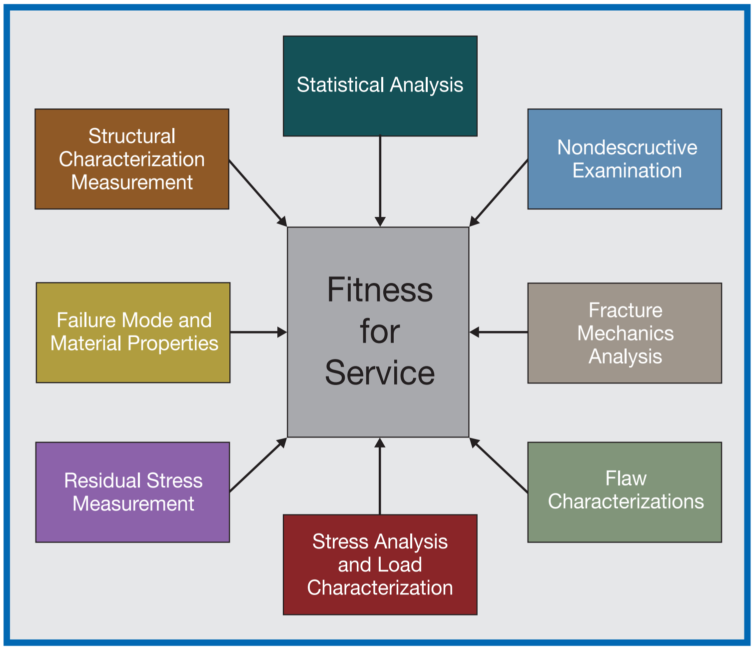
Enhanced Fitness for Service

Stress Engineering Services, Inc. is an employee owned professional engineering consulting company. Founded in 1972, we successfully complete over 3,000 projects per year for more than 1,000 clients worldwide. Our engineers have an average of 20 years experience, many of them with advanced degrees. Because a large number have previously worked directly for oil and gas companies, our engineers have an extensive understanding of operating equipment and plants.

FRACTURE MECHANICS ANALYSIS

Fracture mechanics assessments are widely-used to evaluate the worst-case flaw (a crack) in a pipe, pressure vessel, or structural component. For crack-like flaws, inputs from three categories are combined: geometry (including the wall thickness, flaw geometry, etc.), loading (normal, maximum pressure or stress, cyclic, and residual), and material or structural resistance (yield strength, material toughness, etc.). The material properties are critical to the analysis and often rely on environmental considerations (which is why our fitness-for-service engineers commonly work closely with our metallurgists and process experts).



Incorporating older vessels into new process cycles can dramatically change operating conditions. Stress Engineering Services can evaluate probable results, safe operating windows, and appropriate inspection intervals based on the vessel's current condition and the planned changes in operation.

RESIDUAL STRESS MEASUREMENT

Stress Engineering Services uses the Blind Hole Drilling technique to measure stress near a weld or defect inside a pressure vessel. This provides important information that can be used for determining the likelihood of crack propagation during the next usage cycle. Measured residual stresses are also a permanent record that can be useful for future vessel analysis.

STRUCTURAL CHARACTERIZATION MEASUREMENT AND MONITORING

Vessel performance during service is measured with strain gages, thermocouples and transducers placed in known problem areas. Data is recorded over a period of operation. In addition to acquiring detailed performance data from operating conditions, the results can be input into a structural analysis service assessment.

FAILURE MODE & MATERIAL PROPERTIES

Because long-term aging effects occur at elevated temperatures, present material properties may be quite different from what they once were. The best evaluation is performed by testing material removed from these vessels to ensure that the modeled material properties match reality.

Non-destructive testing, such as in-situ metallography, can be used to evaluate the micro-structure and identify the degree of aging and creep damage. These inputs allow us to establish the likely material properties and how they relate to the time-dependant failure modes.

STATISTICAL ANALYSIS

Fracture mechanics tools, such as the Failure Assessment Diagram (FAD), are useful for assessing fitness-for-service and simple to apply. The FAD assesses evaluated the potential for two failure modes: brittle fracture and plastic collapse. For most problems, the analysis progresses in a deterministic fashion, with the flaw inputs used with worst-case loading and lower-bound material properties. Safety factors are applied to ensure an adequate margin against failure.

A probabilistic approach can reduce this conservatism by including the variability of critical parameters. It also provides a way of including data that is not know accurately. Distributions on material properties, loadings, and flaw populations enable fitness-for-service results to be presented with a failure probability or a quantified, associated risk level.

STRESS ANALYSIS / LOAD CHARACTERIZATION

When operating loads, such as pressure and temperature, are changed for a vessel, a stress analysis based on hand calculations or finite element models should be performed to assure overall compliance with codes, such as ASME Section VIII, Div. 1 and 2, or API 510.

For flawed vessels, the same analysis techniques are used to determine the stress conditions locally near the defect. These results are used in conjunction with tools and procedures to estimate the current and on-going safety margin and to recommend appropriate inspection intervals to ensure that flaws can be reliably detected prior to them reaching a size at which catastrophic failure is possible.

We use non-linear finite element programs, such as ANSYS and ABAQUS, to determine the stress distributions at critical sections near the crack tip. For special cases, cracks are modeled explicitly and the J-Integral value is determined for the specific crack geometry.

NONDESTRUCTIVE EXAMINATION (NDE) AND FLAW CHARACTERIZATION

Inspections utilize a variety of NDE methods to look for indications or flaws (that are then evaluated in the fitness-for-service assessment). Acoustic Emission (AE) is a powerful technique that can listen for crack growth over a large area. Ultrasonic testing (UT) is commonly done locally to measure flaw size or to map a corroded area. Visual inspections are also critical to look for all sorts of damage. This can include corrosion, cracks, creep, erosion, localized thin spots and material degradation.

Our multidisciplinary team of professionals provides expert turnkey Fitness for Service solutions. We can help you make practical and fact-based decisions about pressure vessel operation.

STRESS ENGINEERING SERVICES INC.

13800 Westfair East Drive ▪ Houston, Texas 77041

visit us on the web at **www.stress.com**

HOUSTON	CINCINNATI	NEW ORLEANS	BATON ROUGE	CALGARY
281.955.2900	513.336.6701	504.889.8440	225.769.9772	403.256.2527