

# CHALLENGES IN HEAVY MANUFACTURING

## PART III: IMPROVING FATIGUE PERFORMANCE

**EWI**<sup>®</sup>  
*We Manufacture Innovation*



# FATIGUE LIFE

*HEAVY STRUCTURES ARE RARELY SUBJECTED TO CONSTANT LOAD IN THEIR LIFETIME . . .*

For fabricators of welded structures that are subjected to cyclic loading, fatigue life analysis is critical—a significant percentage of engineering failures are due to fatigue. Heavy structures are rarely subjected to constant load in their lifetime, as factors like varying service and environmental conditions cause load to fluctuate. These fluctuations can cause cracks to develop in the structure, which can in turn lead to sudden catastrophic failure.



# HOW TO IMPROVE FATIGUE PERFORMANCE

EWI has the capabilities to characterize fatigue failure of welded structures. Accurate assessments can be made with a combination of simulation, analytical, and experimental methods and knowledge of the loading modes. Weld test data is used to support the analysis and prediction methods appropriate for welded structures. EWI has developed and performed testing on a wide array of materials, including steel, titanium, and aluminum alloys, as well as composite-reinforced materials. Fatigue performance can be predicted and improved through non-destructive testing, structural modeling, welding and joining techniques, and/or improved materials.



*EWI has a full suite of software and analytical tools to model thermodynamics, structural response, and microstructure prediction to support structural integrity and fatigue performance improvement.*

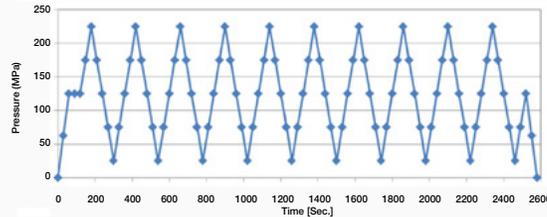
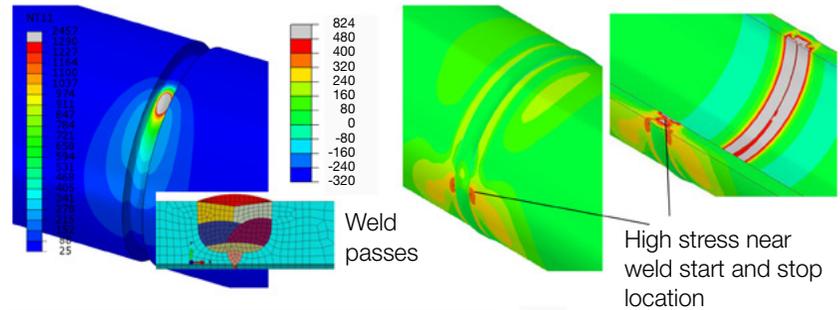
# ASSESSING STRUCTURAL INTEGRITY

Structural integrity assessment includes strength and toughness calculations, weldability evaluation, material testing, structural analysis, and lifecycle prediction. When determining a structure's reliability, it is critical to answer the following questions:

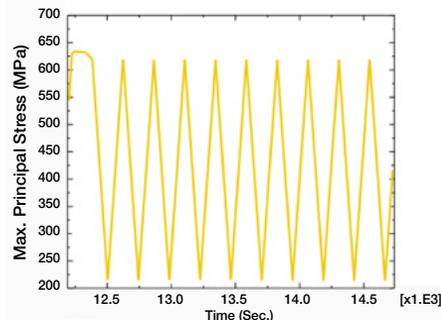
- Does the structure have sufficient strength, ductility, and toughness to meet the demands placed on it?
- Can the base material and weld metal resist catastrophic crack propagation?
- What discontinuities can be tolerated?
- Will the structure pass qualification tests?
- Can the desired lifetime be achieved?

Maximum Weld Residual Principal Stress (MPa)

Temperature (°C)



Modeling cyclic loading including weld residual stress for fatigue life prediction



Finite element modeling of a multi-pass weld for fatigue life prediction

# ENGINEERING CRITICAL ASSESSMENT

**EVALUATE** base material and weld metal strength and toughness

**DETERMINE** the limiting flaw size based on loading conditions, material, and weld properties

**DEVELOP** inspection criteria

**ESTIMATE** design life based on expected service conditions

EWI designed a testing program to evaluate fatigue improvement techniques on a full-scale structure. Three improvement techniques were tested on fillet-welded sleeves for 168-mm-diameter pipes using resonant fatigue. Improvements were observed when treatments were applied even after 50% of the cyclic lifetime has been consumed. An 8 times extension of the remaining life was observed when compressive stresses were induced in the toe of the weld along with blunting of sharp transitions.

## REPAIR & LIFE EXTENSION TECHNIQUES

- Repair weld development
- Fatigue Improvement Techniques

# SPECIALIZED TESTING

## Resonance Fatigue Testing

EWI designed its resonant fatigue testing systems to test the next generation of materials and allow simulation of many years of service in a matter of hours or days. EWI has successfully tested low modulus materials like titanium and aluminum pipe in resonant bending fatigue without the need for expensive modifications to the test equipment or addition of flanges on the end of the test samples. Based on the results from the initial evaluation, EWI developed a “High Fatigue Performance Procedure” to install strain gages on low modulus materials.



## Materials Testing

EWI has the full range of standard metallurgical and mechanical testing capabilities to support design analysis and life prediction.



## ABOUT EWI

EWI's extensive work with predictive modeling and simulation, as well as next generation advanced high strength steels (AHSS), advanced nondestructive evaluation (NDE), advanced welding and joining, emerging heavy fabrication technologies, and other innovations give our heavy manufacturing customers an upper hand in today's fiercely competitive market. To learn more about EWI's experience helping OEMs and suppliers in the heavy manufacturing industry use technology innovation to become more competitive, contact Aaron Haines, Market Segment Manager, at [ahaines@ewi.org](mailto:ahaines@ewi.org) or **614.688.5146**.

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