items:

1. Material types and whether a lower-cost solution is available
2. Technology used to assemble the components
3. Manufacturing platforms used to fabricate components

Changes in Product Specifications

As product needs evolve over time, it may become apparent that certain components are "over–engineered" and have been "grandfathered" into the design. When this is the case, the door is open to implement design changes that could deliver cost savings. These types of changes are driven by the requirements change. These changes may enable the following benefits:

1. Reducing wall stock of molded components
2. Simplifying assemblies
3. Eliminating components



One billion pounds of plastic is approximately equal to a cube measuring 250 feet on each side.

Changes in Purchasing Strategies

Building on the items described in this article, there may also be opportunities to explore purchasing options. Beyond engineering changes, there are traditional purchasing strategies that can deliver to the bottom line. These include some of the items described. SES works with customers to provide the true cost for components and provide specific talking points for current suppliers on what the real price should be. In addition, SES can explore strategies and options for the best manufacturing locations (including guidance on international locations). SES specifically manages material costs, labor content, and gross margins of products.

Future Cost Savings to Medical Customers

Recently, federal legislation has imposed a device tax on medical products. This tax is based on gross revenues and is significantly impacting profits. The medical industry is currently moving to address the potential loss in profits. SES is mobilizing to help our customers on the cost side of the equation for medical devices and consumable components.

Traditionally, medical customers are primarily focused on reliability and safety. This attitude is driven by the fact that the downside of failure is high. For disposable components, the cost of a consumable item can be only a fraction of the cost of the instruments they interact with, again shifting the focus toward reliability and safety versus cost.

Based on SES's experience in implementing cost saving initiatives and working with numerous medical device customers, there are real opportunities to reduce cost without sacrificing performance in medical consumables and devices. SES is uniquely positioned to help customers enjoy these benefits based on our history of successful projects. The combination of reliability engineering, failure remediation, and cost modeling, in addition to traditional engineering skill-sets, allows SES to help push the cost of consumables and devices down without affecting performance.

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Blast-Containment Enclosure Design and Assessment

by: Saltuk B. Aksu, Ph.D. and Lawrence M. Matta, Ph.D., P.E., CFEI

The failure of a pressure vessel during operation or testing poses a significant hazard, and protecting personnel and property from this hazard is critical. Determining the potential failure modes and establishing effective approaches for mitigation are necessary for preventing serious consequences of potential failures.

When fluid is stored under pressure, much of the work done to compress the fluid is converted to potential energy that can be released when the pressure is reduced. In pressure vessels, the potential energy is stored primarily in two forms—the pressure of the fluid and the strain energy of the vessel. When a pressure vessel fails by any means (from a failed fitting to a full vessel rupture), the potential energy is uncontrollably released to the surroundings. The amount of energy stored in a pressure vessel depends on a number of factors, including the phase of the stored fluid. While compressed gases generally store more energy than compressed liquids, both can be potentially dangerous at high pressures.

An explosion resulting from failure of a pressurized test article or fixture can cause major damage to nearby equipment and structures. Even more importantly, these failure events can result in injury (or fatality) to facility personnel. Inspecting, monitoring, and predicting the failure limits of equipment under pressure—while always desirable—is not always possible. Consequently, test facilities that operate or test pressurized equipment must be prepared for these types of incidents. The most direct approach to ensure safety in a facility is to install a containment structure to serve as a protective barrier between the high-pressure test area and nearby personnel and equipment.

Many factors, some of which are difficult to foresee, can contribute to the failure of pressurized systems. These factors include (but are not limited to) the following:

- Use of components or systems that were not designed in accordance with recognized codes and standards
- Re-use of existing equipment at conditions outside its original design envelope
- Material defects
- Poor workmanship
- Lack of proper inspection
- Ineffective/inconsistent monitoring of corrosion and wear
- Operator error

Existing recognized engineering design codes for pressure equipment are highly valuable tools when applied in a thorough design and validation process. Engineering design codes for pressure equipment were created with one over-arching goal—preventing failure during operation. However, when equipment containing significant amounts of energy is subjected to operational testing, the potential for failure—even though unlikely—must be taken into account and planned for.

Failure Scenarios for Pressurized Equipment

Failures of pressurized equipment are typically characterized by two principal damage scenarios (modes). The first is structural damage caused by the blast wave generated by the sudden release of highly pressurized fluid (mainly of concern when the test medium is gas). The second damage scenario to be considered is impact of projectiles (typically metal components) that are launched by the blast and impact the surfaces of the enclosure at significant velocities.

Blast Loading

When a high-pressure vessel fails suddenly, the result is an explosion and sudden expansion of the contained fluid. The resulting blast pressure wave may be modeled as a distributed force placed on the enclosure structure. The force of the blast wave is dependent on the calculated blast energy, which is a function of gas properties, pressure, temperature, volume, and distance of the location of interest from the explosion.

While the propagation of a blast wave and its interaction with objects is usually quite complex to model, various simplifications may be applied in the analysis to derive useful results. Peak overpressure caused by the sudden release of the stored energy can be analytically calculated. As a blast wave propagates away from an explosion, the peak pressure of the undisturbed wave at any distance from the explosion is referred to as the incident pressure or the side-on overpressure. Typical calculations will reveal that the peak pressure decays rapidly with distance. Figure 1 illustrates a typical decay as a function of distance.

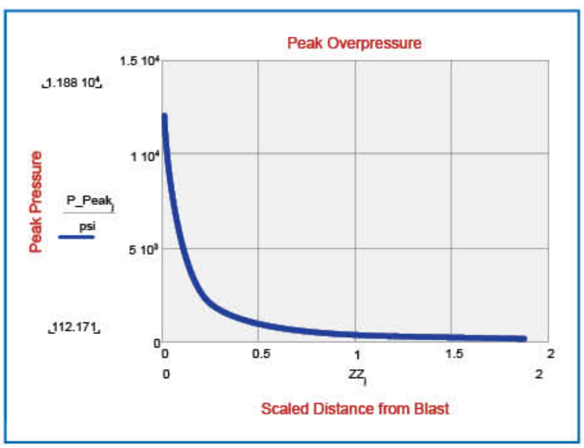

Figure 1: *Decay of peak blast pressure with distance.*

Projectile Analysis

Fragmentation of a vessel or ejection of parts (e.g., fittings) can result in the launching of projectiles or missiles. The energy of a projectile depends on the calculated blast energy, properties of the compressed gas, mass and shape of the projectile, distance from the blast to the impact site, and energy transfer efficiency. When analyzing the damage potential of a projectile, penetration of the projectile through the enclosure and/or absorption of the projectile's kinetic energy must be addressed.

Small Projectiles

Methods to model projectiles that are relatively small (compared to the overall volume of the vessel) are different from those used for relatively large components or pieces. Smaller objects (e.g., fittings and nuts) may be launched in any direction toward the walls, doors, or roof. Penetration of these surfaces by a small fragment would pose a threat to personnel near the test enclosure.

Penetration of a launched projectile can be characterized by the following parameters:

- Impact angle
- Geometric and material characteristics of the target and projectile
- Impact velocity

Due to the complexity of modeling penetration phenomena, it is not straightforward to address a large range of projectile velocities, projectile sizes, and target types with one model.

Large Projectiles

Large projectiles (e.g., large pieces of a vessel or heavy flanges), due to their mass, possess a large amount of kinetic energy that must be dissipated if the objects are to be arrested. Since energy is conserved, this kinetic energy must be converted to another form. For a launched fragment, the energy can be absorbed by deforming the surface it impacts. Engineered energy-absorbing materials make use of this approach by providing a surface with a high capacity for deformation, similar to "crumple zones" designed in modern automobiles to help protect the passenger compartment.

An ideal material for absorbing energy exhibits a stress/strain curve with a wide and flat plateau region (as demonstrated in Figure 2). After the compressive strength of the material is exceeded (by an impacting object), the material begins to permanently deform. The force required to crush the material remains nearly constant as the material continues to deform and absorb the energy of the projectile. The force applied by the energy-absorbing material to the projectile gradually slows it down, eventually stopping it if the material can absorb enough energy. The energy per unit volume absorbed by the material is represented by the area under the curve (the shaded region in Figure 2).

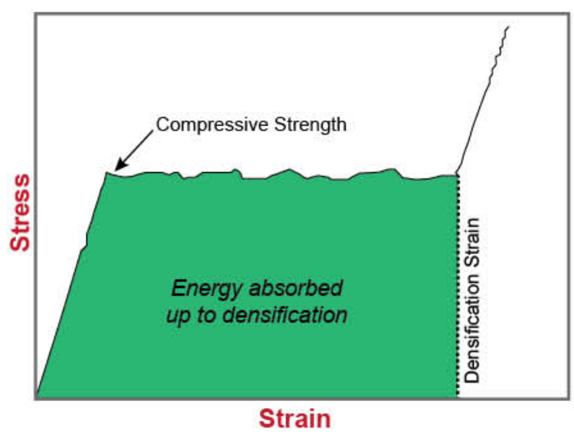

***Figure 2:** Stress versus strain behavior of effective energy absorbing material*

It is well established in the literature that energy-absorbing capacity is different for each material and there is no generic mechanism appropriate for every application. Each specific problem must be evaluated considering the total energy of the projectile under consideration, and a specific energy-absorbing design must be developed for each scenario. The kinetic energy of an anticipated fragment must be converted to strain energy by means of, for example, elastic and plastic deformation of wall plates designed with an energy-absorbing mechanism. The structural integrity of the enclosure wall or cover must be designed with sufficient safety factors to safely contain the projectile within the enclosure.

Approaches used to contain large fragments include the following:

- Honeycomb structures
- Stabilized aluminum foam
- Structural tubes (energy-absorbing systems consisting of various tubular components are frequently used in the automotive industry)

These are only a few examples. It is important to understand that no generic solution exists due to the fact that some of the critical properties listed below must be custom-engineered for the application under consideration.

- Energy-absorption capability
- Strength-to-weight ratio
- Strain-rate dependency
- Stress/strain curve characteristics

These properties will alter the peak loads during the energy-absorption process and may cause structural collapse. A dynamic load and stability analysis must be completed for individual cases.

Our Approach to Blast-Containment Design

Stress Engineering Services has developed a standard protocol for designing blast-containment enclosures. The structure of our design methodology is summarized as follows:

1. Closely collaborate with the Client and define typical test articles, test parameters, and failure modes. The following list of parameters is provided as an example:

   - Medium – water (Note: If the test medium is gas, the design approach changes significantly. An empirically-derived solution is adopted to quantify the dynamic loads of the blast field. This is usually based on the standard metric of TNT equivalence, which defines characteristics of the blast field as a function of the radius from the blast center.)
   - Pressure – 22,500 psig
   - Temperature – ambient
   - Test article – API xxx valve (of xxx internal volume)

- Failure modes – (this study must be very detailed)
  - Local failures of fittings and flanges (blow-out of 2 lb pipe plug)
  - Body rupture
- Desired enclosure size – 12 ft x 12 ft x 10 ft

2. Evaluate the "small projectile" problem. Smaller projectiles (i.e., small components and fragments) are of concern primarily with respect to penetration of the enclosure wall (and beyond). Terminal ballistics must be analyzed in addition to the strike velocity and strike angle of a projectile against the enclosure wall. If a projectile were to penetrate the containment structure, it could represent a serious safety hazard.

3. Evaluate the "large projectile" problem. The key concern for large projectiles (such as flanges) is whether the structural integrity of the enclosure wall or cover is sufficient to safely contain the projectile within the enclosure.

4. After the preliminary design work is completed, perform a detailed FEA to optimize the enclosure design. This analysis will address both static and dynamic loads on the test enclosure. An example of a dynamic analysis is illustrated in Figure 3. The figure illustrates the interaction of the enclosure and the peak dynamic load transferred for the projectiles under consideration. An FEA model (Figure 4) is used to investigate the dynamic response of the enclosure.

For over 40 years, Stress Engineering has served a wide variety of clients and industries, and helped them better define the capabilities (as well as the destructive power) of a variety of types of pressurized equipment. Stress Engineering is also highly experienced in the design and development of effective safety barriers and enclosures, and provides advanced, full-scale testing services for these projects at its test facilities in Houston.

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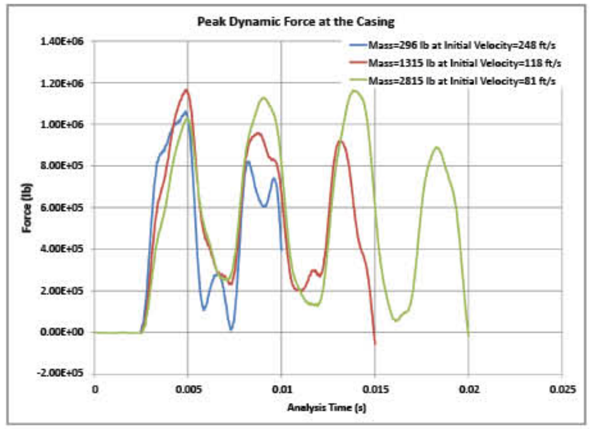

Figure 3: Peak dynamic force during impact

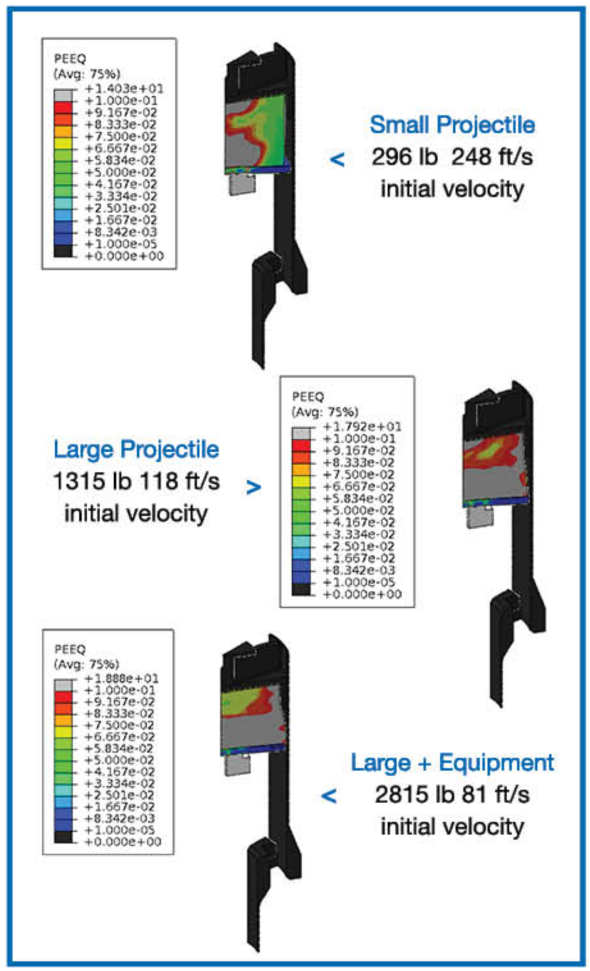

Figure 4: Residual equivalent plastic strain (PEEQ) after impact

Testing Today's Technical Challenges

by: Randy Long, P.E.

Stress Engineering Services has been in business for more than 40 years and has been performing testing projects for clients for about 35 of those years. Over this time, we have seen a huge increase in demand for testing services, and have ventured into new areas of testing that we could not have imagined 35 years ago. With industry's demand for testing continuing to expand, there are lots of newcomers trying to break in to the testing business. While there are now more choices out there, it is important that your company carefully consider what to look for in a testing facility. At Stress Engineering, there are several elements that we recognize as critical for effective testing.

Safety

Performing all tests safely should be the number-one priority of any test lab. For every test, it is critical to consider the amount of stored energy and the impact of that energy on the appropriate shielding and/or containment, and to follow safe procedures throughout preparation, testing, and demobilization. At Stress Engineering, a full safety review by highly experienced engineers must be completed and signed off prior to every test, whether large or small. In addition, anyone can stop a job at any time if they believe that there is a safety issue, without any fear of retribution.

Calibration

All critical measurement equipment used in testing must be calibrated at least annually, and the calibration should be traceable to a recognized standard (NIST, for example). Without proper calibration of all sensors, test results are at best questionable and may be worthless or (even worse) misleading.

Employee Training

Having engineers and technicians who are fully familiar with the capabilities as well as the limits of the lab equipment being used in a test is key to successful testing. We conduct in-house training to enhance the knowledge of our staff and to ensure that they understand the safe and efficient operation of all equipment they are using.

Participation in Industry Organizations

Expertise in testing comes from knowledge of industry requirements as well as knowledge of test equipment. Our engineers are very active in many industry organizations and committees, which means that they are fully familiar with any new innovations in the industry. Stress engineers are active in API, ISO, ASTM, ASME, ASM and other industry groups.

Broad Engineering Capabilities

At Stress Engineering, 67% of our engineering staff have been awarded advanced engineering degrees (Masters, PhD). Our technical staff comprises mechanical, structural, electrical, metallurgical, material, and other engineering disciplines. We have the knowledge and ability to determine the causes of unexpected test results, failures, etc. to assist our clients.

Employee Retention and Qualifications

Our staff members have been with the company for an average of nine years. Consequently, our clients are often working with someone who has performed a similar test previously, either for them or another client. No amount of training can compare to actual hands-on experience.

Equipment Capabilities

Having the right test equipment for the job is imperative. Sometimes this requires designing a new test frame or adapting an existing one to meet the client's needs. Stress Engineering has designed much of our own equipment and DAQ/control capabilities to suit specific test needs from industry.

Service Attitude

At Stress Engineering, we strive to be the best at what we do and to adapt to the constantly changing needs of the industry and our clients.

Our motto is "deliver the right stuff on time." Finding a test facility that understands your needs and strives to deliver accurate test results in a timely manner is invaluable. With testing parameters continually becoming more stringent, it is important to work with test engineers and technicians who can adapt to meet your requirements.

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New/Improved Test Equipment at Stress Labs

- New 2.5 M lb (11,120 kN) load frame
- New four-point bend frame – 12.5 M ft-lb (16,950 kN-m) capacity
- New 17' x 20' x 15' deep (5.2 m x 6.1 m x 4.6 m) test pit under a 50 ton (445 kN) capacity crane
- New tendon flex element test frame (4,000 ton/35,600 kN, ±15° rotation)
- 500 kip (2,224 kN) MTS machine added to materials test lab
- Gas pressure testing capability to 45,000 psi (310 MPa)
- Resonant fatigue testing of pipe, welds, and connectors for sizes from ¼" (6.4 mm) OD tubing through 44" (1,118 mm) OD tendons

500 kip MTS machine (2,224 kN)

> *"We have remained on the cutting edge and continue to lead the industry into many new areas of testing."*

2.5 Million Pound Load Frame (11,120 kN)

Stress Engineering's Cincinnati Office Becomes ISO 9001:2008 Certified

by: Earl Hudspeth

Quality was defined by Joseph M. Juran, an influential quality evangelist of the 1970's, as "Fitness For Use."

This definition meant that users (customers) of products or services should be able to rely on products and services 100% of the time, without worry of defects. Stress Engineering Services has adopted a similar goal of providing services to our clients that are "worry-free."

Achievement of this goal began in 1994 with the development of our quality management system (QMS). The starting point for successfully implementing our QMS was the development of our core Vision and Values. Our Vision and Values were established by Stress Engineering's management and leadership, and are captured in our quality policy statement: Stress Engineering Services is to deliver "the right stuff on time" for every assignment our clients entrust to us. Our quality policy statement is the driving force for defining and achieving the culture needed throughout SES in the quest for 100% quality compliance.

In 2012 we implemented a strategy to continually improve our processes based on objective measurements that consider the future needs and expectations of our customers, in addition to providing "worry-free" services. Through leadership, we have established a unity of purpose that has created and maintained a culture with a devotion to achieving these quality objectives.

Our overall QMS performance goals in 2012 were to:

- Increase customer loyalty
- Increase repeat business and referral
- Improve our flexibility, speed and responsiveness to our customer needs

- Reduce our cost and cycle time through effective and efficient use of resources which will allow us to continue to meet our customer's needs at a competitive price
- Establish goals and objectives for continual improvement
- Increase our customer's confidence in our effectiveness and efficiency as we have already demonstrated by establishing one of the best reputations in the industry
- Investing in technology to better service our customers

The framework for Stress Engineering's QMS, which meets and exceeds the requirement of ISO 9001:2008, helped us achieve the performance goals noted above.

In 2012, our office in Mason, Ohio achieved its ISO 9001:2008 certification for its quality management system. This certification was achieved by 100% cooperation and support of all the employees. This independent certification validates our commitment to quality and affirms that we have effectively implemented its quality processes while meeting the stringent qualifications for the global ISO 9001:2008 standard.

Stress Engineering's QMS was assessed by an accredited registrar from Smithers Quality Assessments in November 2012. The registrar performed an in-depth assessment of our QMS against the requirements of national and international standards for quality. In December 2012 our Mason, Ohio office received formal registration approval and is now officially recognized as an ISO 9001:2008 certified company.

Achieving the ISO 9001:2008 certification reflects our continuous efforts to achieve superior service, quality and reliability, and assures our customers that our processes are effectively implemented and maintained.

ISO 9001:2008 is accepted worldwide as the standard that defines quality. The certification indicates that an organization conforms to a QMS which can consistently provide a product or service that meets customer and applicable regulatory requirements. It was established by the International Organization for Standardization (ISO), an organization of national standards institutes of 175 countries and the foremost authority on quality standards that is designed to provide companies with a set of principles that ensures a systematic approach to achieving customer satisfaction.

This certification is an important milestone for everyone at Stress Engineering Services. Our customers rely on us for critical support services, and this certification demonstrates our rigorous quality standards and commitment to continually improving our business processes. Customers can be confident that we have a systematic approach for achieving their satisfaction that delivers "worry-free" results. Our QMS processes reflect a set of principles that ensure a common-sense approach to managing our business activities that builds on our experience of more than four decades.

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Mason, Ohio Office Opens Spacious New Facility

The 51,000 square foot facility includes a 20,000 square foot testing lab equipped for a variety of test programs including accelerated aging of polymers, elastomers and composites; measurement of creep properties for high temperature metal alloys, plastics and composites; medical and consumer products testing; characterization of polymer chemistry; and stability storage of medical and pharmaceutical devices.

The well-designed office environment features a number of conference and meeting rooms including a large 50 person capacity conference room suited for meetings, seminars, and training sessions. Employees get to enjoy a variety of amenities such as an outdoor courtyard, exercise room, and a comfortable lounge/break area.

New Orleans Office Settles Into New Facility

by: Greg Garic, P.E.

History

There is a good bit of local history in Stress Engineering's newest building in the New Orleans suburb of Metairie, Louisiana. Métairie is the French word for a small tenant farm. In the 1720's, French explorers became the first Europeans to settle Metairie. The early farmers paid the landlord with a share of the crops, also called "share-cropping."

The first settlements were located in an area known as Metairie Ridge, a natural levee formed by an ancient branch of the Mississippi River. Native Americans used this ridge as a road, and it is the oldest road in the New Orleans area. Paved in the 1920s, it is now named Metairie Road.

The area north of Metairie Road, where the Stress Engineering office is located, was not developed until after World War II when the cypress swamps between Metairie Ridge and Lake Pontchartrain were drained. This resulted in rapid population growth in Metairie in the 1940s and beyond.

The new Stress Engineering building is in the heart of New Metairie, and was originally constructed in 1961 as a VFW hall. For 50 years it hosted veteran's events, weddings, and dances as Metairie grew up around it. The building was renovated in 2011 for use as our engineering offices and a state-of-the-art metallurgical laboratory, providing a much-needed face lift to this aging structure.

Construction of Veteran's Memorial Blvd. in 1955

Improved Infrastructure and Efficiency

Stress Engineering's newest building has improved more than the looks of the neighborhood; it has improved our ability to respond to client projects with:

- An expanded and improved metallurgical laboratory
- Improved conference facilities
- A new electronics laboratory to support our vibrations and acoustic emission practices
- Room to grow our engineering staff
- Ample parking for staff and clients

New Orleans Office Entrance

New & Expanded Metallurgical Lab

Expanded Receiving Area

The original renovation reserved about a third of the building's 14,000 square feet for future expansion. Due to the rapid expansion of our business, we are currently planning for a Phase II expansion to begin in late 2013. Phase II will include additional office space along with improved and expanded conference facilities.

Serving the Louisiana Petrochemical Corridor

The New Orleans office of Stress Engineering opened in 1996 to provide better service to the extensive network of chemical plants, refineries, and pipelines in the Louisiana Petrochemical Corridor. This region is a major force in the US energy infrastructure with over 150 major chemical plants and refineries along the roughly 170 river-miles between the north end of Baton Rouge and the south end of New Orleans.

With 10 major refineries along the petrochemical corridor, several among the nation's largest refineries, our office is within a 90-minute drive of nearly 15% of the total US refining capacity! Add to that the estimated 150 chemical plants in the same area, and the need for a local presence to service these clients is clear.

A Krewe of Jefferson Mardi Gras Float on Veterans Blvd.

Mardi Gras

A side benefit of our location in the business-center of Metairie is that our office is located a short 150-foot walk from the route of the Metairie Mardi Gras parades. Since it would clearly be irresponsible not to take advantage of this, we hold an annual Mardi Gras day celebration for employees, family, and clients. Fat Tuesday (Feb 2nd) of 2013 was our second annual Stress Engineering Services Mardi Gras Party.

With food, drink, music, and 250 Mardi Gras floats parading a mere 150 feet away, it is destined to be our most popular annual event.

CityBusiness Magazine's "Best Places to Work 2012"

CityBusiness "Best Places to Work 2012"

We were also honored in 2012 as a "Best Places to Work" winner by CityBusiness magazine. Competing in the "large company" category, we were honored to be named among the Best Places to Work alongside such local institutions as Phillips66 Alliance Refinery, Hyatt Regency Hotel, and First NBC Bank.

Stress Engineering realized early in our 40 years of practice that one of the best ways to make sure our clients are happy is to make sure our employees are happy. Attractive office facilities, flexible work hours, strong profit-sharing programs, and our Employee Stock Ownership Program (ESOP), among many other benefits, all contribute toward making our employees happy and motivated to deliver the best possible service to our clients.

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