Extend the Life of Pressurized Equipment and Avoid Unplanned Outages with Fitness for Service Assessments

- The 5 W's of FFS Assessments
- Examples

What is a Fitness for Service Assessment

Objectives of an FFS assessment

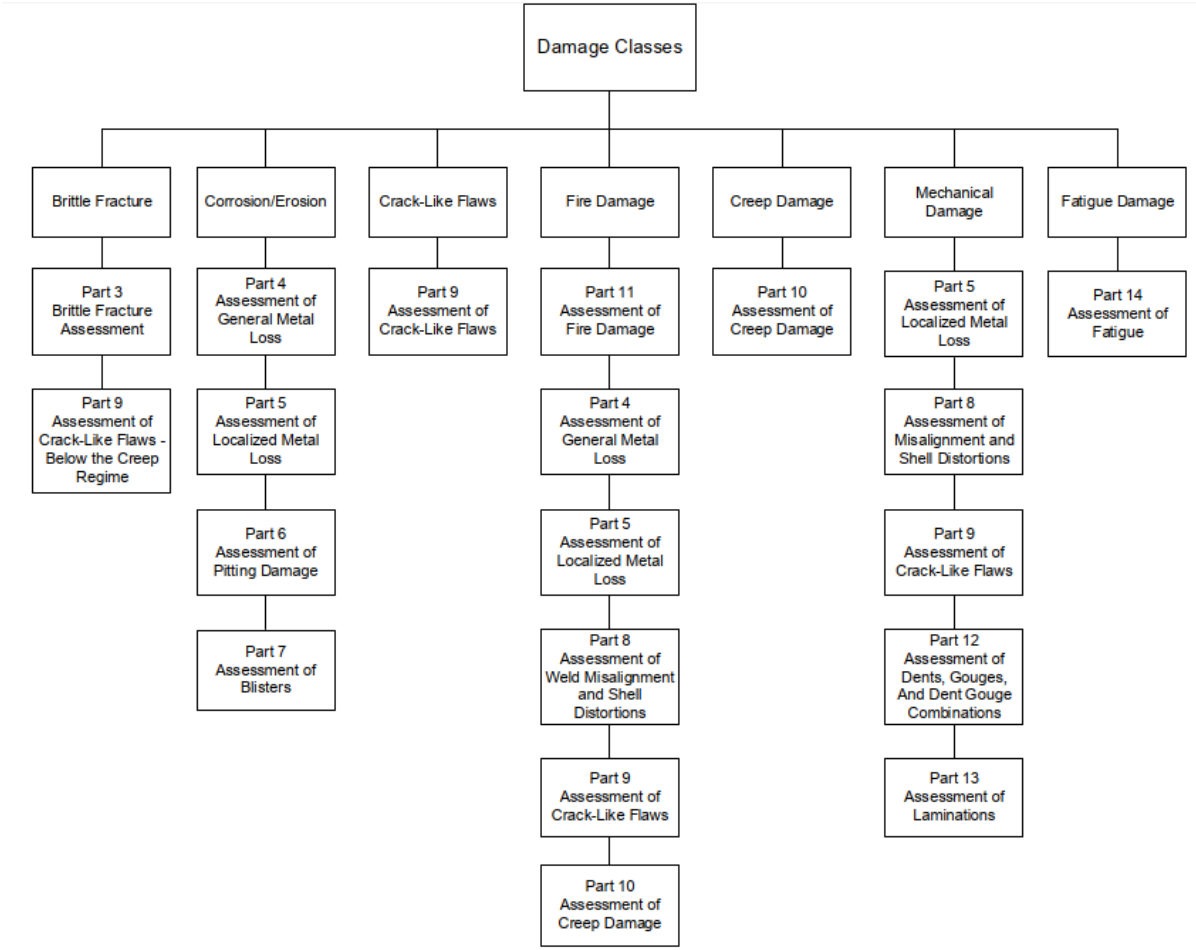
- Quantitative engineering evaluations performed to demonstrate the structural integrity of an in-service component containing a flaw or damage
- Run, Repair/Rerate, Replace decision

What types of flaws or damage can be evaluated

- API 579 classes

When assessments are typically performed

- Reactive vs. Proactive



FFS Assessments

Why perform an FFS assessment

- Life extension – Get more life span on the invested equipment or increase run time to a planned shutdown and reduce downtime by eliminating unnecessary repair
- Improve efficiency of maintenance and inspection programs, integrate into RBI programs
- Ensure the safety and reliability of aging equipment

Who should be involved

- Multi-disciplinary approach to determine if equipment is fit for continued operation
- Coordination with Operations and Inspections groups

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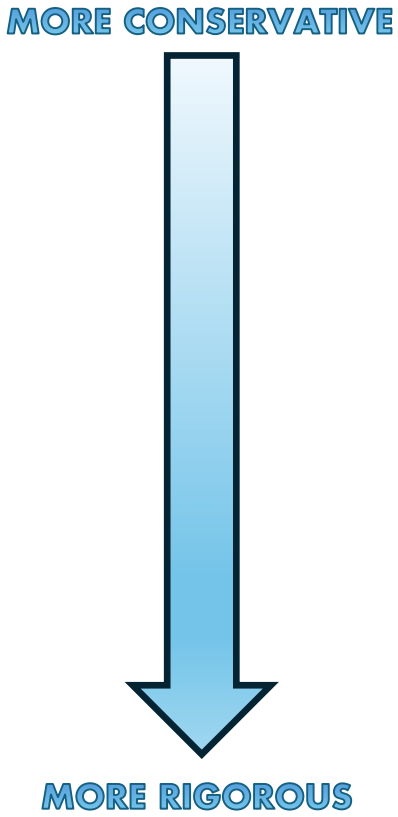
Assessment Process

- ✓ Gather Data
- ✓ Assessment Technique
- ✓ Acceptance Criteria (S_a, RSF , FAD)
  - ✓ Sensitivity Study
- ✓ Remaining Life
  - ✓ In-Service Monitoring
  - ✓ Remediation, Repair, Replace
- ✓ Documentation (NB-403)



Screening Levels

Level 1
- Screening via conservative criteria
- Minimal data required
- Typically performed by inspector or in-house

Level 2
- Detailed analysis via code calculations
- Increased inspection data requirements
- Completed by an engineer

Level 3
- Most rigorous evaluation
- Typically required finite element analysis (FEA)
- Produced the most precise results.

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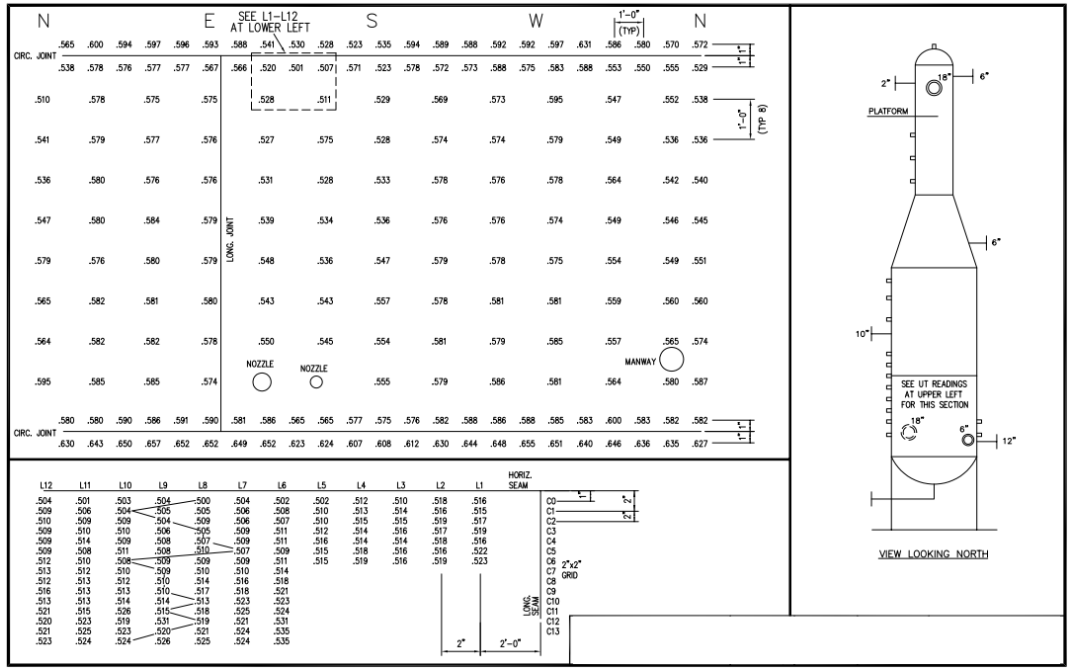
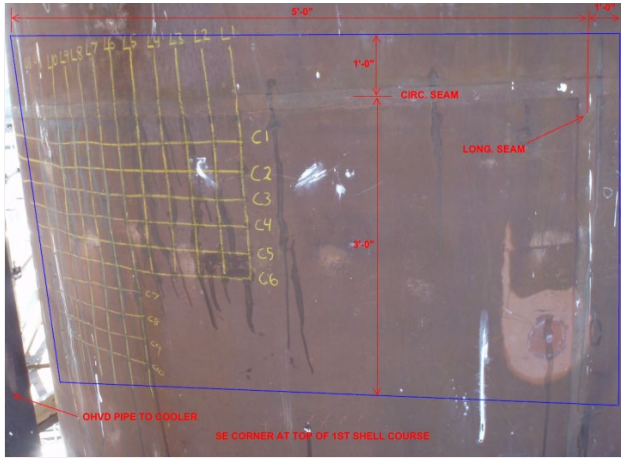
General Corrosion Assessment Example

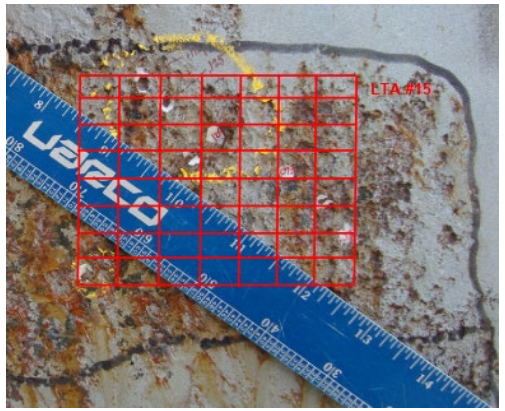


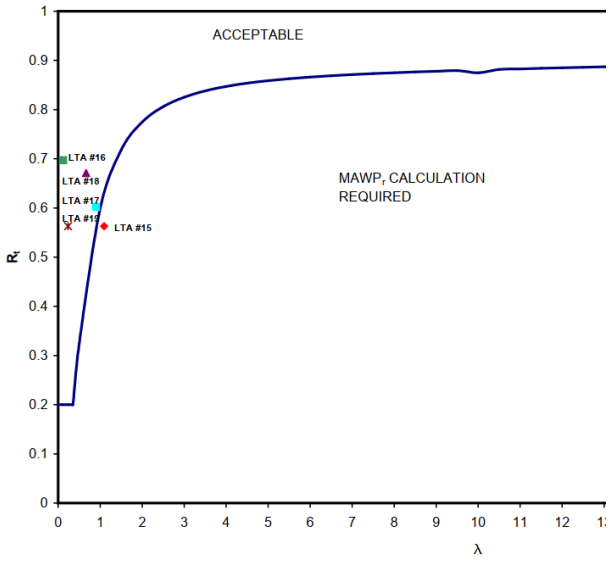


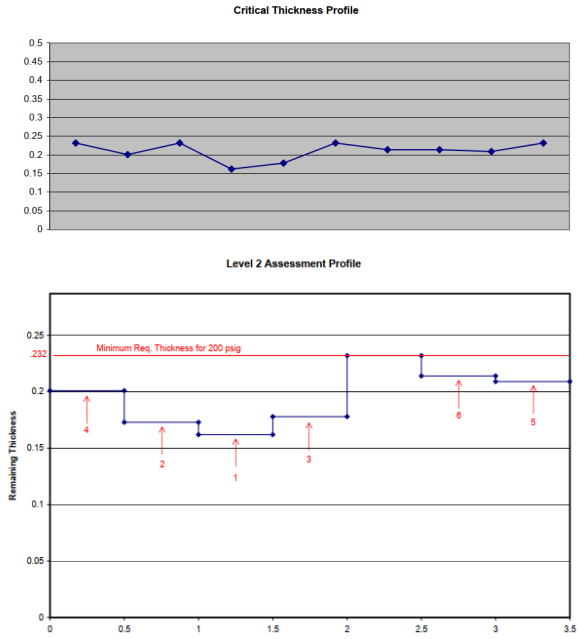
Impingement Damage on Vessel Wall

- Increased unit rates caused impingement damage on vessel wall opposite of the inlet nozzle.
- Derating the vessel was not an option
- Level 2 assessment conducted to estimate remaining life of 14 months
- Used FFS results to avoid shutdown and plan repair/replacement.
  - Flush patch repair on tower
  - Inlet device installed
  - Able to schedule during normal annual shutdown

Pitting Evaluation Example



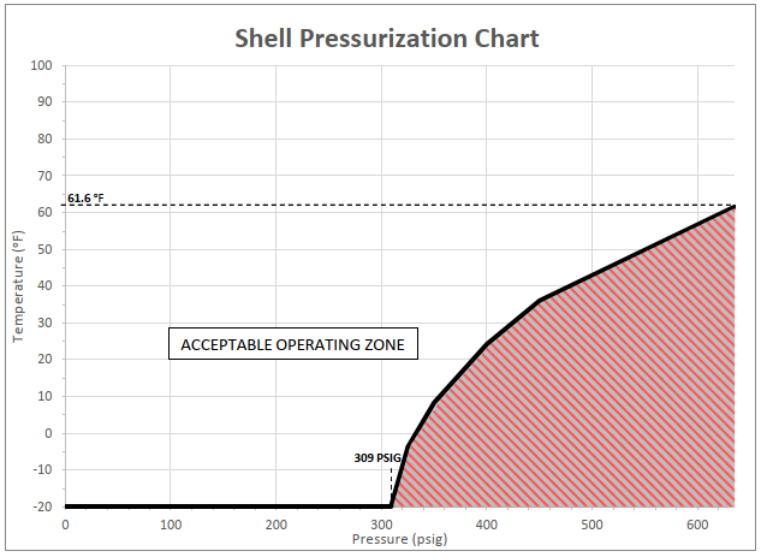


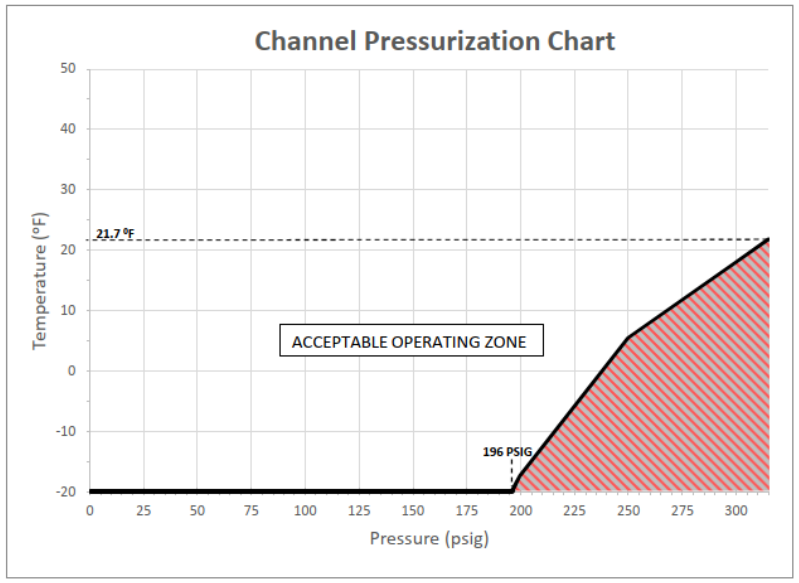


Propane Bullet with Corrosion Under Insulation (CUI)

- Extensive Pitting Damage – widely scattered with pit depth 0.100” and 0.300”
- Detailed inspection would have been costly
- Coordinated with operations and Anvil process team to rerate vessel to lower the MAWP and required t_{min}
- Both Level 1 and Level 2 assessments utilized to reduce inspection / engineering analysis
  - Level 1 used for remaining thickness of .209” to 0.382”
  - Level 2 used for remaining thickness less than 0.209”
  - Required both pitting and LTA asssesments
- No shutdown required and minimized repair cost to applying an external coating manage corrosion rate

Brittle Fracture Assessment Example





Exchanger MDMT greater than -20˚F requiring specific operational startup and cleaning procedures

- Section VIII vessels built prior to 1987 were not designed with additional requirements for brittle fracture prevention
- A -20˚F MDMT rating was not achievable
- Developed pressure-temperature operating curves per a Level 2 assessment for use in revised operating procedures.

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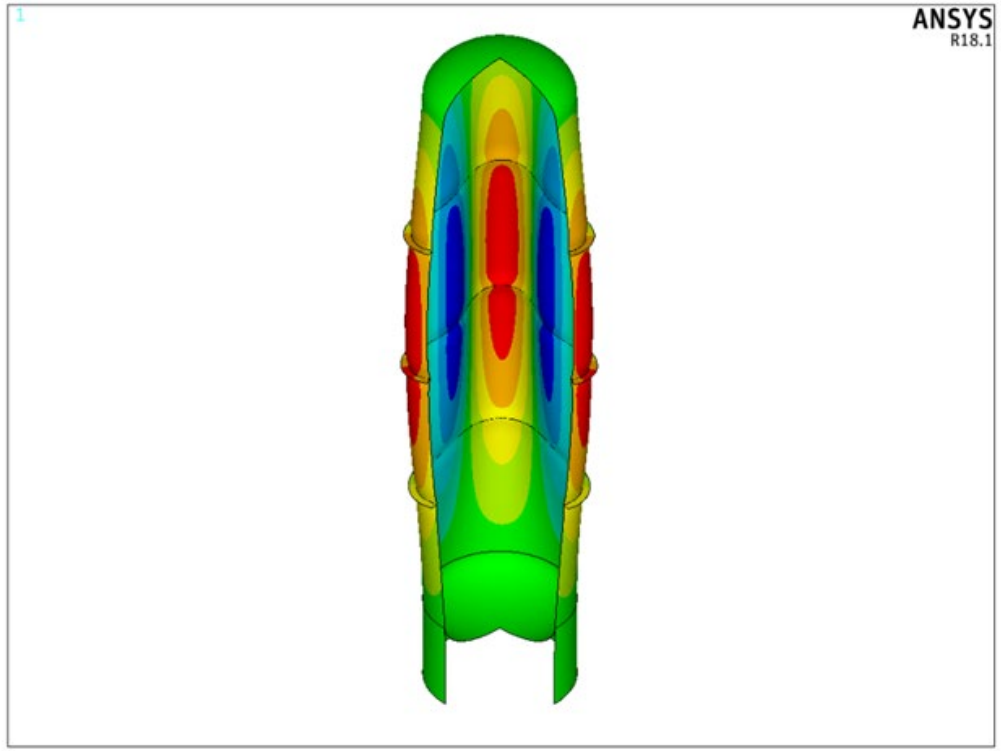
Level 3 FEA Assessment Example



Load Case	Future Corrosion Allowance (in.)	Collapse Load Factor[1]	Criterion[1][2]	Pass/Fail	Figure
1a	0 (Nominal)	4.72	4.50	Pass	Figure 69
1b	1/32	4.68	4.50	Pass	Figure 70
1c	1/16	4.48	4.50	Fail	Figure 71
2a	1/32	4.63	3.96	Pass	Figure 72
2b	1/32	4.49	3.96	Pass	Figure 73
4a	1/32	4.17	3.96	Pass	Figure 74
4b	1/32	4.66	3.96	Pass	Figure 75
4c	1/32	4.55	3.96	Pass	Figure 76

Shell Distortion in Vessel

- Classified as general shell distortion with up to 2” of deformation. Identified with laser scan
- Level 1 assessment in excess of code out-of-roundness tolerances
- Coordinated additional inspections for thickness, hardness, and temperature scanning
- Used laser scan data to help model the geometry in Ansys
- Level 3 FEA conducted to evaluate for protection against plastic collapse, local failure, buckling, and ratcheting.
- Vessel acceptable for continued service with limited future corrosion allowance.
    - Increase inspection interval to monitor thickness and temperature (hot spots)

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Operating equipment with flaws or damage can be done safely as long as an assessment is performed per standardized rules to determine acceptability and Anvil can assist you with this process.

Thank You

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