Cyclic Mean Stress Relaxation DataBase "How-To"

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F.D.E. RS sub-comm.
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Stress-strain sequence from an un-notched axial loaded sample.

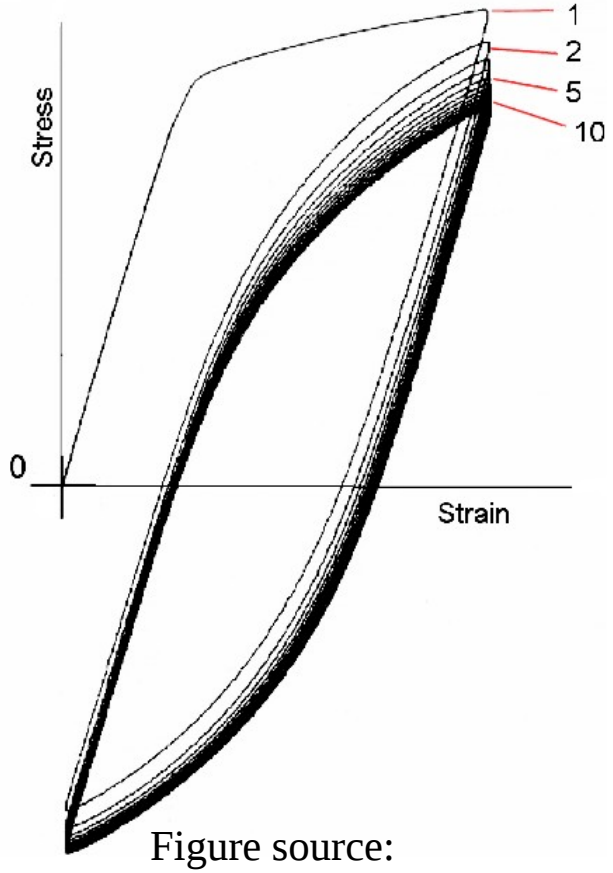


Figure source:
R.W. Landgraf

An animation of cyclic mean stress relaxation:
http://fde.uwaterloo.ca/Fde/Notches.new/Weld+Residuals/VideoA/animation.gif (9Mb)

Additional new web page on relaxation of mean stress in Aluminums (2022):
https://fde.uwaterloo.ca/Fde/Articles/relaxAlumPres-Nov2022-4web.pdf

If you have hot-spot strains use a simulator such as :
https://fde.uwaterloo.ca/Fde/Materials/Steel/Lowcarbon/A36/mergedA36_sim.html

- A36 ASTM Structural Steel (SAE1026) (Miller/Reemsnyder 1983)
  (not quite enough long life data to create a reliable fitted curve and calculator)
- A36 Normalized (Dindinger 2012) Fitted Calculator
- A36 Hot Rolled (Dindinger 2013)
- A36 Merged File of three above files
  Fitted Calculator Stress-Strain Simulator Neuber Simulator
  (Note: The cyclic stress-strain curve is used in the Calculator
  and Simulator above. The actual loop shapes may differ somewhat.
  See report by H.R.Jhansale TAM Rep.#383 1974)
- A36 Hot Rolled (T.J. Deves, 1982)
- A36 Simulated HAZ (Higashida 1976) Fitted Calculator Neuber Simulator
  Plot comparing Tensile tests

Axial un-notched specimen fatigue test simulator for strain input

These simulators are available at:
F.D.E. Material fatigue database:
https://fde.uwaterloo.ca/Fde/Materials/dindex.html
or use a plasticity FEA model such as Abaqus to generate
the stress-strain hysteresis loops created during fatigue cycling.

e.g.:

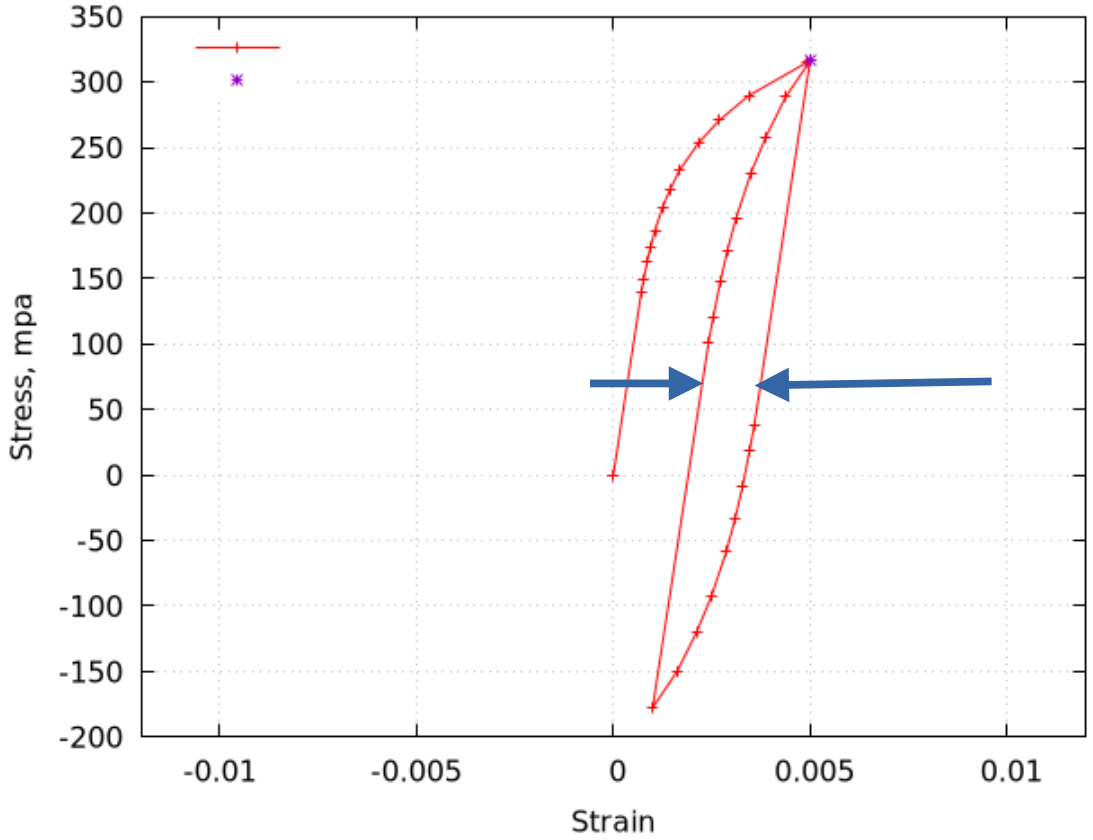
Note that in this example the hysteresis loop has a non-zero mean stress due to the strain sequence.

#MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the

#MagFactor= 1.0 # Enter your Strain Reversal Points:

0.005 | 0.001 | 0.005 | | | | | |

Click here



#TOTDAM90= 0.1400440E-04 allowed Repeats= 71406.1 nrev= 3

Measure the width of the loop. This is the Plastic Strain **Range**.

Divide by 2 to get the Plastic Strain **Amplitude**.

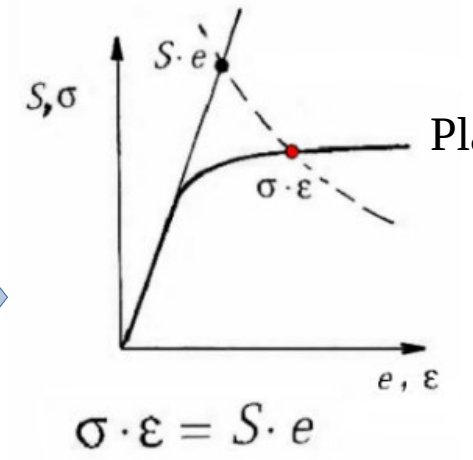
Go to the mean stress relax database and enter a set of target plastic strain values that straddle the measured amplitude.

If you have computed a Kt or used Elastic FEA use this method to compute Plastic Strain Amplitude

Kt

Smax

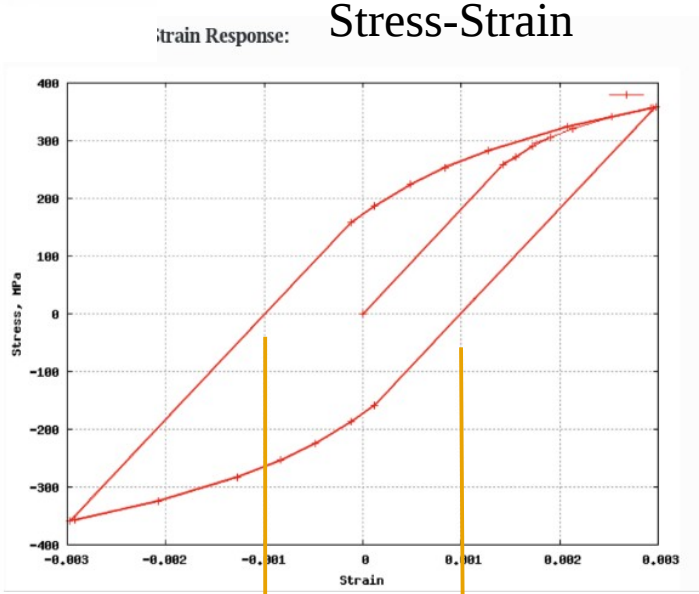
Smin



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

Apply Neuber Plasticity Correction

Get Local Stress-Strain

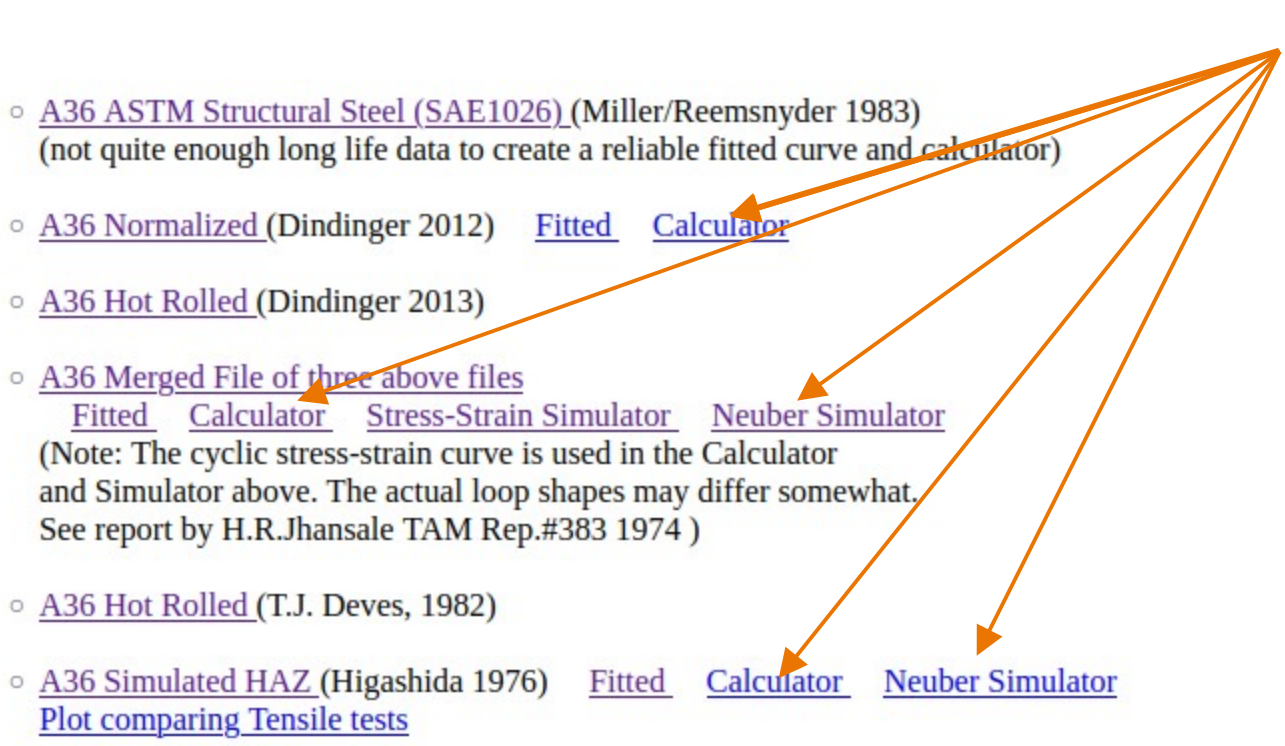


$\Delta\epsilon_p$

$\Delta\epsilon_p/2$

Again there are simulators available on-line

Estimate Plastic Strain Amplitude



Simulators for elastic FEA stress inputs.
(or a nominal stress and Kt input)

These simulators are available at:
F.D.E. Material fatigue database:
https://fde.uwaterloo.ca/Fde/Materials/dindex.html
or use a plasticity FEA model such as to generate
the stress-strain hysteresis loops created during fatigue cycling.

e.g.: https://fde.uwaterloo.ca/Fde/Materials/Steel/Lowcarbon/mergedA36_fc.html

1. Your Material (Digital-Fitted Curves):

#

```
#
#Copyright (C) 2012  F.D.E. Committee
#This data file is free software - you can redistribute it and/or
#modify it under the terms of the GNU General Public License as
#published by the Free Software Foundation; either version 2 of the
#license, or (at your option) any later version.
#This data file is distributed in the hope that it will be useful,
#but WITHOUT ANY WARRANTY - without even the implied warranty of
#MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
#GNU General PUblic License for more details.
```

#

2. 1.0 **History Magnification or Multiplication factor**

#

3. Enter Elastic Kt*Nominal (or Finite Element) Stress History (Rainflow counted cycle sets) Below:

MPa !

- Cycle Set #1 : Smax 800 Smin 200 Cycles 1
- Cycle Set #2 : Smax Smin Cycles
- Cycle Set #3 : Smax Smin Cycles
- Cycle Set #4 : Smax Smin Cycles
- Cycle Set #5 : Smax Smin Cycles
- Cycle Set #6 : Smax Smin Cycles

#

4. CALCULATE ***(Page will be submitted to UoWaterloo Website)***

Calculator input example

Aside:
OpenSource simulator program codes are available at :

https://github.com/pdprop/pdprop2

Calculator output example

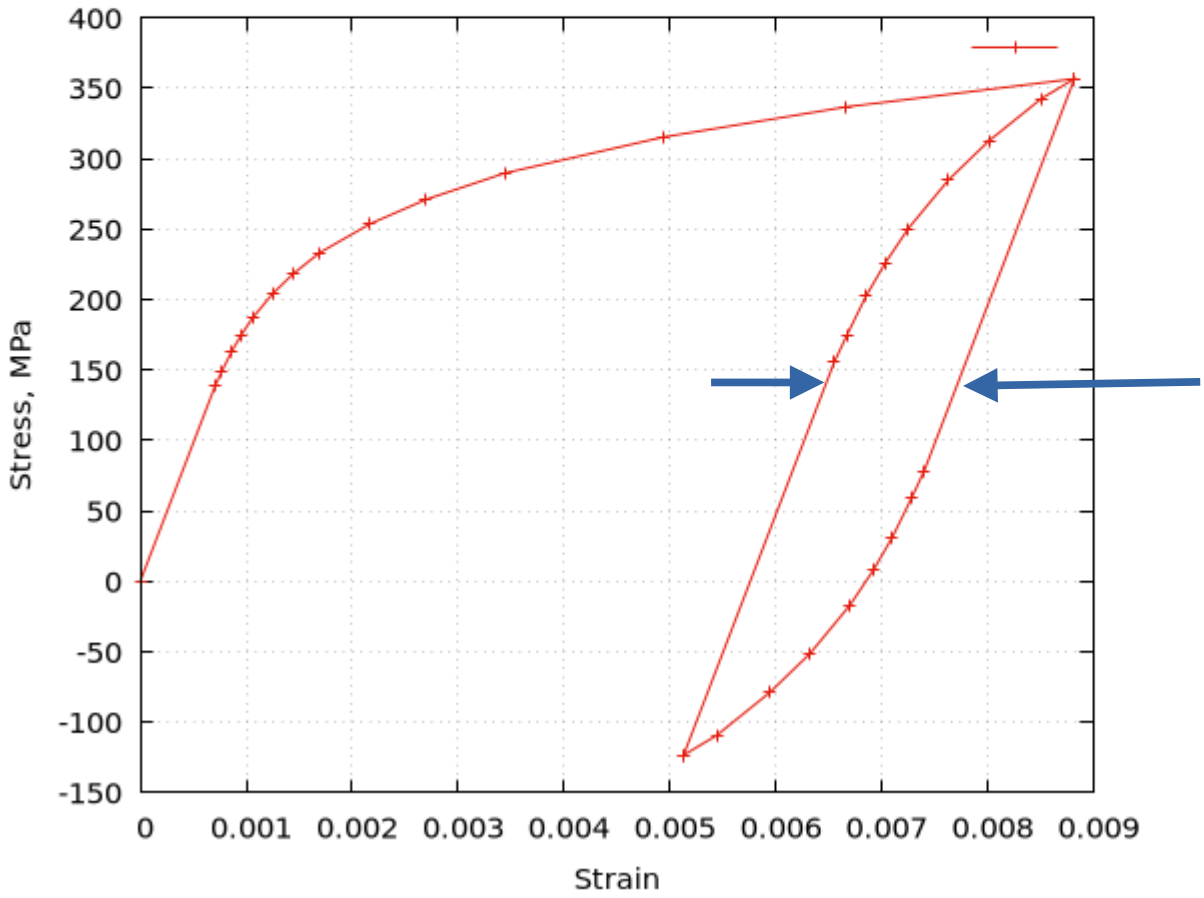
Nominal and Local Stress-Strain:

```
#xcalc2 Loop   Smax    Smin        N  Sigmax  Sigmin Delta Epsmax Epsmin DeltaEps  %Eps %SWaT %Sts %Morr %Goodm
#xcalc2    1   800.0   200.0       1.0   357.  -123.  480. 0.00882 0.00513 0.00368 100.0 100.0 100.0 100.0 100.0
```

Life Predictions (history repetitions):

```
#xcalc3  StrainLife_Reps SWaT_Life_Reps StressLife_Reps   Morrow_Reps   Goodman_Reps (Reps= Repetions)
#xcalc3    182279.5         65033.6        182279.5         33937.1         9112.2
```

Local Stress and Strain Response:



Measure the width of the loop.
This is the Plastic Strain **Range**.

Divide by 2 to get the
Plastic Strain **Amplitude**.

So Relax database at: https://fde.uwaterloo.ca/Fde/RelaxDB/startRelaxSoDB.html

F.D.+E. Steels Cyclic Mean Stress Relaxation

Note!! : Charts and information are offered with **No Warranty Whatsoever**.
They are intended for research purposes and not for design.

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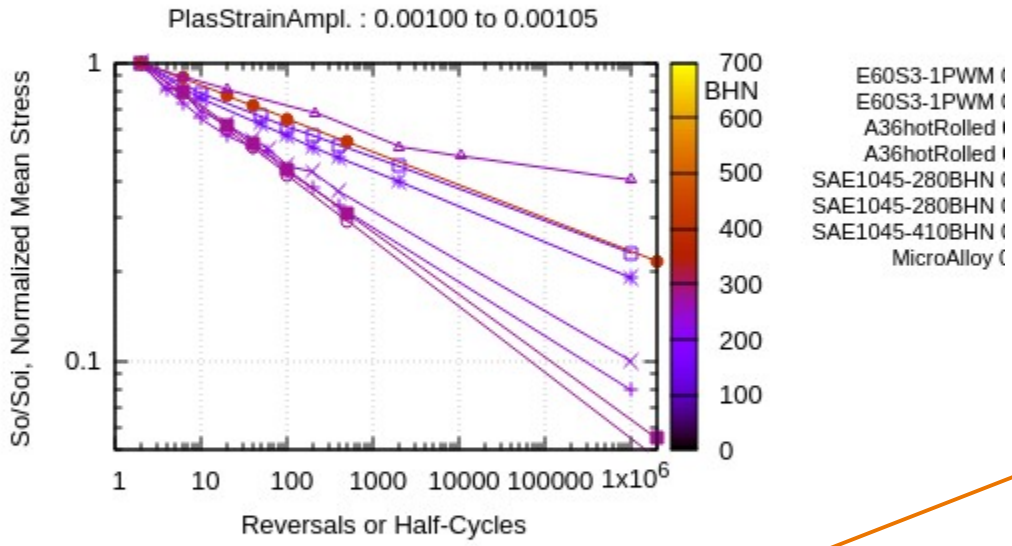
Created: Jul. 2024

Background Steel (11Mb) Background Aluminum (2Mb) How to Use (1Mb)



Enter a set of target plastic strain values that straddle the measured amplitude.

1. Enter your Plastic Strain Ampl. Bounds:
#Lower PlsStrAmpl= 0.00100 #Upper PlsStrAmpl= 0.00104
(Range between Lower and Upper is limited to 0.002 strain)

Pick one: # ◉ Chart of So # ○ Chart Normalized So/Soi #
#Green= 0

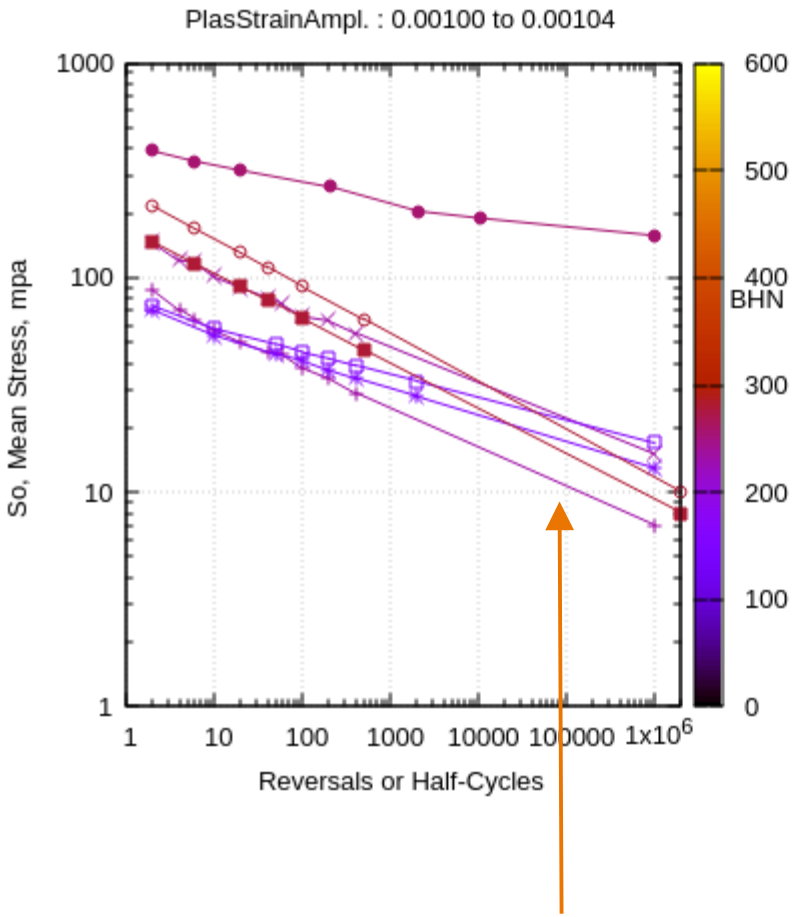
Get Chart

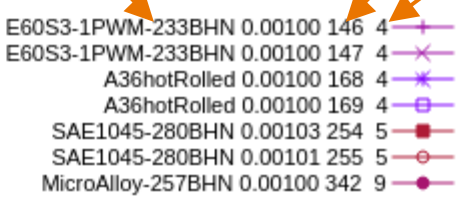
Select if you want a Normalized plot

Click for plot

Output example from Relax DB web page

Material Plastic Str.Ampl. File Ref.





Most researchers only measured relaxation for ~200 or 1000 cycles.
Measured points are shown.
Points at 1 or 2 million are from extrapolations.

Extrapolations from the measured points

End of “How To” for now. Have fun.