



# Progress report

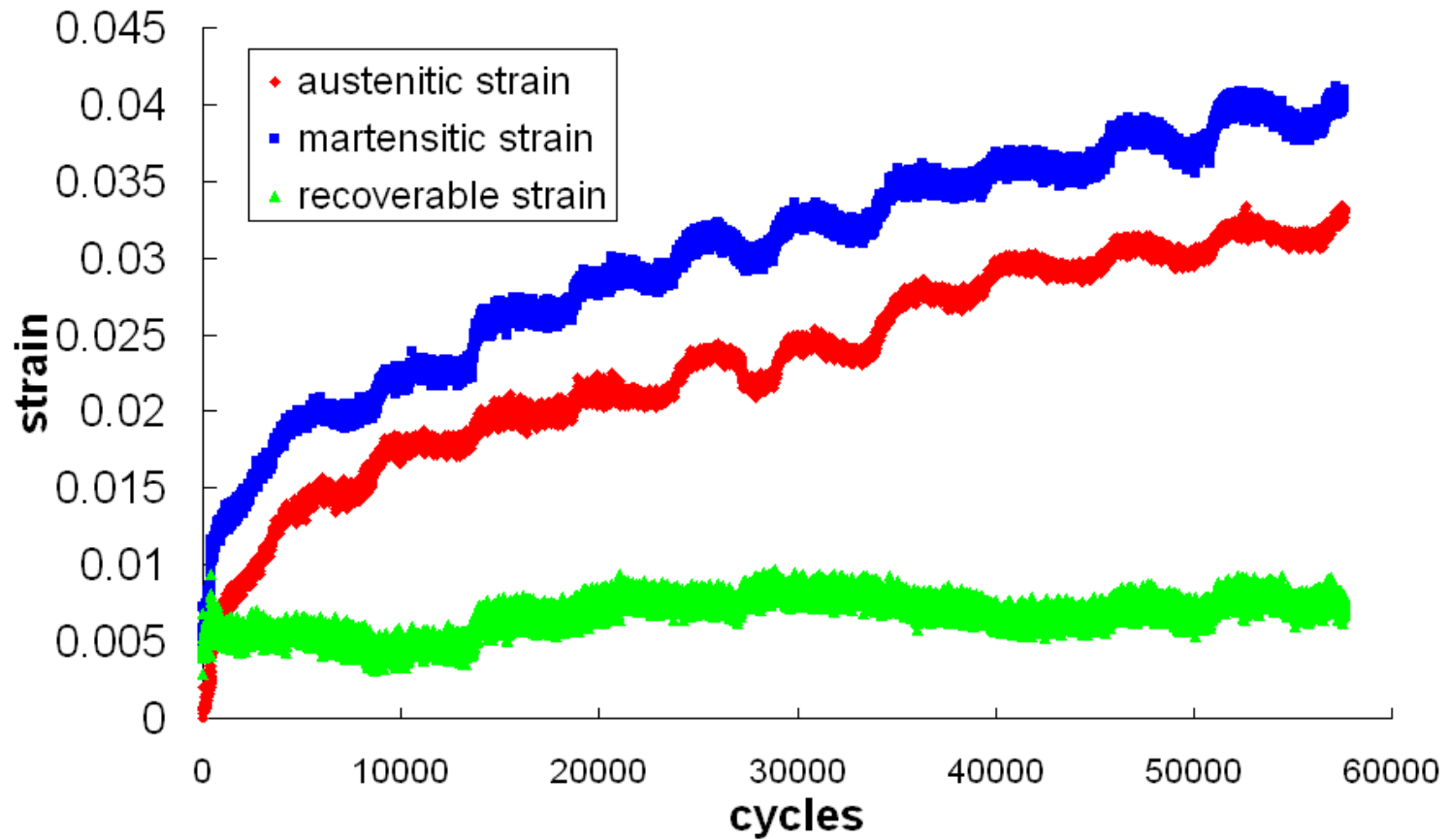
# Thermomechanical fatigue of Boeing 60-NiTi

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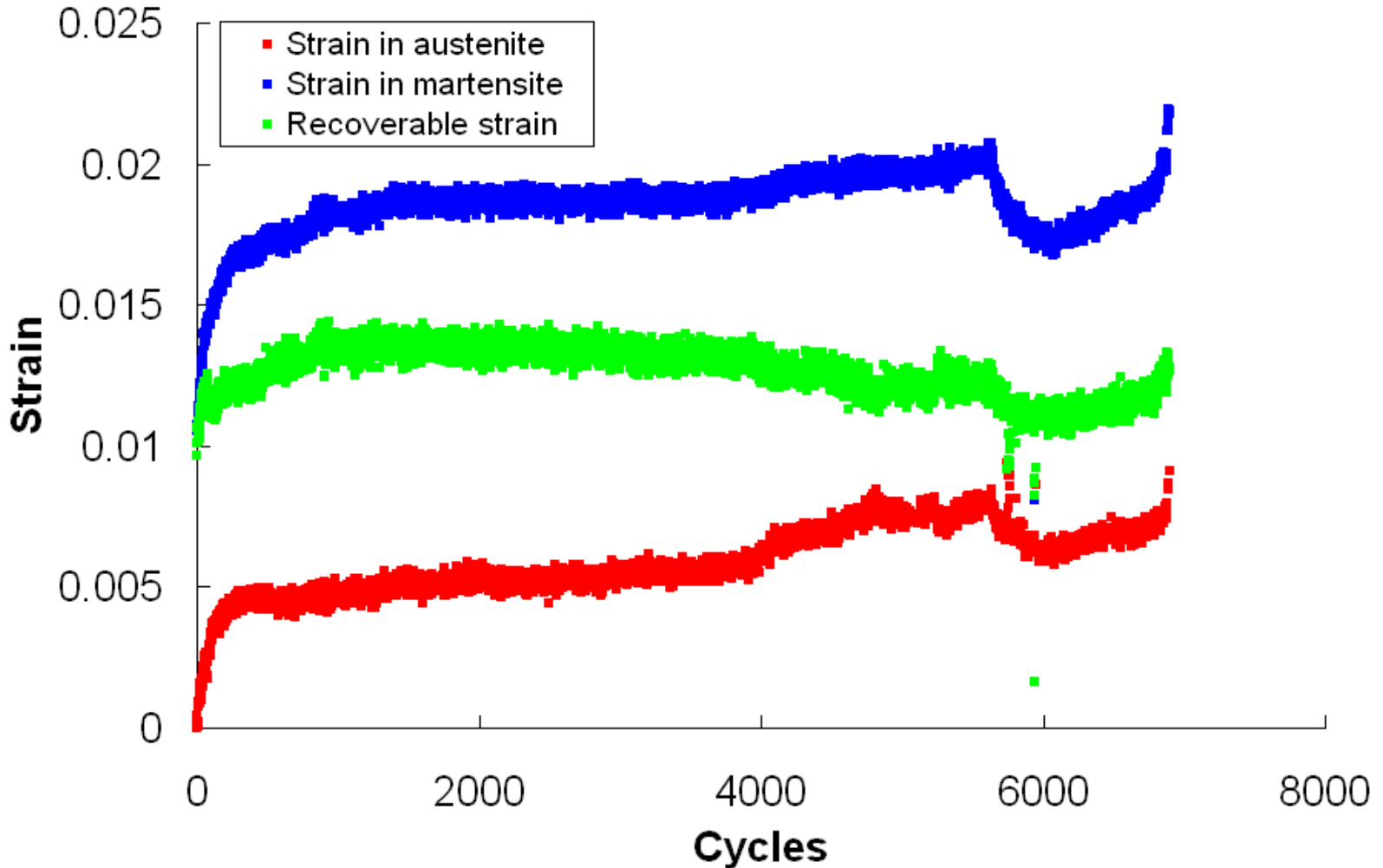
8/1/2007

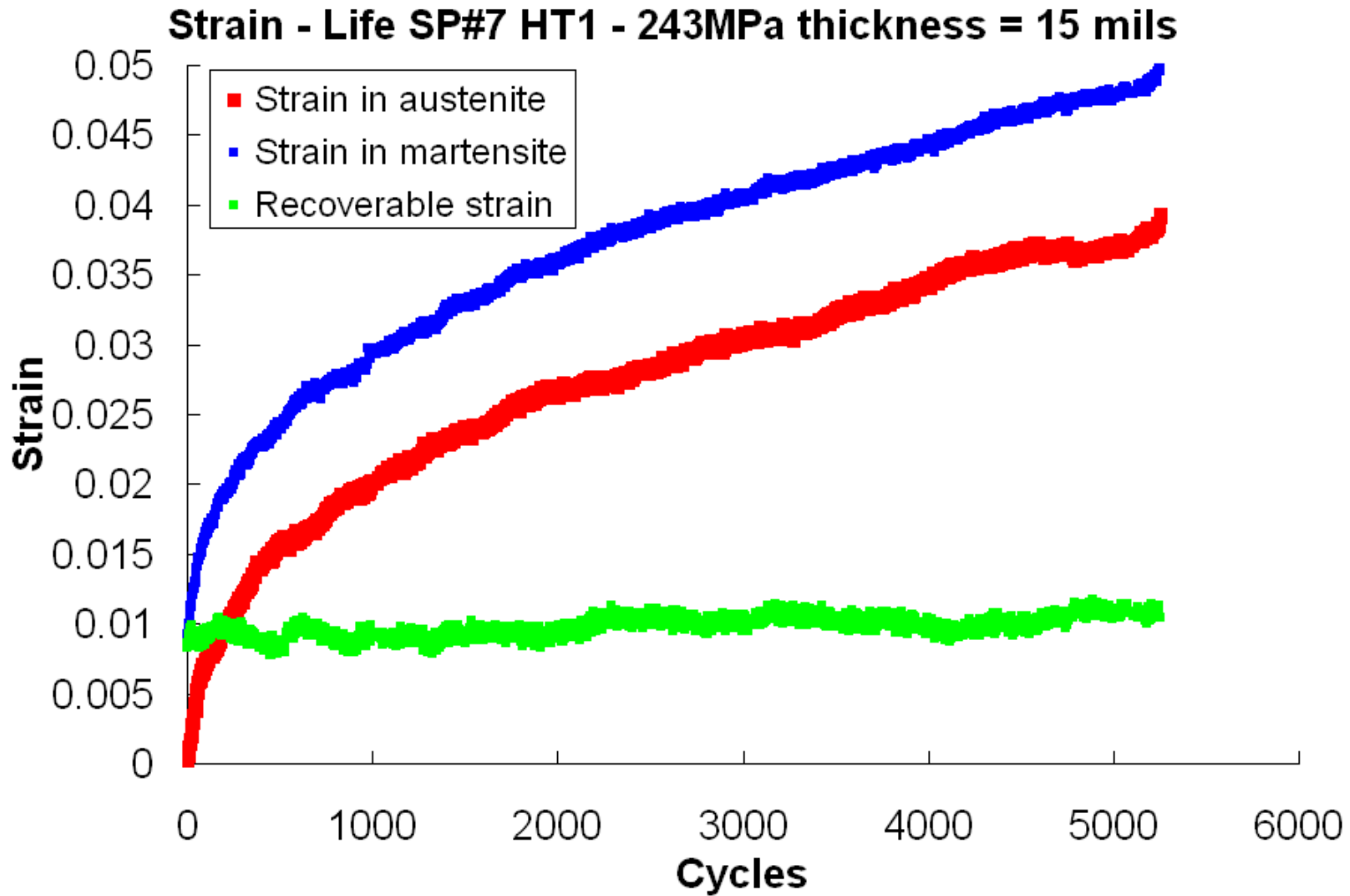
# Fatigue Results Heat Treatment #1

**SP#5 HT1 90MPa thickness = 10 mils**

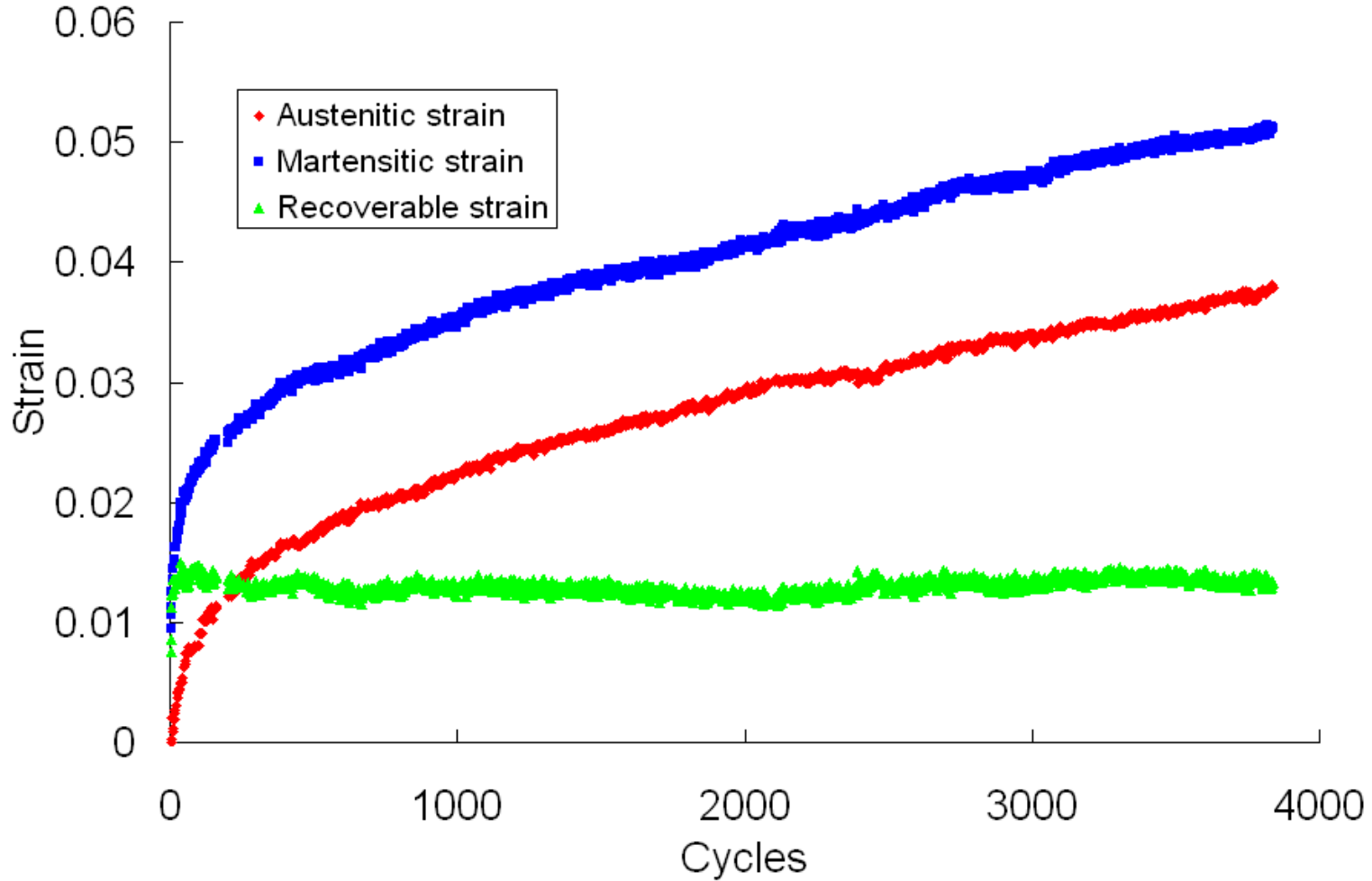


### Strain - Life - SP#3 HT1 - 204MPa thickness = 5 mils



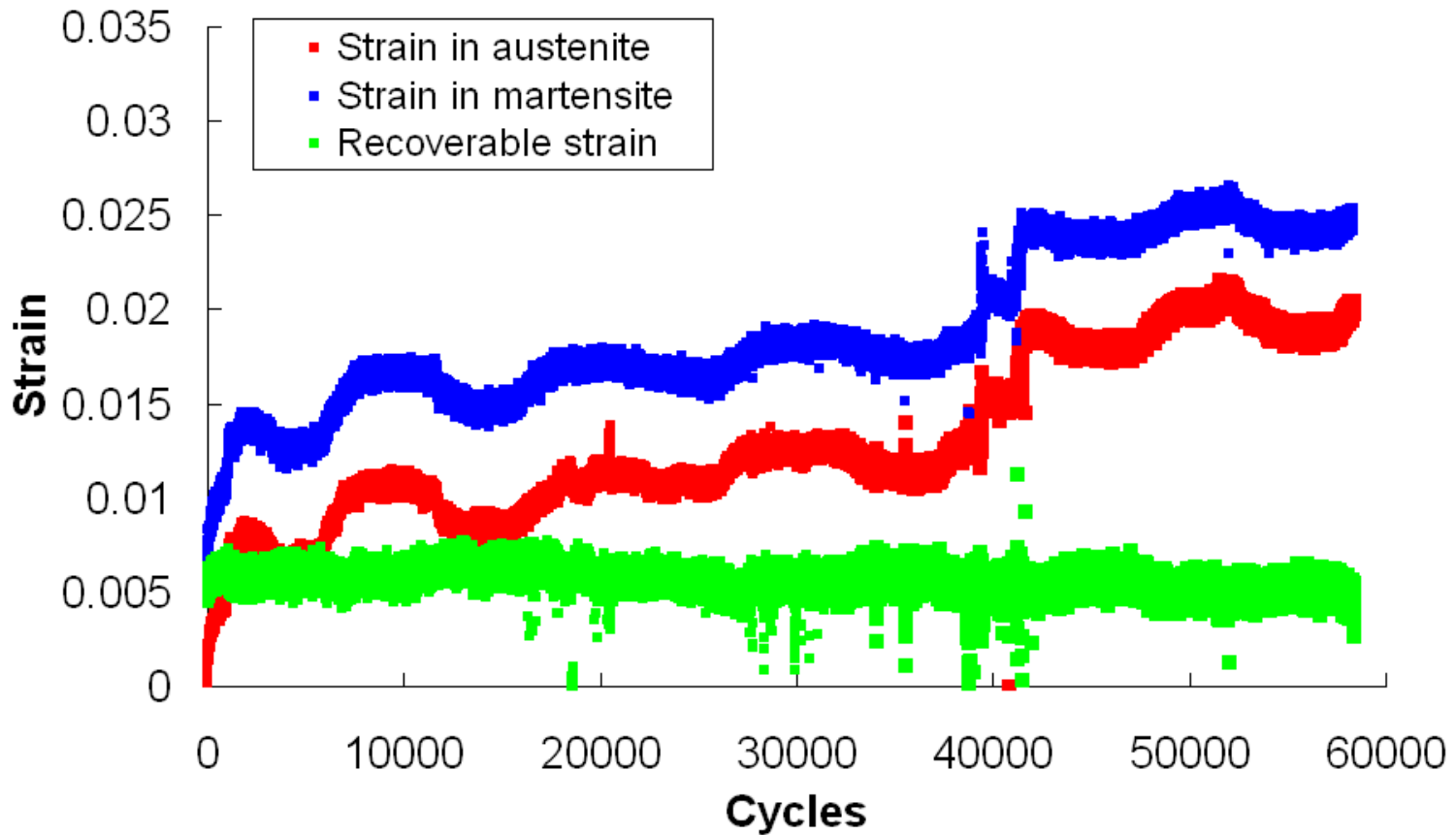


Stress - Life - SP#2 HT1 - 250MPa thickness = 10 mils



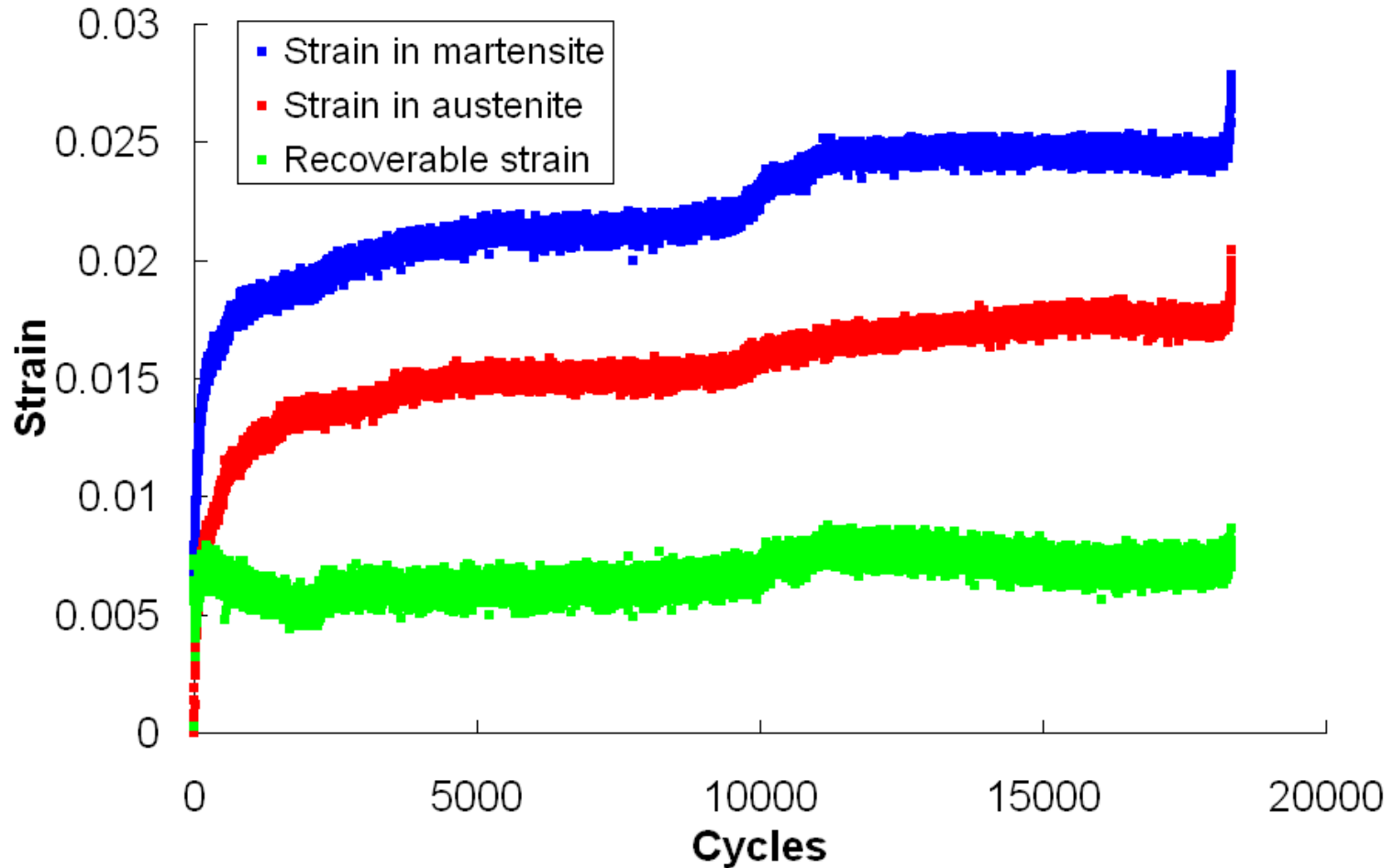
# Fatigue Results Heat Treatment #2

**Strain - Life -SP#5 HT2 - 103MPa - thickness = 5 mils**  
**No failure**

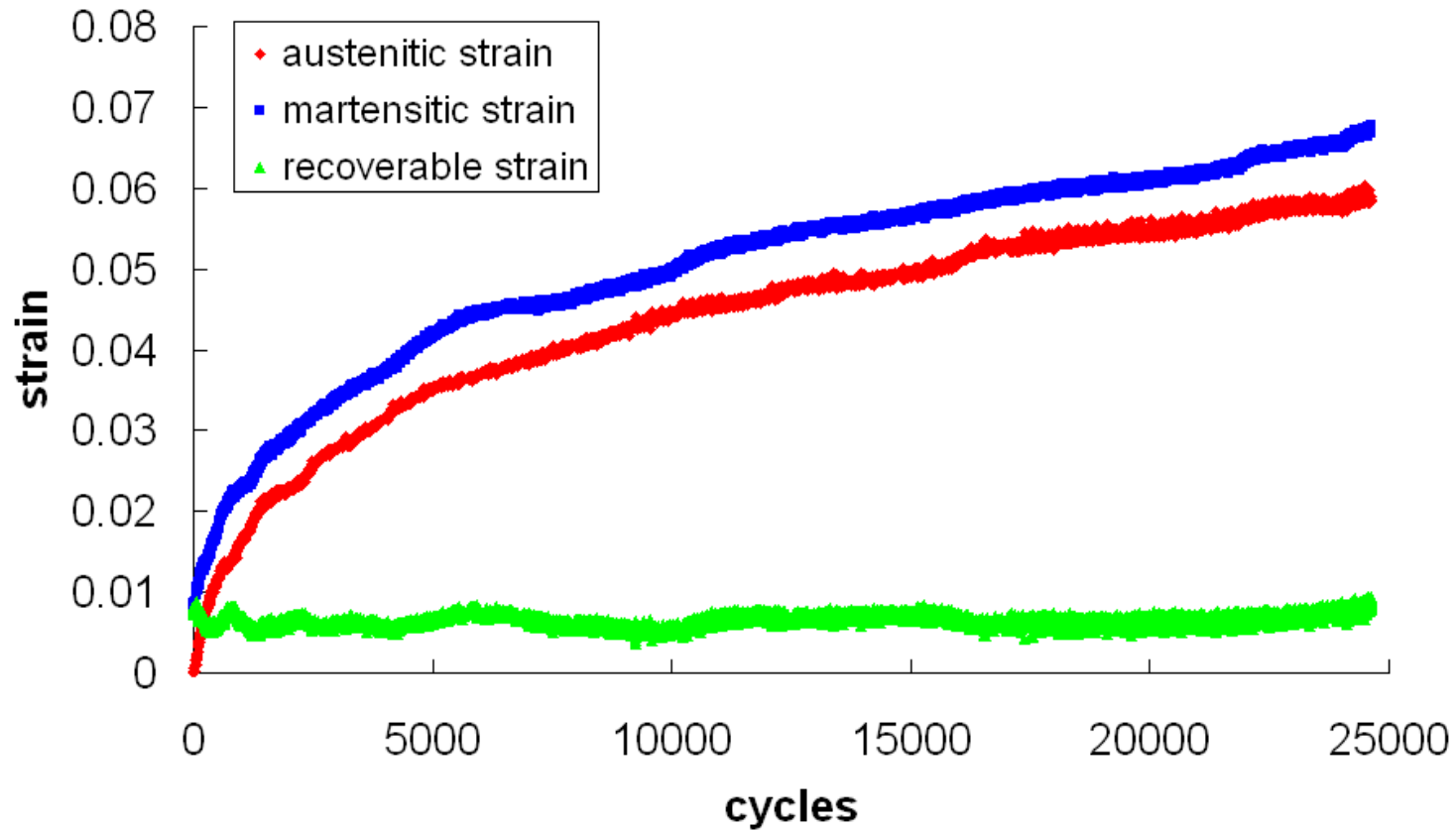


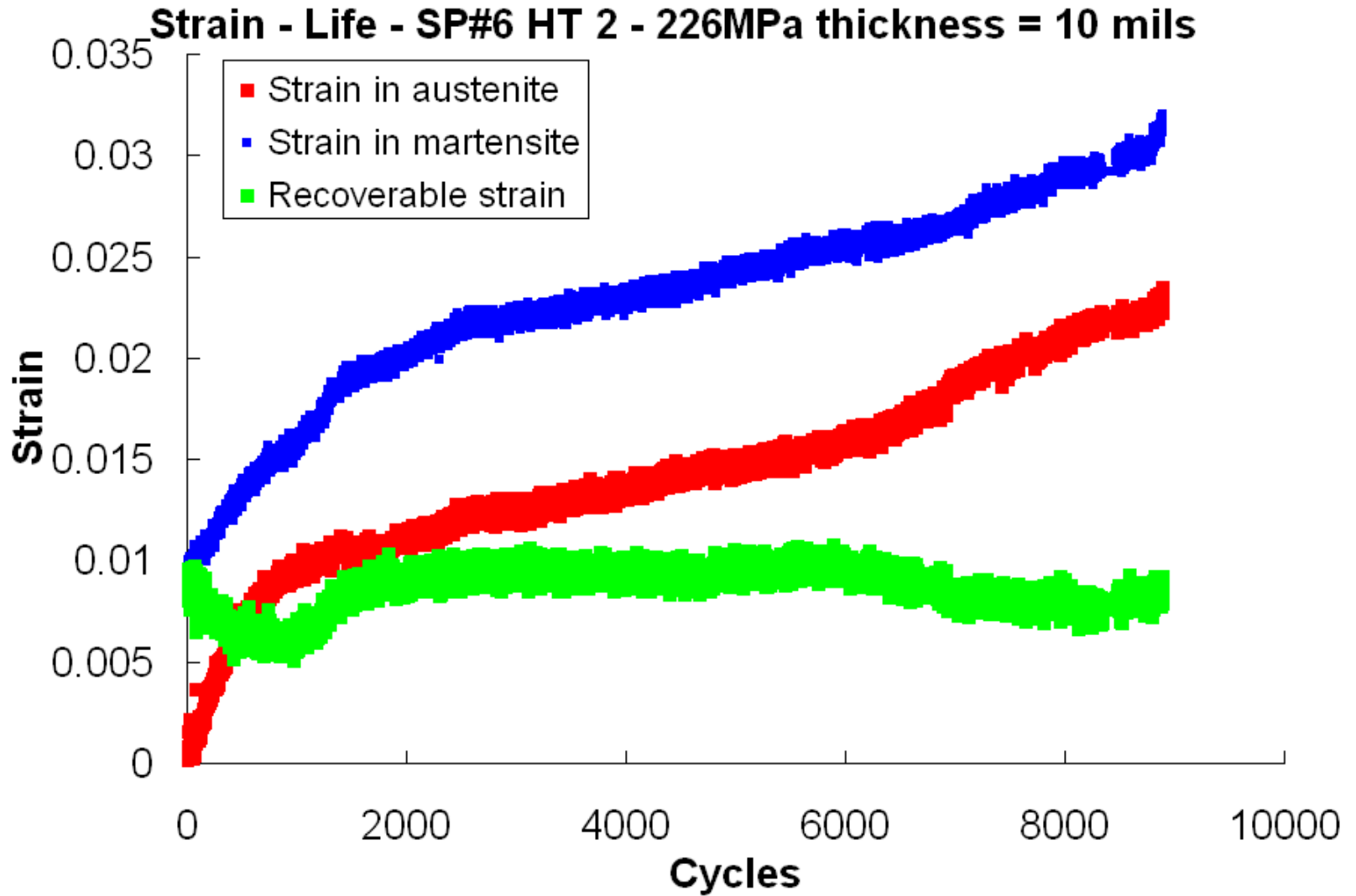


**Strain - Life - SP#4 HT2 - 107MPa thickness = 5 mils**

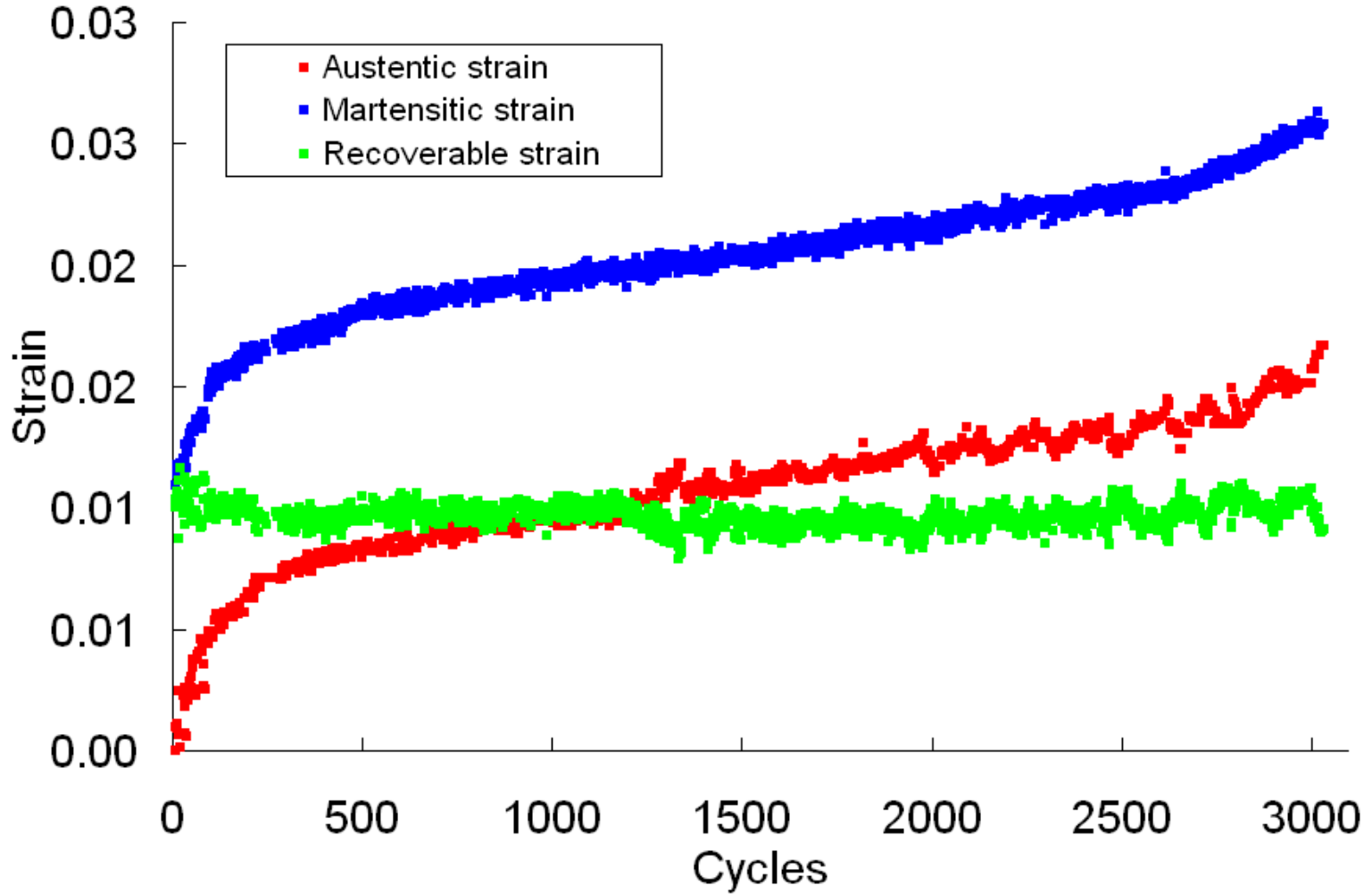


**SP#3 HT2 142MPa thickness = 15 mils**





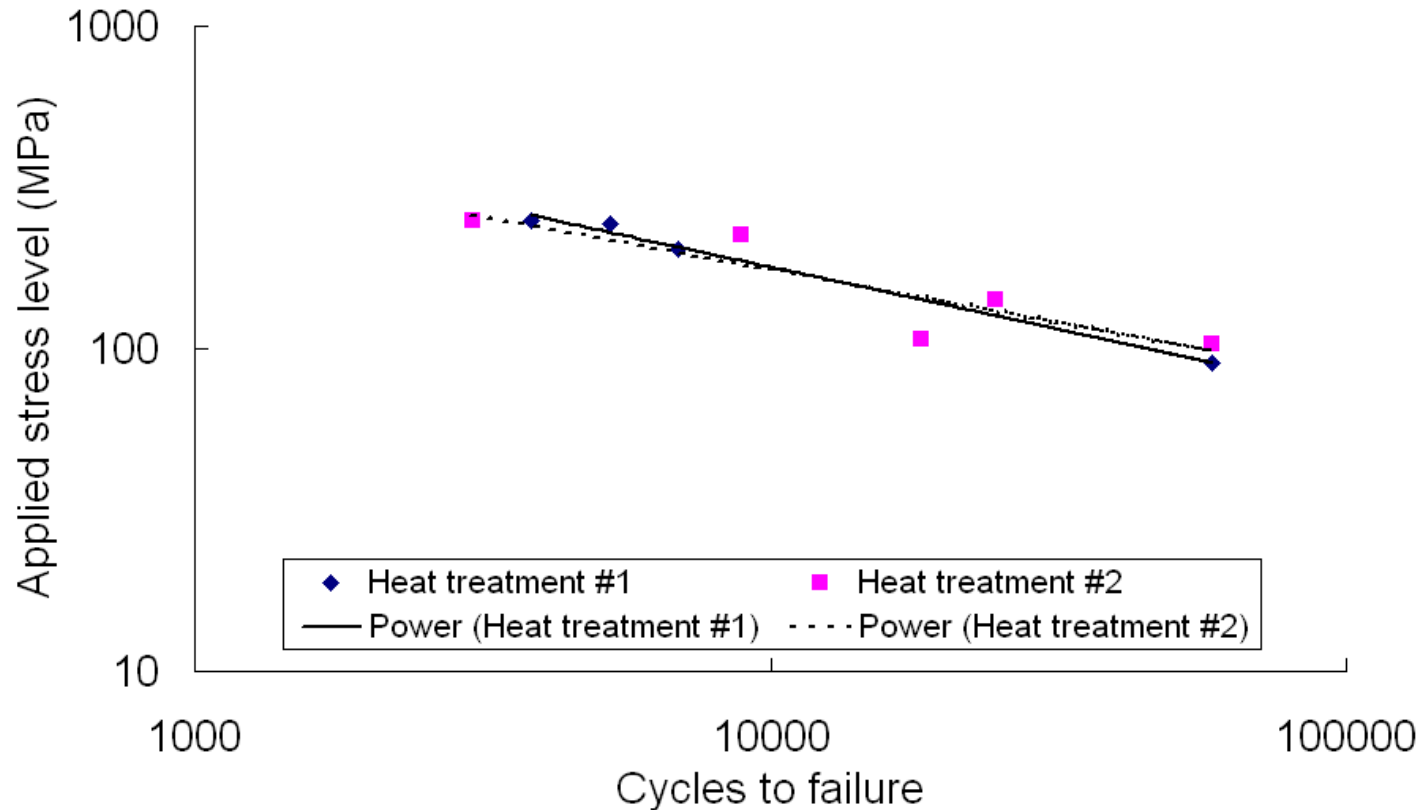
Stress - Life - SP#7 HT 2 - 250 MPa thickness = 5 mils



# Cumulative results

# Stress – life: first results

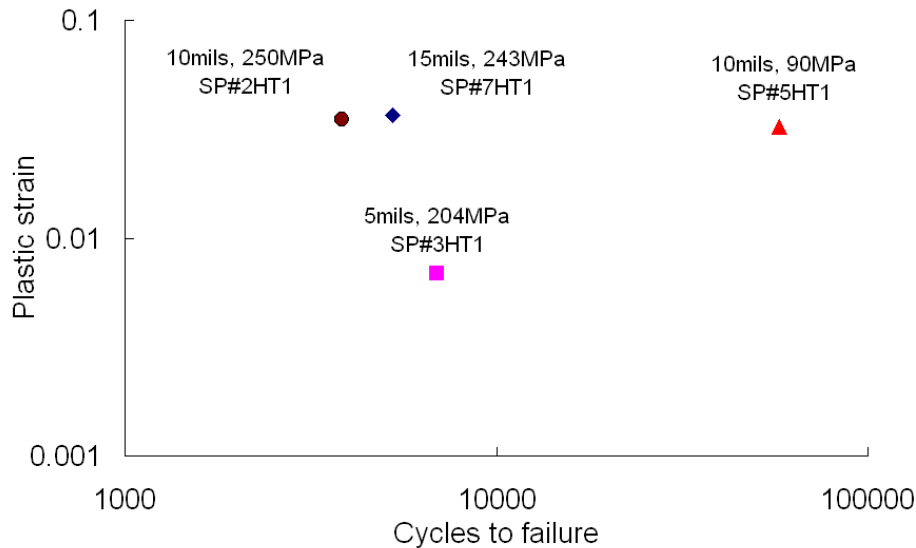
Stress - Life: Heat treatment #1 vs. Heat treatment #2



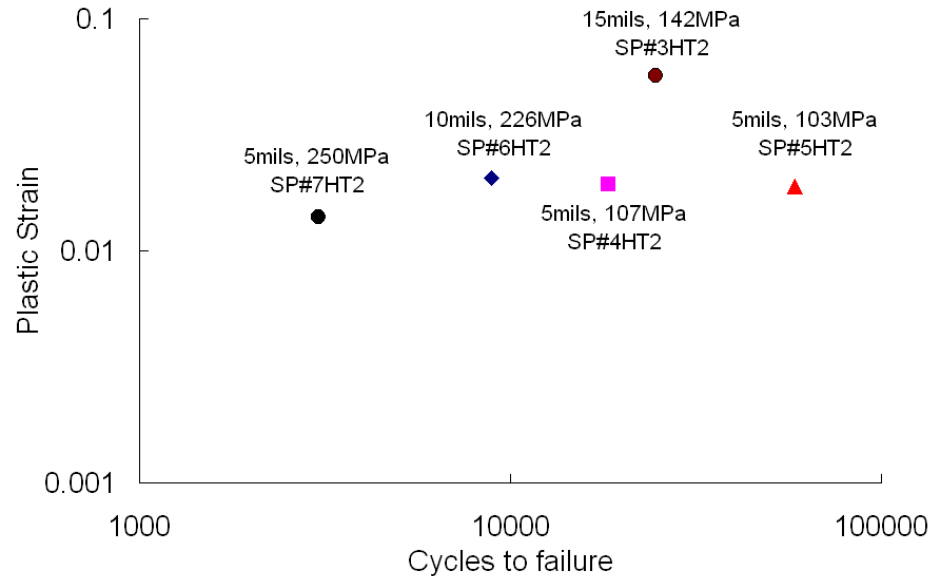
- Not enough fatigue data to draw conclusions on the performances of the two different heat treatments

# Plastic strain: first results

Plastic strain - Cycles to failure - Heat treatment #1



Plastic strain - Cycles to failure - Heat treatment #2



- Saturated plastic strain values at failure do not show trend in terms of amount of plastic strain related to the applied stress level
- However, the first observation we make is a higher plastic strain level attained for thicker specimens

# Specimen details:

- tested
- damaged
- non applicable
- test with control specimen



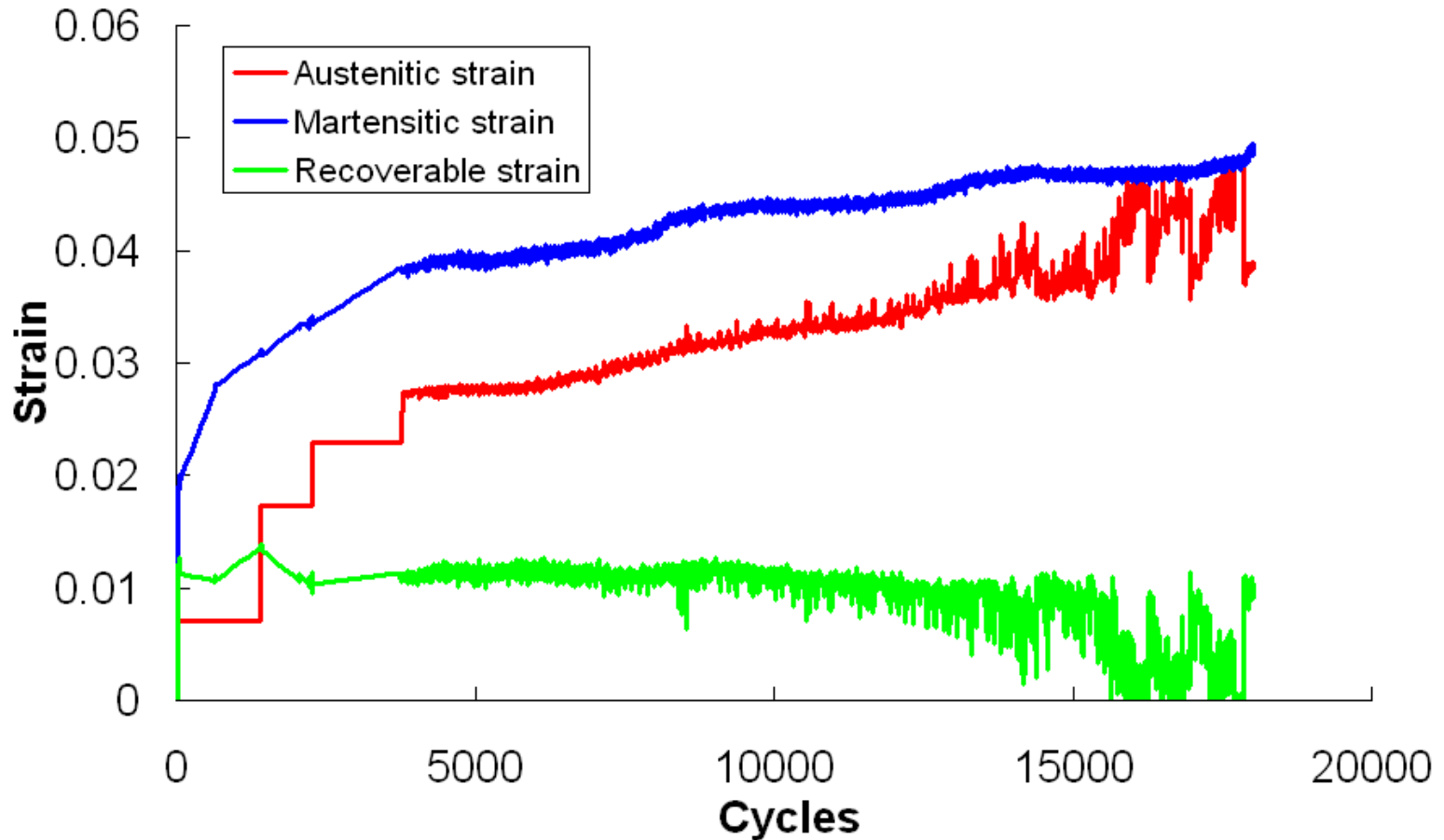
# Specimens tested – damaged – non applicable

Run order	Specimen #	Heat treatment	Thickness (mils)	Applied stress (MPa)
1	SP# 6 HT2	A2	10	226
2	SP# 4 HT2	A2	5	107
3	SP# 3 HT1	A1	5	204
4	SP# 7 HT1	A1	15	243
5	SP# 5 HT2	A2	5	103
6	SP# 5 HT1	A1	10	90
7	SP# 3 HT2	A2	15	142
8	SP# 7 HT2	A2	5	250
9	SP# 2 HT1	A1	10	250
10	SP# 4 HT1	A1	15	203
Heat Treatments		A1	1 hr @ 850 C, 1 hr @ 450 C	
		A2	1 hr @ 850 C, 20 hrs @ 450 C	

SP# 1 HT1	Damaged during preliminary testing
SP# 1 HT2	Damaged during preliminary testing
SP# 2 HT2	Not applicable for isobaric uniaxial fatigue testing irregular cross section with major notches
SP# 6 HT1	MTS tested
SP# 8 HT2	MTS tested
SP# 5 HT1	No failure (run out at ~60K cycles)
SP# 5 HT2	No failure (run out at ~60K cycles)
SP# 4 HT1	Invalid results (computer malfunction)

# Computer malfunction affecting fatigue data acquisition

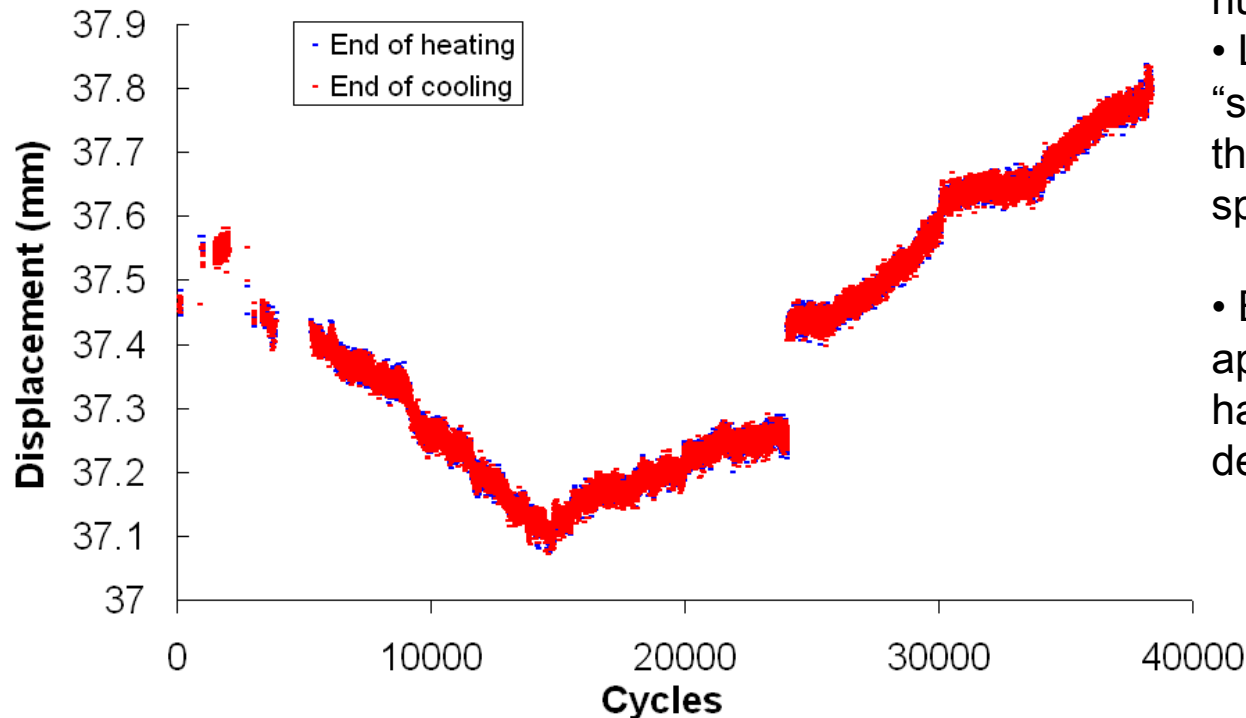
Stress - Life for SP#4 HT1 - 203 MPa thickness = 15 mils



## Test performed with control specimen

Control specimen taken from stainless steel sheet, cut to identical dogbone dimensions. Application of thermal cycles under constant load of 50MPa led to existence of external variations of parameters.

Stainless steel dogbone - Control specimen 50MPa - Thermal cycles - Cycle period = 16 seconds

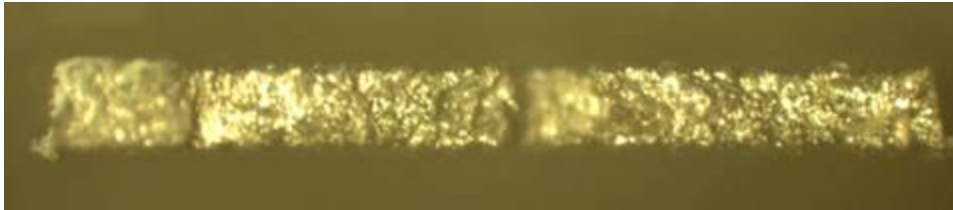


- Computer problems – data collection skipped over large number of cycles
- LVDT measurement shows “shrinkage” for first 14000 cycles, then “elongation” of dummy specimen
- Environmental perturbations appear cyclic with period of nearly half a day (3000 to 6000 cycles depending on cycle period)

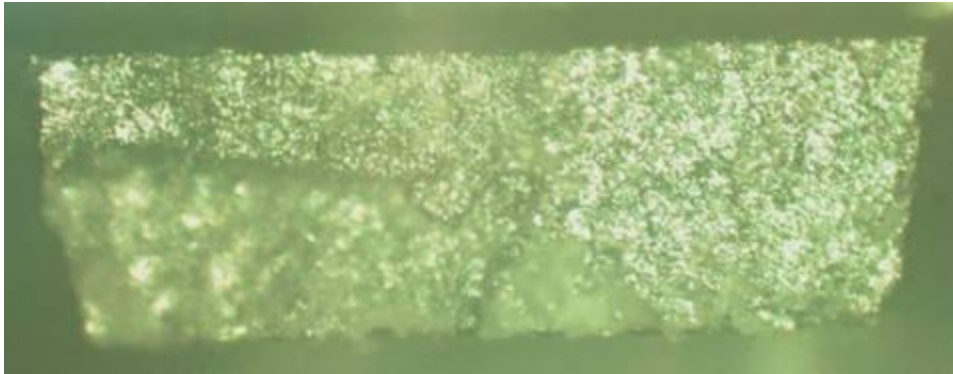
# Optical fracture surfaces and thickness analysis

# Failure of specimens

- Influence of thickness under identical stress level



SP#3 HT1 – thickness = 5 mils

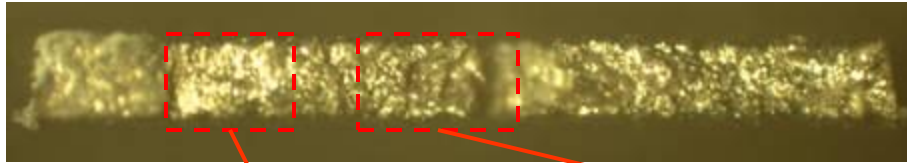


SP#7 HT1 – thickness = 15 mils

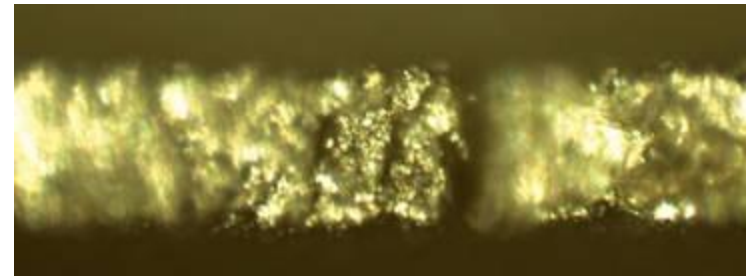
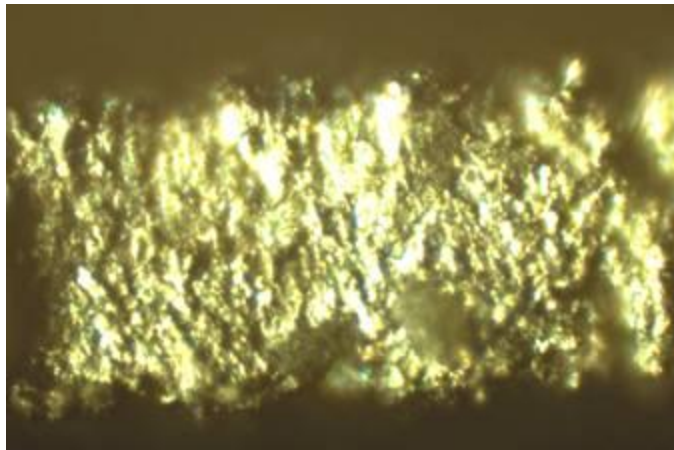


- Influence of thickness can be seen as cracks are generated in the transverse direction of SP#3 HT1 where PS#7 HT1 displays more of a bulk behavior
- Different failure behavior from thickness 5 mils to 15 mils

# Failure of specimens

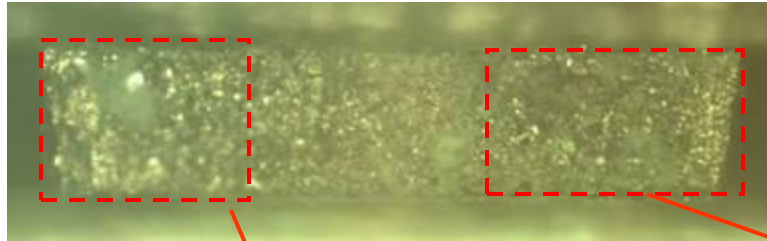


SP#3 HT1 – thickness = 5 mils

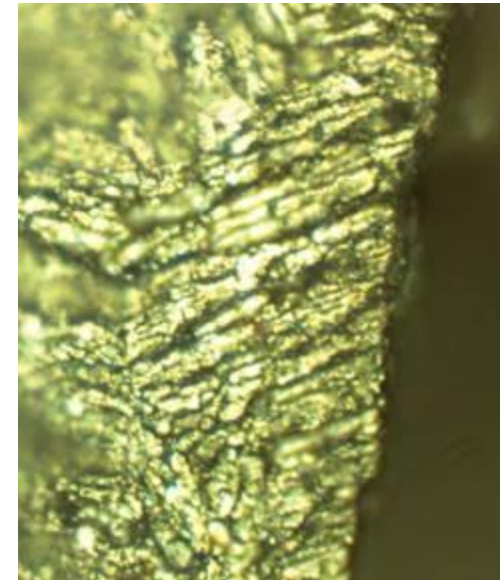
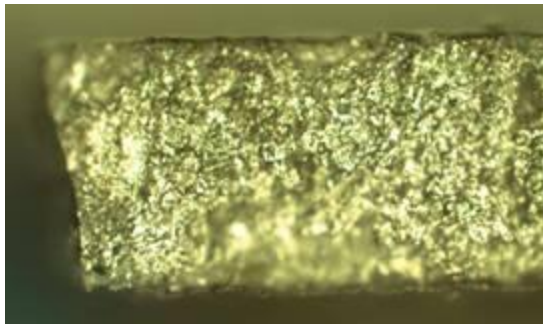
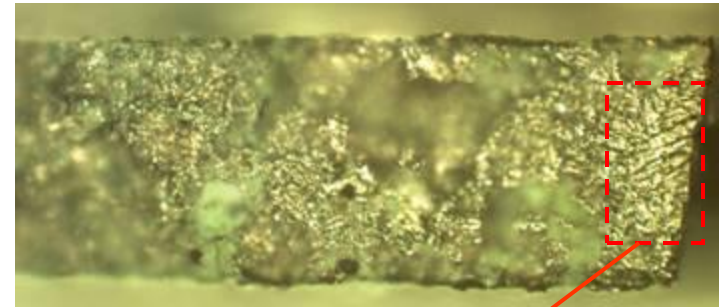


- Transverse cracks and transverse tear up – strong dependency on the width to height ratio
- Propagation of fatigue lines in a transverse pattern

# Failure of specimens



SP#6 HT2 – thickness = 10 mils



- Thicker specimens display bulk behavior with multi-axial fatigue damage and propagation