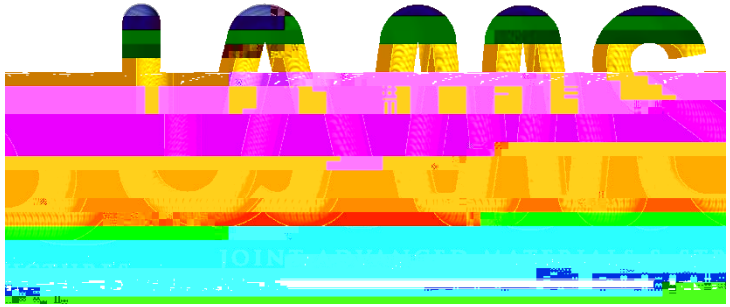


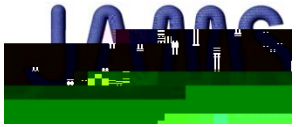
Development of Dynamic (DMA) Calibration and Testing Procedures

Development of Dynamic Mechanical Analyzer (DMA) Calibration and Testing Procedures

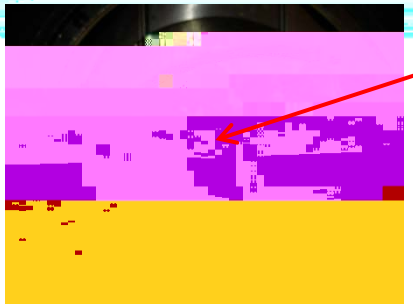
- Principal Investigators & Researchers
  - John Tomblin, PhD, NIAR/WSU
  - Matthew Opliger, NIAR/WSU
  - Yeow Ng, NIAR/WSU
- Technician & Research Engineer
  - Ping Teoh
- FAA Technical Monitor
  - David Westlund
- Industry Participation
  - Joy Wu, Hexcel
  - Chuck Olson, Cytec
  - Grant Pomering, Intec
  - George Parker, Boeing
  - John Moylan, Delsen

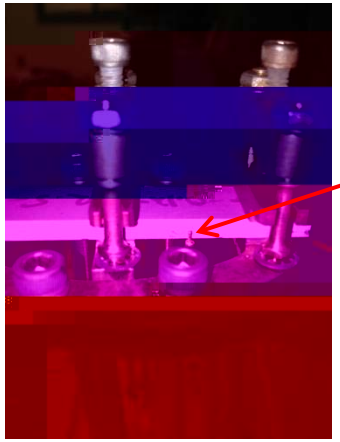
Development of Dynamic Mechanical Analyzer (DMA) Calibration and Testing Procedures

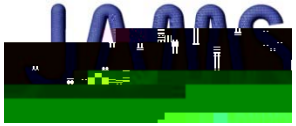
- Objective
  - Reduce the lab-to-lab and equipment-to-equipment variability of Tg measurements by developing universal guidelines for temperature calibration and testing procedures for DMA equipment to enhance pre-existing testing standards.
  - Improve industry applications and safety
    - Material service temperature definition
    - Quality control



Thermocouple Location – Test Configurations







Thermocouple Location – Test Results

50mm 3-Point Bend Fixture

Approximate Location of Furnace Wall

Thermocouple Location – Conclusion

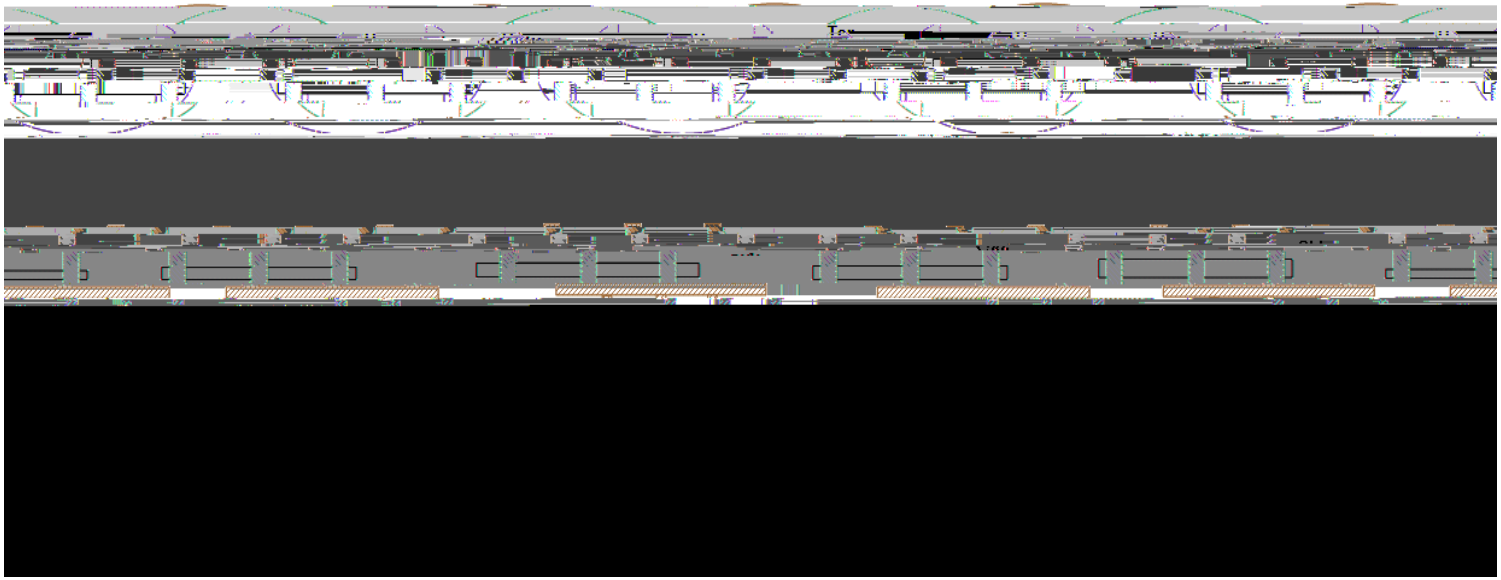
- Thermocouple (TC) Location Evaluation
  - Significant differences between TC locations
  - The fixture acts has a heat sink, affecting heat transfer to the sample. This is evident by low Tg values observed at TC1 and TC2.
  - The proximity of the test specimen to the furnace becomes more critical at higher temperatures
- Recommend TC3 Location
  - LocationsTC2, TC4, and TC6 can result in a damaged TC if a highly deformable material is tested.
  - Location TC3 is least affected by the fixture heat sink and furnace proximity.
  - Tg values obtained at TC3 were in the top half of all TC locations

Specimen Dimensions

- Specimen Dimensions Evaluation
  - Determine if specimen dimensions affect Tg
    - Evaluate changes in thickness
    - Evaluate changes in width
    - Evaluate changes in length
  - Possible effects include
    - Thermal lag
    - Specimen stiffness

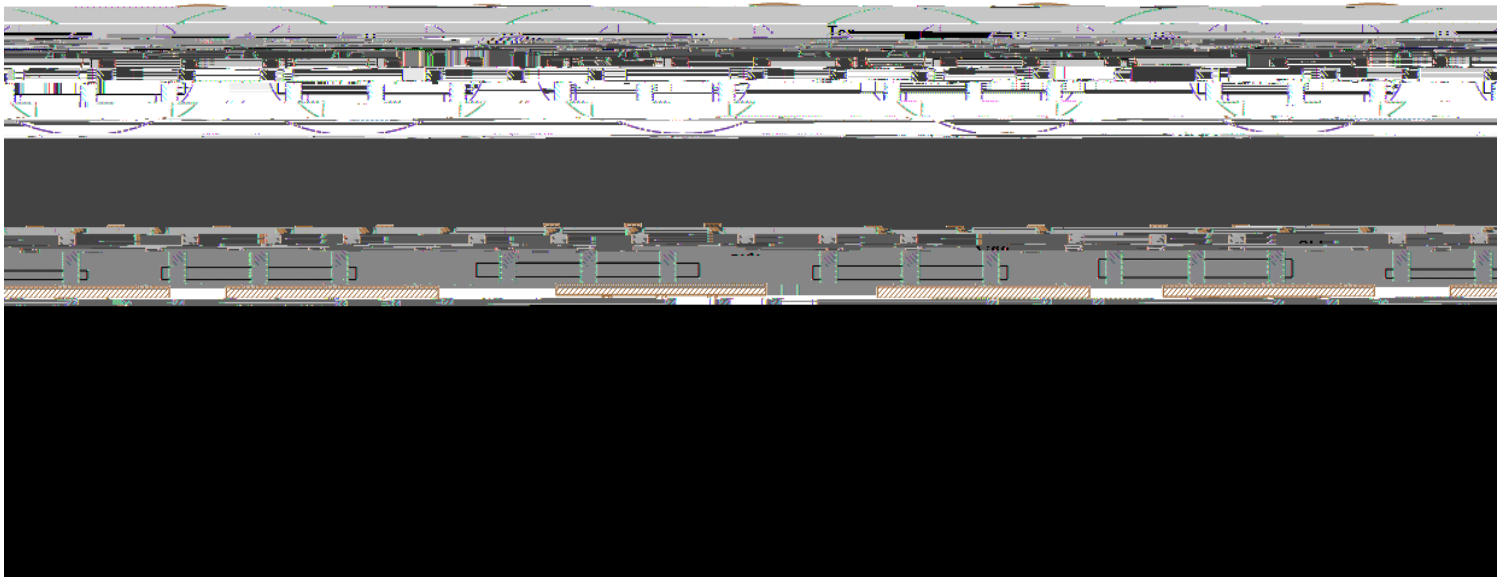
Specimen Dimensions – Test Configurations

Figure 2



Specimen Dimensions

Figure 2



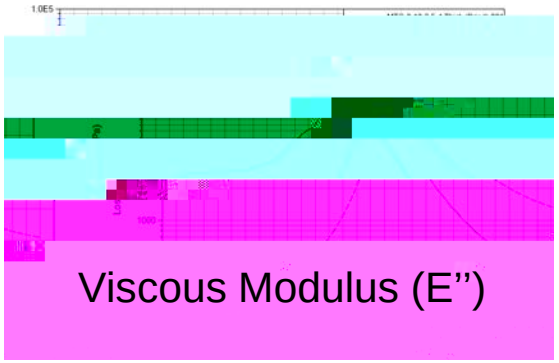
Specimen Dimensions – Conclusion

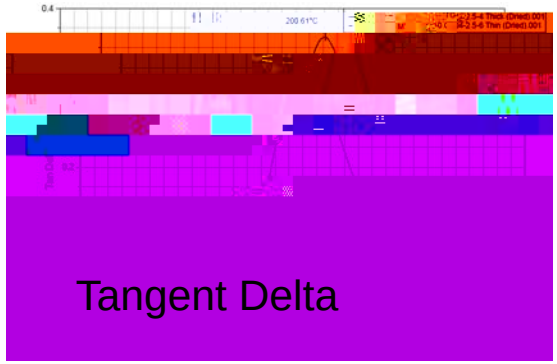
Thickness dependent material behavior

0.12” (Thick) ——————

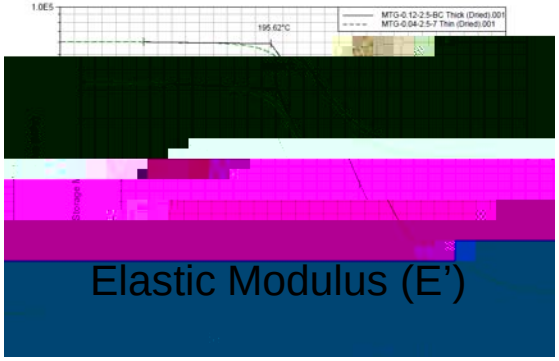
0.04” (Thin) - - - - - - -

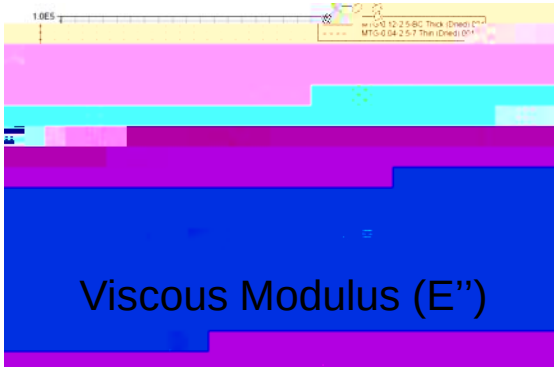
50mm 3-Pt Bend Fixture

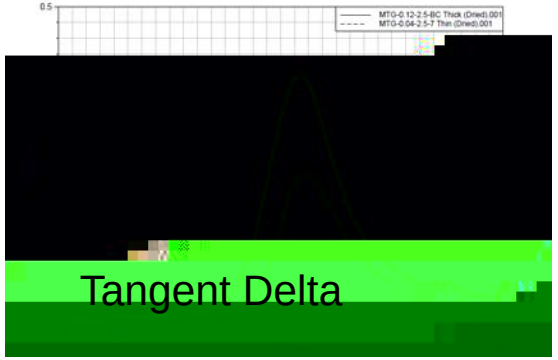




35mm Dual Cantilever Fixture

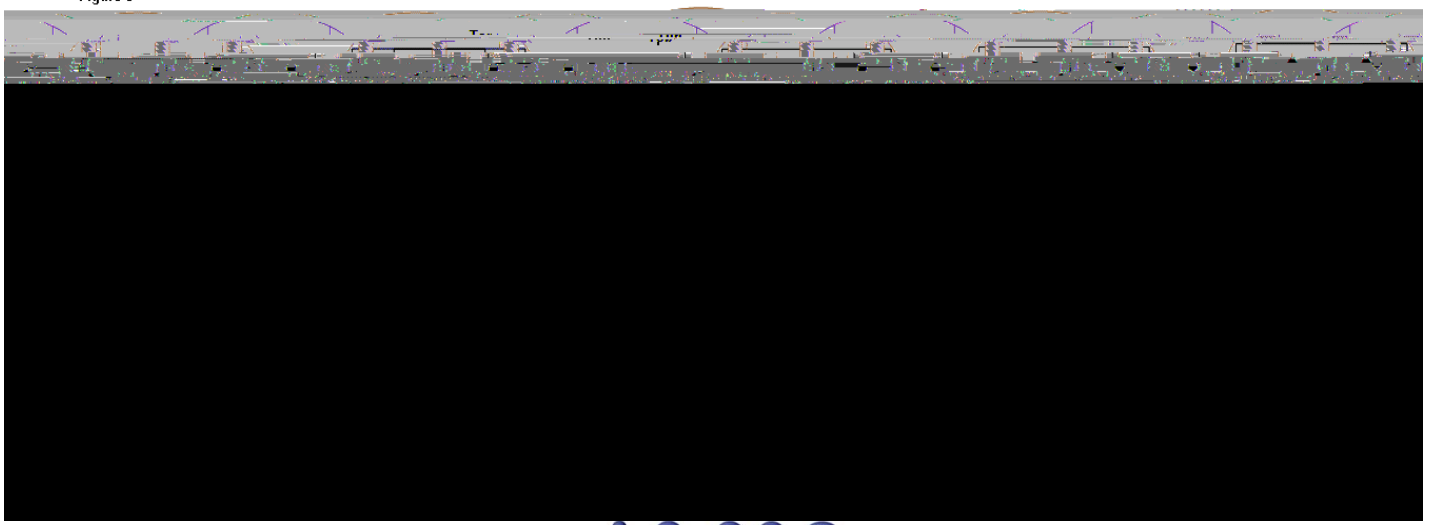






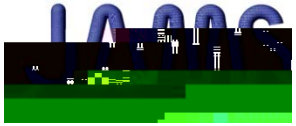
Temperature Calibration – Support Dimensions & Configurations

Figure 3



Temperature Calibration – Support Material

Temperature Calibration – Support Material, Test Results



Development of Dynamic Mechanical Analyzer (DMA) Calibration and Testing Procedures

- Development of Calibration and Testing Procedures
  - Utilized data from the DMA evaluations
    - TC location
    - Specimen dimensions
    - Span support dimensions/configuration
    - Span support material
  - Distributed new calibration and testing procedures and materials to labs for round robin testing for evaluation of procedures.
    - Low-to-high Tg materials are being evaluated

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Inter-Laboratory Testing – Test Results

- Round Robin Test Results
  - Tests have been completed from three of the six labs

    The standard deviation of the dry tested samples is much improved from the ASTM D 7028 round robin.

    The standard deviation of the wet tested samples is worse than that obtained from the ASTM D 7028 round robin.

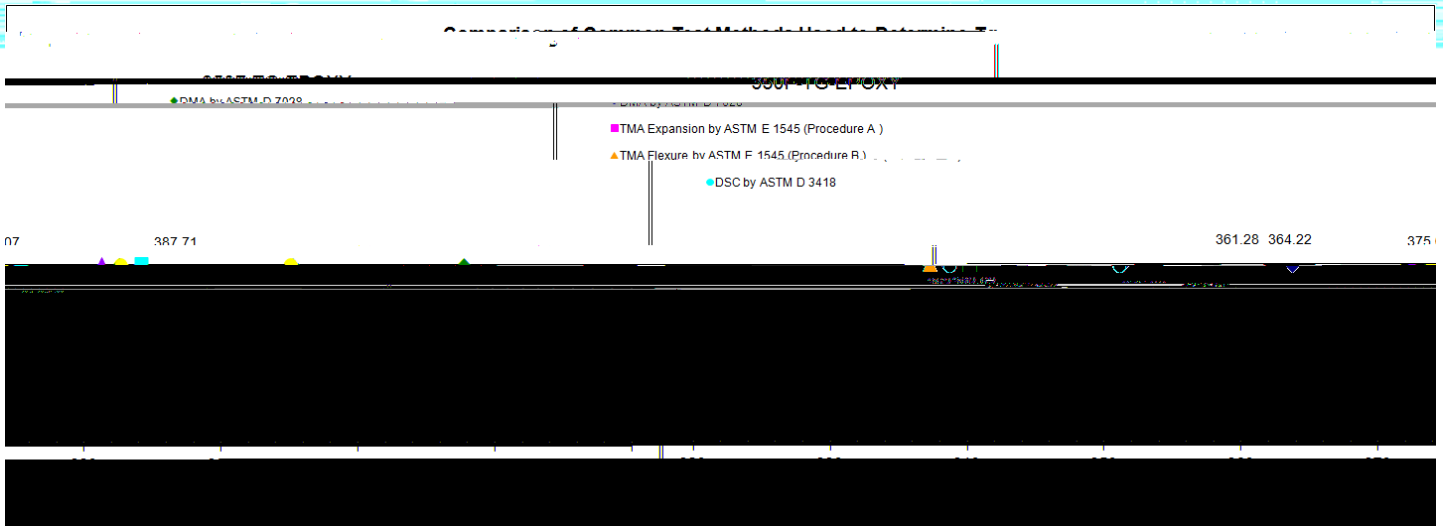
    Two of the labs required relatively thin (0.06”) samples and the third and remaining labs are using a relatively thick (0.12”) sample.

    There is reason to believe that the thin samples lost more moisture than the thick samples before the Tgrruc

Comparison to DSC & TMA Techniques

Comparison to DSC & TMA Techniques – Test Results

Comparison to DSC & TMA Techniques – Test Results



Looking Forward

- Benefit to Aviation