

NCSX
Short Race-Track Coil Test
At LN2 Temperature

13-May-2004

Test Objective

- Performed cyclic fatigue test of short race-track coil sample SRT3 at liquid nitrogen temperature.
- Goal:
 - 130,000 fatigue cycles at 2X expected strain.
 - Maintain sample at LN2 temperature.
 - Measure sample parameters before, during and after fatigue cycles.

Test Procedure

- Cool down sample coil and test fixture to LN2 temperature.
- Characterize sample coil with several slow pulls before, after and at several points during fatigue cycles.
- Fatigue cycle at high cycle rate (3.8 Hz max) and 15,000 lbf peak load.

Test Sequence

- Cool down coil and fixture
- First slow cycle to 20,000 lbf
- Second slow cycle to 20,000 lbf
- 65,000 rapid cycles to 15,000 lbf
- Slow cycle to 15,000 lbf
- 35,000 rapid cycles to 15,000 lbf (100,000 cycles total)
- Slow cycle to 15,000 lbf
- 50,000 rapid cycles to 15,000 lbf (130,000 cycles total)
- Slow cycle to 15,000 lbf
- First slow cycle to 20,000 lbf
- Second slow cycle to 20,000 lbf
- 20,000 rapid cycles to 15,000 lbf (150,000 cycles total)
- Warm up coil and fixture

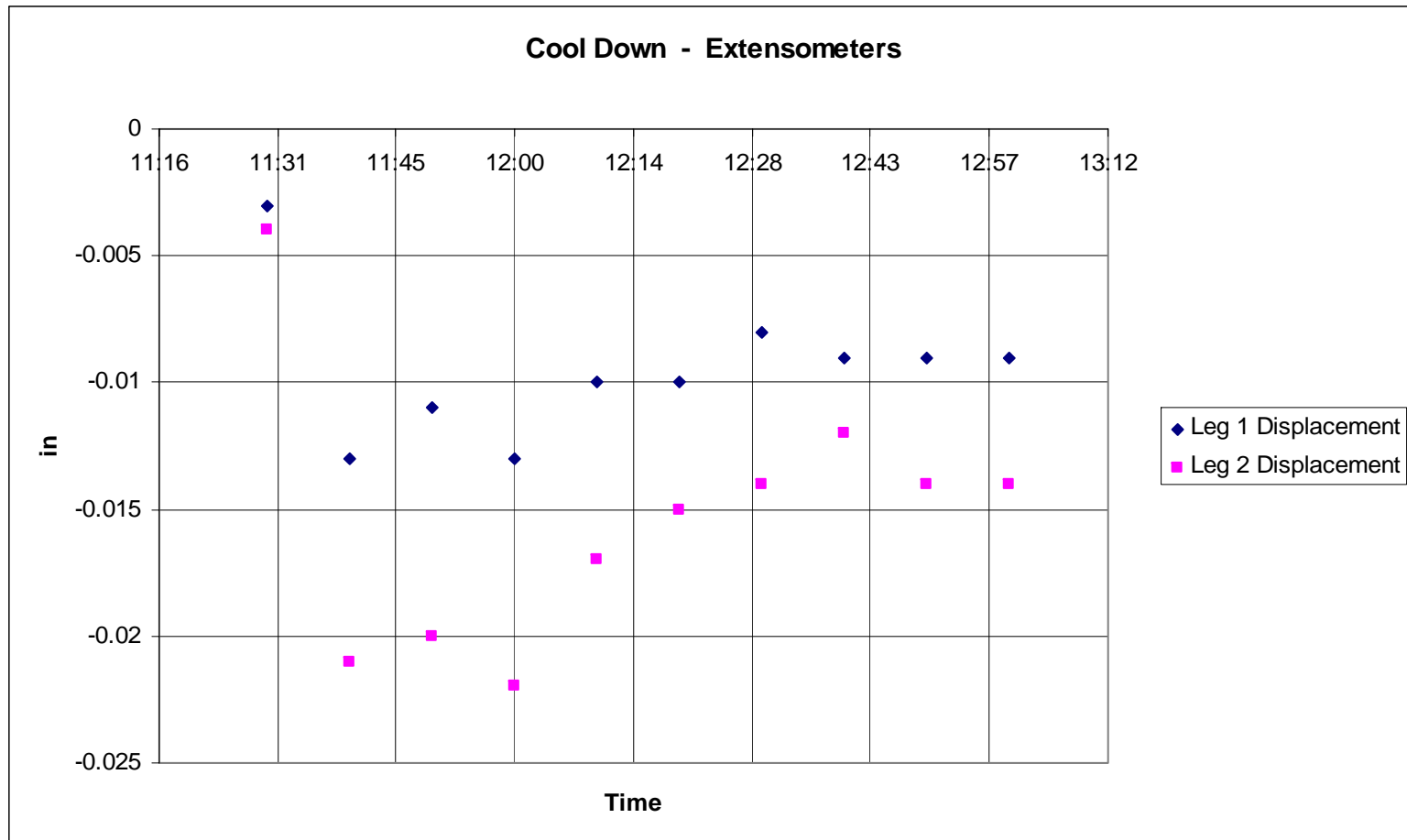
Test Data

- For stress and modulus calculations used area equal to copper core area plus two layers of 0.007" glass on all sides of core.
- Single conductor area = 0.130 sq in
- Total sample coil area = 1.040 sq in

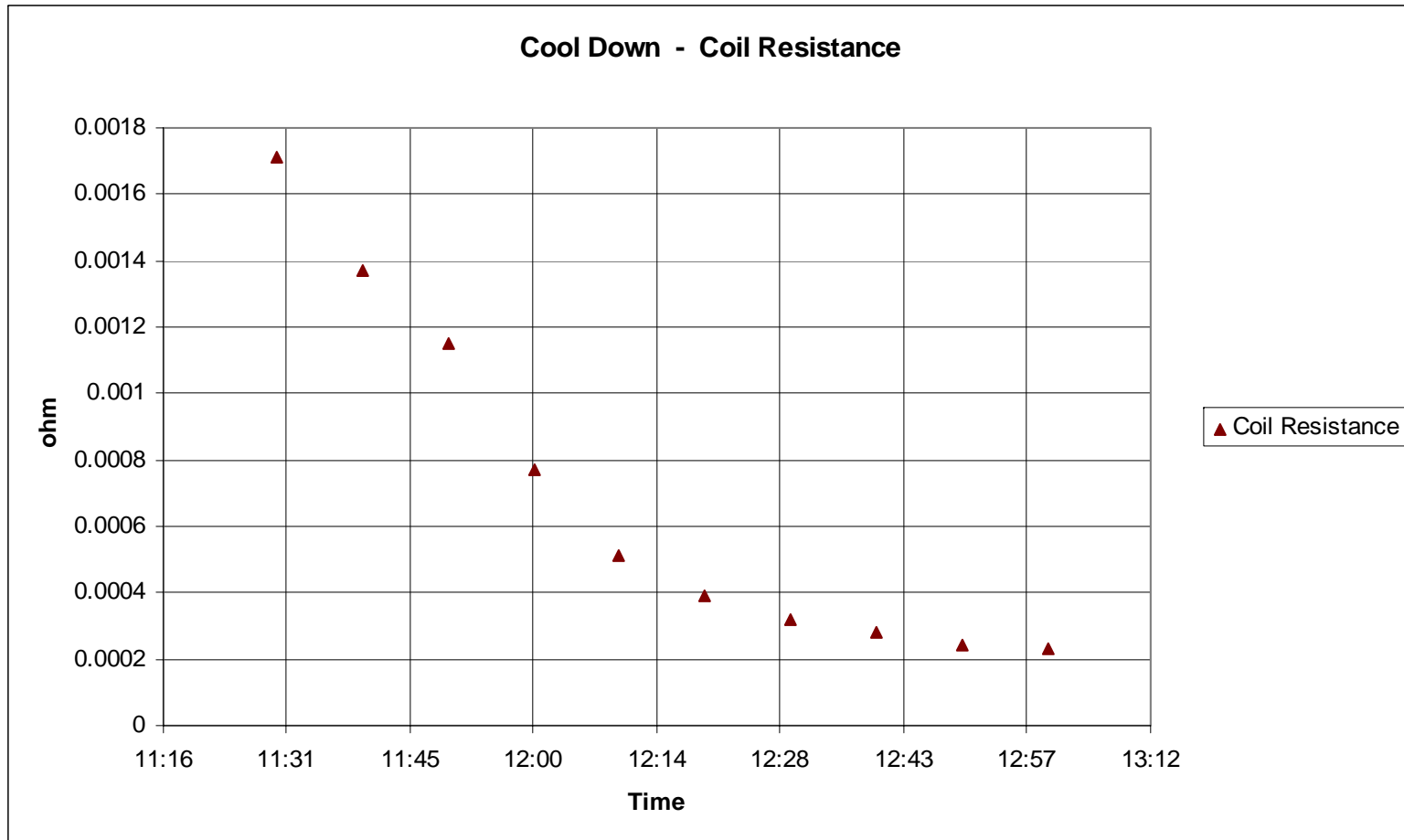
Test Fixture



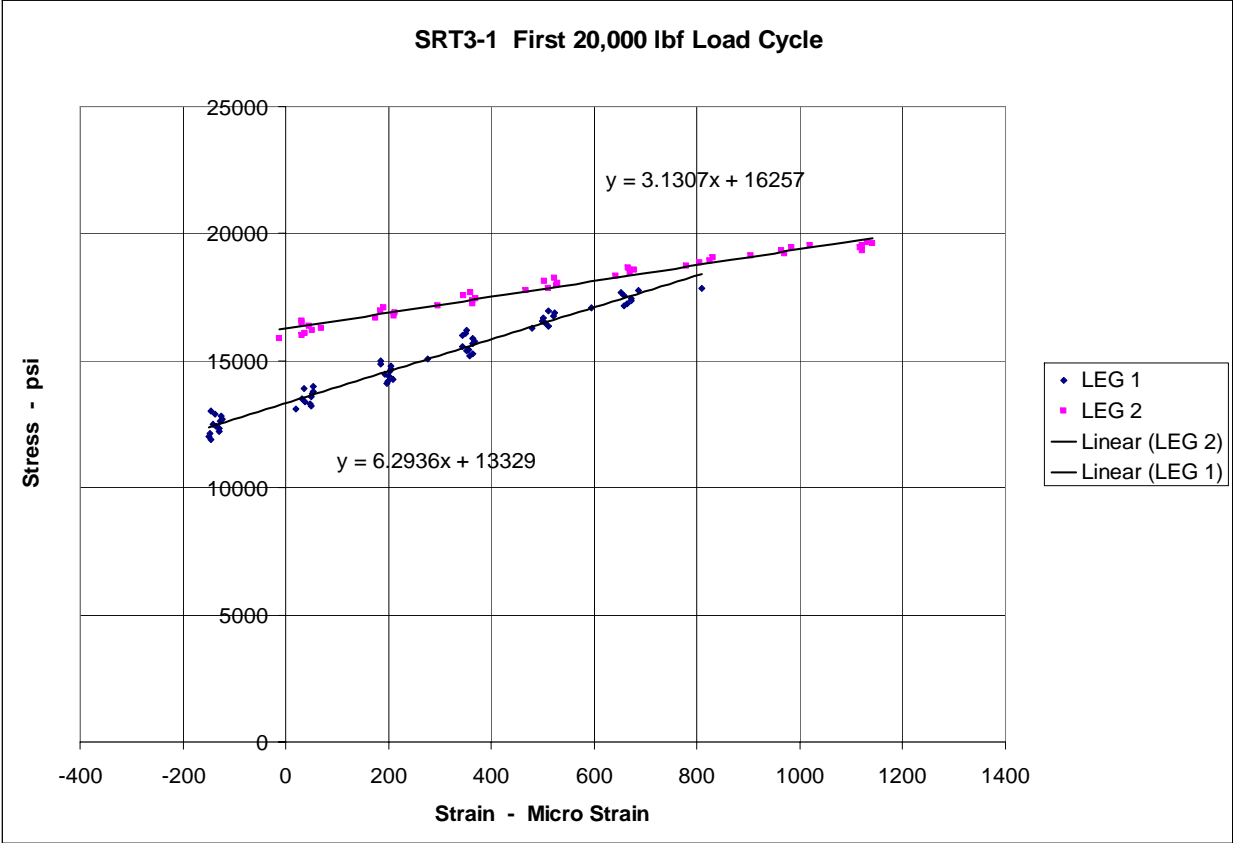
Sample Cool Down

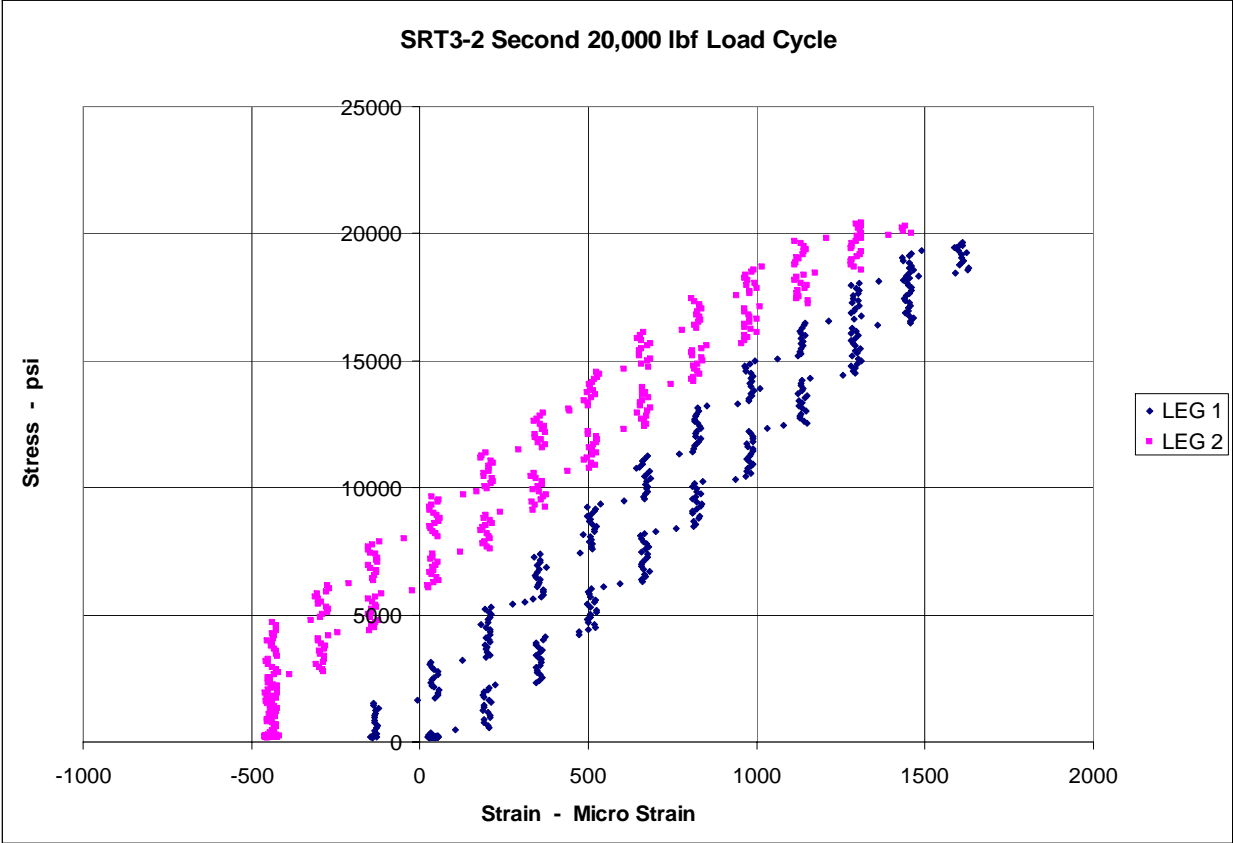


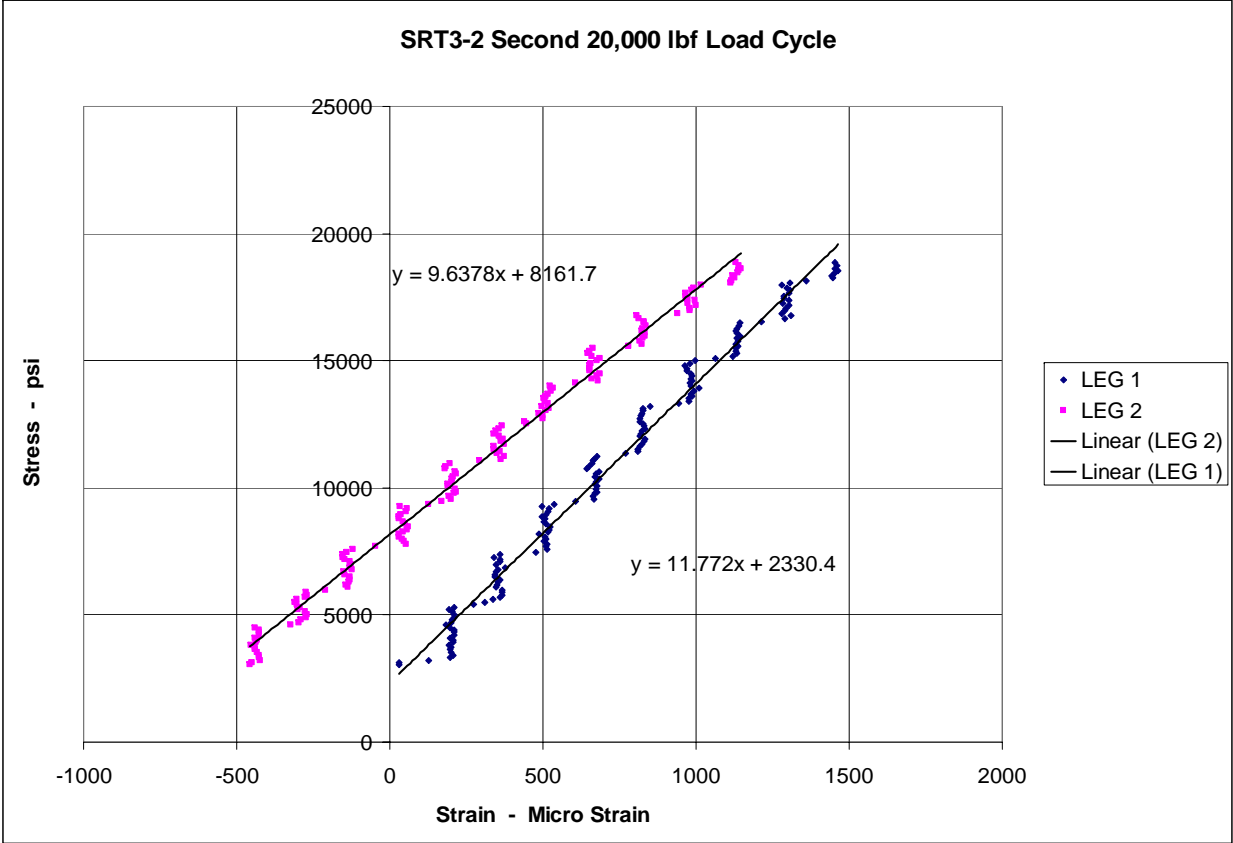
Sample Cool Down

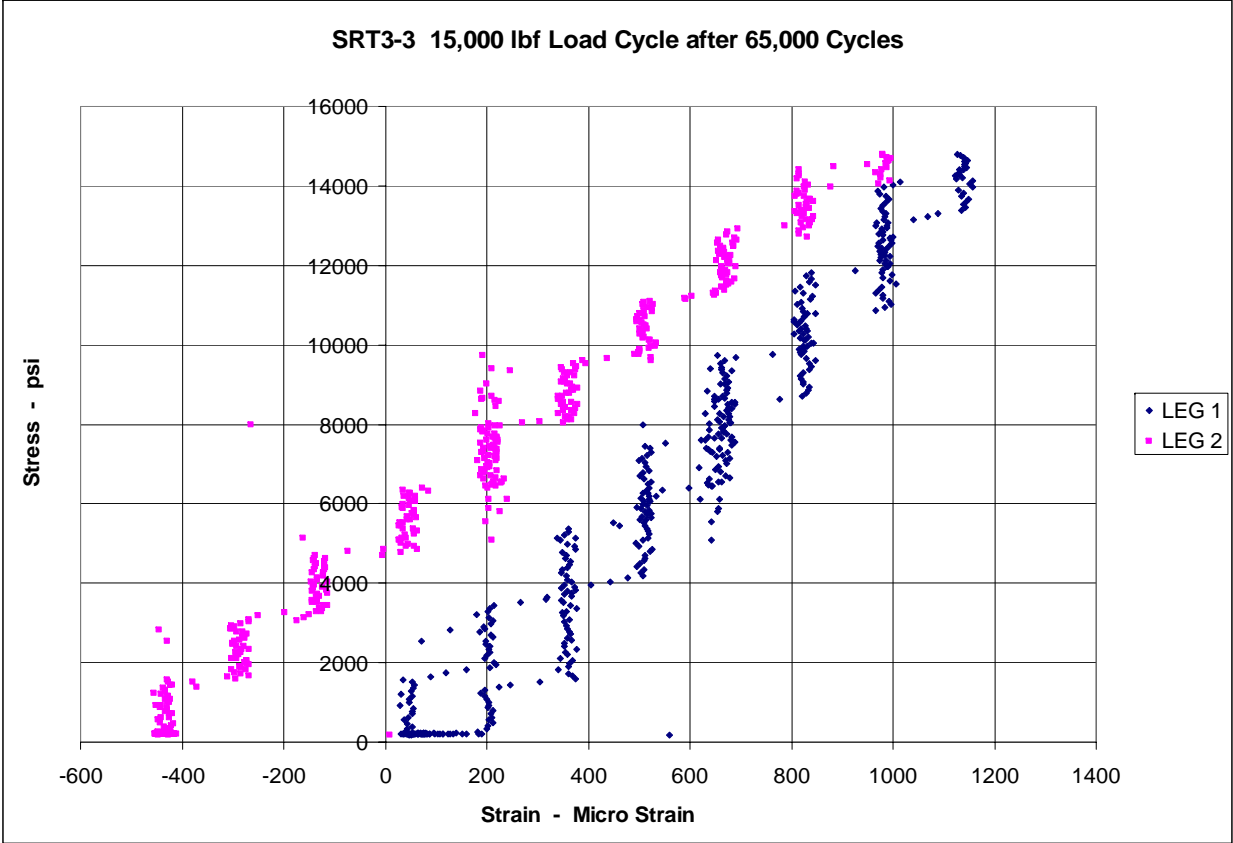


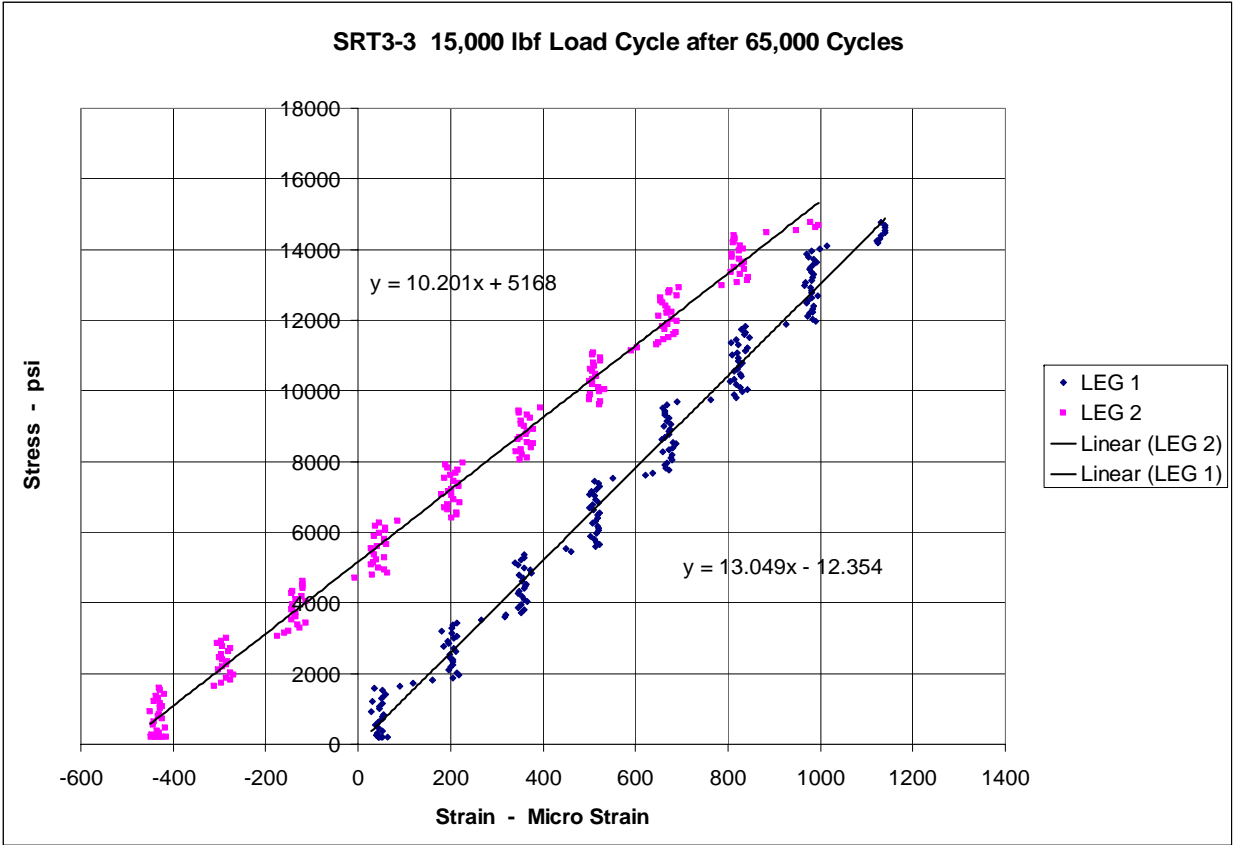


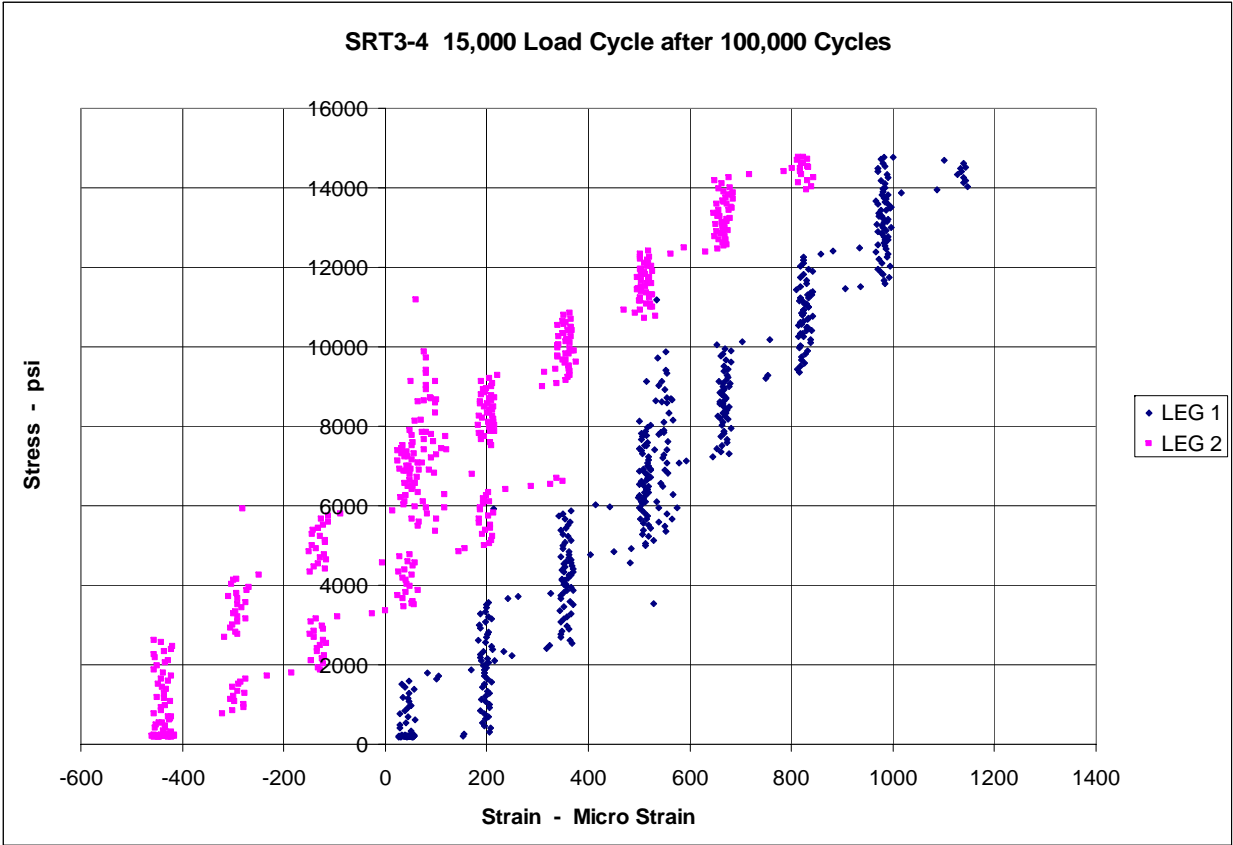


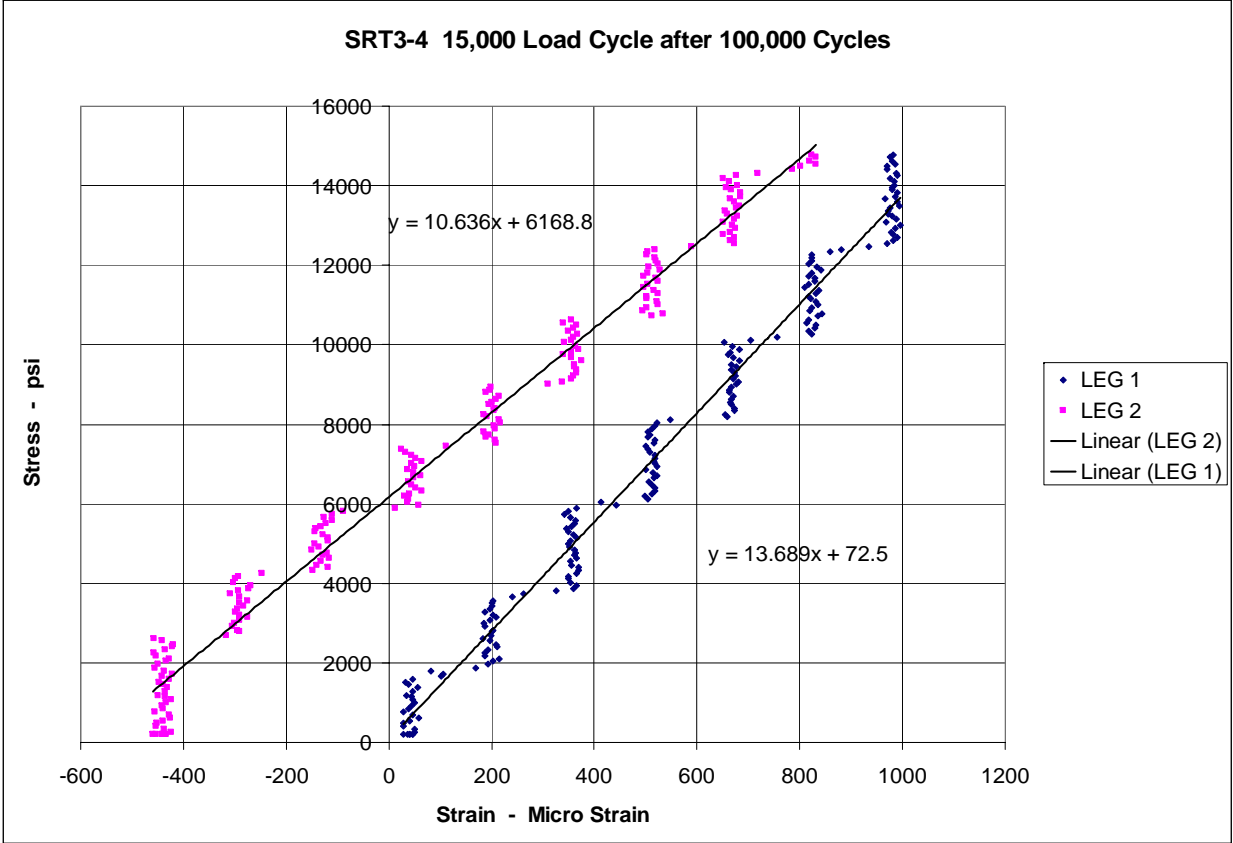


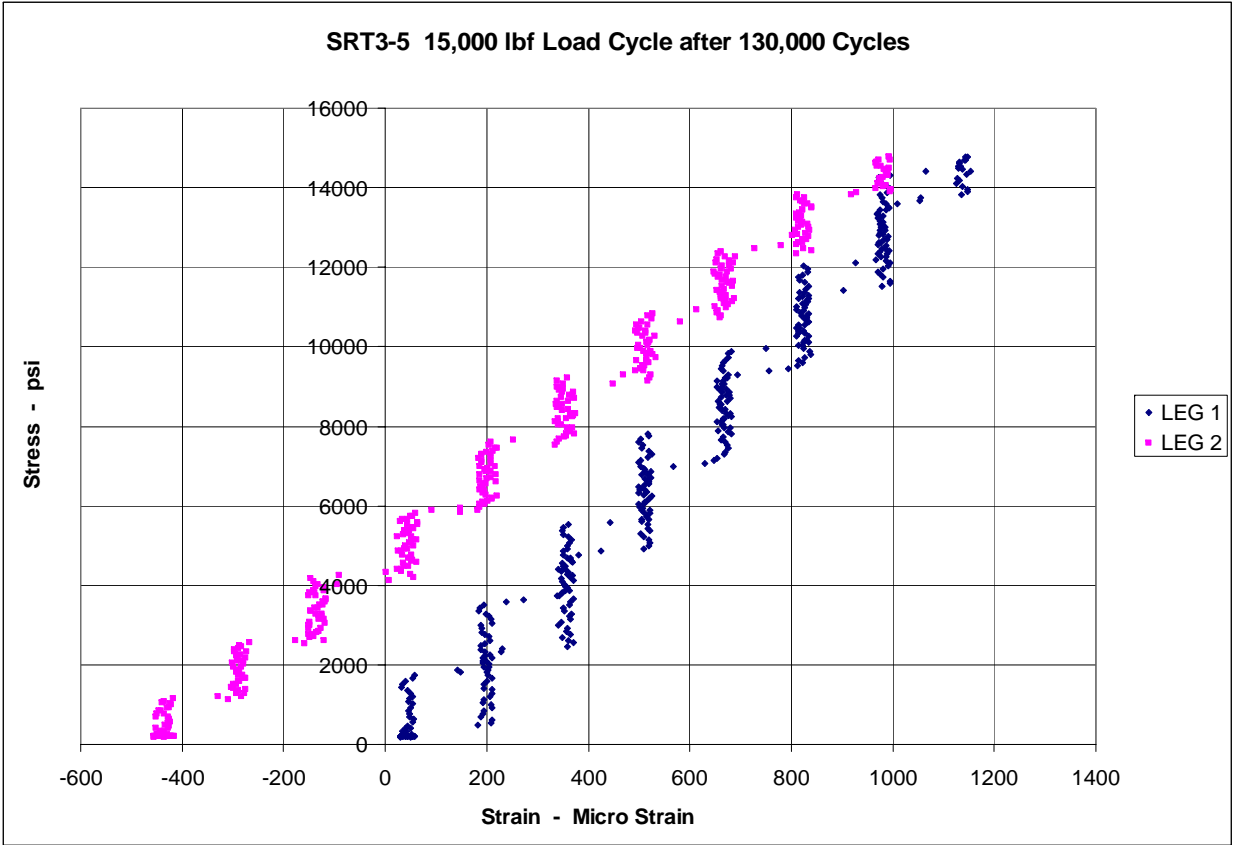


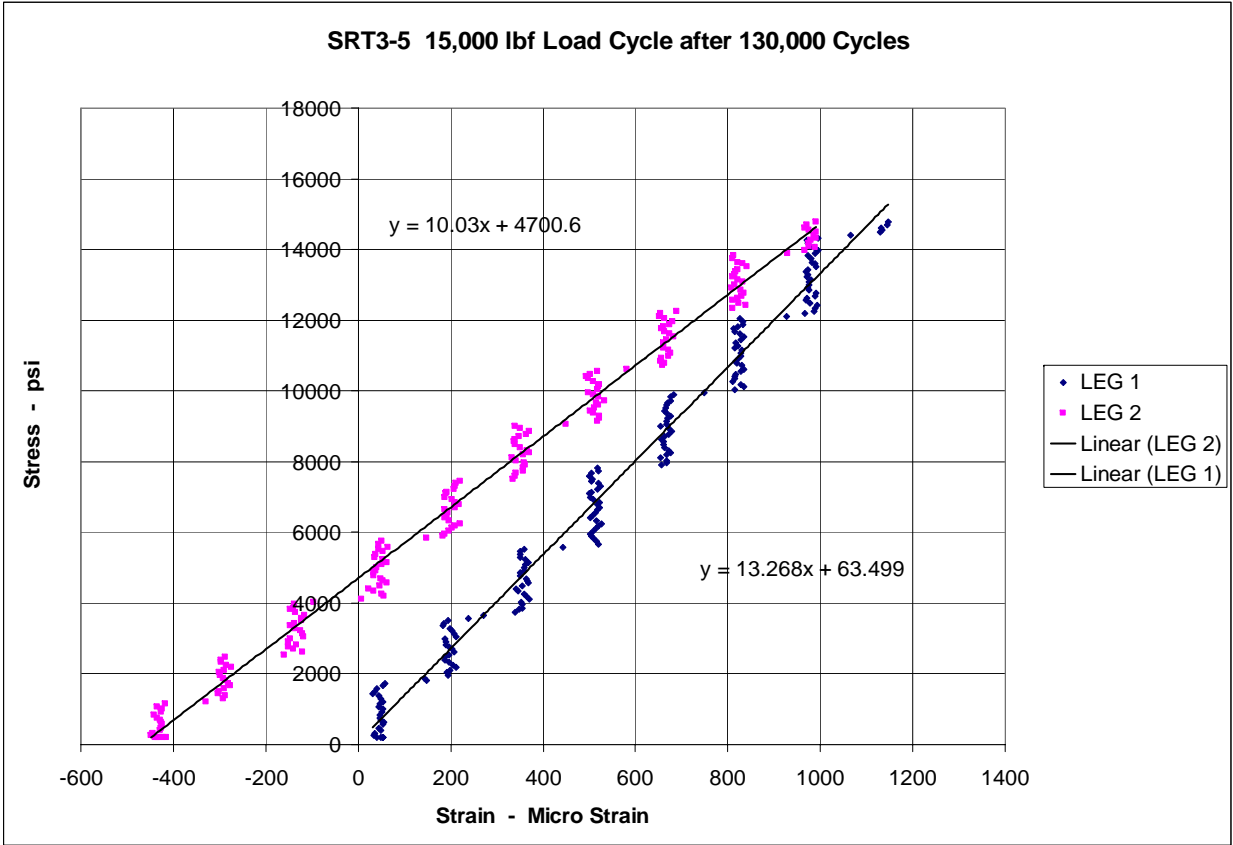


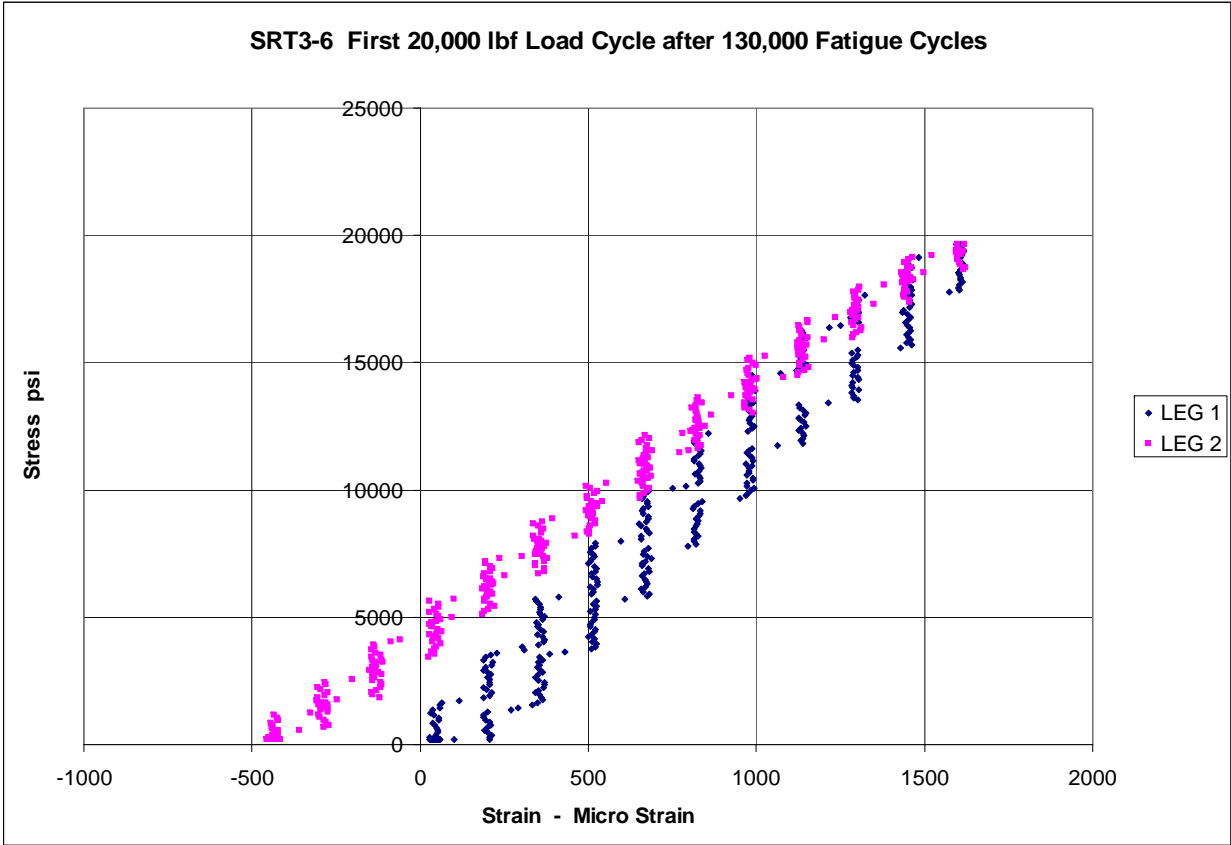


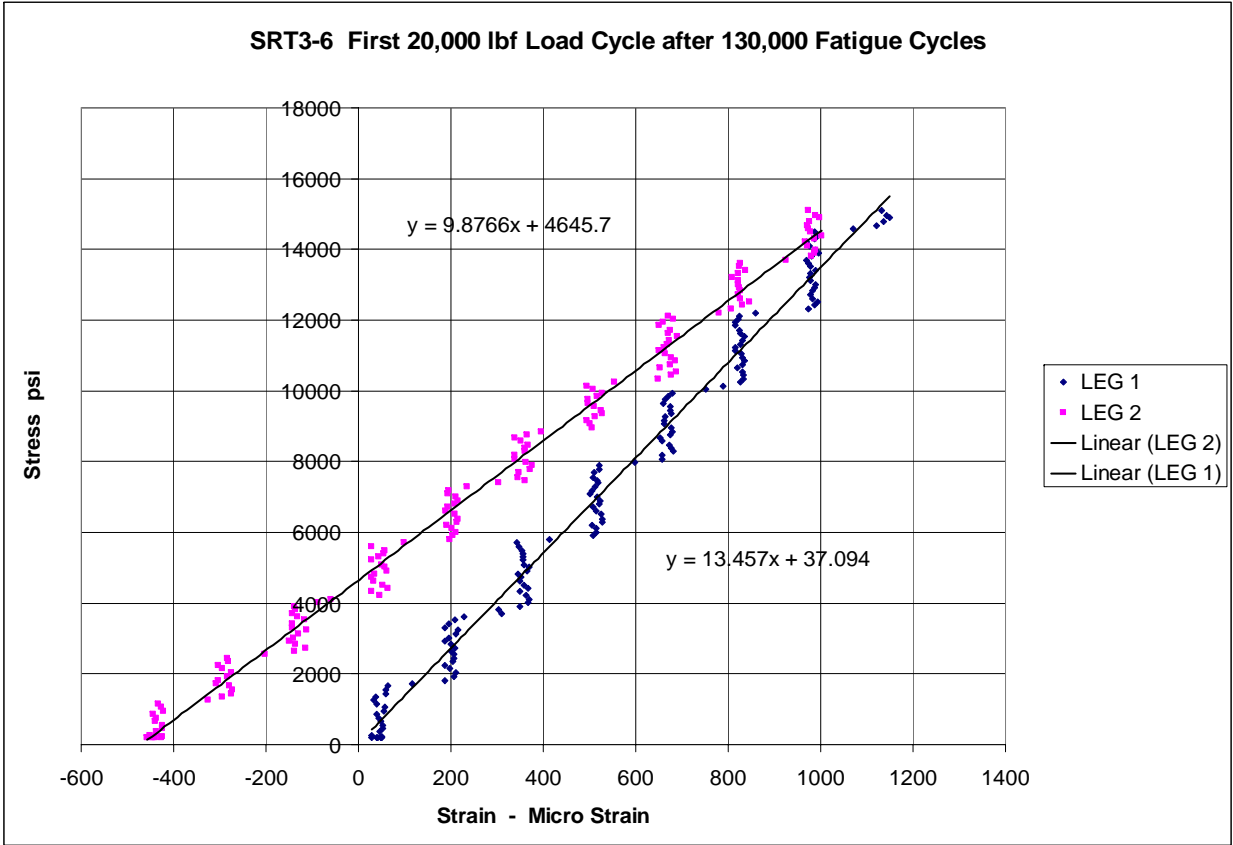


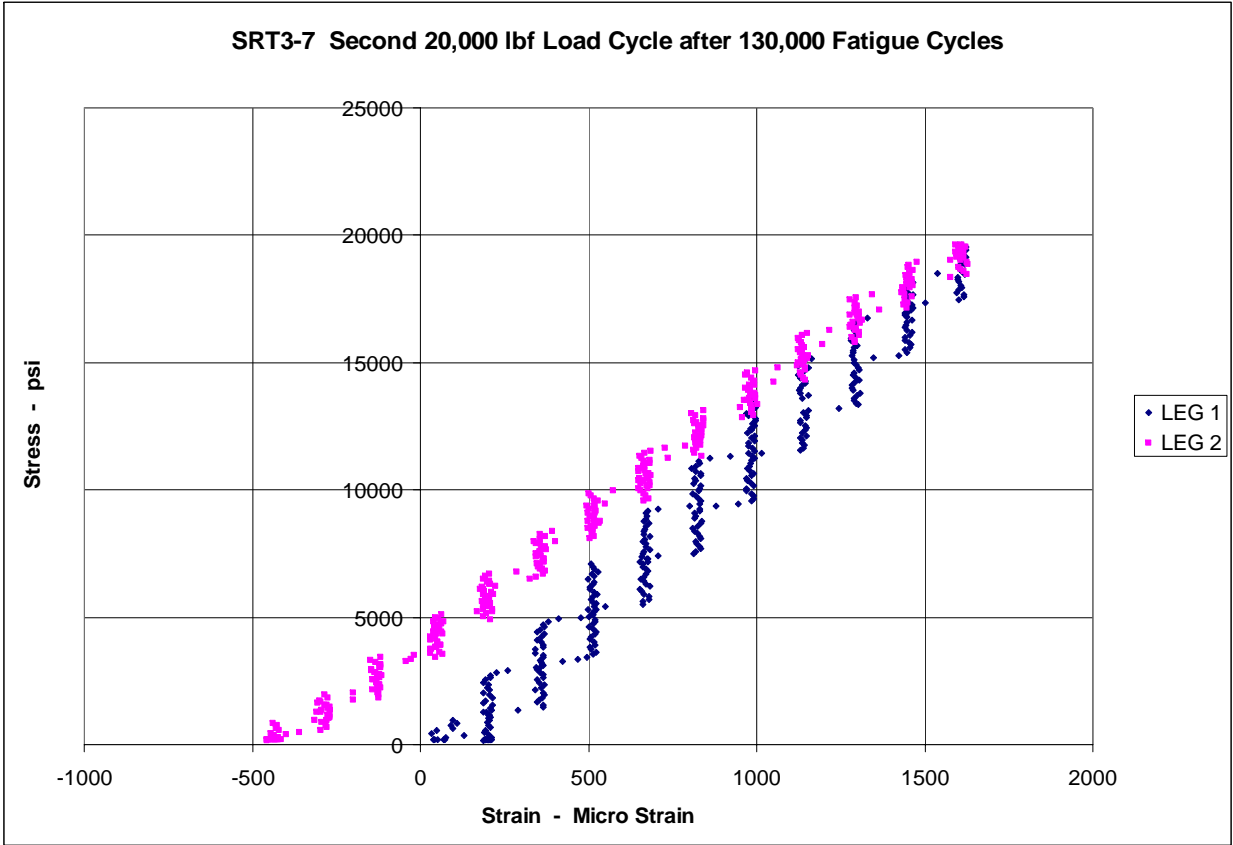


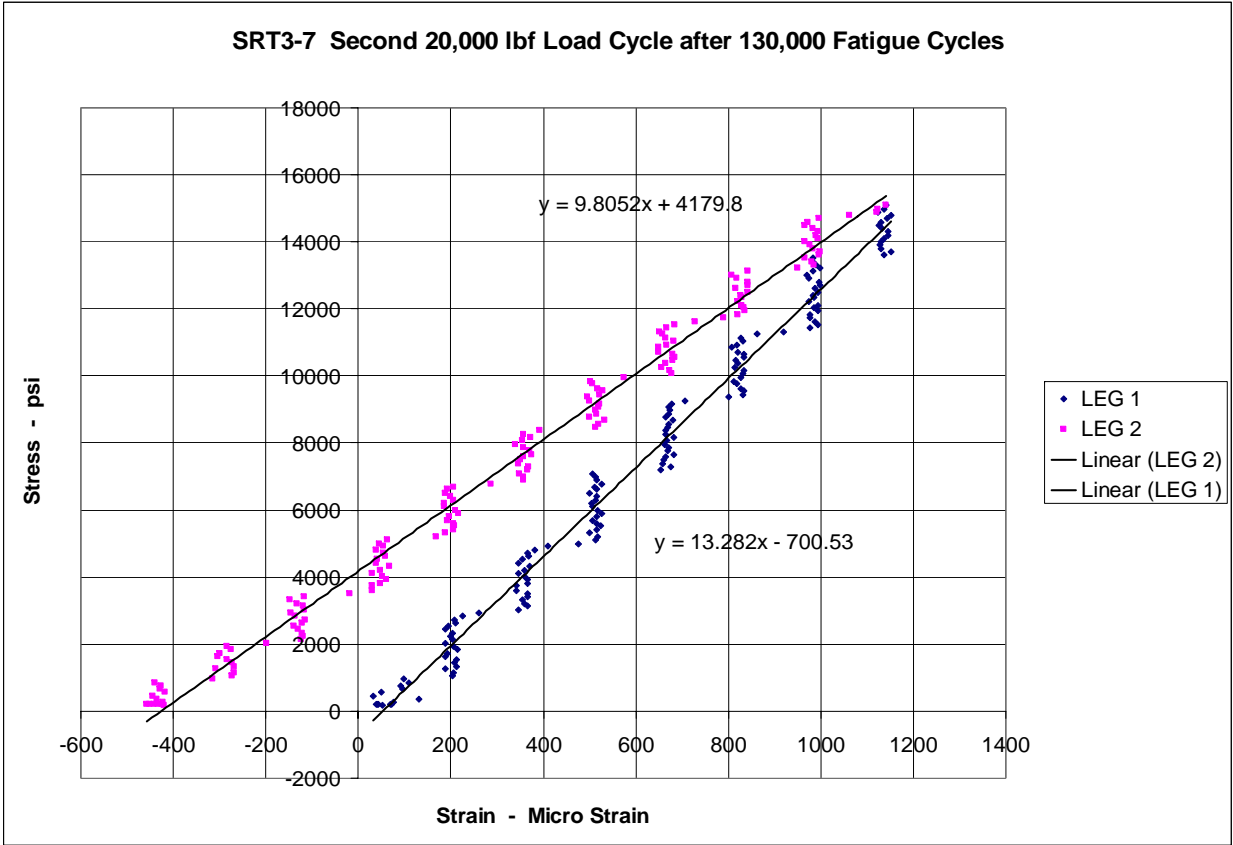












Modulus Summary

Test Cycle File	Test Cycle Peak Load lbf	Cumulative Fatigue Cycles	Leg 1 Modulus Msi	Leg 2 Modulus Msi	Average Modulus Msi
SRT3-1	20,000	0	6.3	3.1	4.7
SRT3-2	20,000	0	11.8	9.6	10.7
SRT3-3	15,000	65,000	13.0	10.2	11.6
SRT3-4	15,000	100,000	13.7	10.6	12.2
SRT3-5	15,000	130,000	13.3	10.0	11.7
SRT3-6	20,000	130,000	13.5	9.9	11.7
SRT3-7	20,000	130,000	13.2	9.8	11.5
Average (excluding first cycle)			13.1	10.0	11.6

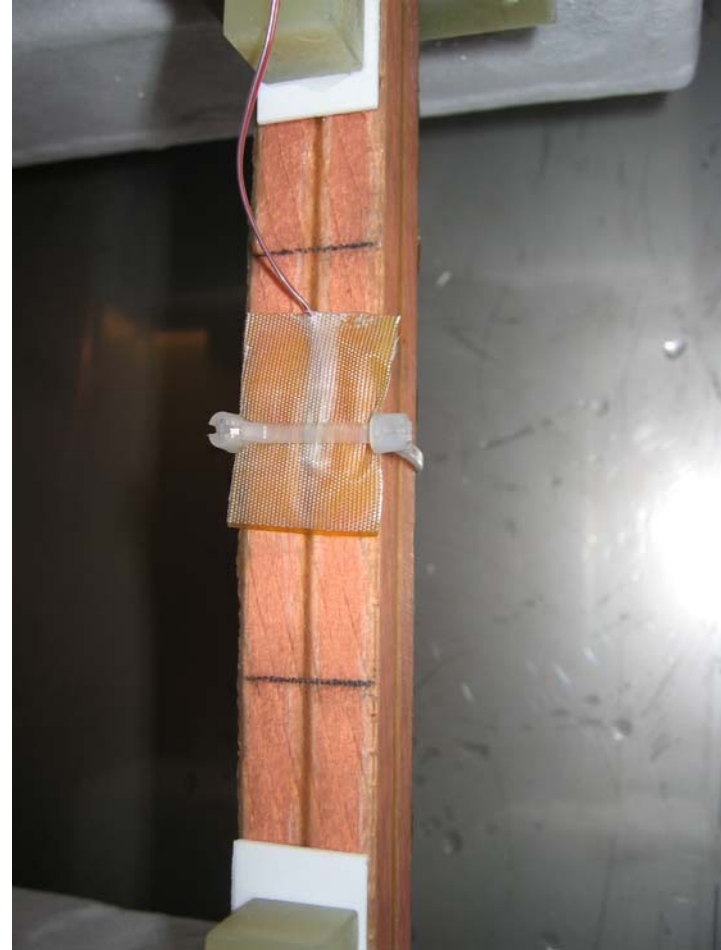
Modulus Results

- The variation in the tensile modulus between the two legs is probably the result of unequal load sharing.
- The average modulus is representative for the strain resulting from a uniform stress over the total cross-section.

Coil Condition After Fatigue Cycles

- The race-track coil legs are in excellent condition after the 150,000 load cycles.
- Leg 1 (in left picture, next slide) has a casting mark in the center from the manufacturing process, not the cycle testing.
- Leg 2 has a thermocouple attached to its front face.
- No change in coil resistance from fatigue cycling.

Coil Legs After 150,000 Cycles to 15,000 lbf



Next Tests

- This sample, SRT3, will be slow cycled at room temperature to provide comparative modulus values.
- Two more short race-track coils will be cycle tested at LN2 temperature.
- One sample will have a variation in the attachment of the pin block in an attempt to improve the leg-to-leg load equalization.