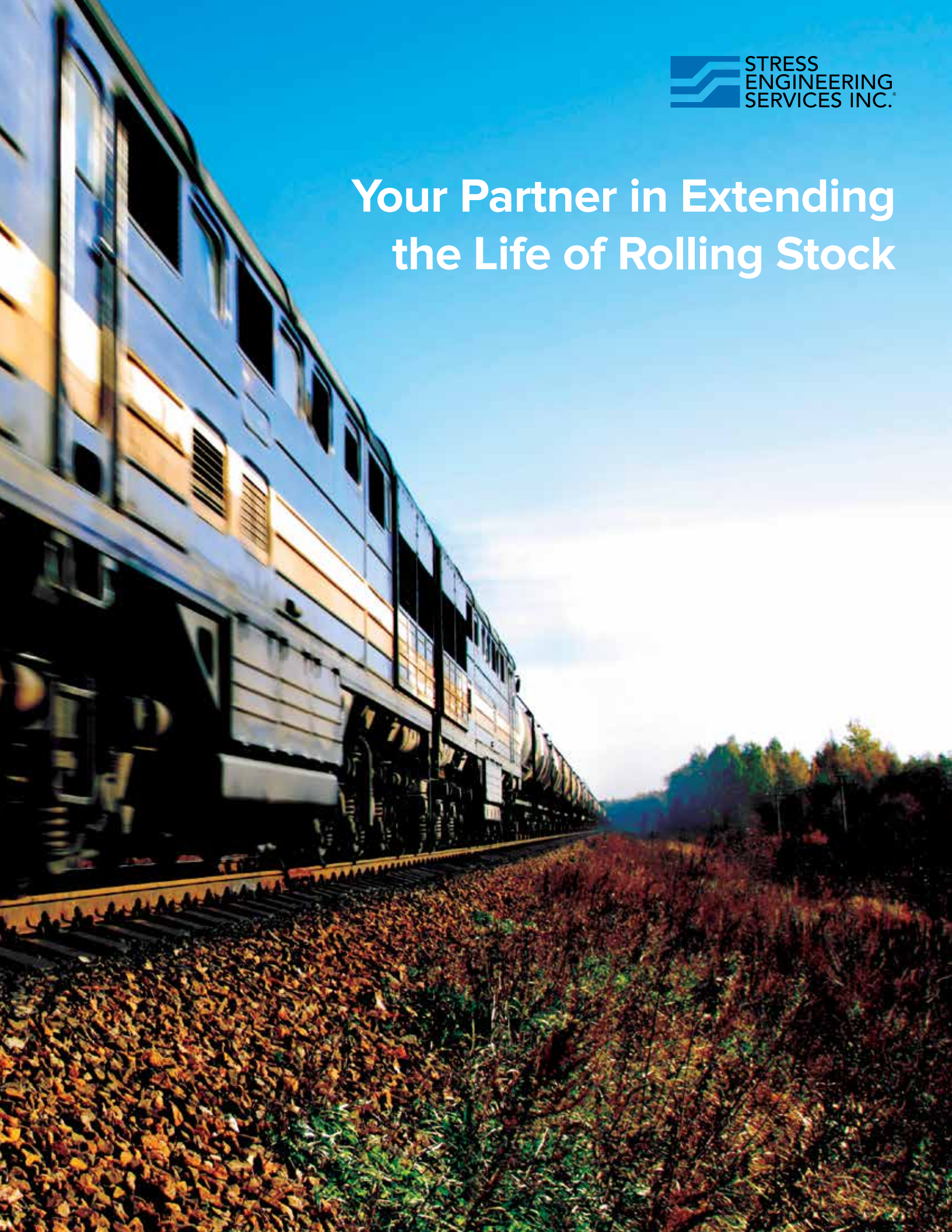
STRESS ENGINEERING SERVICES INC.®

Your Partner in Extending the Life of Rolling Stock



Nothing lasts forever and ultimately, all machinery and equipment have a limited "safe usable life" determined by the "use and abuse" while in service. For industries like rail, petrochemical processing, power, refining, and off shore oil structures, the challenging environments in which the equipment operates takes its toll, imposing a very heavy responsibility to ensure worker and public safety. For these reasons manufacturers, owners, and operators diligently monitor and evaluate the health of their equipment and processes. **Because the replacement cost of the equipment can be staggering, a body of engineering has emerged, Life Extension Engineering (LEE), that is focused on life assessment and modification to safely extend the useful life of equipment in these and other heavy industries.**

At Its Highest Level, the Objectives of Life Extension Engineering Are:

- Quantify the current health of an equipment system using proven engineering life assessment methodologies
- Identify appropriate methods to reliably extend the life of the equipment based on the health assessment
- Evaluate the effectiveness of life extension concepts using sound engineering analysis
- Validate the effectiveness and any life extension modifications via field testing

Stress Engineering: Your Partner for Life Extension Services

Stress Engineering Services, Inc. (SES) is a specialty engineering services firm with deep life extension engineering expertise in many industries, including rail. With more than 40 years of experience providing LEE project planning, strain/force measurement, and analytical/finite element-based life-related analysis services, we have seen and done what few others have in the field of life extension engineering.

Corrosion damage plays an important role in limiting the life of some components. Whether it be reduced wall thickness in a high pressure steam line or missing braces and panels in a carbody, SES has the metallurgists and structural designers needed to evaluate remaining life and to design a "repair" to extend the life.

Our uniqueness in the assessment of structural life for railroad applications is bolstered by the fact that we provide these services day-in and day-out for a host of other industries where safety is paramount, usage environments are extremely aggressive, and capital demands are staggering.

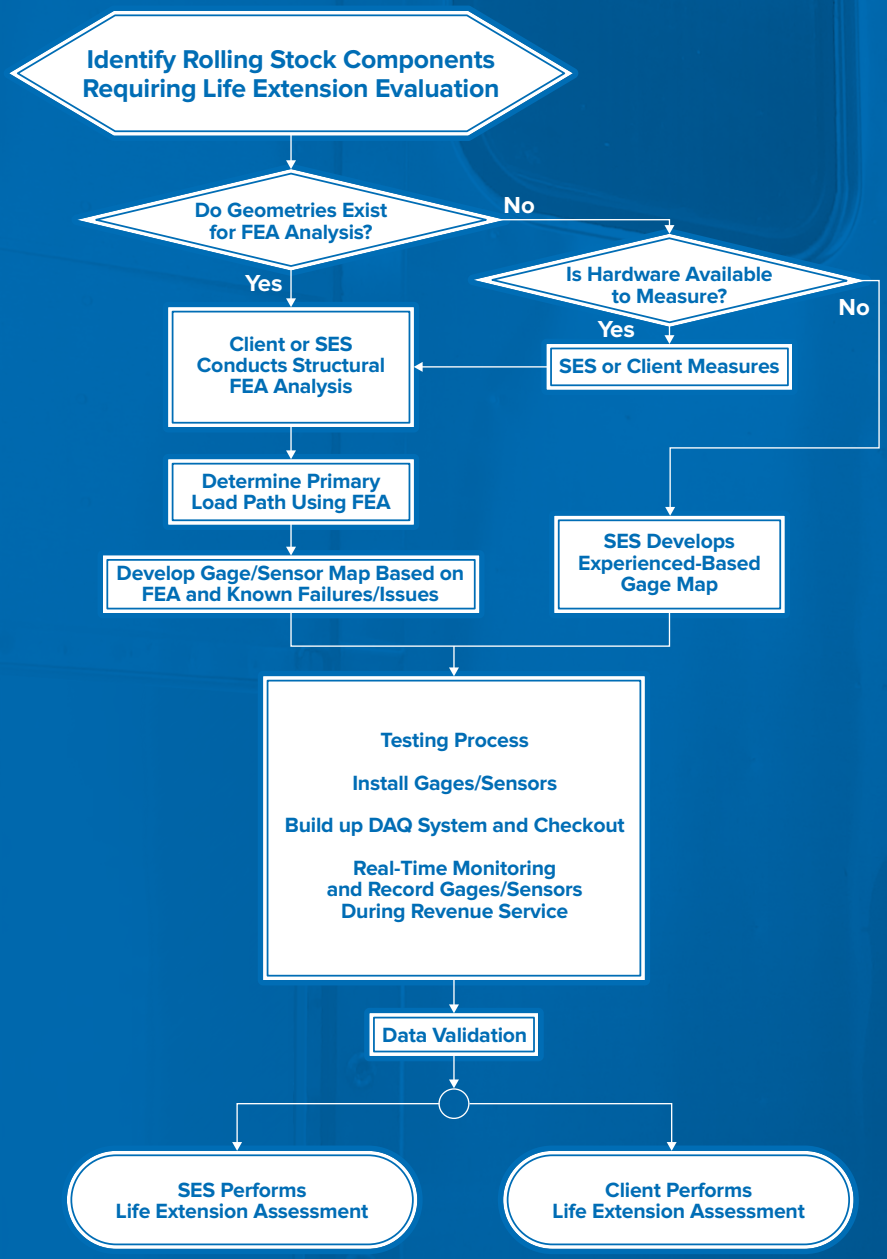
Results Are Only as Good as the Data You Collect and Analyses You Perform!

For rail, SES's testing and analysis efforts are led by Dr. Dan Morrow, a long-time veteran of life extension work and an expert in the development of sensor installation strategy on rail structures, sensor development and installation, fatigue and fracture mechanics, data analysis, and rail life extension project management. **SES has assembled a team of engineers and field technicians to efficiently and cost effectively execute rail projects, wherever they occur.**

Executing Successful Life Extension Assessments

The 10 Key Elements of a Successful Life Extension Project Include:

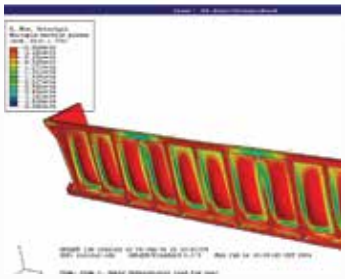
1. Identification of Rolling Stock Components Requiring LEE
2. Planning LEE Logistics
3. Capture Geometry of All LEE Components
4. Structural Analysis of LEE Components to be Evaluated
5. Develop Installation Map: Gage/Sensor/Transducer Placement
6. Data Acquisition
7. Data Processing/Validation
8. Life Assessment
9. Implementation
10. Validation of Modifications with Field Test



PLANNING AND GEOMETRY ACQUISITION

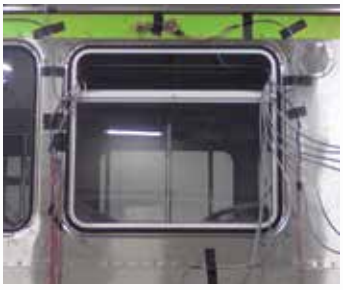
The complexity of the geometry for most rail LEE projects demands a great deal of logistics. Often the first "heavy lift" in this process is defining the geometry of the rolling stock structures. In many cases drawings are available and are used to enable the initial finite element analyses to define the most productive locations for sensor placement. However, for old equipment, drawings may not be available, requiring on site measurements of the structural geometry and verification of construction/assembly methodology.

Typically our client manages the planning and execution of the geometry acquisition task and, depending on their resources and experience, may also perform the initial FEA to determine sensor placement. However, if the client is resource constrained, we can complete the geometry documentation task and finite element analysis work.



SENSOR PLACEMENT MAPPING

Ideally SES (or the client) has conducted a finite element analysis to identify the locations where gage/sensor placement is most effective. Regardless of who conducted the analysis, we will work with you to develop a sensor installation map. **In the most extreme cases where the situation is emergent, we have successfully developed an installation map by leveraging engineering judgment based on prior experience alone.**



TIME-SYNCHRONIZED HIGH-SPEED DATA ACQUISITION: A REQUIREMENT FOR COHERENT MEASUREMENTS!

It is not uncommon for rail life extension projects to require the installation of hundreds of sensors, all of which must be simultaneously sampled to preserve coherence of the data and must also be sampled at speeds high enough to capture all of the important dynamic responses of the rolling stock during test. These requirements often generate terabytes of raw data. **We continuously invest in hardware and software to manage this task.**

SES has the capability to simultaneously sample and record (using a sample-and-hold on every channel) up to 528 channels of dynamic data at sample rates up to 10kHz sustained. Our DAQ system also provides the ability to assign 160 high bandwidth channels that are sampled at 25kHz, sustained, continuous. This creates a fully coherent data set of strain, voltage, force, acceleration, pressure, displacement, current, etc., all synchronized in time. This is in contrast to most data collection systems which use a multiplexer to sequentially scan each channel of data, producing a sequential offset by an increment of time and phase. The multiplexed sequential approach introduces coherence errors when comparing the structural response in various locations at the same instant in time, potentially jeopardizing the integrity of the results.

SES High Speed Data Acquisition Capabilities

- 528 Simultaneous Channel Sampling
- 10kHz Sustained Sample Rate, Continuous (5.2 million samples/sec)
- 160 High Band Width Channels at 25kHz, Sustained Sample rate, Continuous
- 24 Bit Accuracy, All Syncronized in Time
- Portable Rack Mounted
- Custom Quick Cabling Features

Accuracy of the measurement is also critical, so we use data acquisition systems with 24-bit precision on most all rail life extension projects.

It is the rule, not the exception, that the real-world test environment is harsh! It is inevitable that unplanned events will occur that change test schedules, measurement channels, logistics, etc. during the completion of a test program. Our field staff are veterans of this test environment and have the experience and flexibility to respond under pressure when unanticipated real world events throw a wrench into the plan!

For our clients this means that we deliver a measurement with the very large dynamic range and precision of 1 part in 16,777,216.

SES's Data Acquisition Systems Are Not Obstructed By Tunnels Or Underground Operation

Another essential feature of data collection on rail life extension projects is navigational accuracy. For that reason our data package includes high-quality, high-accuracy navigational information that assures our clients know the location and direction of the equipment in tunnels and underground. **This capability enables the development of an accurate map, typically within a few feet, of the occurrence of a measured dynamic event.** An ancillary benefit of this capability is realized as the instrumented car body or truck moves along the rail by providing insights as to the health of the track itself.

POST PROCESSING OF DATA SETS: SPEED VIA AUTOMATION AND ANALYTICS

When there are hundreds of gages/sensors in close proximity to the operating environment, you WILL lose some data channels. The "holes" these losses create in the data sets can significantly complicate the data reduction task. Test planning to include "redundant" measurements of critical areas can help to fill in these holes and keep the data reduction on course.

Part of post-processing of the data involves reviewing all the recorded channels, looking for anomalies and fixing or flagging them for further analysis. **It's simply not practical to manually "sift" through data files that may be terabytes in size because it takes too much time. To overcome that problem, we have developed unique skills and software for rapid assessment of these huge data files to quickly prepare them for use in the life extension analysis.**

LIFE ASSESSMENT LEADS TO LIFE EXTENSION

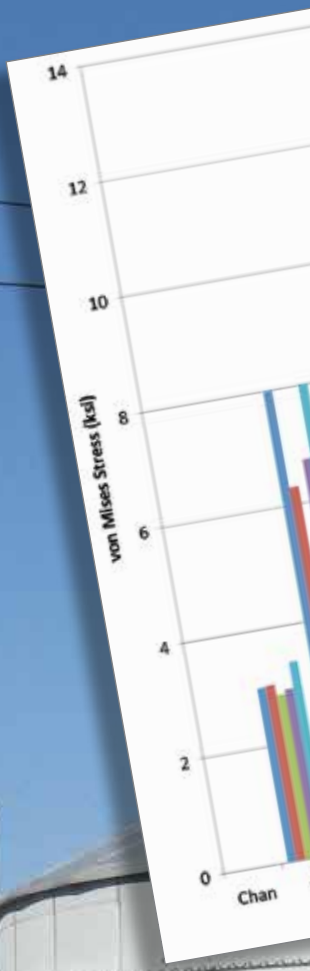
The three pillars required to develop a team of engineers with depth of skills in fatigue assessment specifically for life calculations are:

1: **Hire staff with the right academic training.**
2: **Have them work under the direction of world-class leaders in the field.**
3: **Do a lot of it – repetition is key!**

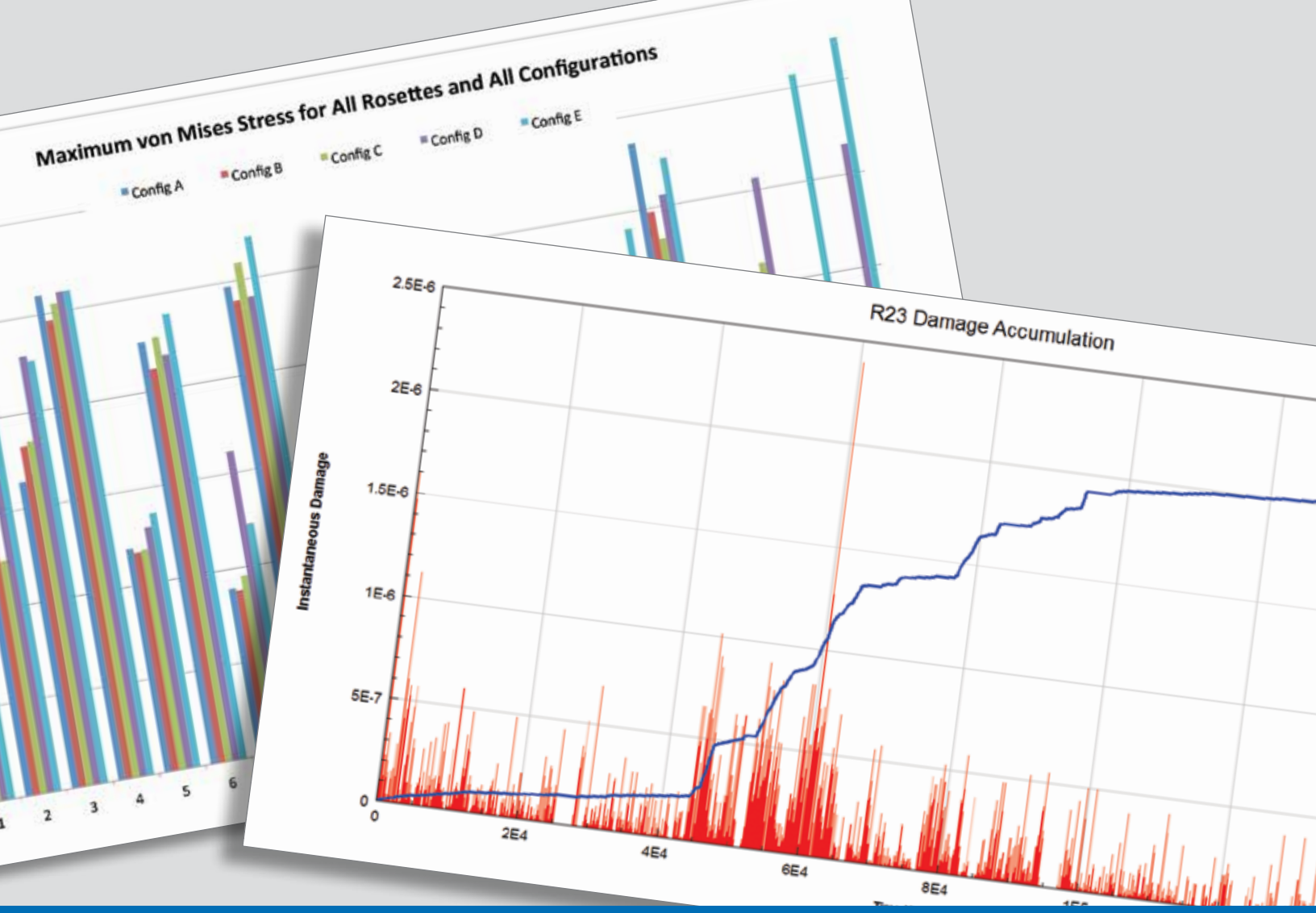
We have built an organization based on these three pillars, and there are few companies with a bench as deep as ours with regard to fatigue assessment of cast and welded structures.

Our team includes engineers with advanced degrees in Theoretical and Applied Mechanics, Mechanical Engineering, Electrical Engineering, and Metallurgy.

As with any task, repetition is key to building strength and expertise, and we do a lot of reps!



When Our Engineering Team Is Not Working on a Rail Life Extension, We're Working on Life Extension Projects for Offshore Oil Structures, Cyclically Loaded Production Vessels or Flanges, and Piping in Power, Petrochemical and Refining Industries.



Life extension projects, particularly when dealing with welded structures, are not “cookbook.”

Engineers need to be aware of the limitations of the fatigue damage curves and the linear elastic fracture mechanics for the standard they are using in terms of how the damage accumulation is related to the calculations they are making. When interpreting predictive computational models for these structures, our engineers have the training and experience to handle conditions that fall outside of most typical weld standards (e.g. AWS, CEN, BS, CSA, API, DIN, etc.), such as local plasticity or initial shakedown relative to damage accumulation and remaining life.

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Railfan: “a person interested in a recreational capacity in rail transport.”

Not only does the rail industry serve as the backbone for the movement of both people and goods, for a railfan the railroad industry can be a focal point of their recreational passion. The four images below: freight, passenger, regional transport, and historic, were provided by a consummate railfan and longtime friend of SES, John Burchnall, West Chester, Ohio.

Investment in talent and tools is the hallmark of SES’s services in life extension. SES can support the planning, instrumentation, data collection, data processing and analytical needs of life extension projects. We can support the entire project or just those portions where you need to supplement your resources. Call SES to discuss your Rail Life Extension needs!

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