

Structural Mechanics Validation Efforts with Variable Loading and High Strain Gradient Fields

**ASME V&V Conference: Validation Methods for Solid
Mechanics and Structures Subgroup Meeting**

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May 24, 2013

***Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin
Company for the United States Department of Energy's National Nuclear Security
Administration under contract DE-AC04-94AL85000**



Overview

- Motivation and objectives
- Validation approach and hierarchy
- Physical and simulation test results
- Validation efforts

Application and Objectives

- Application: Tooling for a disassembly process was redesigned and must be shown to meet interface control document specifications (ICD).
- Objectives:
 - Finite element analysis to aid the tool redesign through a parametric analysis.
 - Use the tool model in conjunction with an assembly model of the larger system to determine if the ICD specifications are met.

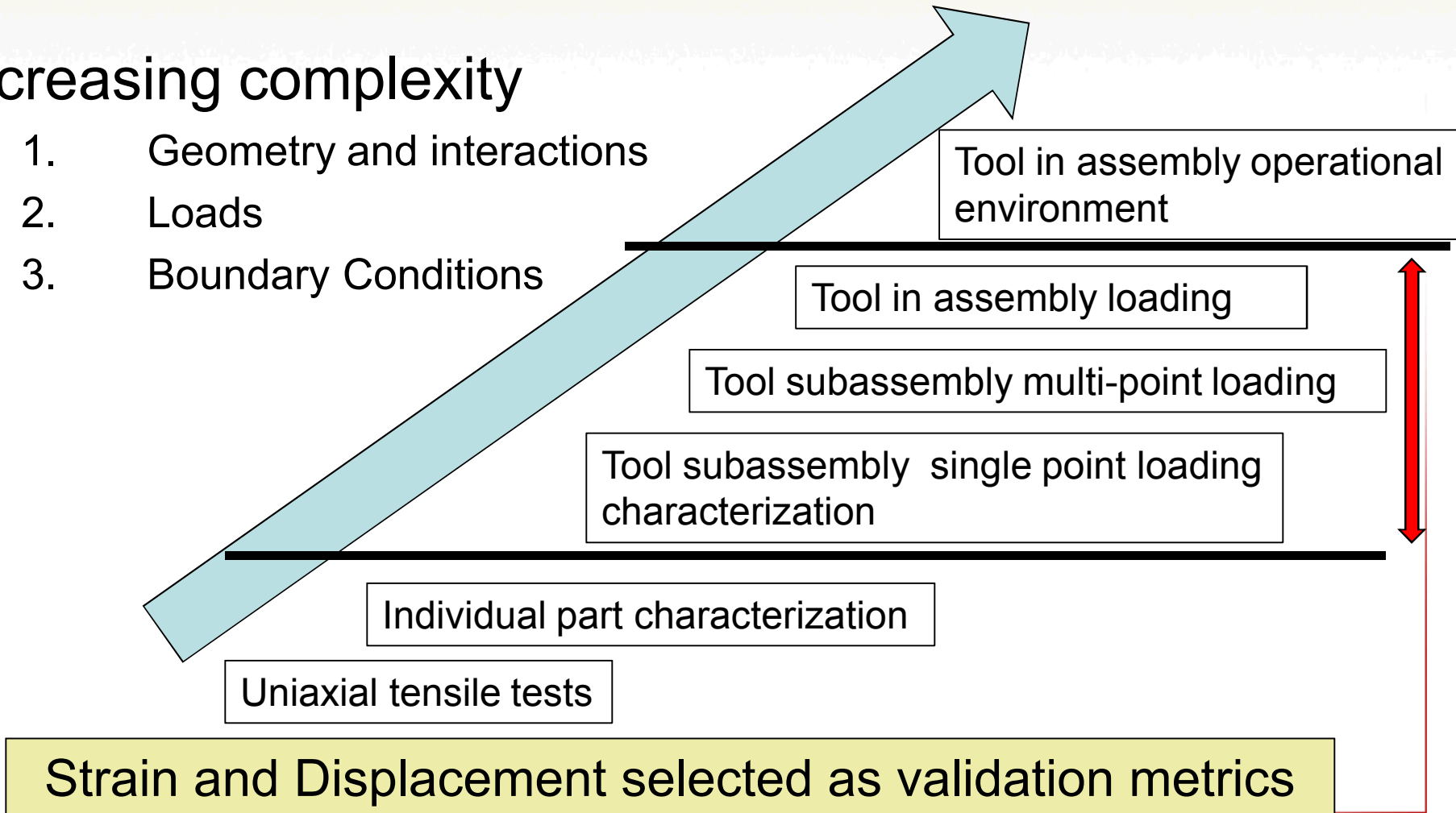
Direct testing for qualification is problematic due to how the specification is written and measurement access to locations in the larger system.

Although direct testing is not programmatically desirable, model validation was requested to gain confidence in the simulation results.

Validation Approach and Heirarchy

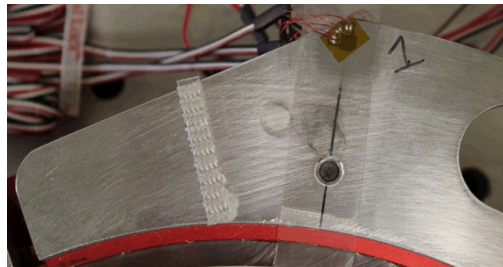
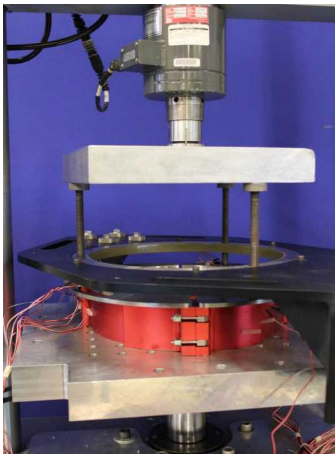
Increasing complexity

1. Geometry and interactions
2. Loads
3. Boundary Conditions



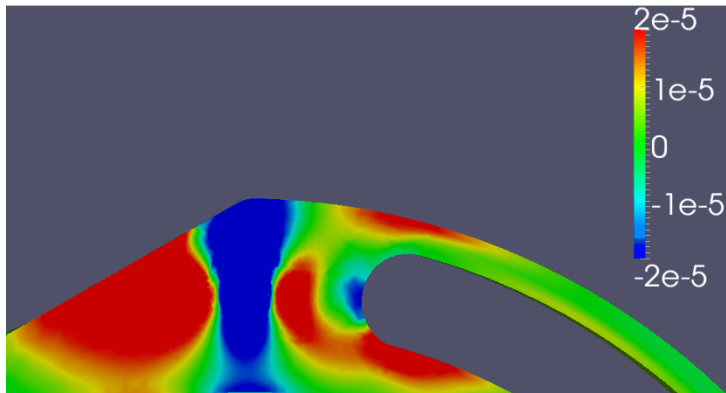
Tool Characterization

- Initial characterization of the tool
- Pre-test check out of the instrumentation
 - Three strain gages placed near each of three load points (total of nine gages).
 - Hoop and radial stresses measured at each gage.
- Loading with a 22 kips MTS load frame

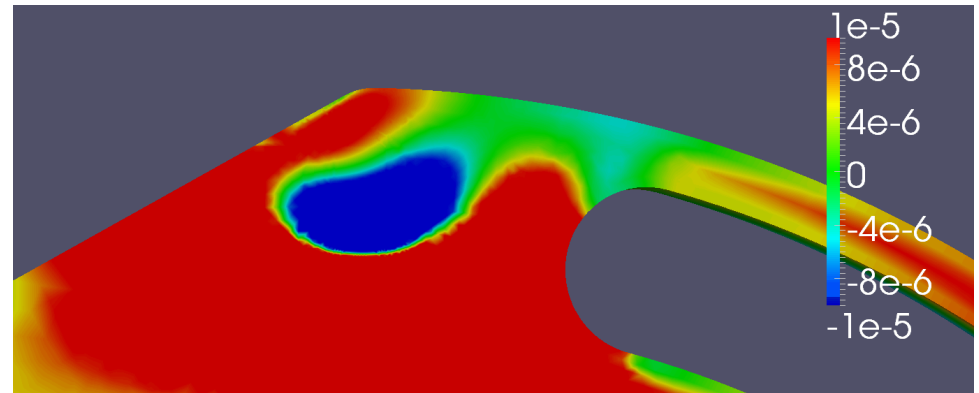


Strain Measurements

- Large gradients near load points.
- Relatively low magnitudes (some less than 10 microstrains)
- Advised to use only as a qualitative validation tool under these conditions.

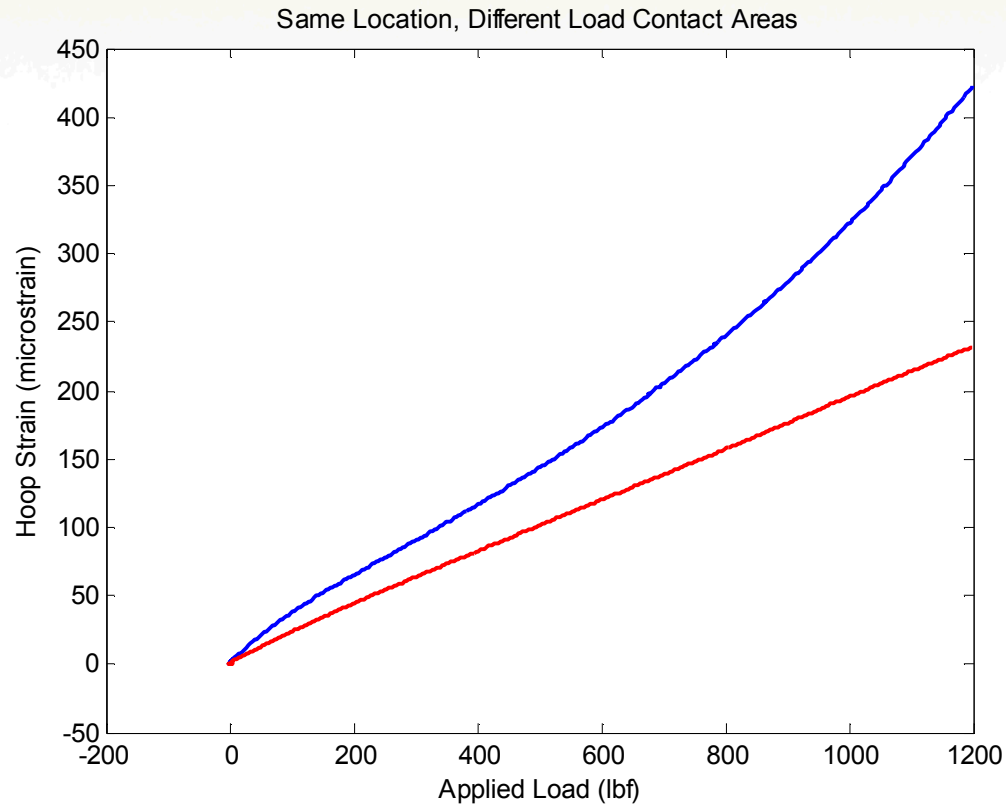


Hoop Strains



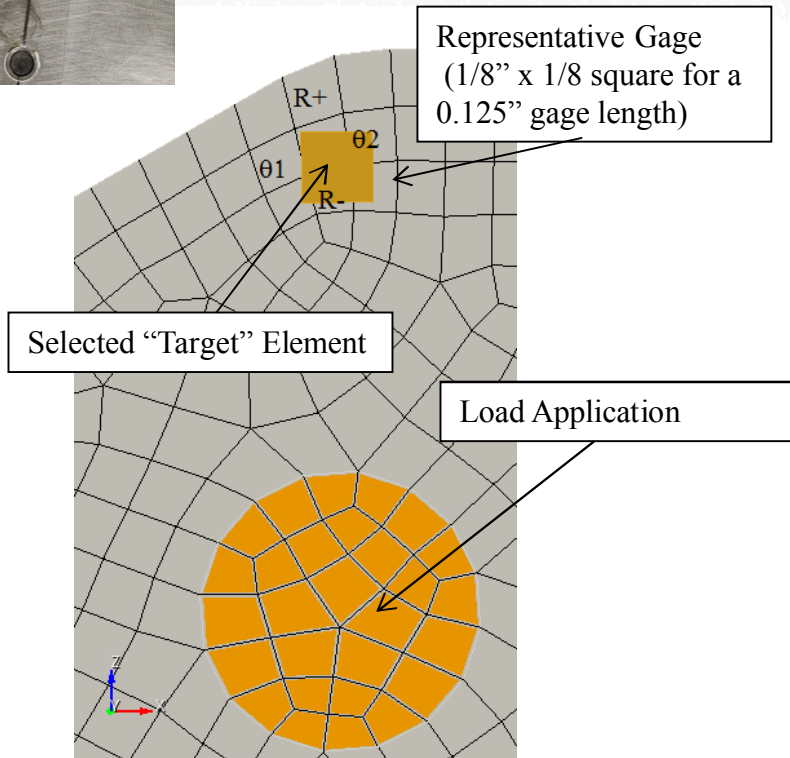
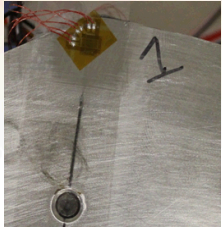
Radial Strains

Strain Plots

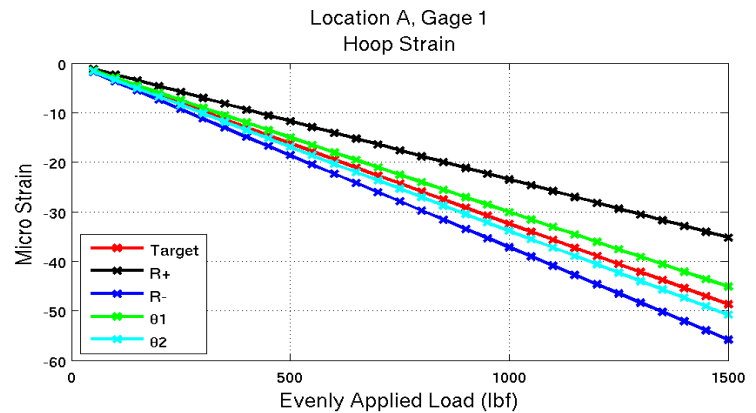
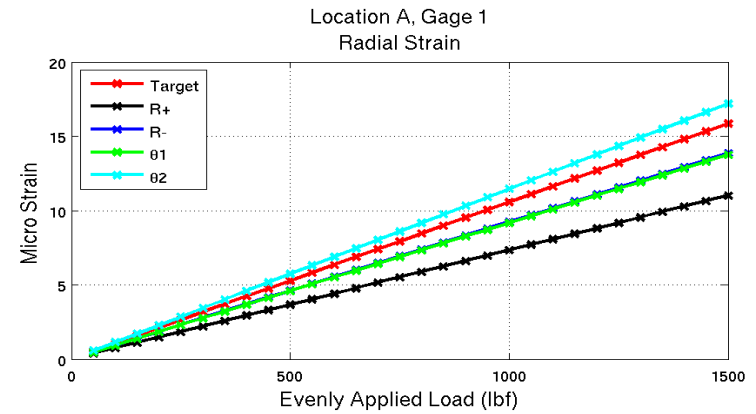


Contact area affects measured strains. Implies load adjustment between contact points may impact measurements significantly.

Strain Plots

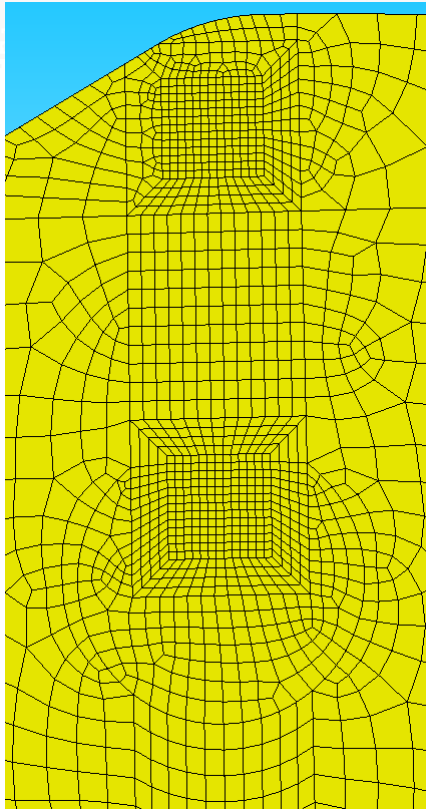


Initial Finite Element Mesh

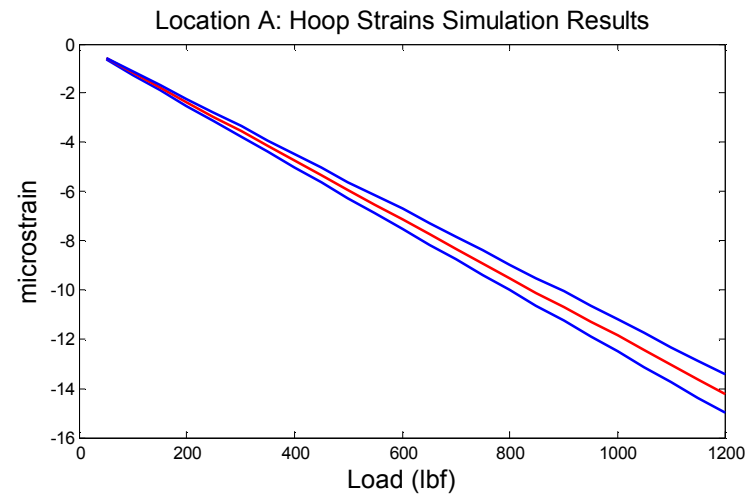
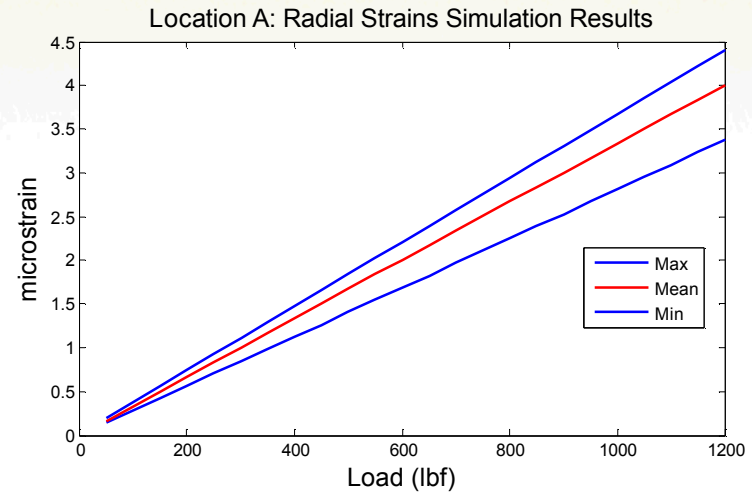


Range of values depending
on element selection

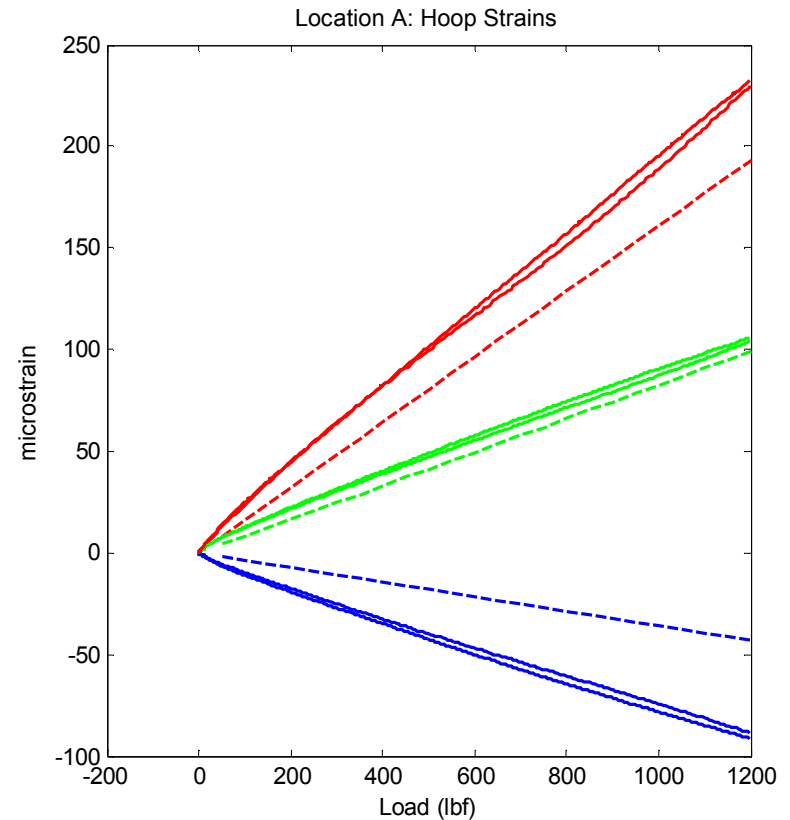
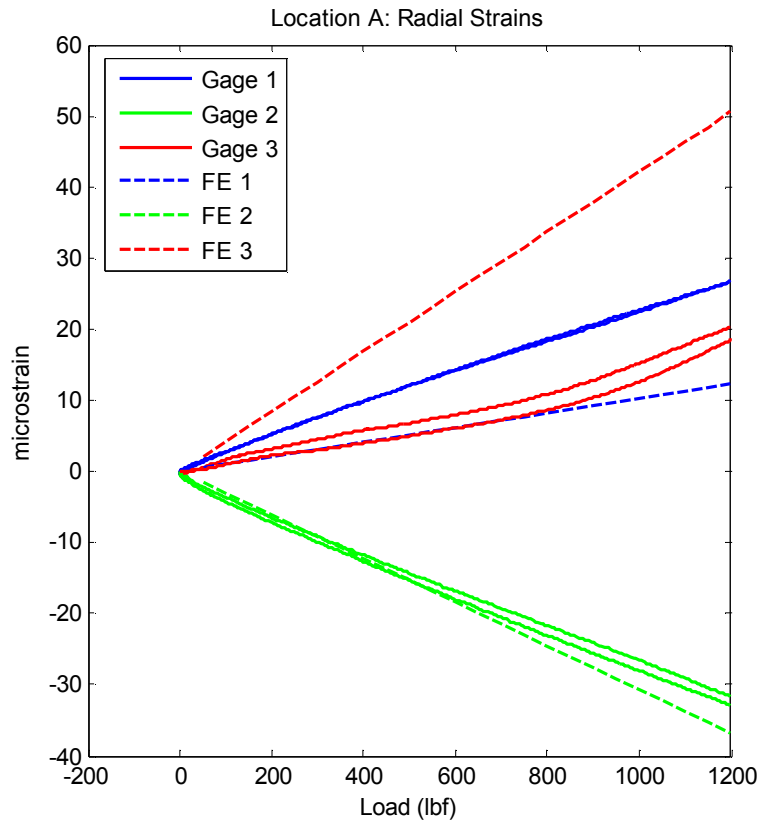
Refined Mesh Around Gage Locations



Elements selected by spatial location to match gage dimensions within each grid for radial and hoop strains.

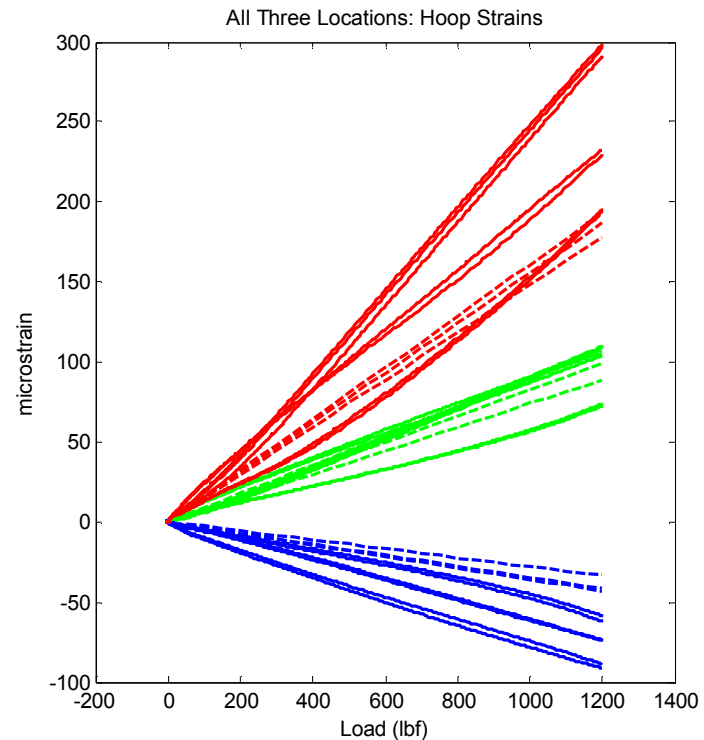
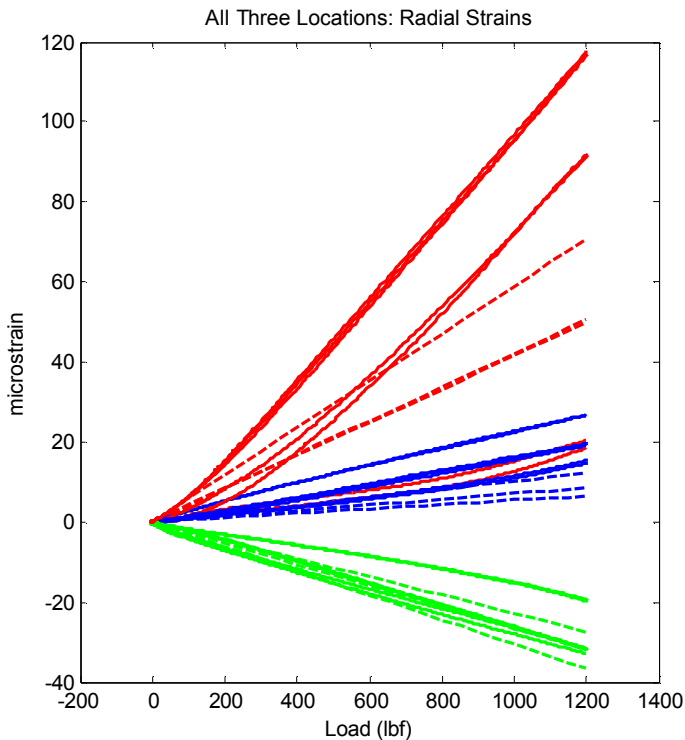


Single Point Loading Strain Plots: Location "A"



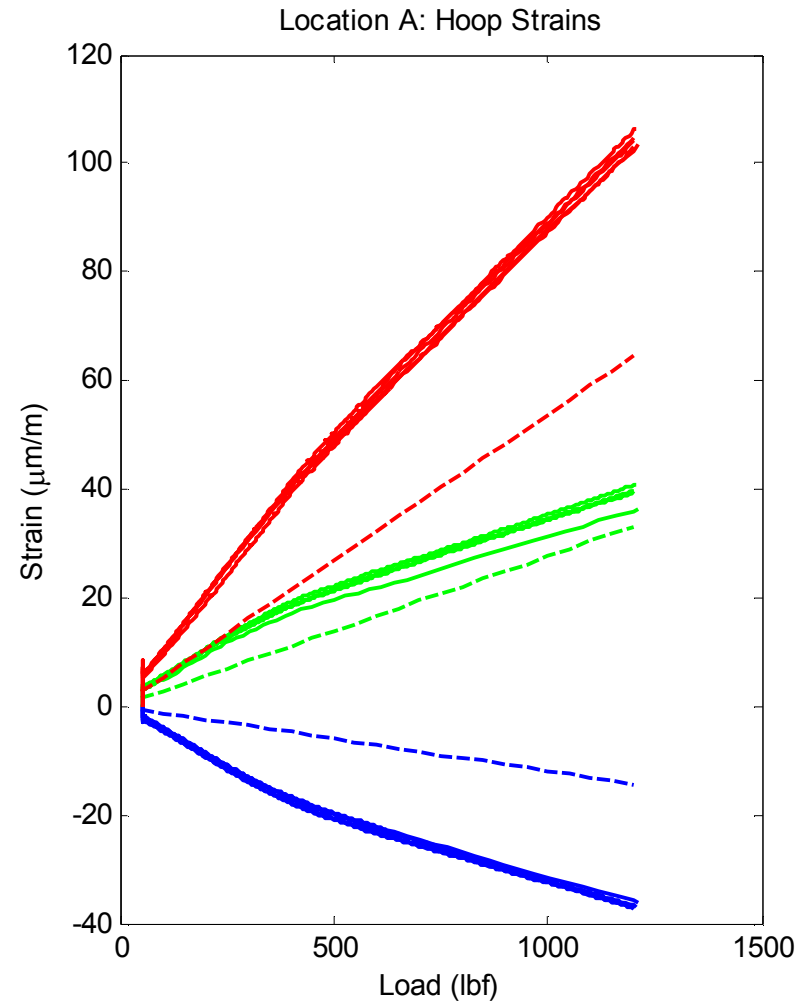
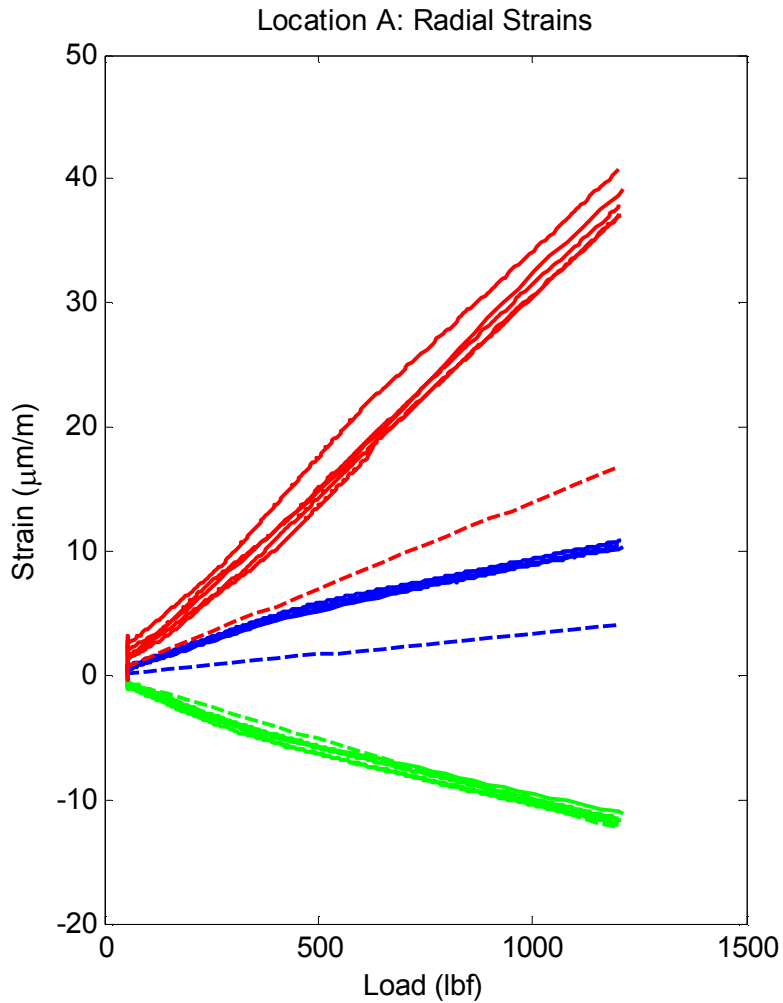
Best match at gage 2, lower outside flange lip.

Single Point Loading, All Locations

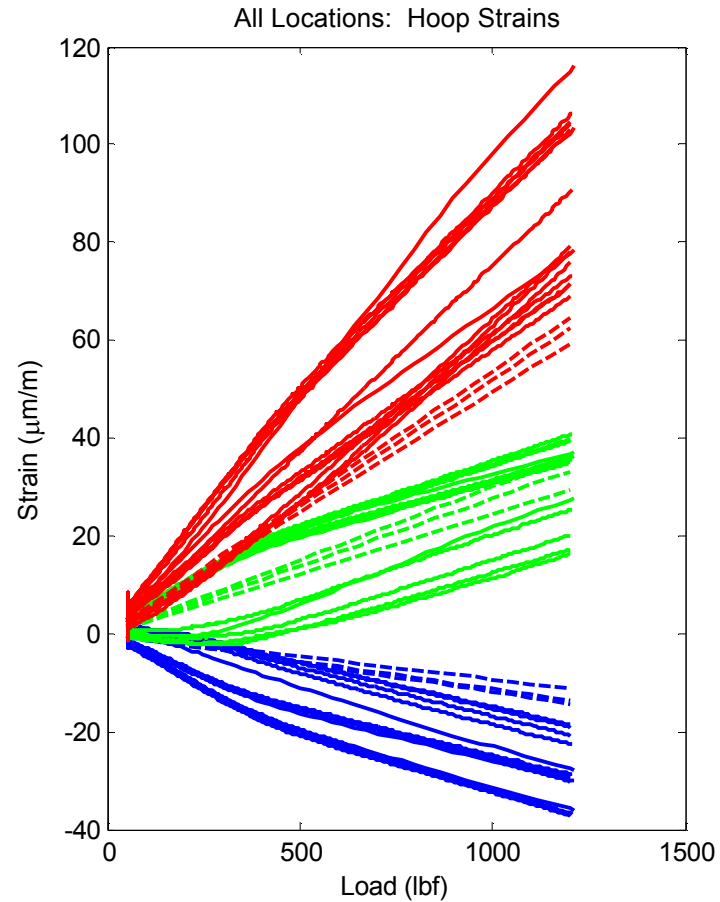
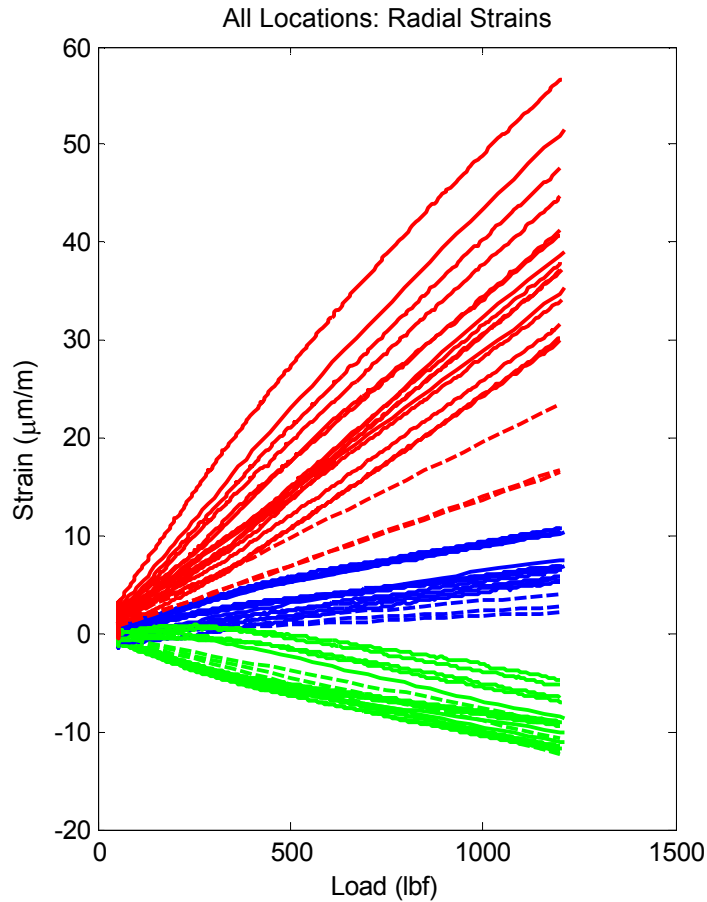


Model generates less response spread at each location than the physical test

Three Point Loading, Location "A"



Three Point Loading, All Locations



Parting Thoughts

- Is the model valid?
 - An a priori requirement was not set, cannot claim validation.
 - Range of deviation is not satisfying.
 - The behavior of the model is better characterized, and qualitatively matches the strain trends.
 - Validation for the particular application may come down to the accepting a hit on the margin of the predictions in meeting the ICD.
- As anticipated at the onset, the boundary conditions, complex geometry, and variable loading conditions make validation difficult in this case.
- Even though validation is not claimed, the model is still exercised in this application in absence of better information.