TITLE SLIDE INSTRUCTIONS

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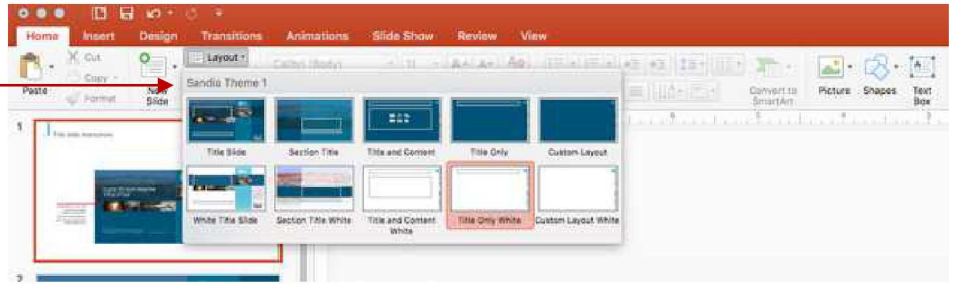
Choose from dark and white background layout options from the "Layout" tab in the menu bar



Title font: Gill Sans MT

Change photos in the slide master by using the "Picture or texture Fill" from the "Shape Options" panel. Choose a photo with similar proportions.

Body text/ support font: Garamond MT

Additional program/partner logos can be added here

Add Sand Number to the funding statement within the Master Title slide

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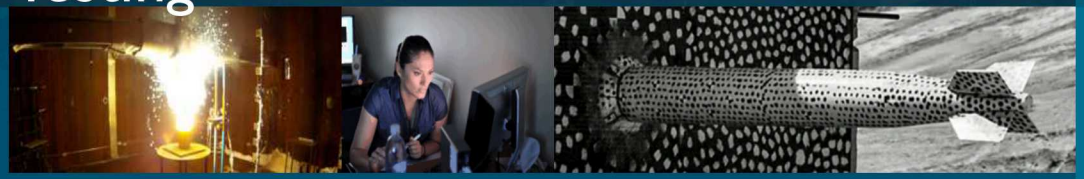
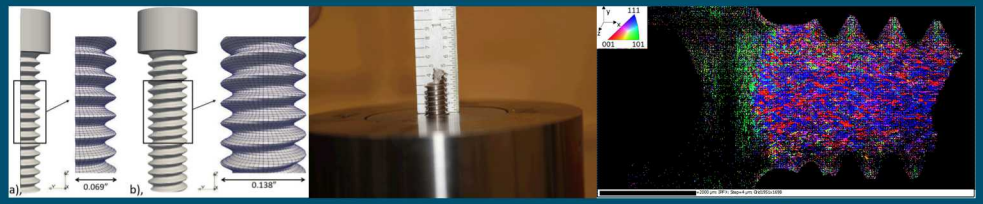
Evaluating the Influence of Size Effects on Load-Displacement Behavior and Failure in Threaded Fasteners, Part I: Experimental Testing





PRESENTED BY

Thomas R. Bosiljevac, PE

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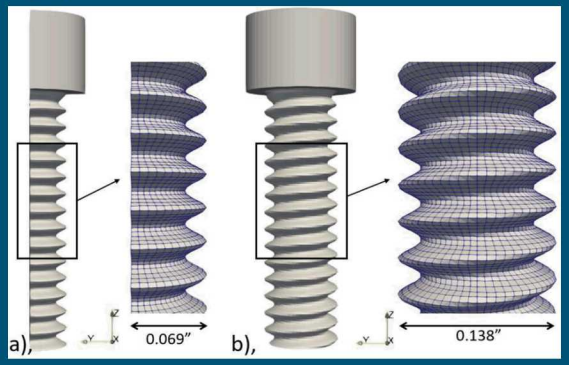
Introduction and Purpose

- Quasi-static load-displacement behavior and failure of small fasteners
  - Experimental tensile testing
  - Provide calibration and validation data for the analysis portion of the study
    - Modeling Empirical Size Relationships on Load- Displacement Behavior and Failure in Threaded Fasteners (Peter W. Grimmer[1], John P. Mersch[1], Jeffrey A. Smith[1]

- Fasteners Tested - A286 stainless steel fasteners
  - NAS1351N00-4 (#00) Diameter = 1.524 mm 0.0015 mm/s
  - NAS1352N02-6 (#02) Diameter = 2.184 mm 0.0022 mm/s
  - NAS1352N04-8 (#04) Diameter = 2.845 mm 0.0028 mm/s
  - NAS1352N06-10 (#06) Diameter = 3.505 mm 0.0036 mm/s
  - NAS1352N4-24 (#4) Diameter = 6.350 mm 0.029 mm/s

- Small fasteners are common components making up jointed connections of various geometrical shapes, sizes, and applications



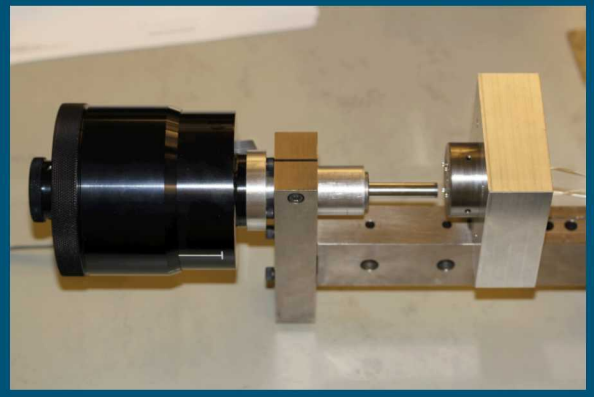
[1] R&D S&E Mechanical Engineering, Component Science & Mechanics, Sandia National Laboratories, Albuquerque, NM

Testing Methodology

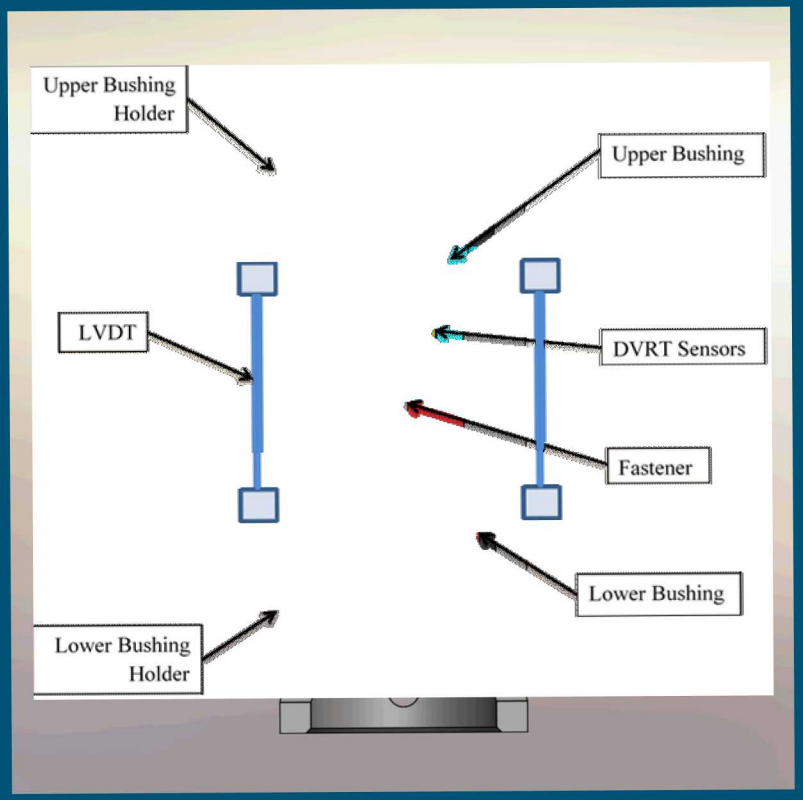
- New test fixture and bushing design
  - Allows a lighter test fixture
    - Reduce preload influence
  - Minimizing compliance issues in the load train
  - Provide robust

- Redesigned test fixture and bushings referenced in the NASM1312-2 Standard
  - 4340 steel heat treated to 42-46 Rockwell hardness (Rc)
  - Bushings designed based upon NAS1351 and NAS1352 datasheets

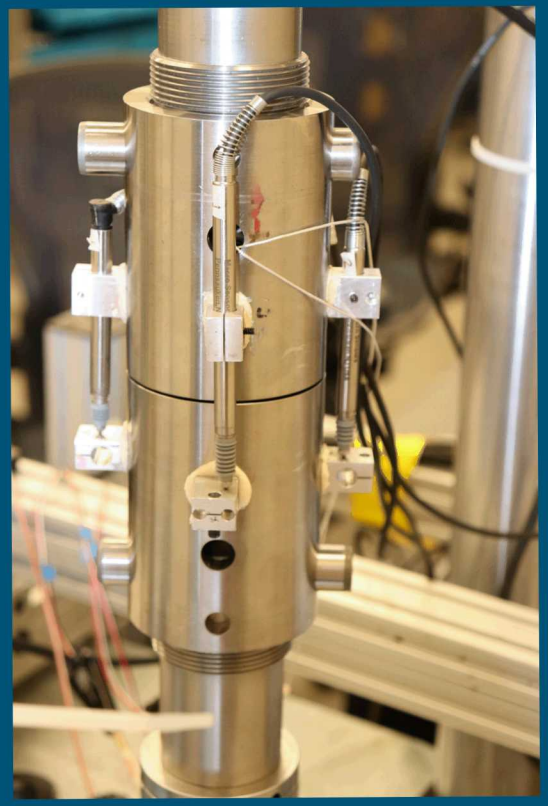
- Allow global and localized displacement measurements to enhance characterization
  - Stroke
  - Linear Variable Differential Transducers (LVDTs) located on the outside edge of the bushing fixtures to measure a more global response and monitor rotational movement
  - Differential Variable Reluctance Transducers (DVRTs) to measure the relative displacement of the bushing faces (1.5 mm high resolution stoke & 1.5 μm resolution)



Fixturing/Test Setup



Test Fixture



Test Fixture

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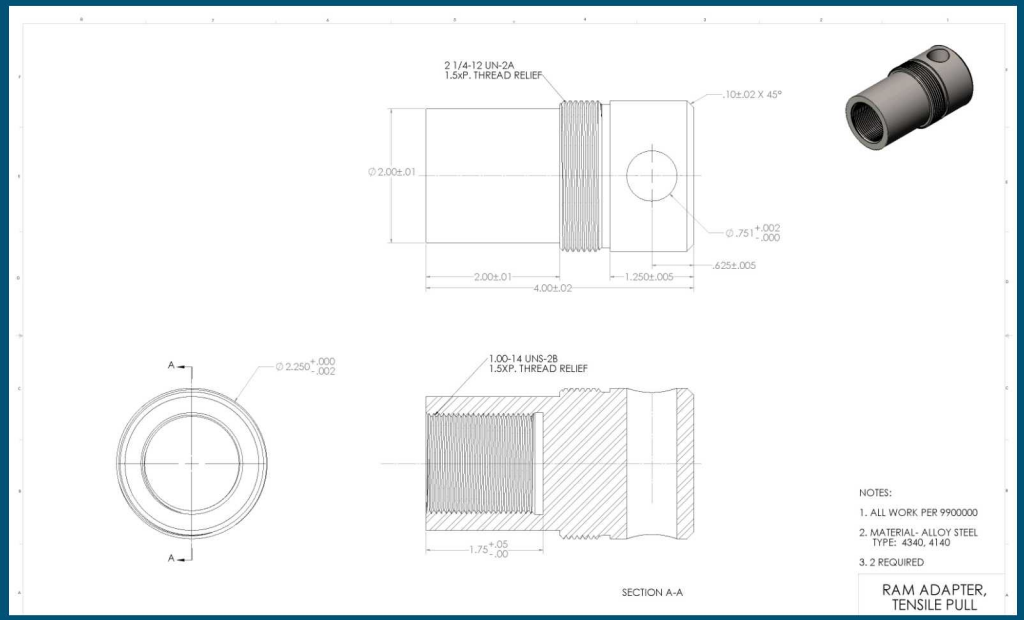
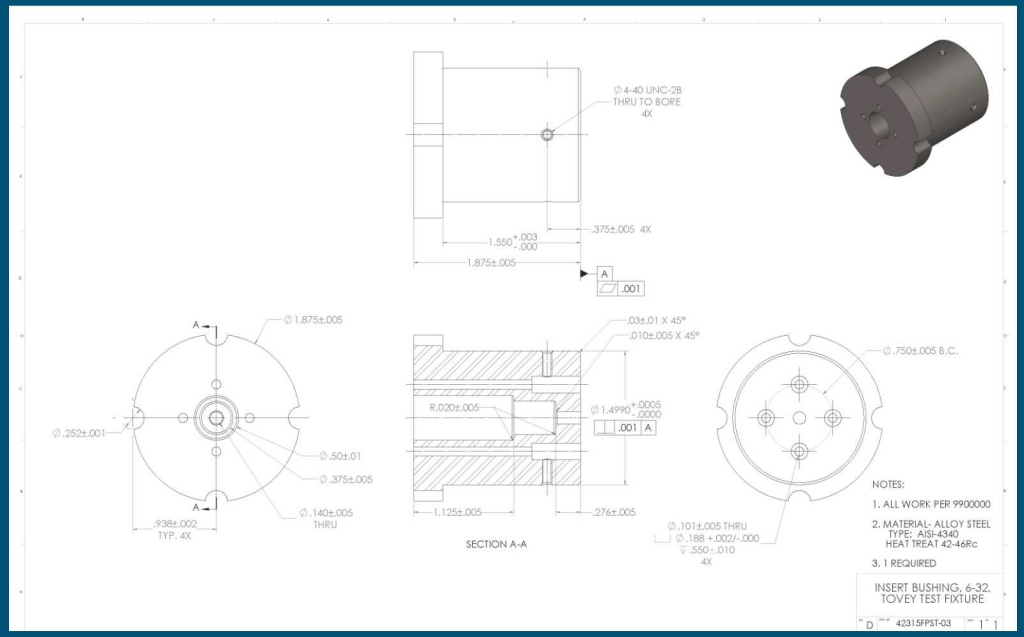
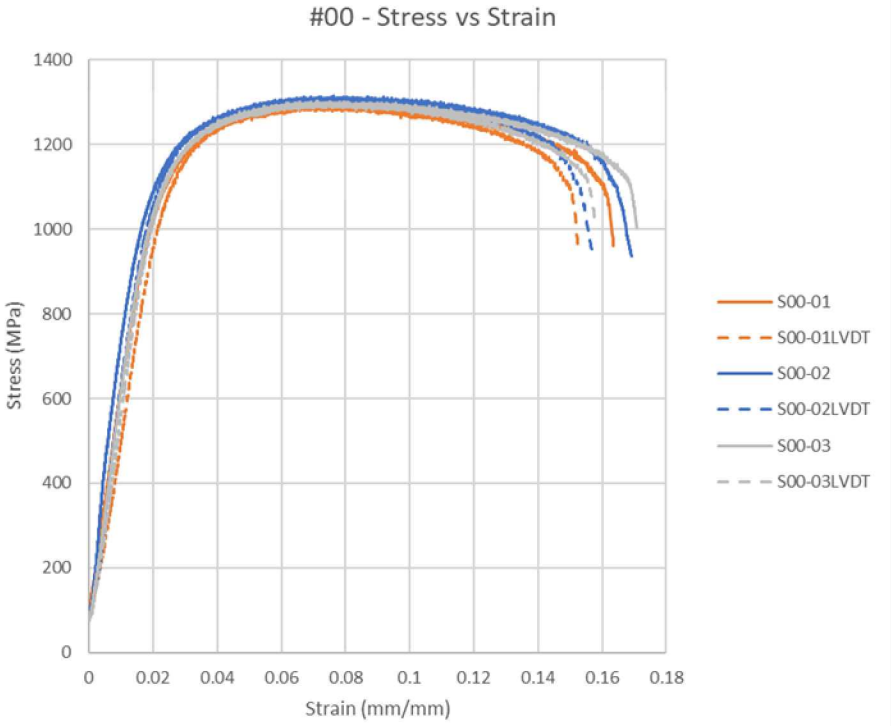
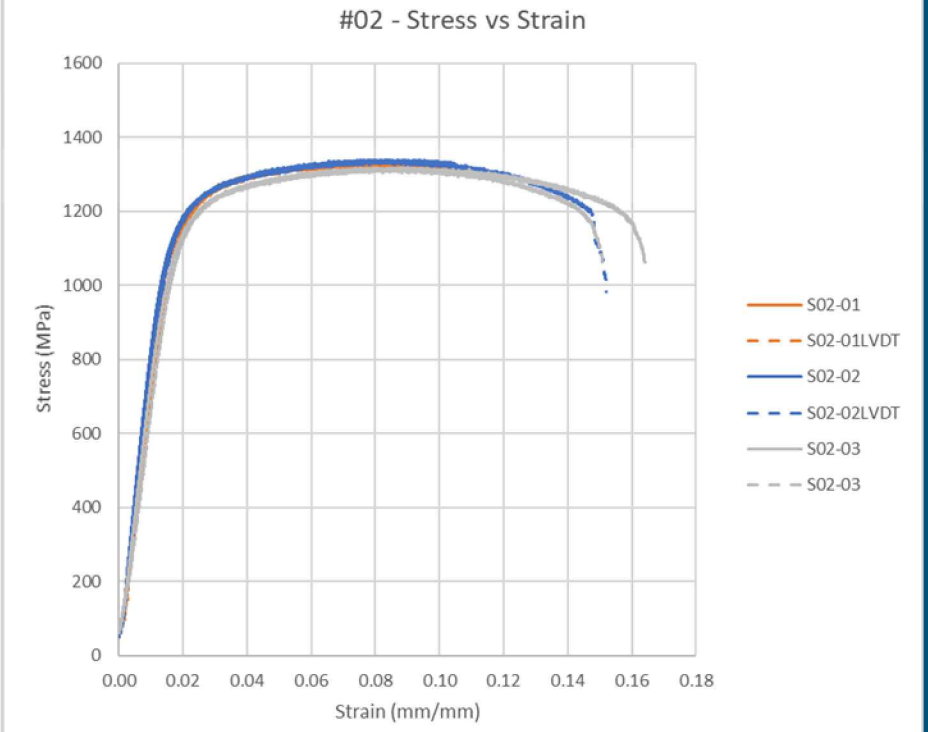




Data Reduction





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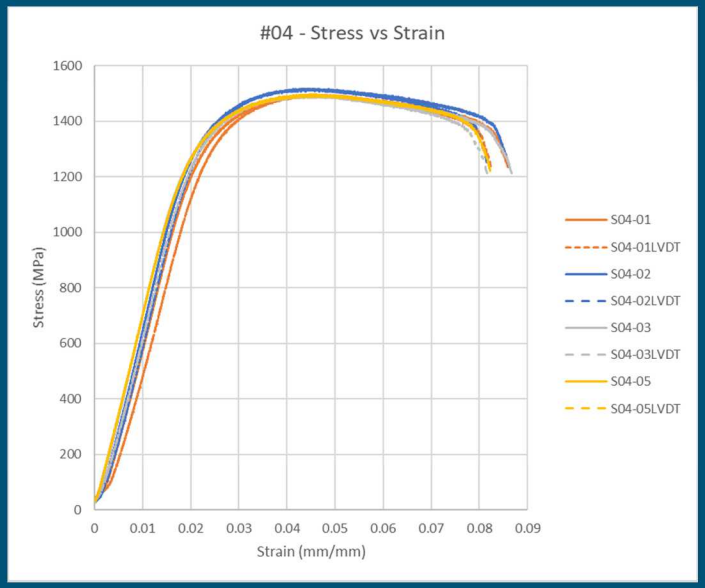

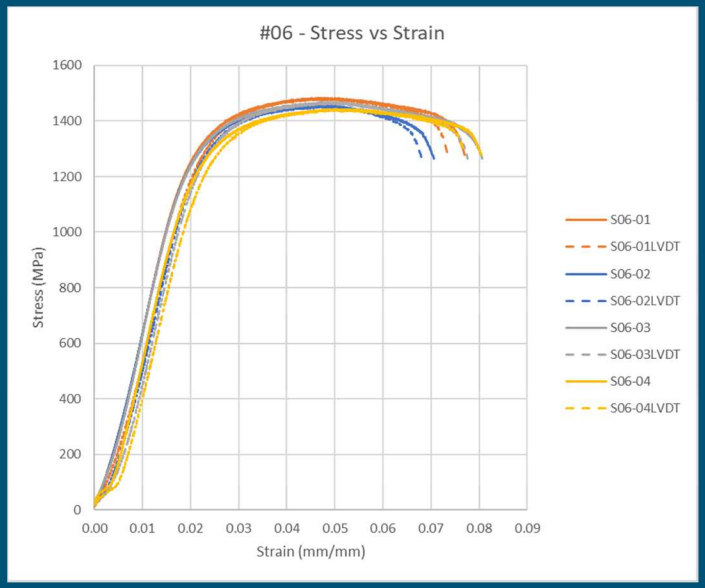

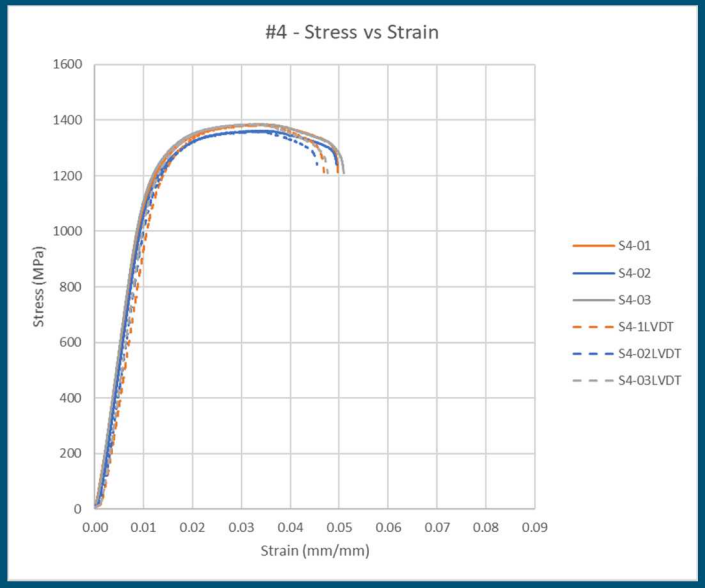

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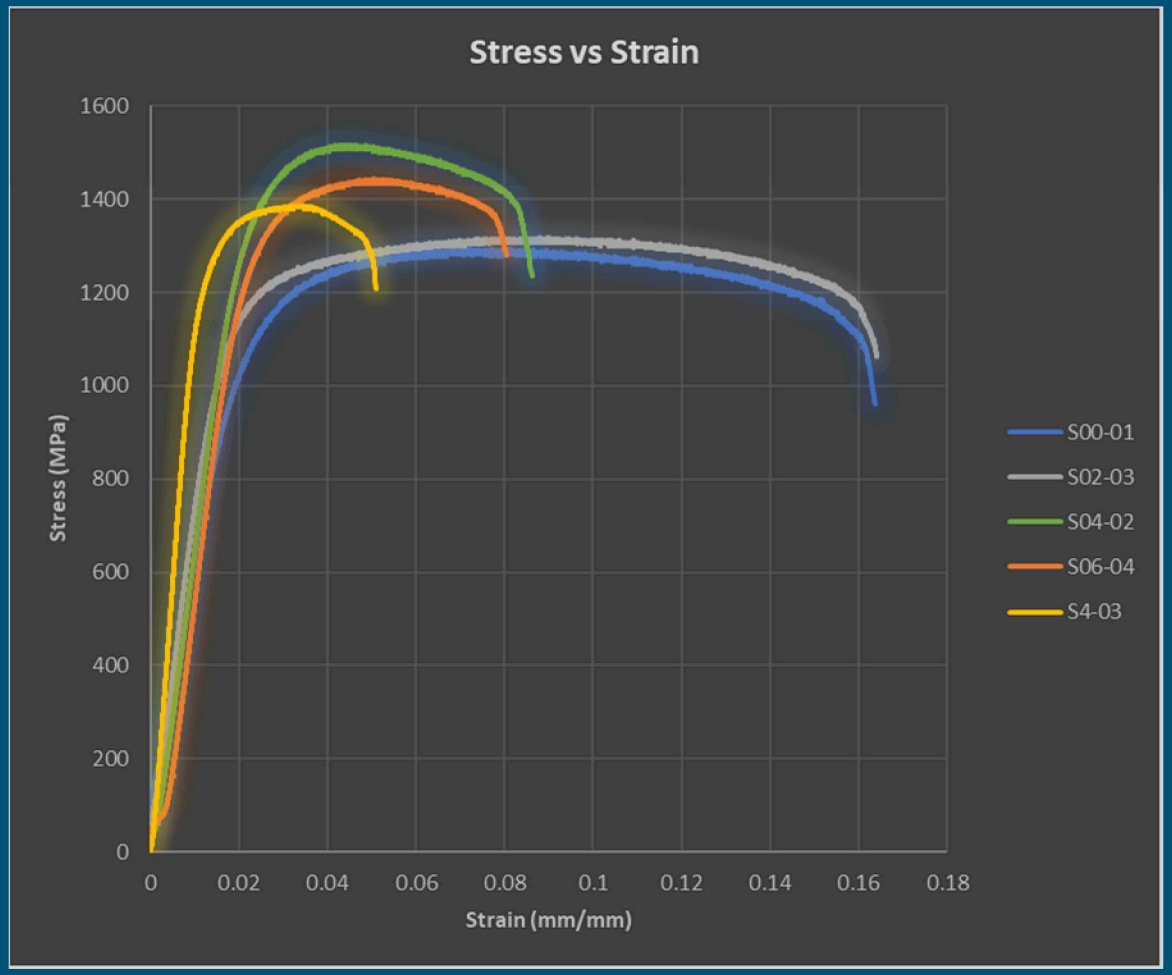
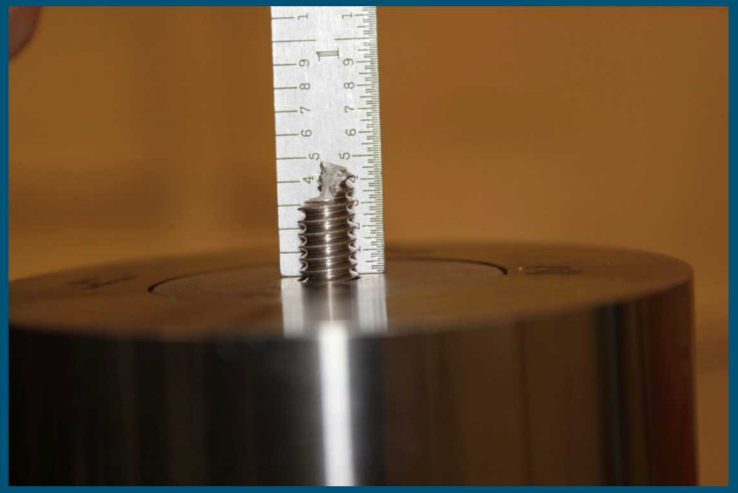
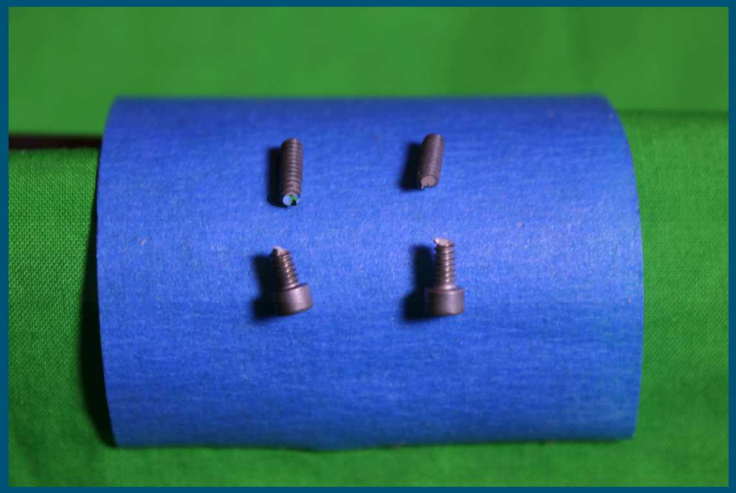
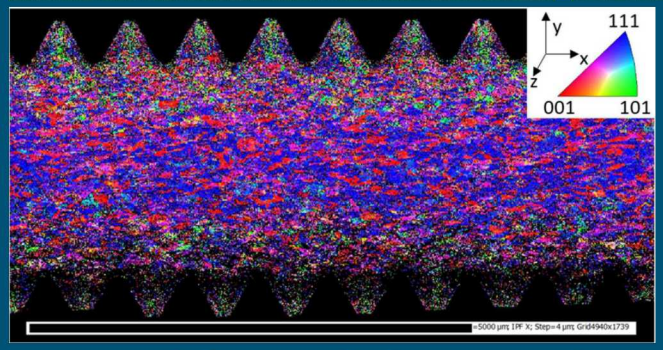


Post-Test Images





Post-Test Images



Electron Backscatter Diffraction (EBSD) Analysis
(Yuriy Veytskin, PhD)

- Most common type of fracture being a step fracture occurring over two threads
  - The smaller sizes show closer to a 45° fracture to the loading axis, which is often the case in ductile materials that tend to have more necking than in brittle materials
- The largest size, #4 shows a 90° failure plane
- Helical geometry of the threads introduce a complexity which alter traditional interpretations of specific angles associated with ductile or brittle fracture
  - The presence of threads promote failures to occur at thread roots and alters the fracture paths that would otherwise been seen in thread-less geometries.
  - Discontinuous step fractures across thread roots were observed

Results/Conclusion

- Trends for these tests can be difficult to evaluate in load-displacement space because the area and gage length vary amongst the different size fasteners.
  - Load-displacement responses were converted to stress-strain using the threaded tensile stress area calculation referenced in ASME B1.1-2003 [7]
  - Gage length of the tested fastener based on the cap head seat distance of each sensor bushing.
  - The stress-strain curves provide clear insight related to the size relationship on load-displacement behavior and failure in the threaded fasteners.
- Lower peak stresses and ductility in the #00 and #02
- Consistency/repeatability in small fastener tests up to peak stresses
- Strain measurements deviate at failure between the DVRTs and LVDTs
  - Offset by approximately 0.01 mm/mm
- Energy absorption based on the area under the curve can be calculated per Simpson's Rule
  - Used to predict failure
- Forthcoming:
  - A microstructural analysis based on electron backscatter diffraction (EBSD) images
  - Variations (#00, #02 and #04, #06, #4) motivated a microstructural investigation
  - Structure-property relationships

Section Break Slide