# Crack Initiation and Propagation Fatigue Life Prediction for an A36 Steel Welded Plate Specimen

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## A36 Strain-Life



## A36   da/dN

BS-7910
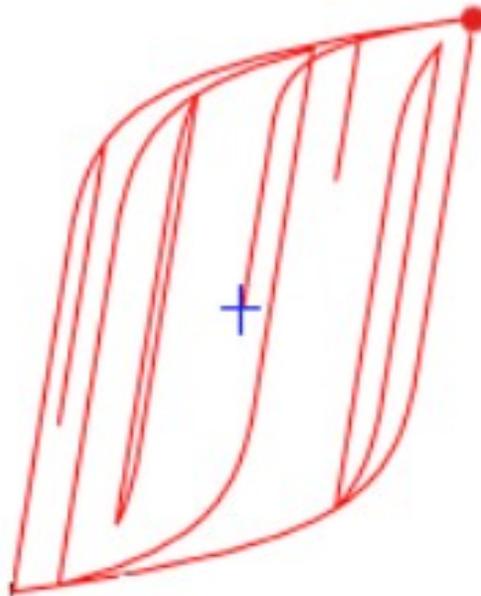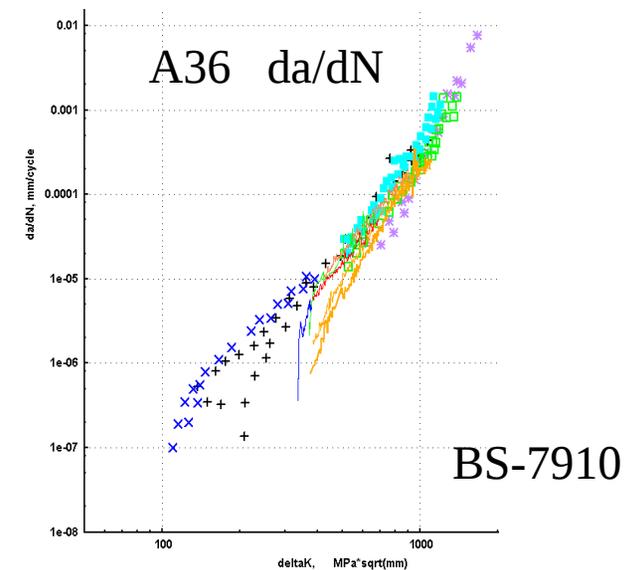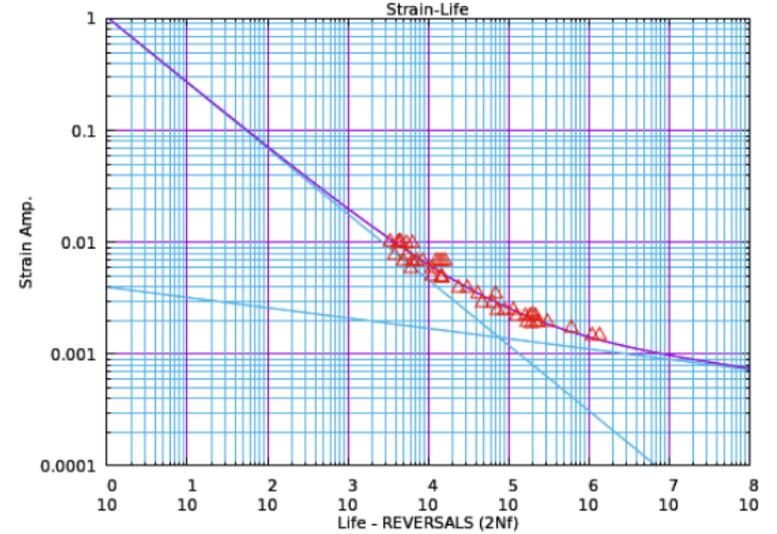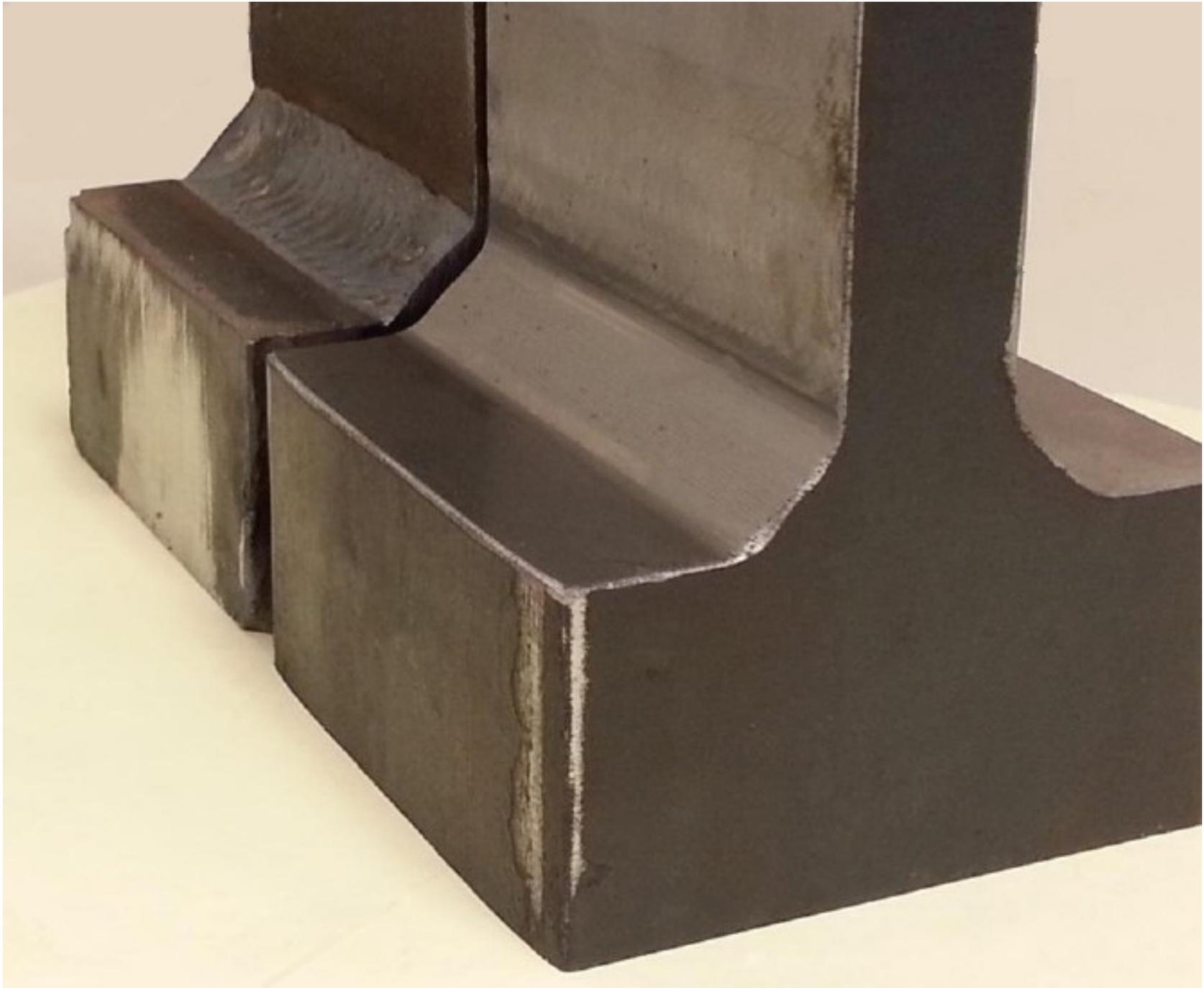
Picture courtesy of F.D.E.Comm. and J.Deere

# Material :  A36 Steel



A36 merged

"mergedA36.html" u 2:1 △
"merged_a36_fitted.html" u 2:1 —
"merged_a36_w_POL_fitted.html" u 2:1 ✳

Strain Ampl.

Reversals, 2Nf

"fde-a36__NewmanR0.1.tbl" u 1:2 +
"fde-a36__NewmanR0.7.tbl" u 1:2 ✕
"haddadSAE1015dadn.tbl" u 1:2 ✳
"klingermanR=0.11.tbl" u 1:2 ☐
"klingermanR=0.4.tbl" u 1:2 ■
"crk0.1black_dadn.tbl" u 1:2 —
"crk0.2blue_dadn.tbl" u 1:2 —
"crk0.3purple_dadn.tbl" u 1:2 —
"crk0.4green_dadn.tbl" u 1:2 —
"crk0.5cyan_dadn.tbl" u 1:2 —
"crk0.5orange_dadn.tbl" u 1:2 —
"a36_Old+New_comboDadn.tbl" u 1:2 ■

da/dN, mm/cycle

deltaK,    MPa*sqrt(mm)

Cyclic mean stress relaxation data taken
from SAE 1015 steel tests.
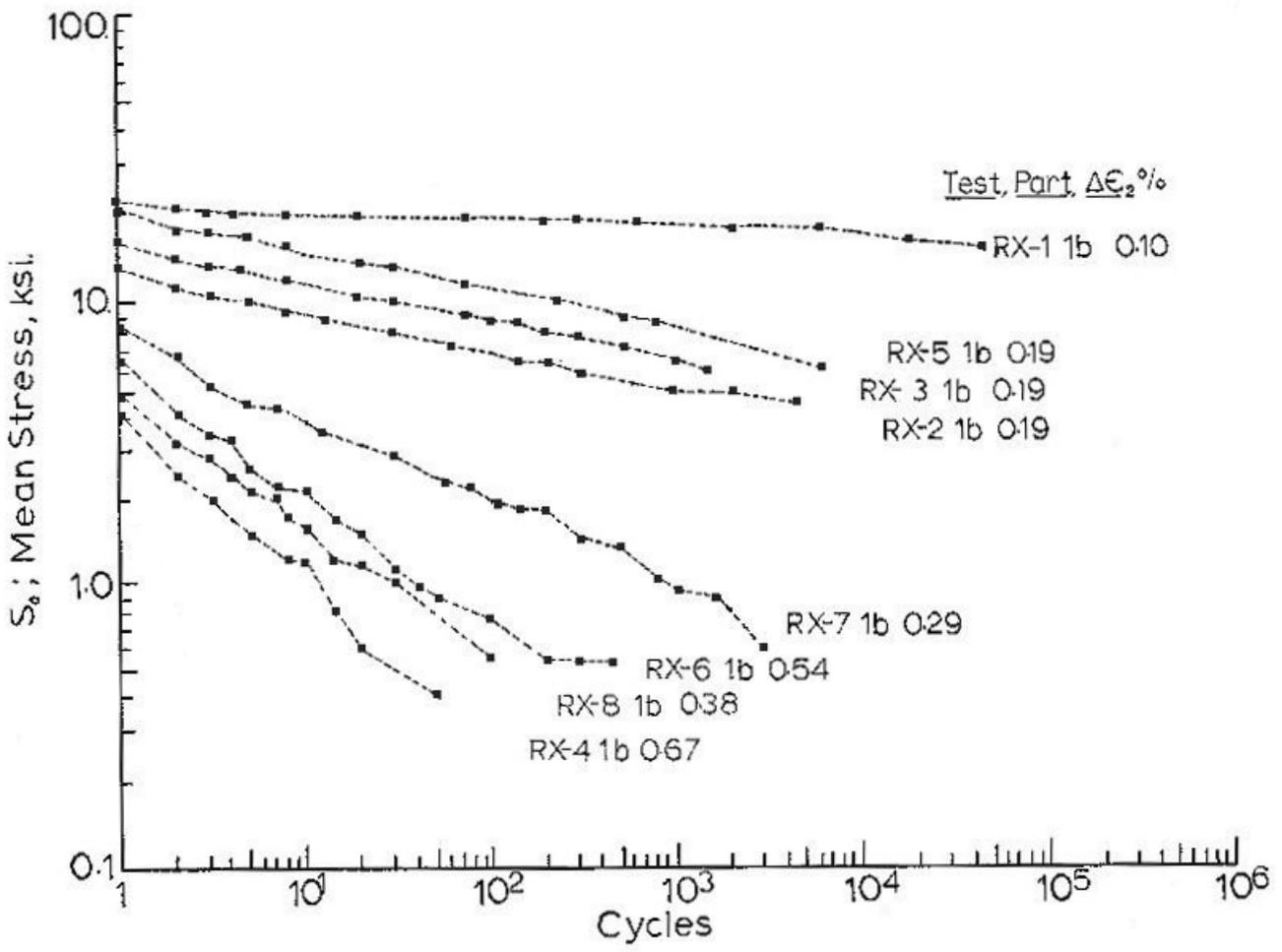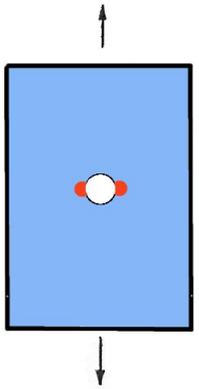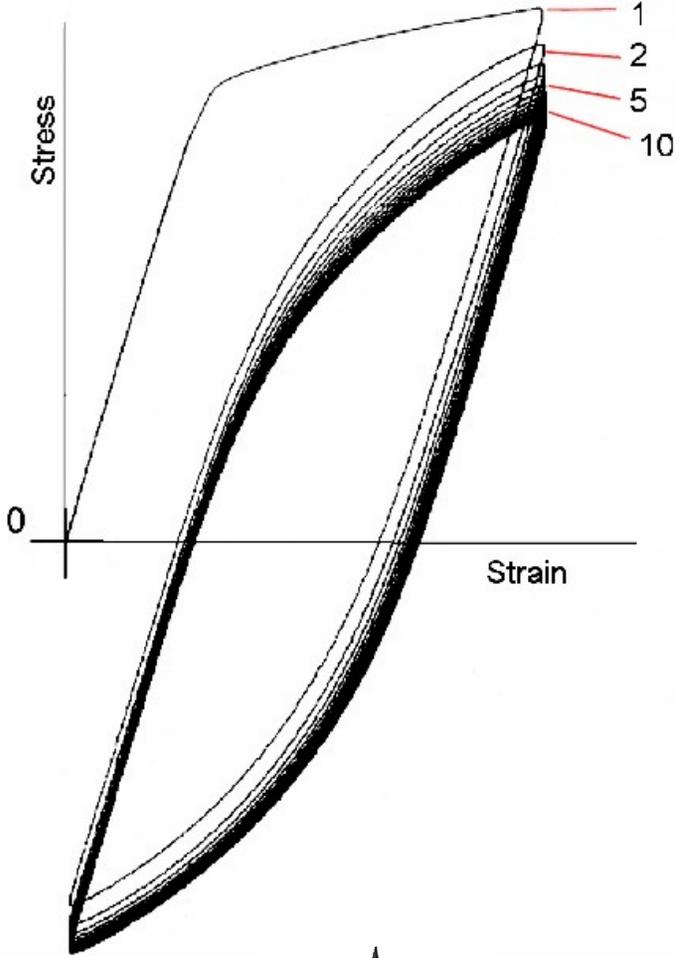


Mean Stress vs. Cycles at Secondary Strain Range $\Delta\epsilon_2$ for
Part 1b of all Tests. (First application of Cycles at $\Delta\epsilon_2$ )

# Load Histories

## Constant Amplitude tests
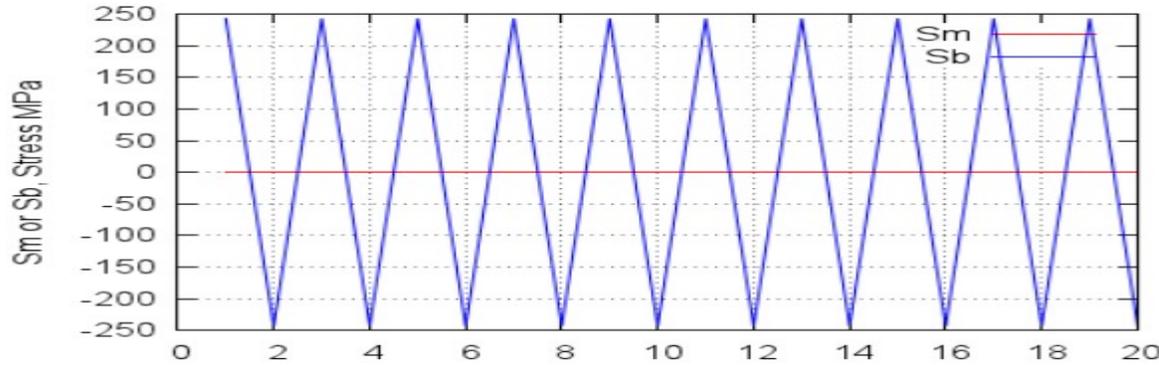


Welded T beams: R= 0.1  0.3  0.5

Machined T beams: R= 0.1  0.3  -1.

( Various  Max.  loads )



Machined T beam

Sub-Blocks of  Const. Ampl.



1 x  Bracket

2 x Suspension
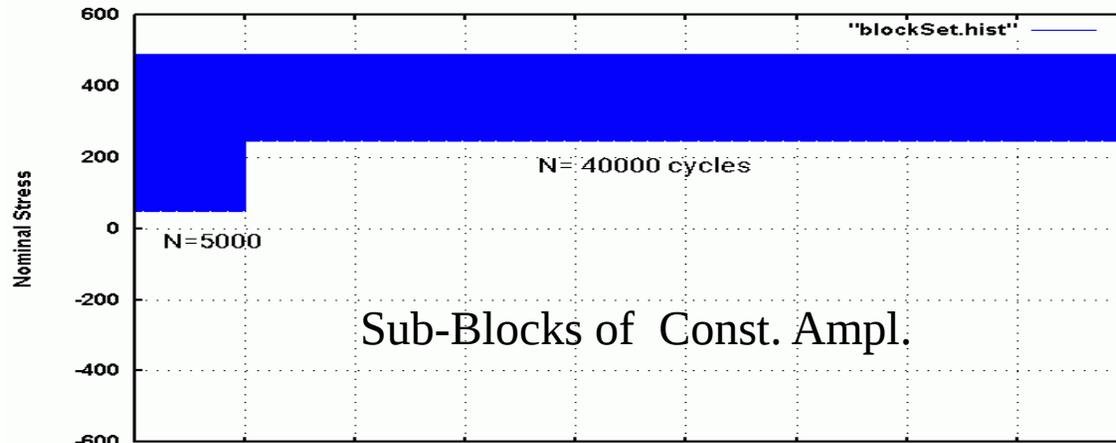
3 x Transm.
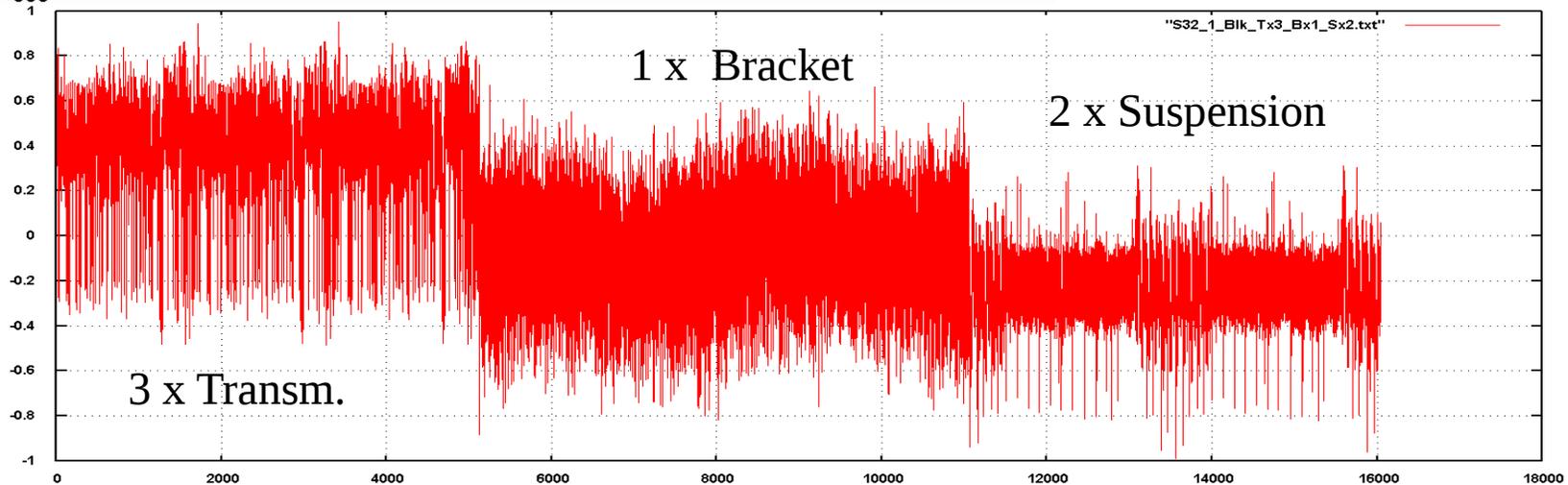
Machined
T beam

# Estimated Kt for Crack Initiation Analysis

Used Kt =
1.8
1.78

Used Kt =
1.8
2.0

Used Neuber Correction for Plasticity

Post this study:  FEA showed Kt = 1.74



2014

SAE FD&E

Machined

Welded
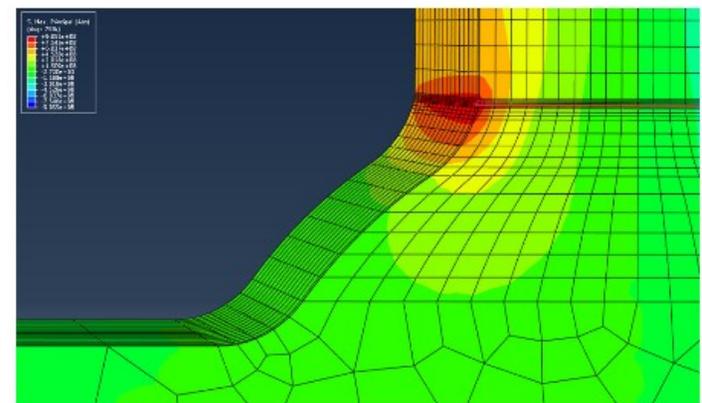
# Stress Intensity Assumptions for Crack Analysis
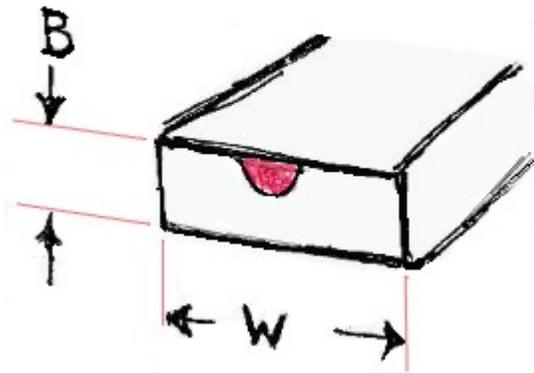
Stress Intensity equations from
British Standard 7910



$a_0 = 0.5$

$c_0 = 4$ mm
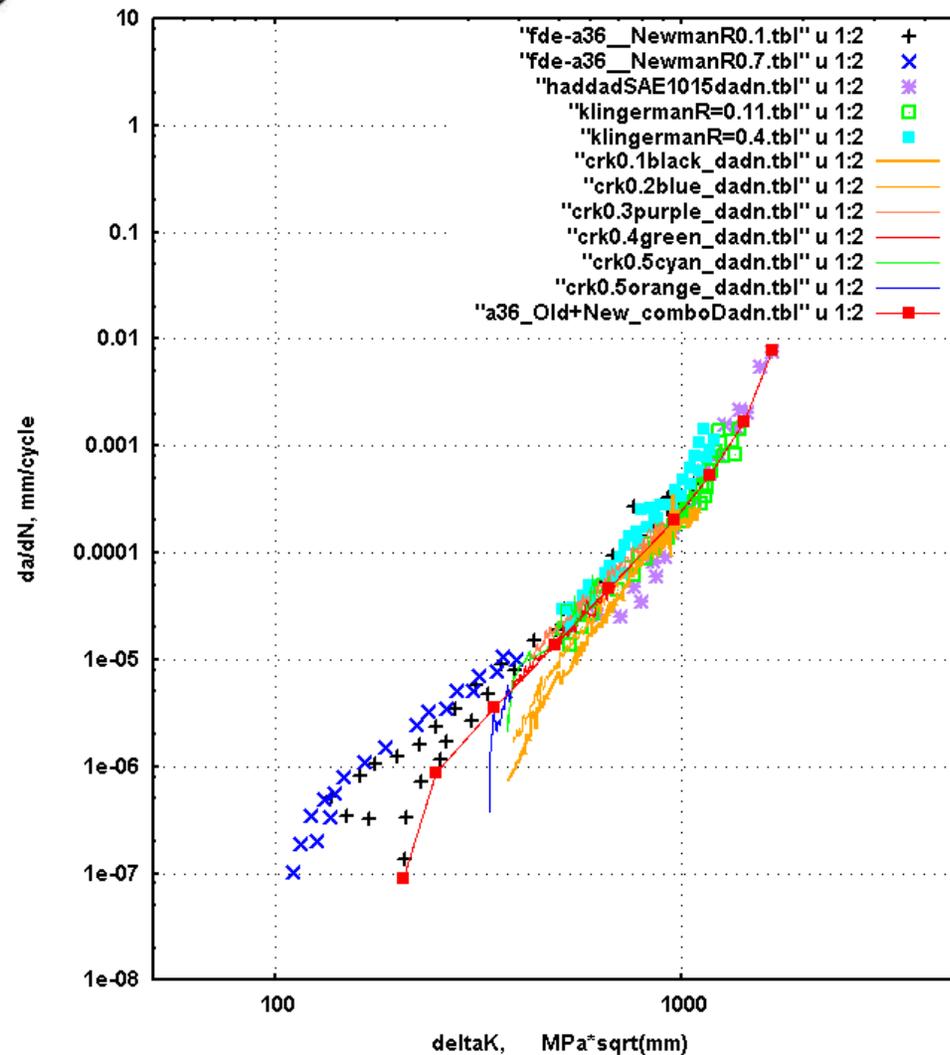
# The Addition of Material Memory to  BS-7910  Crack Propagation Analysis

CSA G40.21-50A

0.008

0.008

| Clim | Tlim |
| -------- | -------- |
| -0.008 | 0.008 |

0

0.008

0

0.002

| Clim | Tlim |
| -------- | -------- |
| -0.008 | 0.008 |
| 0.002 | |

| Clim | Tlim |
|------|------|
| -------- | -------- |
| -0.008 | 0.008 |
| 0.002 | 0.006 |

| Clim | Tlim |
|------|------|
| -------- | -------- |
| -0.008 | 0.008 |
| 0.002 | 0.006 |

0.008

0.006

0

0.002

| Clim | Tlim |
|--------|--------|
| -0.008 | 0.008 |
| 0.002 | 0.006 |
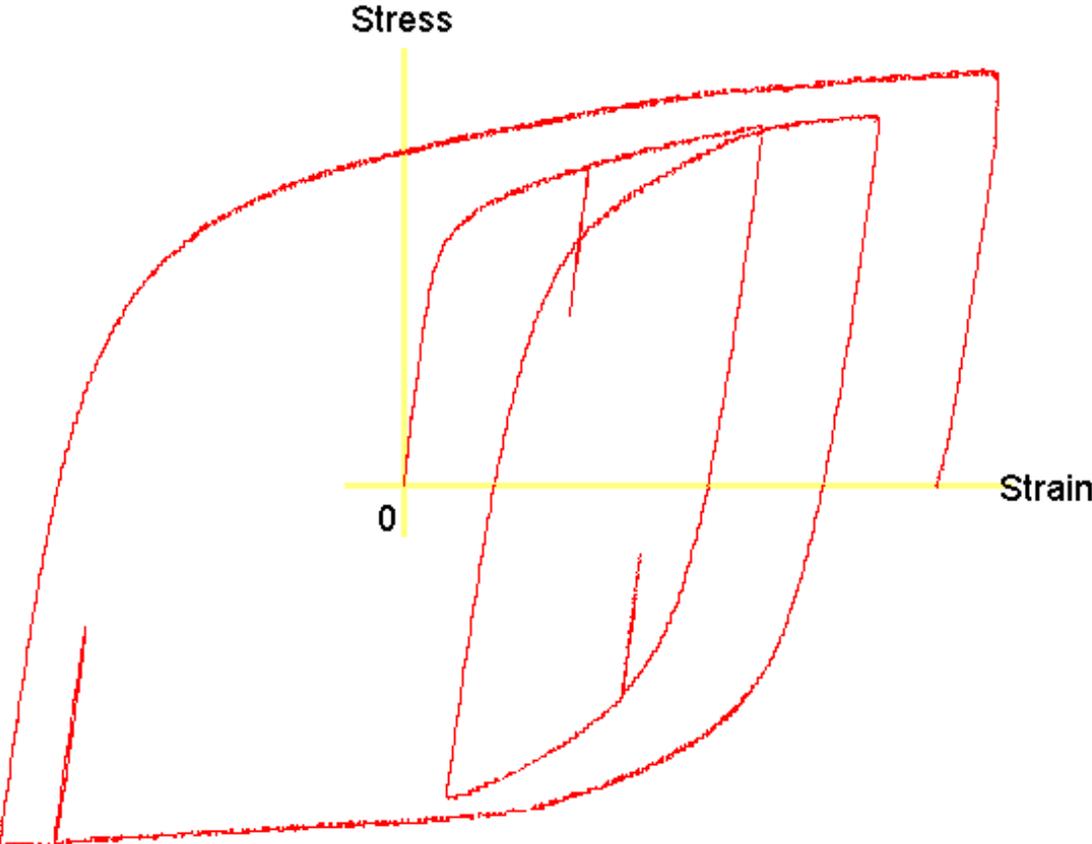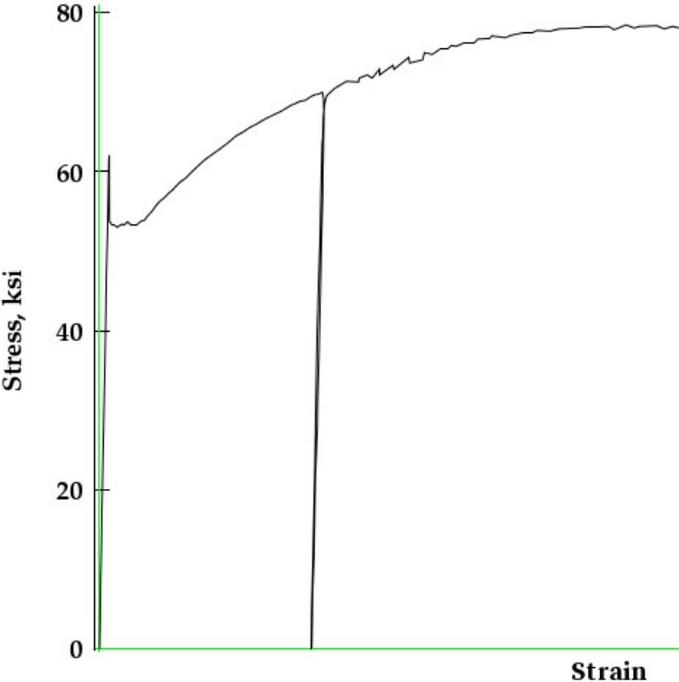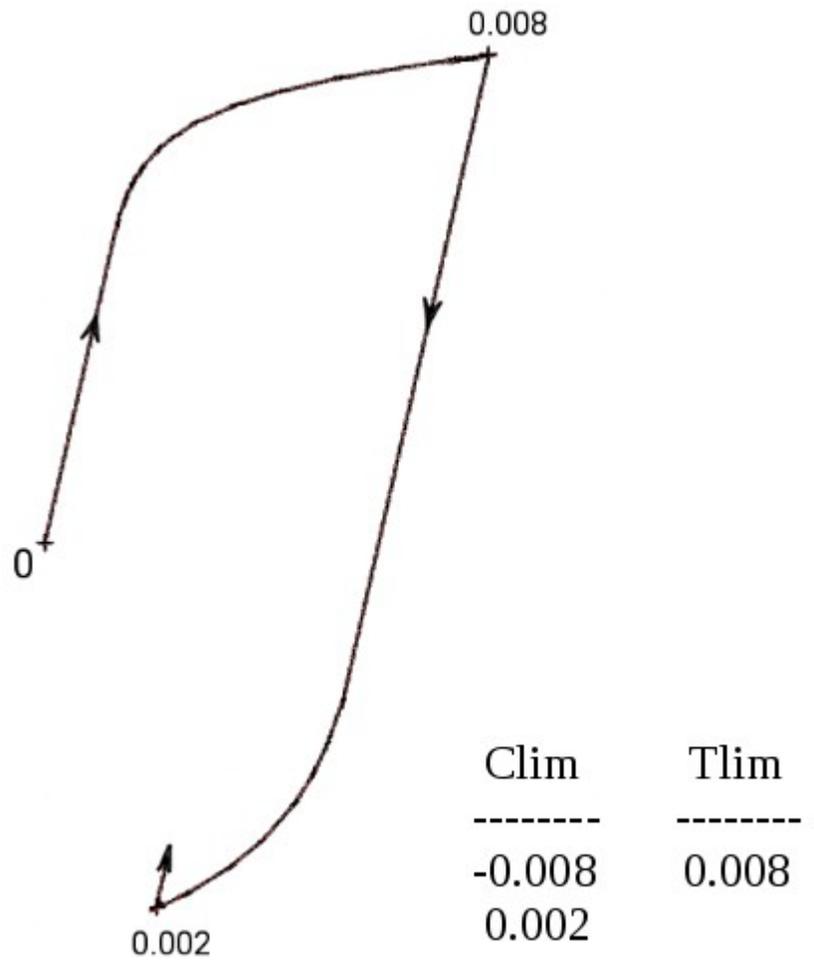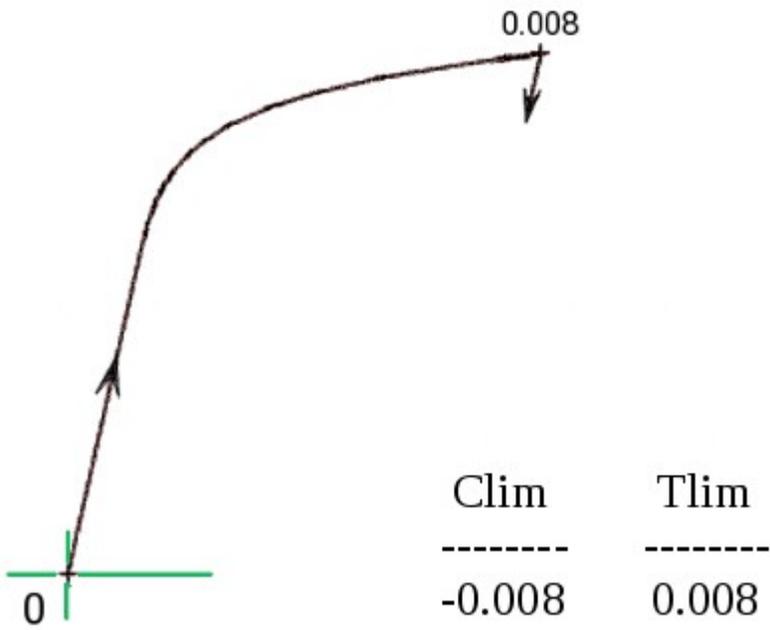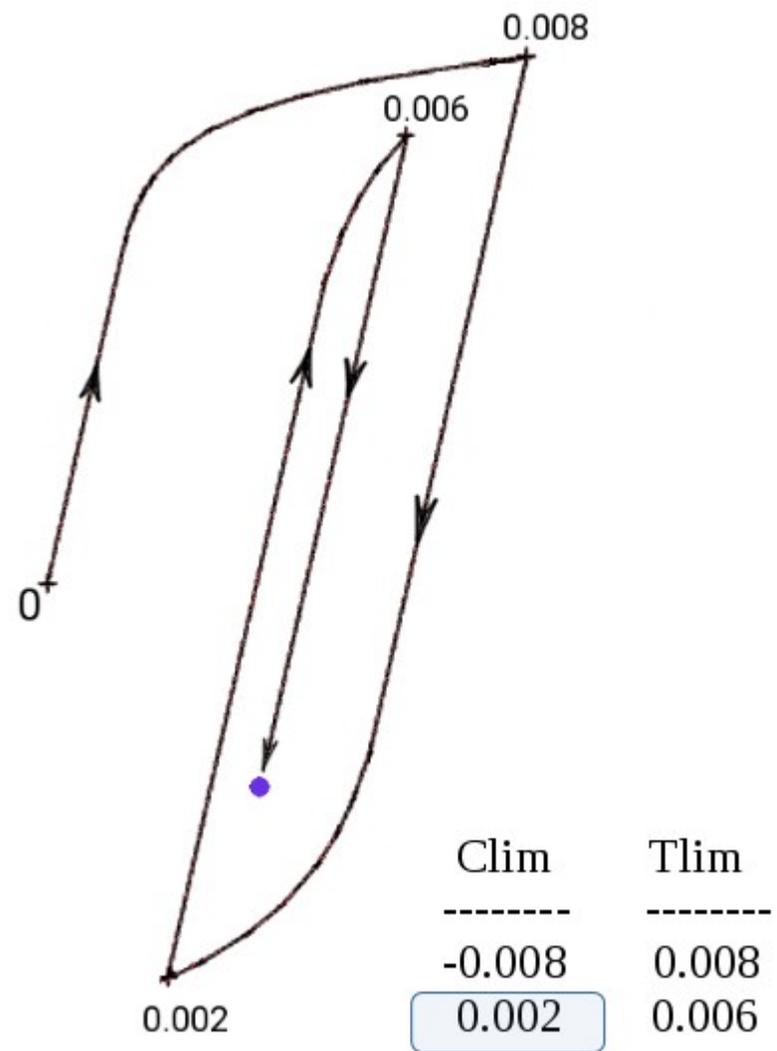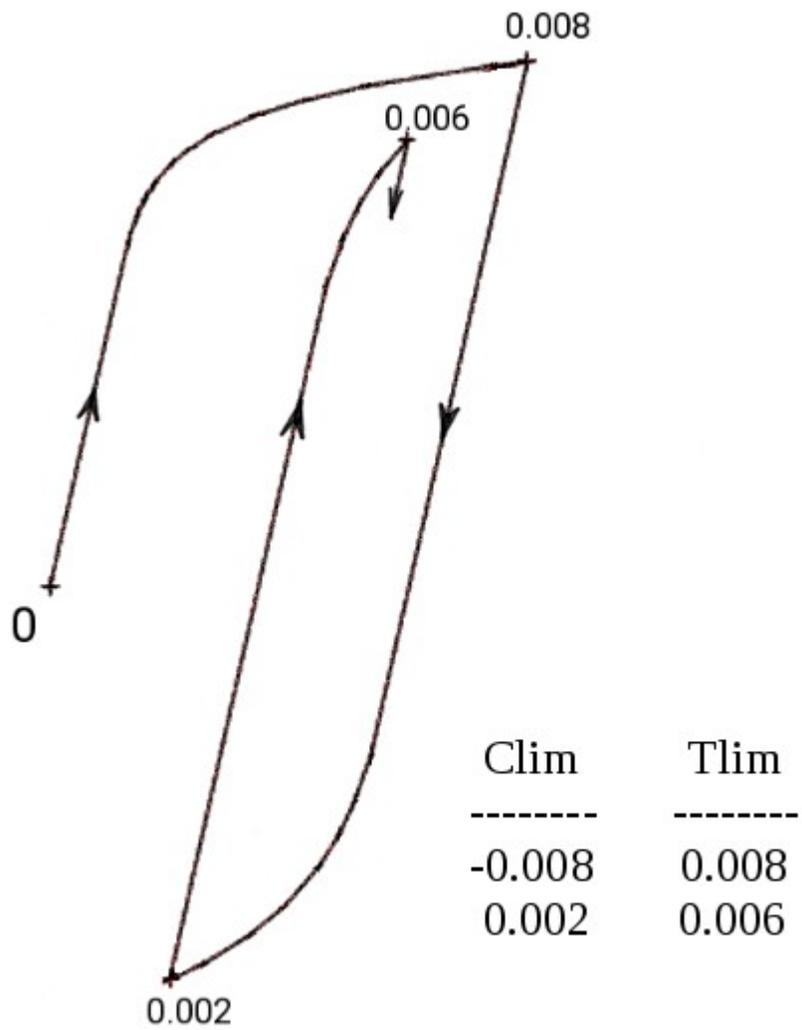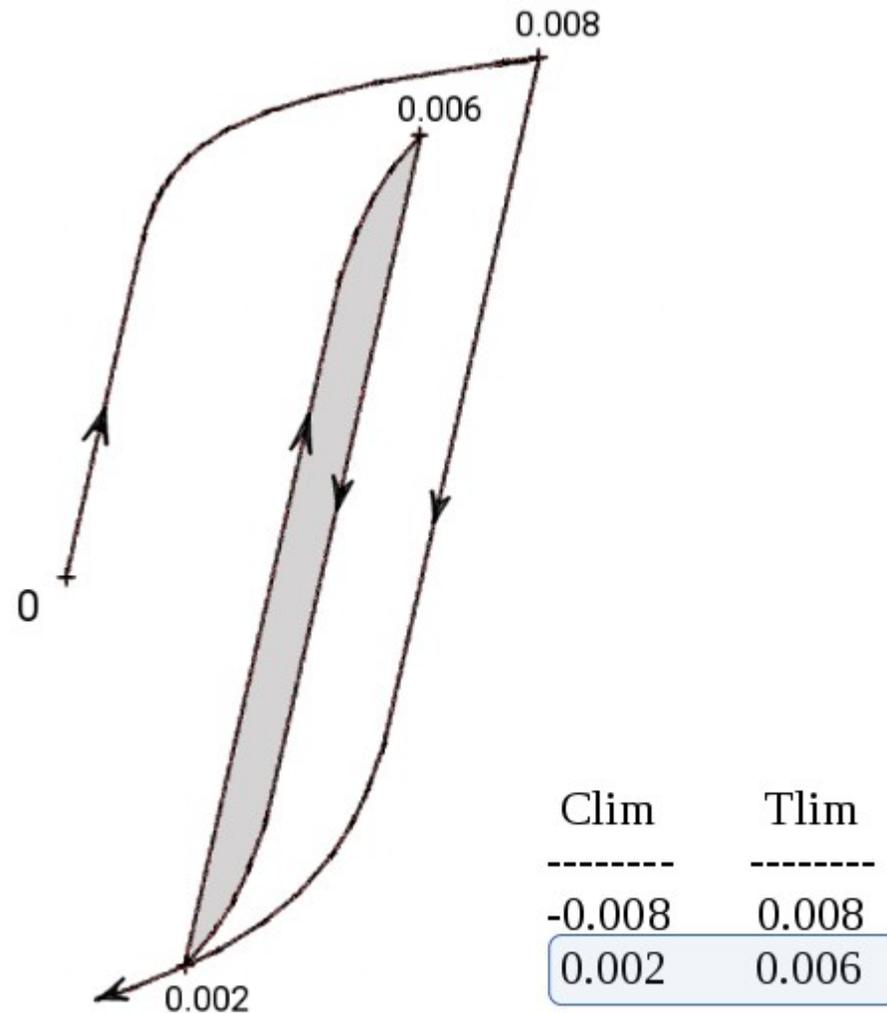
Counting can be done on   Strain,   Stress,   Load,  Stroke, or   **Stress Intensity**

# Prediction Process

Nominal Stress
+
Kt



$$\sigma \cdot \varepsilon = S \cdot e$$

A36 merged

da/dN

$\Delta$ K
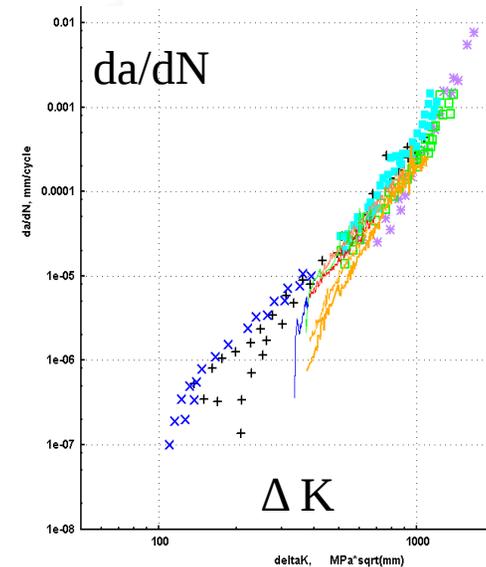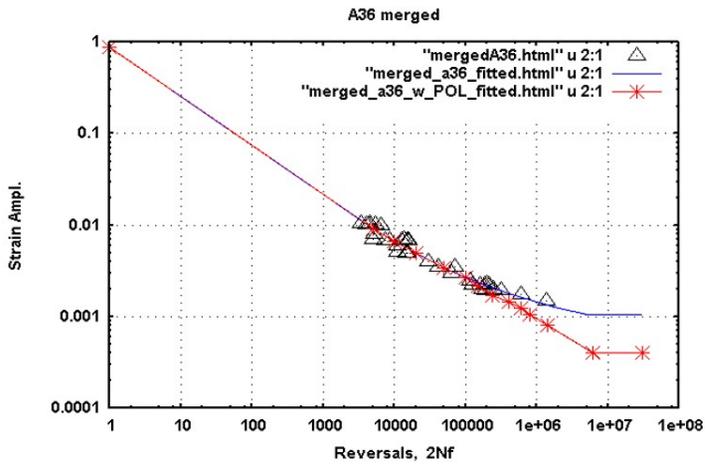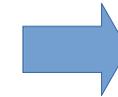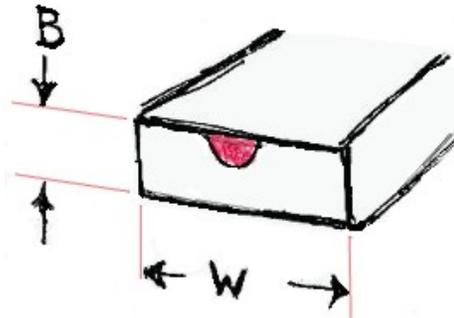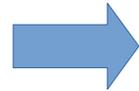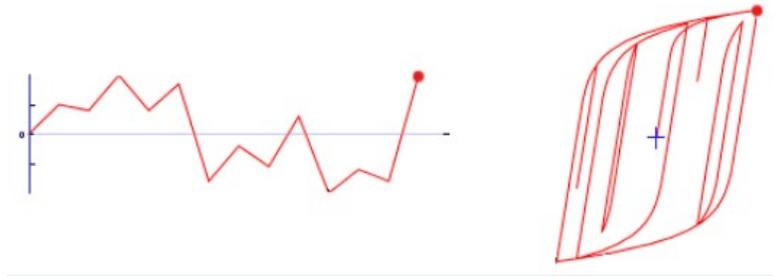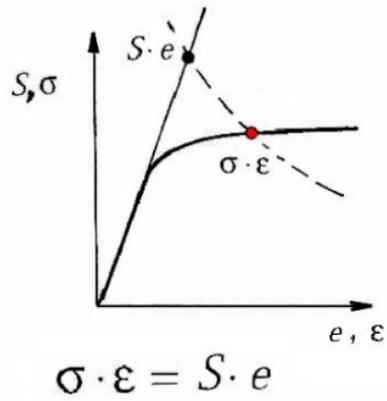
# Simulation Results vs Tests



Test Life vs Simulated   Initiation + Propagation Life, "T" Spec.

Block History: 5000 cyc. at R=0.1, 40000 cyc. at R=0.5
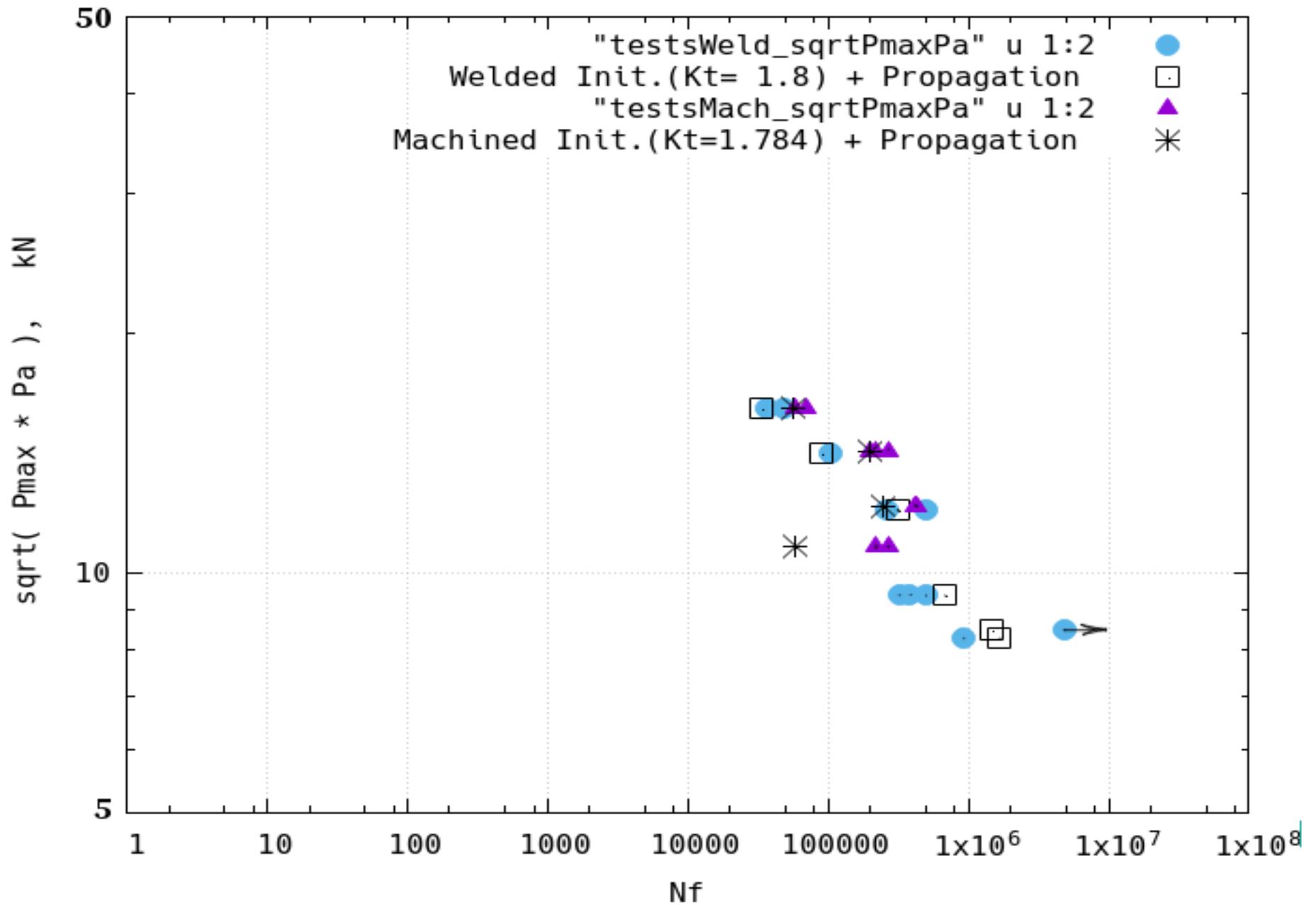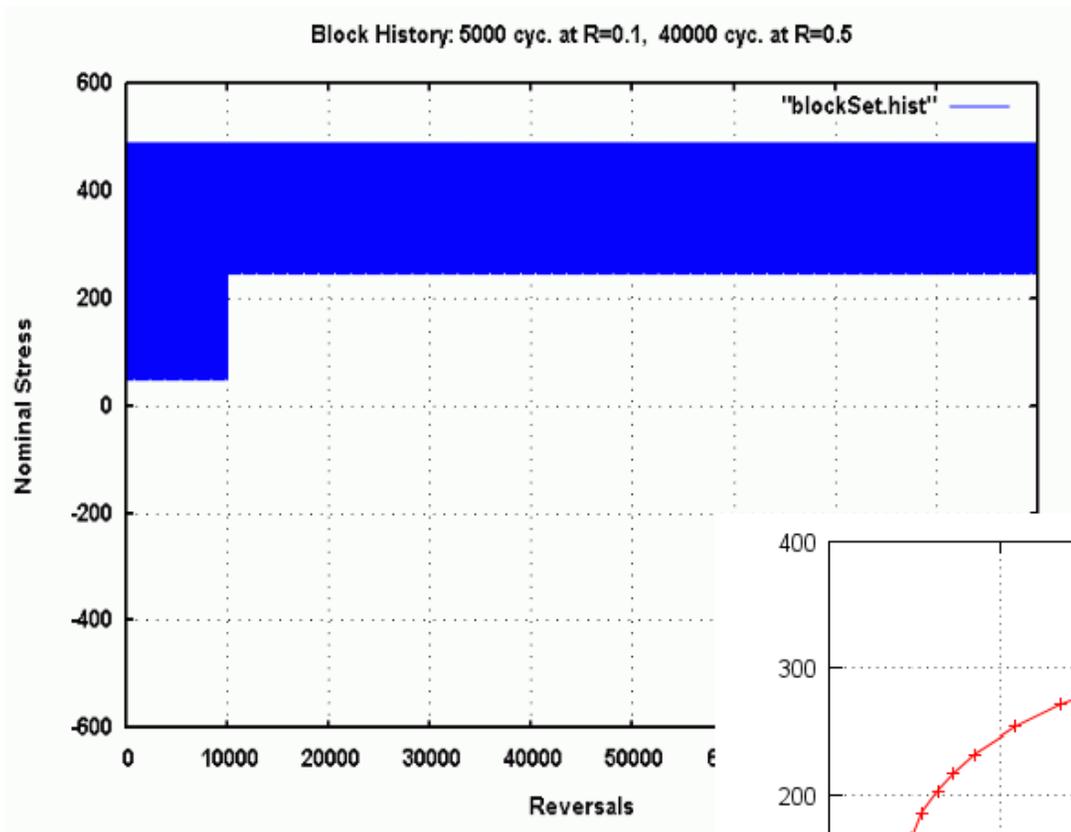
Test total life:        6.9 blks average

Sim.:
    Initiation          7.4   blks
    (non-periodic o/s
     with  relaxation )

    Propagation        <1   blk
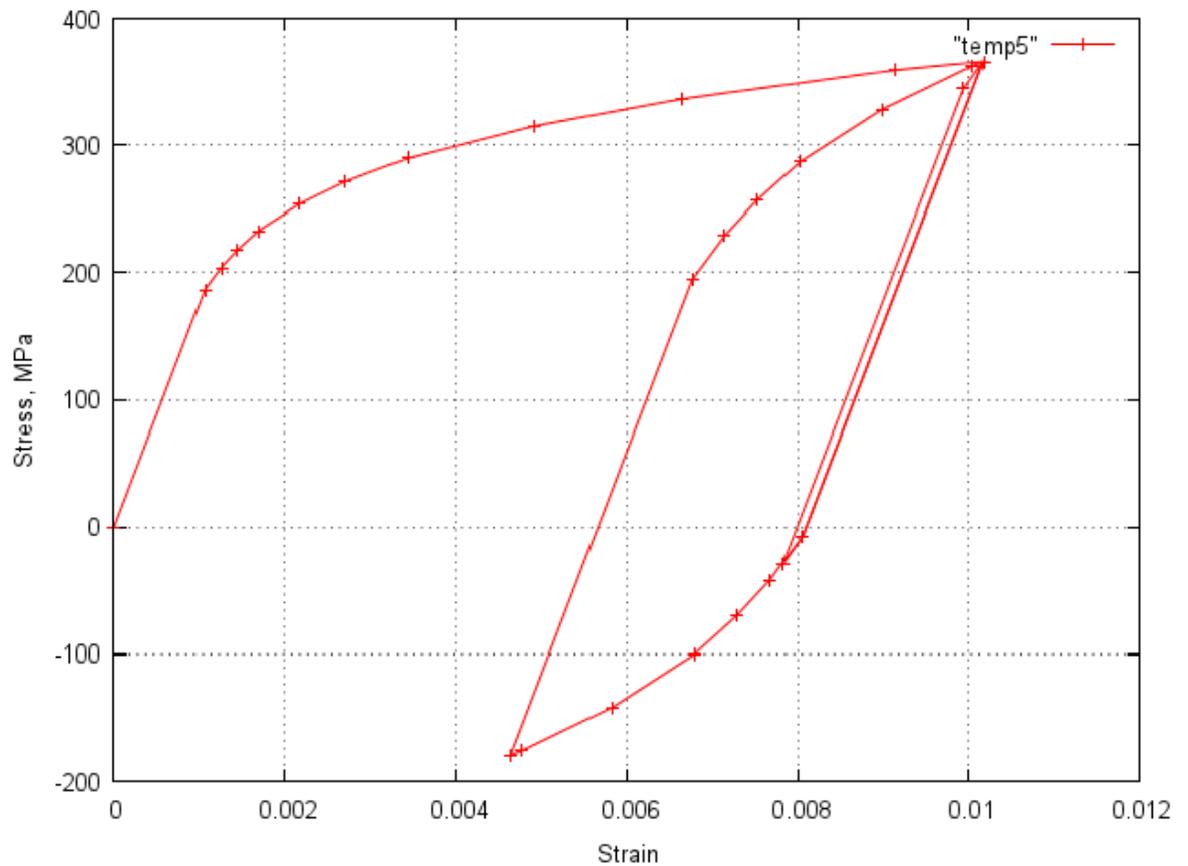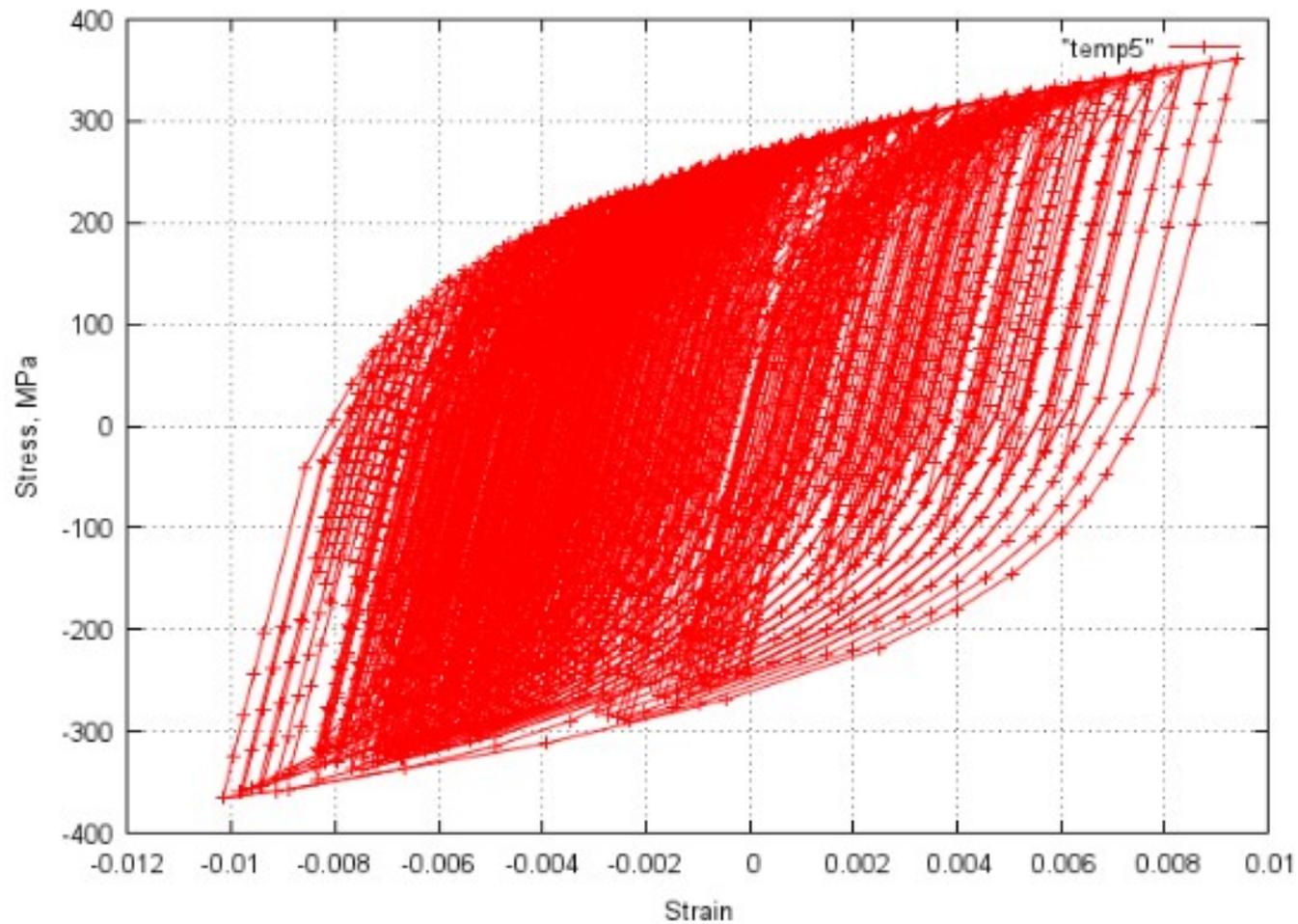
Test total life:     28.5  Blocks, average

Simulation:

    Initiation:       22.3  Blks  (with periodic o/s)
    Propagation=   < 1   Blk.
    Total:              22.5  Blks.

# Summary

Crack initiation   +  BS-7910 with material memory   =   Life prediction  (Factor of 2)

Simulations of tests with  R = -1   could be improved

Compensating for  Cyclic Mean Stress Relaxation   due to plasticity  improves predictions.

Would be nice:    Tests with measurement of   Propagating Cracks