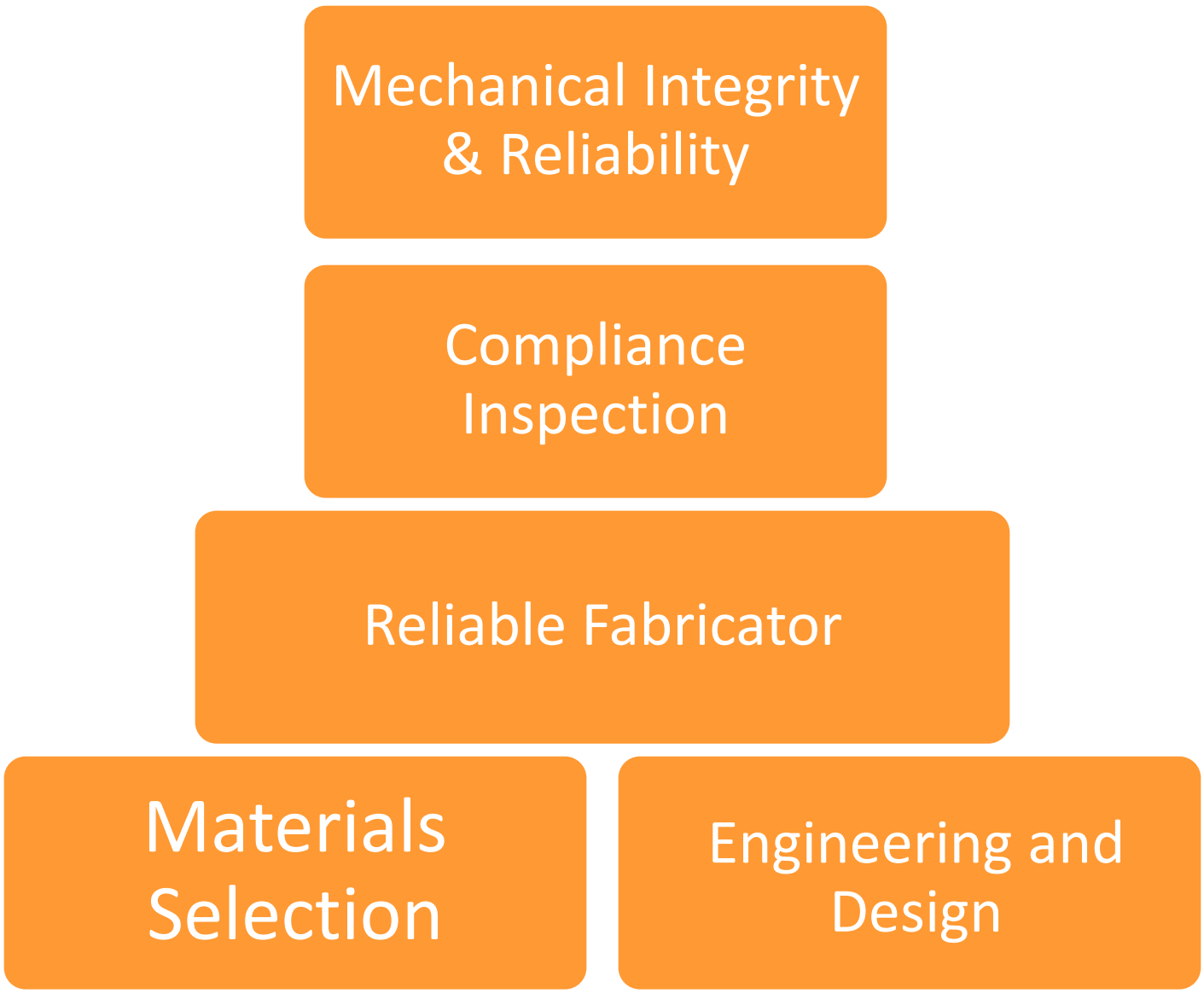
A Key to FRP Longevity –
Inspection and Integrity Monitoring

Geoff Clarkson, P.Eng., ing
Chief Engineer, UTComp Inc.


Mechanical Integrity & Reliability
Compliance Inspection
Reliable Fabricator
Materials Selection
Engineering and Design

Why Inspect?

- Compliance
  - Drawings
  - Standards and Specifications
  - Materials
  - Manufacturing Quality
- Mechanical Integrity

Compliance Inspection

Specify EVERYTHING required to determine compliance.

Details are important!

Compliance Inspection

- In-Process Inspections
  - Witness and Hold Points
  - Early detection possible
  - Verify materials used
  - Verify Quality Control operation
  - Focus on key intermediate details

Compliance Inspection

- TESTING
  - Pressure/Hydrostatic
  - Vacuum
  - Acoustic Emission

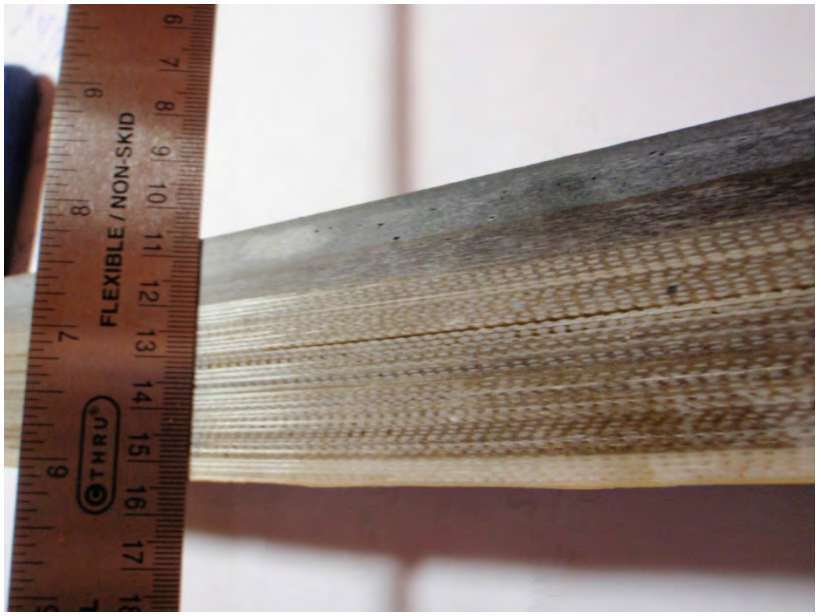
Compliance Inspection

NON-CONFORMANCE REPORTS

- Completed for each item that does not comply with Specification and Design.
- Resolution must be agreed by Owner, Inspector and Manufacturer.

Compliance Inspection

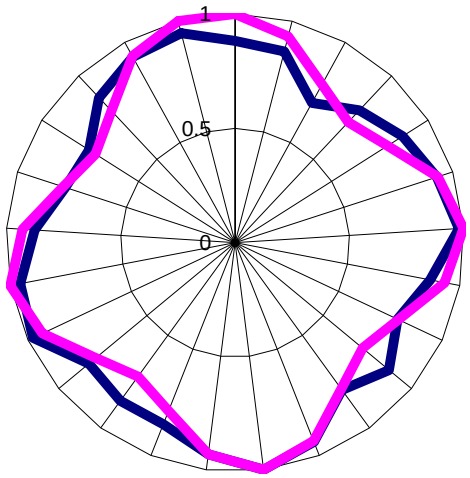
- FINAL INSPECTION
  - Documents: Design, Drawings, QC,
  - Non Conformance Reports
  - Materials
  - Cutouts
  - Resin Cure
  - Dimensions and thickness
  - Physical properties



Compliance Inspection

Ultrasonic Methods to Verify Reinforcement Orientation

Hand Lay Up

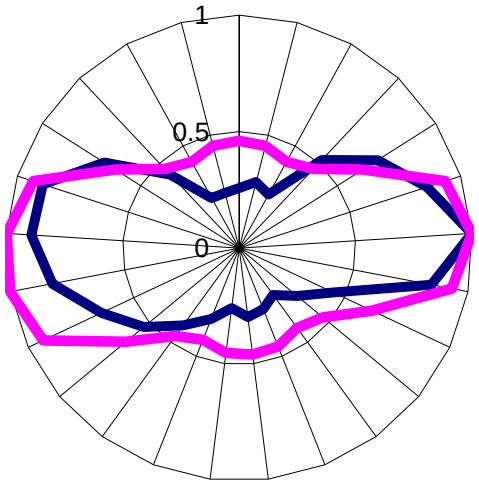


UT Data

Calculated modulus

>99% confidence that data matches Lamination Analysis model

Filament Wound



UT Data

Calculated modulus

>99% confidence that data matches Lamination

Reliability with Compliance

Some fabrication details that can improve reliability.

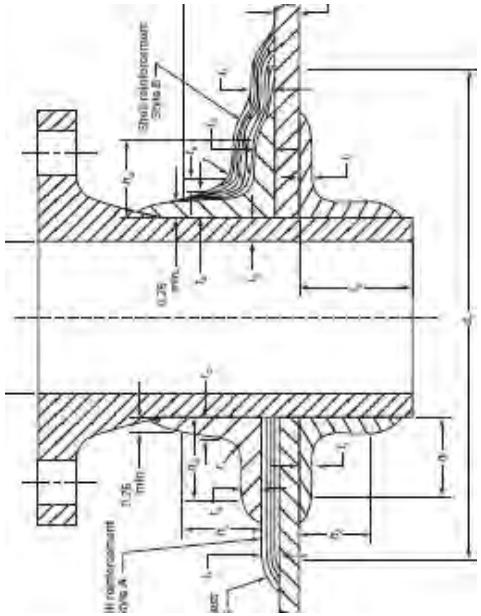
Reliability with Compliance

- Most leaks and failures occur at bonds and joints
- Compliance Inspection must include this

Reliability with Compliance

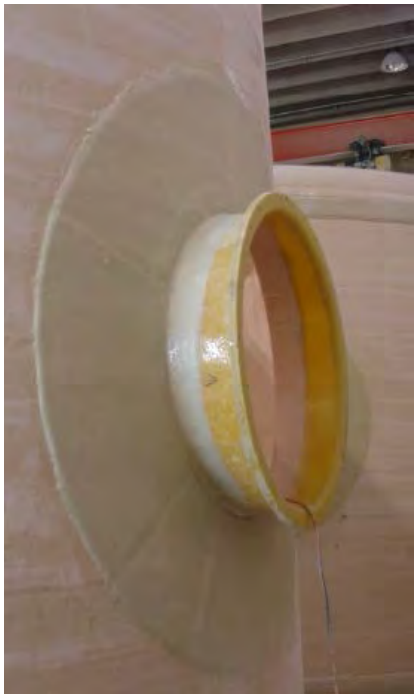
NOZZLES

Use penetrating type for 6” and smaller



OPENING REINFORCEMENTS

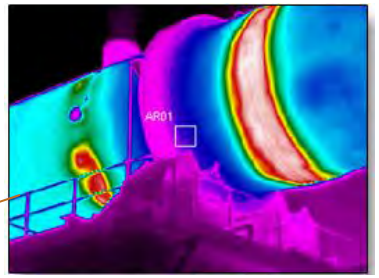
Size, thickness and bonding



In-Service Inspection

For Mechanical Integrity and Reliability

- INSPECTION METHODS
  - Visual External
  - Visual Internal
  - Technologies:
    - Infra Red
    - Ultrasonic
    - Digital X-ray



Mechanical Integrity

Both are 6” nozzles.

Not penetrating installations.

Update existing assets for reliability: Nozzles, Bonds, Joints

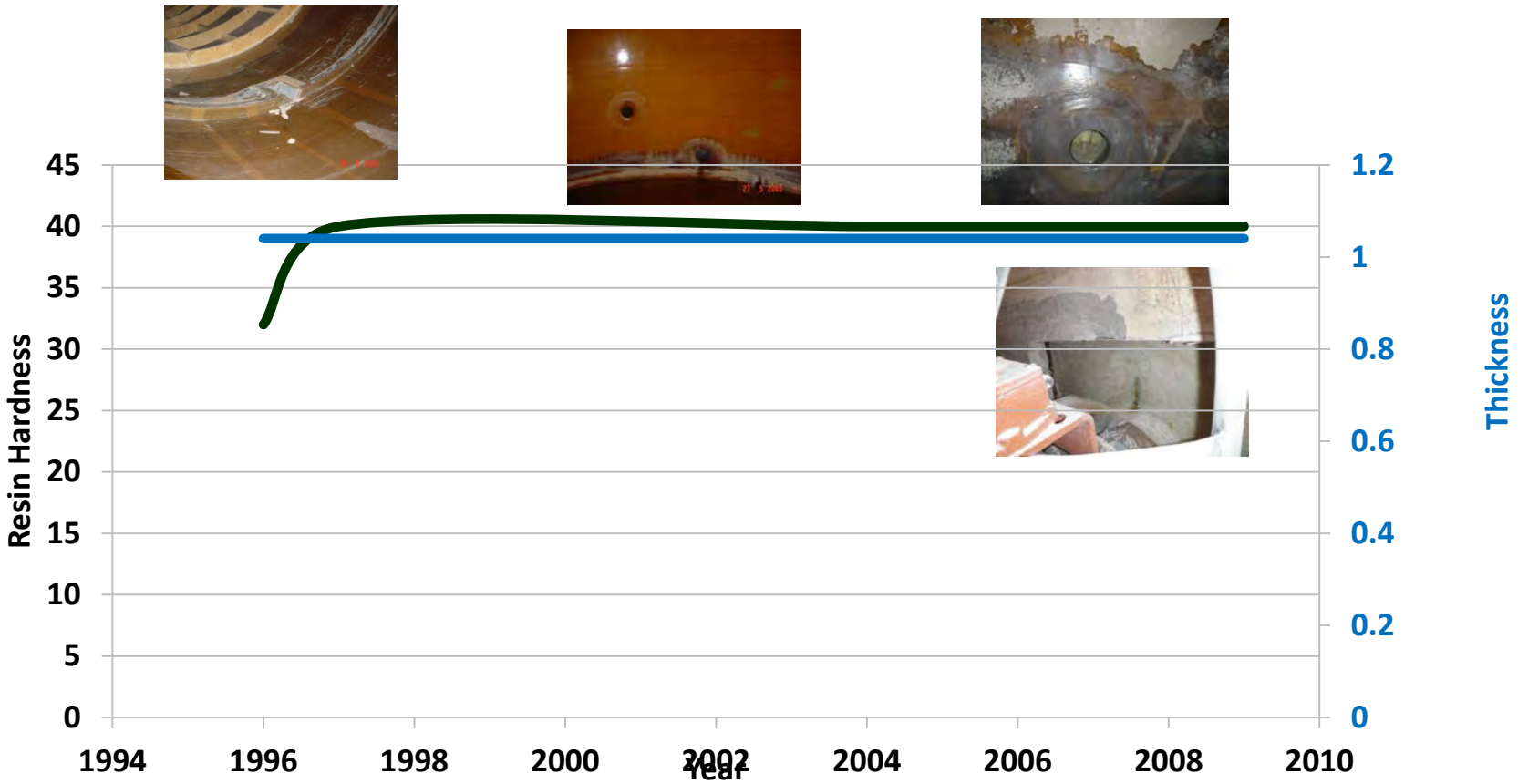
Mechanical Integrity

Internal Inspection focuses on finding necessary repairs

Unnecessary repairs add uncertainty

Mechanical Integrity

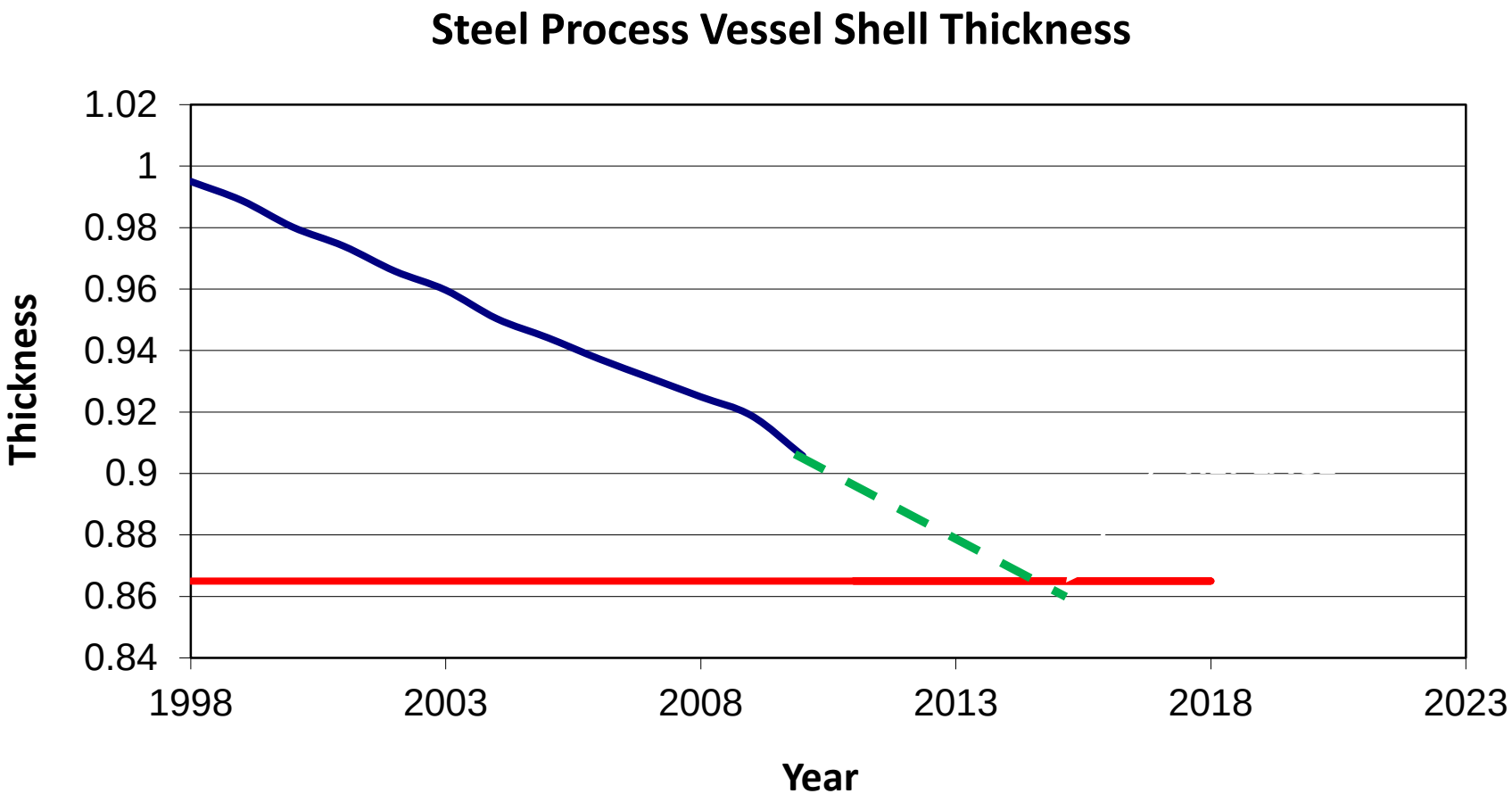
Internal Inspections



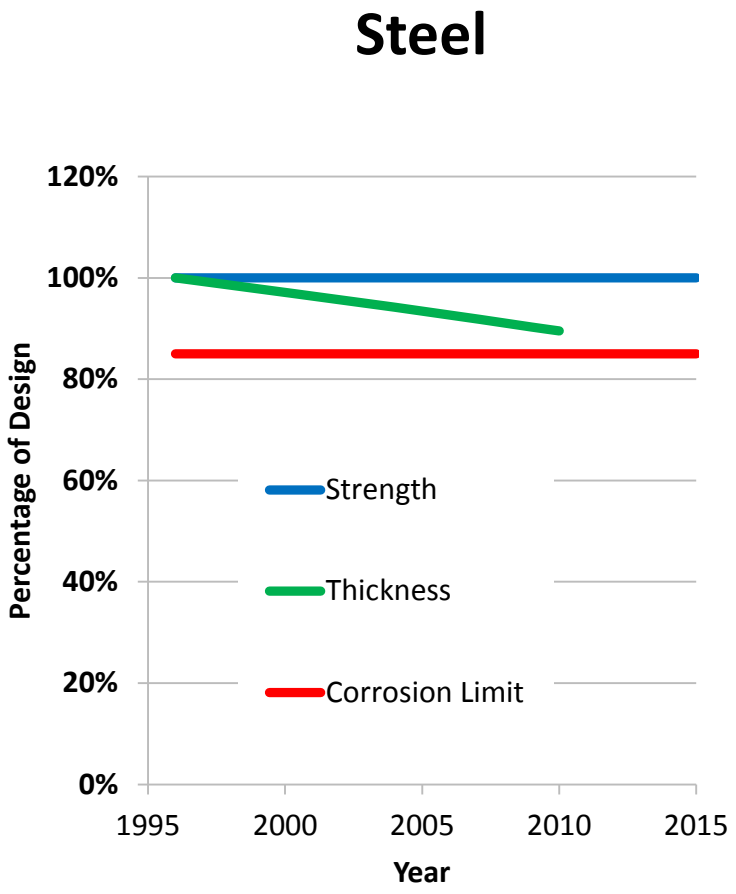
In the extreme…..

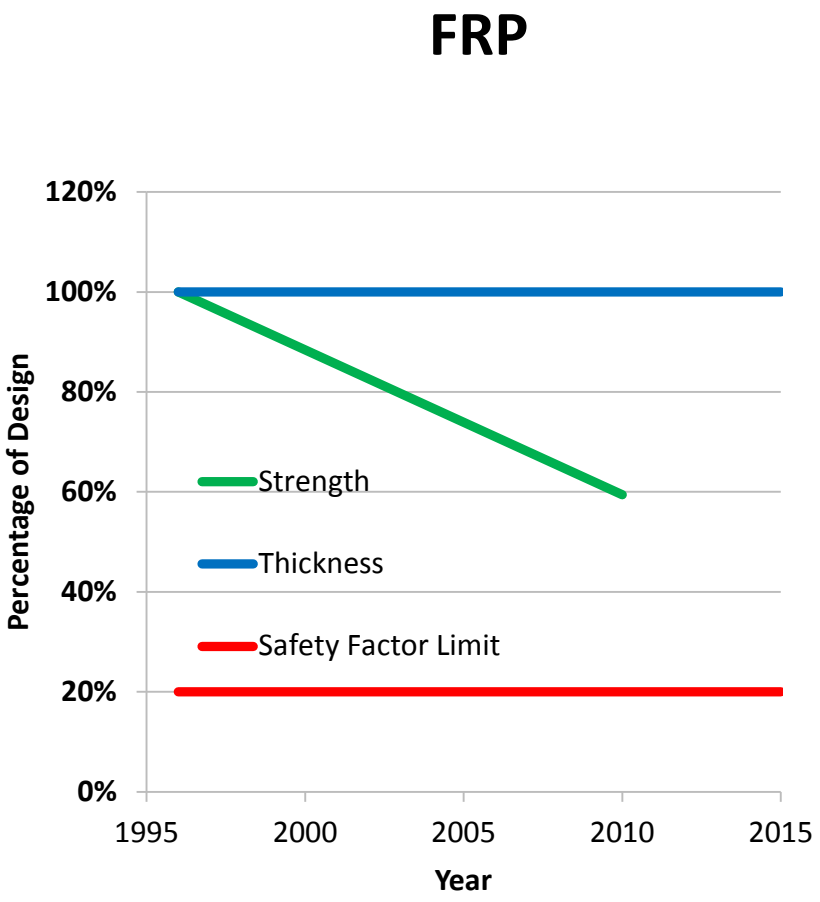
- Vessel had Corrosion Barrier inspections annually for 13 years
- Failure of structural laminate was at structural repairs made when new
- Not detectable from internal or external visual inspections.

"Can we generate a curve to allow us to plan repair & replacement of FRP vessels as for metal vessels?"



Relating Steel to FRP

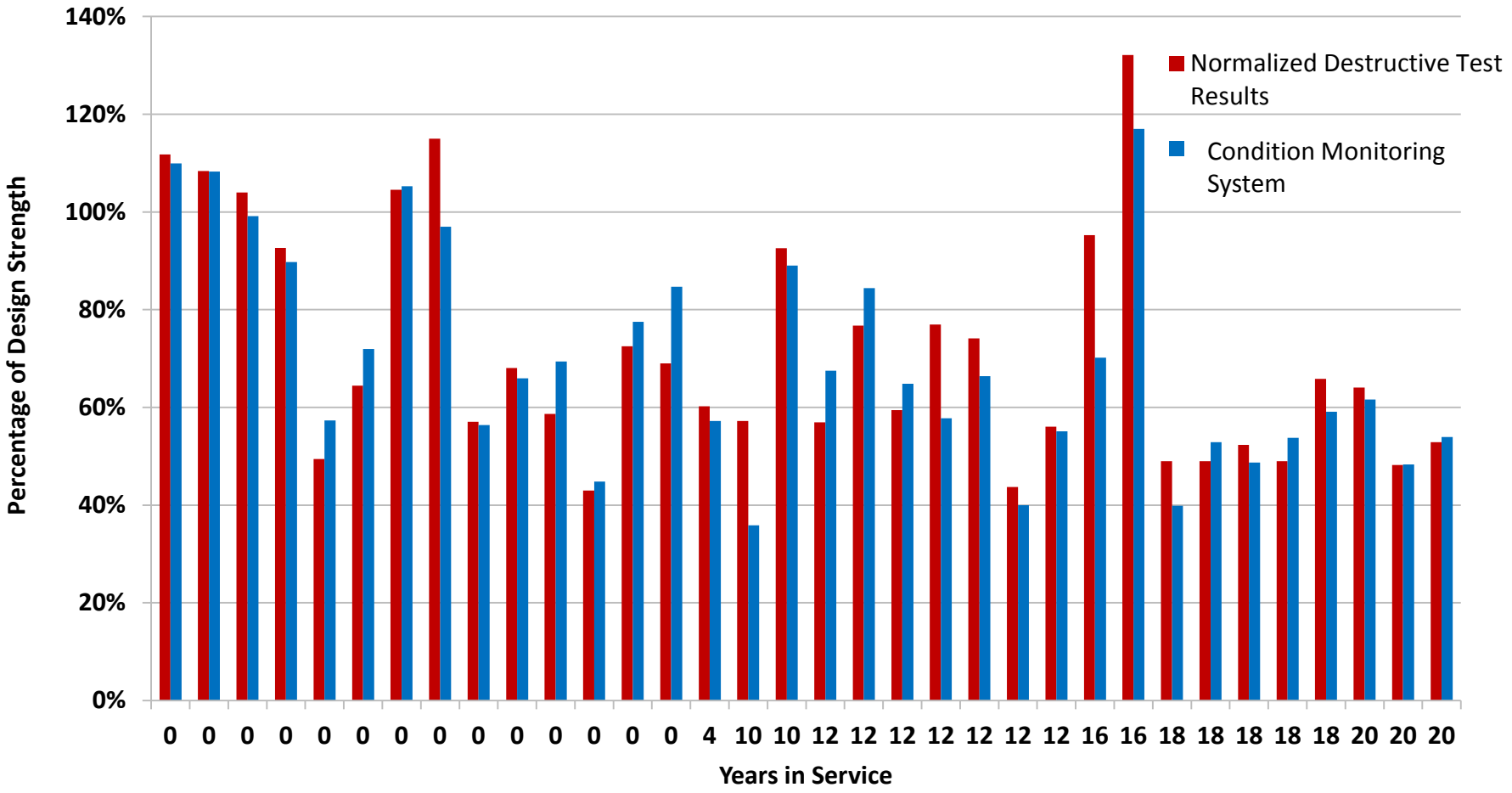




FRP Strength Determination

- Must be:
  - Repeatable
  - Verifiable
  - Non Destructive
- Rocket Science
  - Started in 1960's when NASA looked into NDT of FRP for aircraft

Destructive vs. Non Destructive Results



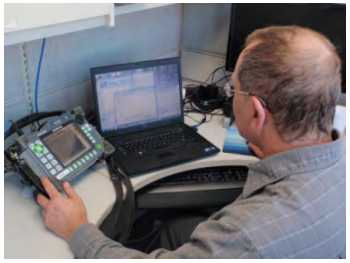
Mechanical Integrity

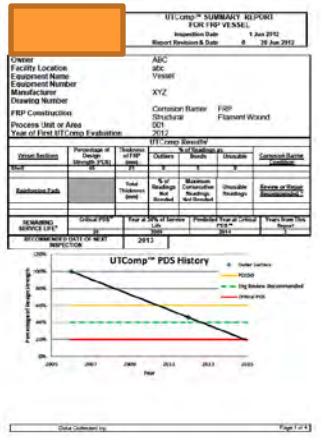
Other features of Mechanical Integrity System:

- Can be used for new equipment to establish starting point
- Corrosion barrier condition can be determined without entry
- Can be done while process operating
- Reinforcement pad effectiveness can be determined

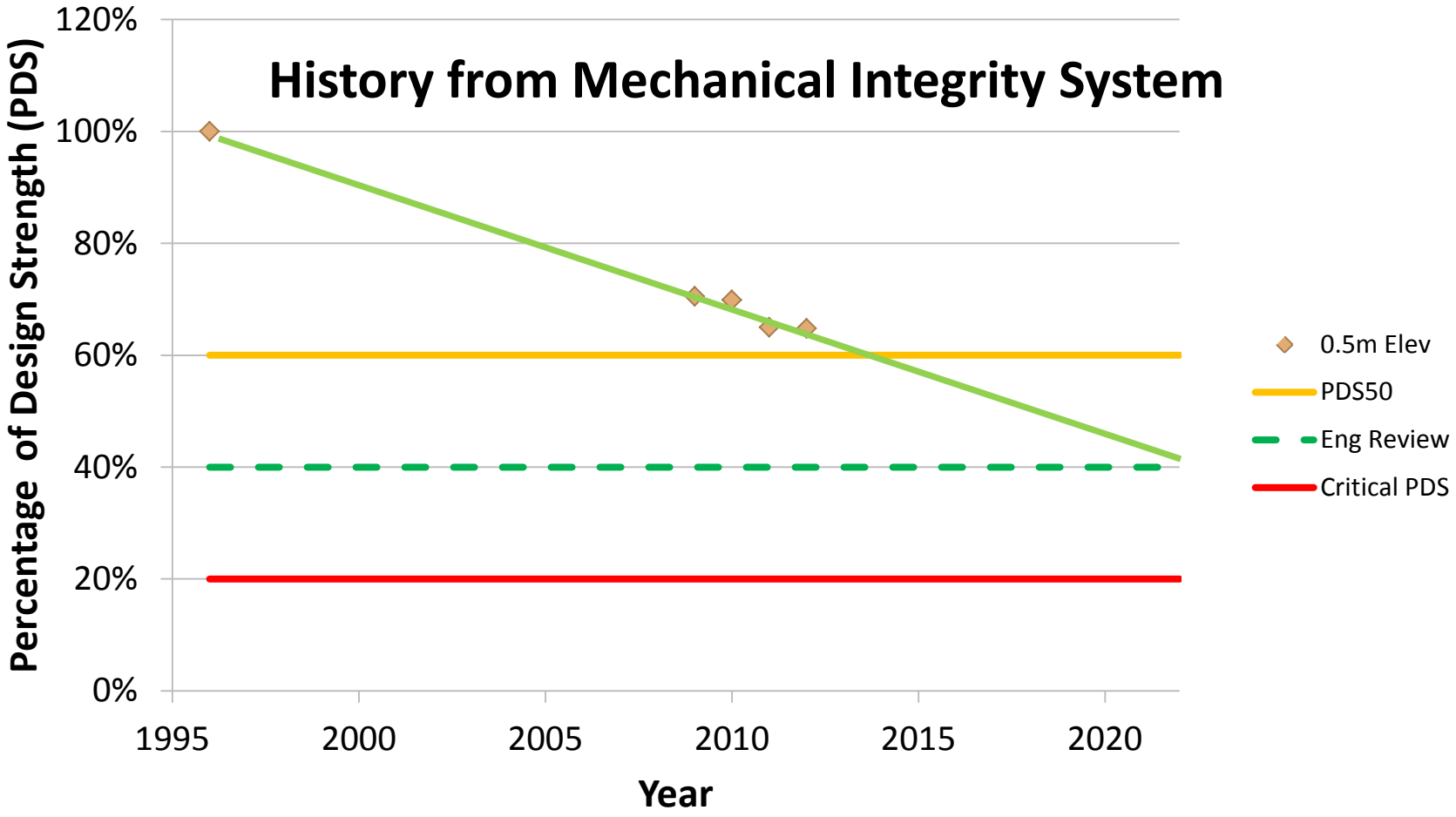
How it Works

1. Field data and asset information.
2. Systematic External Inspection.
3. Systematic Internal Inspection.
4. Readings and information combined into data file.
5. Produce report.

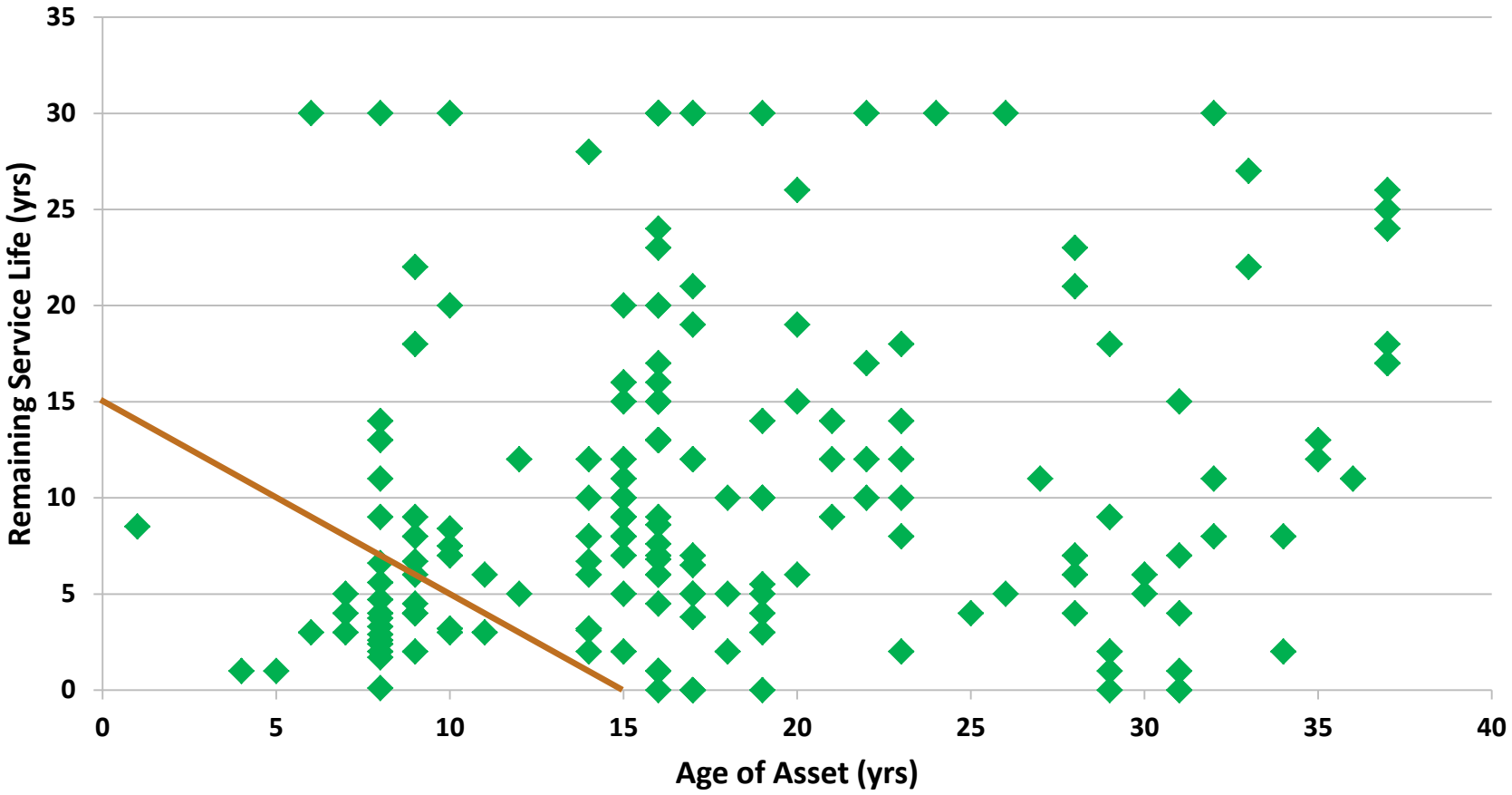




Mechanical Integrity



FRP Asset Remaining Life



Mechanical Integrity System Motivation

Consider these costs…

- Cost of replacing or repairing prematurely with limited scope control
- Cost of not inspecting for compliance with specifications
- Cost of internal inspection (clean out, shutdown time, lost income)
- Cost of risk for confined space entry
- Cost of risk of environmental clean up
- Cost of public relations due to a spill or accident
- Cost of lost opportunity

Consider the value…

- Value of knowing prior to a shutdown what is needed
- Value of repeatability and reproducibility
- Value of being able manage within budget cycle
- Value of baseline information on new equipment
- Value of being able to monitor existing equipment for changes over time

Summary

Inspection for Longevity:

- Detailed specifications to assist Inspector for compliance
- Specify details for reliability
- Update in-service equipment to reliable features – penetrating nozzles, good repads, wide bonds
- Use technology where it makes sense
- Internal inspection only when necessary
- External and Mechanical Integrity Inspection regularly

Thank you