Composite Repair Performance at Elevated Temperatures

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Overview

- Introduction to High Temperature Repairs
- Designing the repair
  - Design methodology via Standards
  - Component testing
  - Alternative design methodology
- Conclusions

Background

- Composite repairs have been used to restore structural integrity to pipes with external corrosion for years.
- As composites become more common, alternative uses are being sought after including:
    - Wrinkle Bends
    - Unique Shapes
    - Dents and Gouges
    - Cyclic Fatigue
    - Underwater repairs
    - High Temperature
- This presentation is focused on the use of composite repairs on high temperature pipelines.

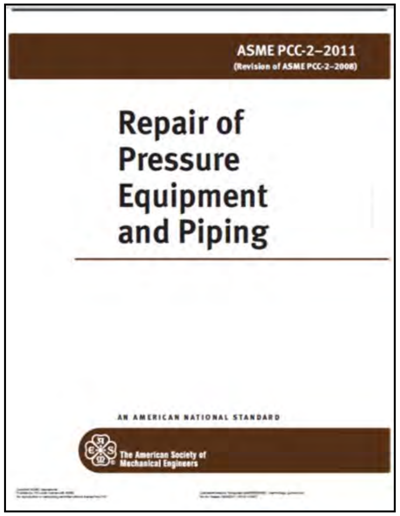
Typical parameters for a "High Temperature Repair"

- Have an operating condition above 150°F?
  - Verify that the "standard" or proposed repair meets temperature design conditions
  - If not, start to consider high-temp repair solutions

- High temperature repairs usually require:
  - Above room temperature conditions to fully cure
  - Either the pipe needs to be heated…
  - Or an external heating element is used
  - Consideration of thermal cycling

Design Methodology Using Composite Standards

- ASME PCC-2 and ISO 24817
  - Provide design equations dictating repair thickness
- Dictates upper bound temperature limit (T_m) of composite components
- T_m is determined by offsetting a value based on a materials:
  - Glass Transition Temperature
  - Or Heat Distortion Temperature



ASME PCC-2–2011
(Revision of ASME PCC-2–2008)

Repair of
Pressure
Equipment
and Piping

AN AMERICAN NATIONAL STANDARD

The American Society of
Mechanical Engineers

TECHNICAL
SPECIFICATION

ISO/TS
24817

First edition
2006-12-15

Petroleum, petrochemical and natural gas industries — Composite repairs for pipework — Qualification and design, installation, testing and inspection

Industries du pétrole, de la pétrochimie et du gaz naturel — Réparations en matériau composite pour canalisations — Conformité aux exigences de performance et conception, installation, essai et inspection

Reference number
ISO/TS 24817:2006(E)

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Temperature Components of Standards

Temperature de–rate factor:

$$f_T = 6 * 10^{-5} * (T_m - T_d)^2 + 0.001 * (T_m - T_d) + 0.7014$$

When a composite has a high T_m
and a relatively low T_d, then

$$f_T > 1.00$$

Implies no loss in material performance
due to temperature.

Replacing the Temperature Derate?

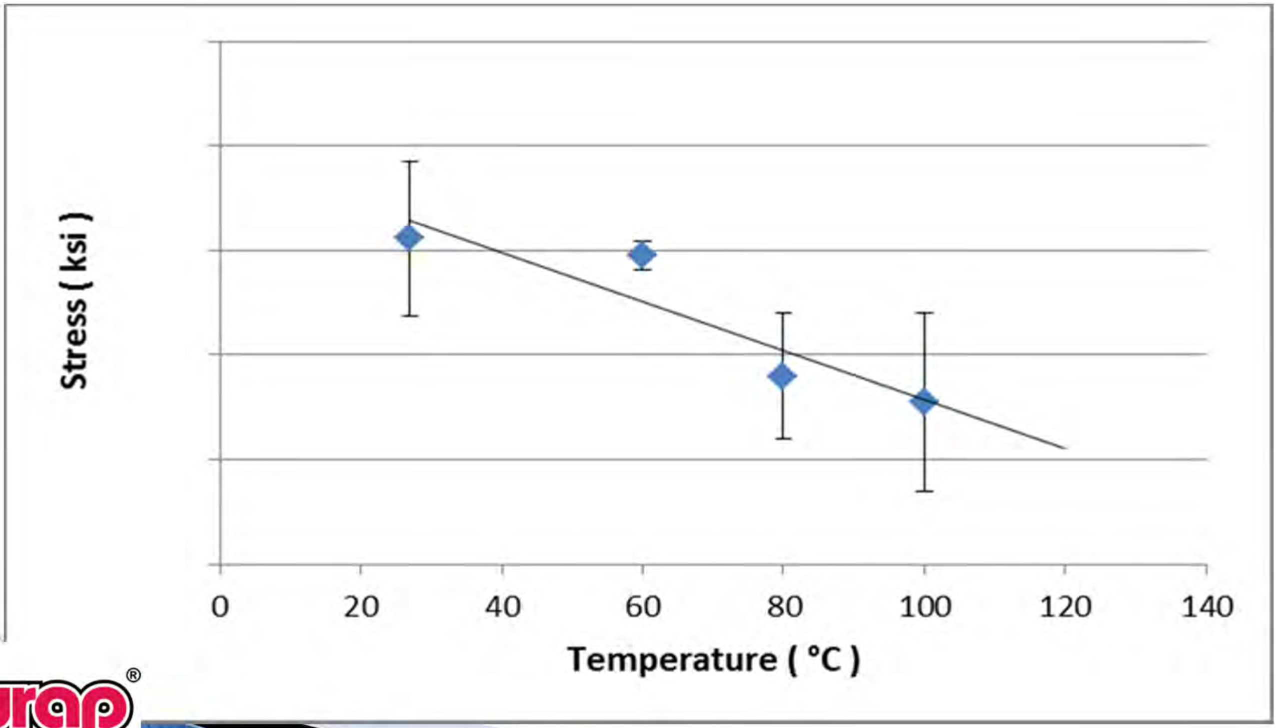
- The temperature derate factor works well for low temperature resins.

- However, as more advanced, high temperature resins are being used, a new testing standard should be examined.

- Several system components were tested at elevated temperatures to determine performance.

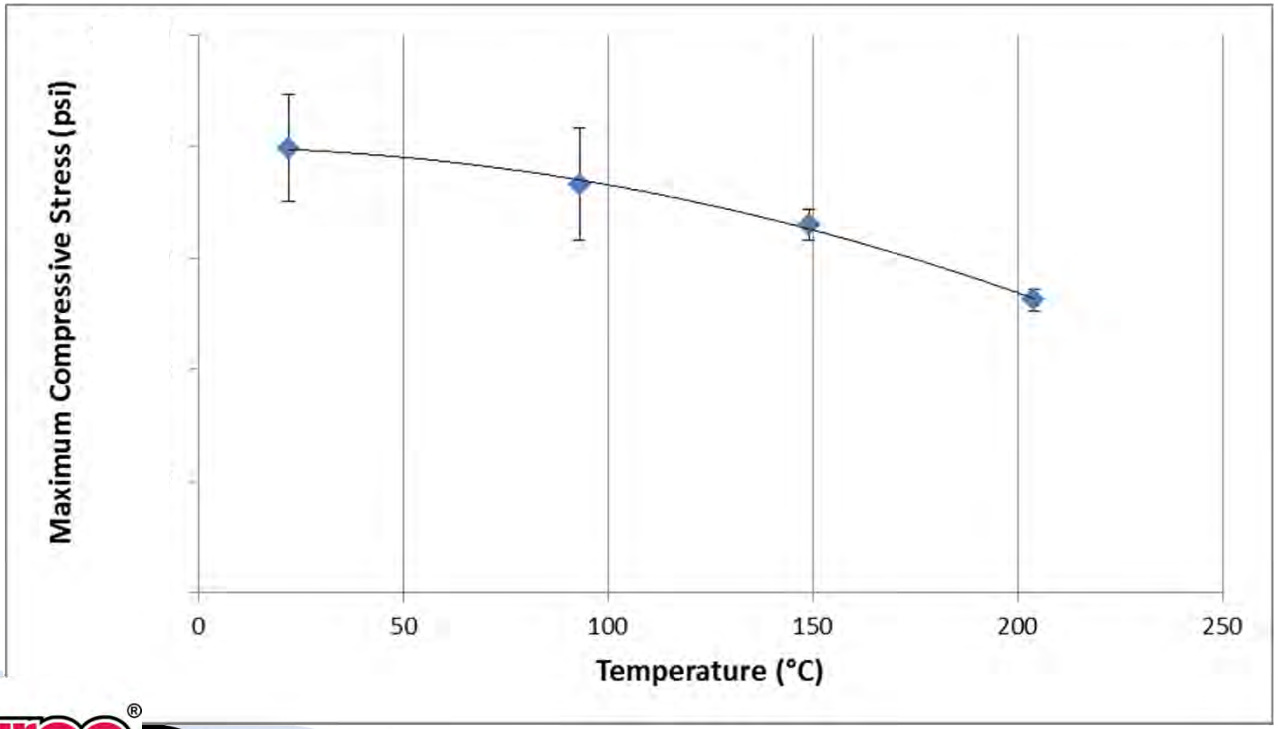
Component Testing – Composite

- Tensile coupons were created according to ASTM D3039.
  - Samples were heated and tested at various degrees
  - Tested composite has a T_g in excess of 250°C
- Tensile strength decreases with increased temperature
  - Even at relatively low temperatures



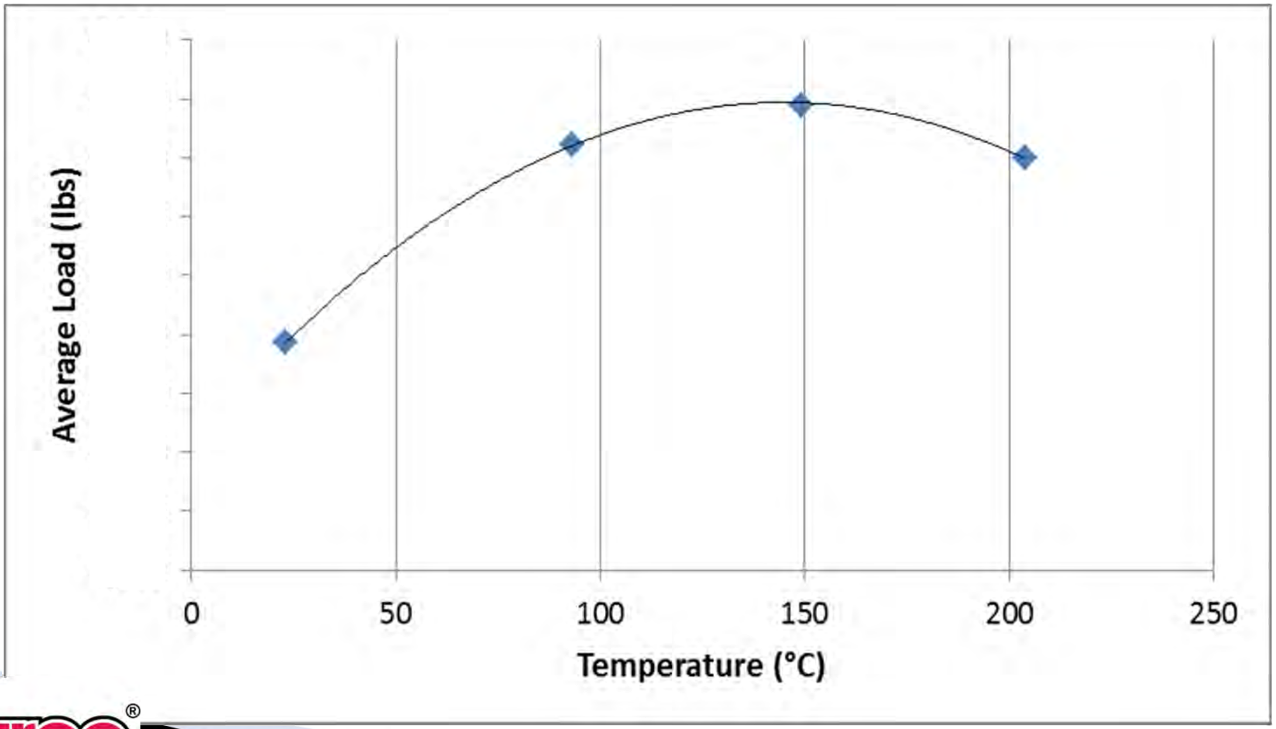
Component Testing – Load Transfer Filler

- Compression coupons were created according to **ASTM D695**.
- Compressive strength decreases with increased temperature.
- At what point are the compressive properties too degraded?



Component Testing – Adhesive

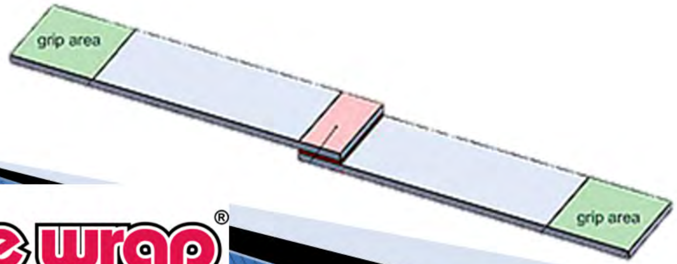
- The lap shear strength of the adhesive was determined by testing a double lap shear sample to **ASTM D3165**
- Samples were initially cured at 120°C; post cured at 230°C.
- Lap shear strength is largest near the initial cure temperature.

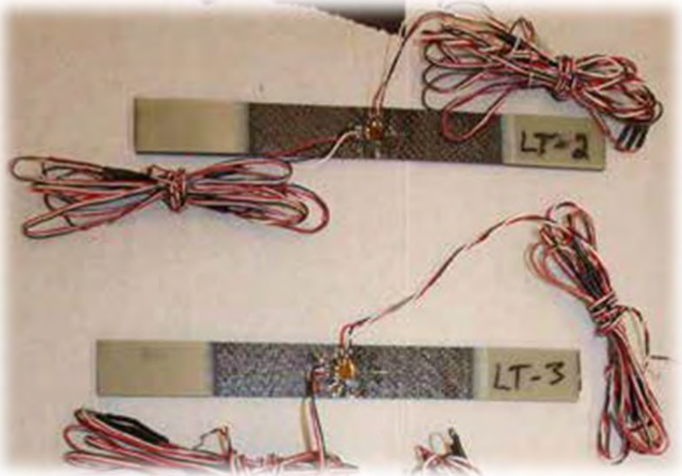


Alternative Design Methodology

Create a characteristic curve based on ASTM standards at various temperatures.

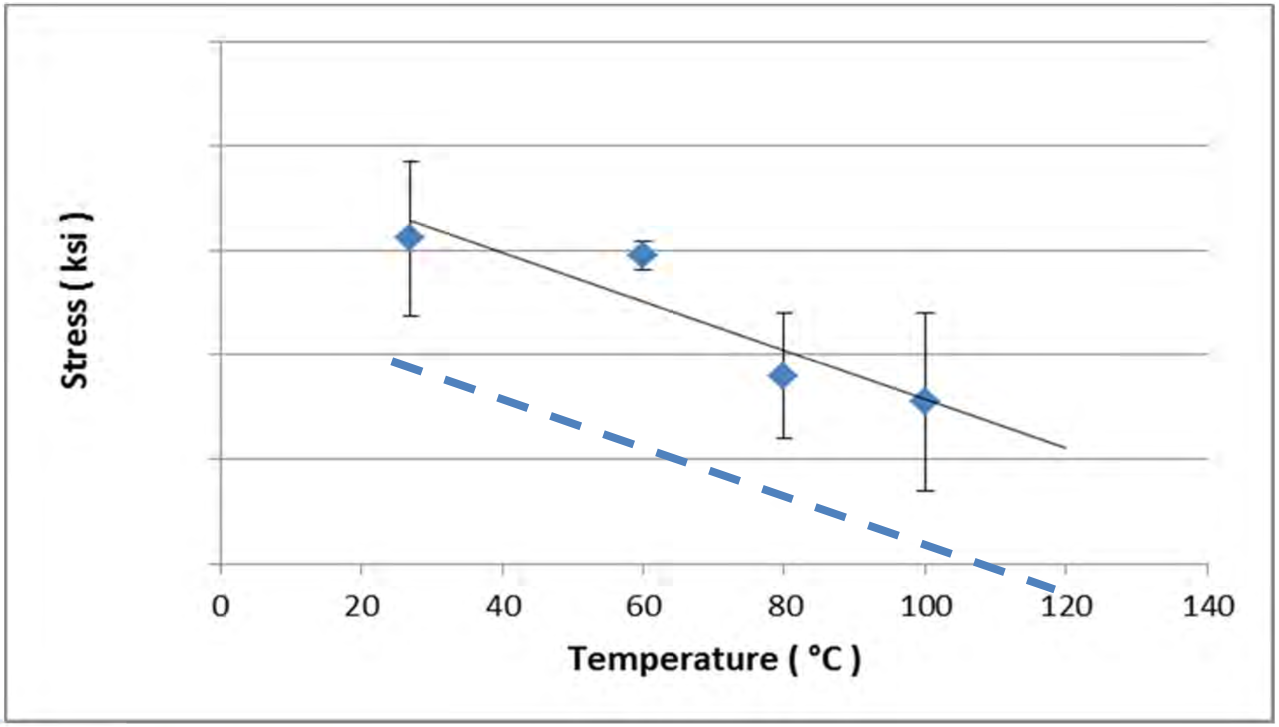
- Load Transfer Filler – ASTM D695
- Adhesive – ASTM D3165
- Composite – ASTM D3039





Characteristic Curves

- By creating a characteristic curve, a materials true property value can be determined by using the design temperature as an input.



Summary

- Mechanical properties at multiple Temperatures were found for:
  - Load Transfer Filler – ASTM D695
  - Adhesive – ASTM D3165
  - Composite – ASTM D3039
- Using fitted values at different temperatures allows for accurate repair designs.
- Can be confirmed with system level testing.