Results for xpipe2.3 : Crack Propagation Int. Pipe Surface Flaw

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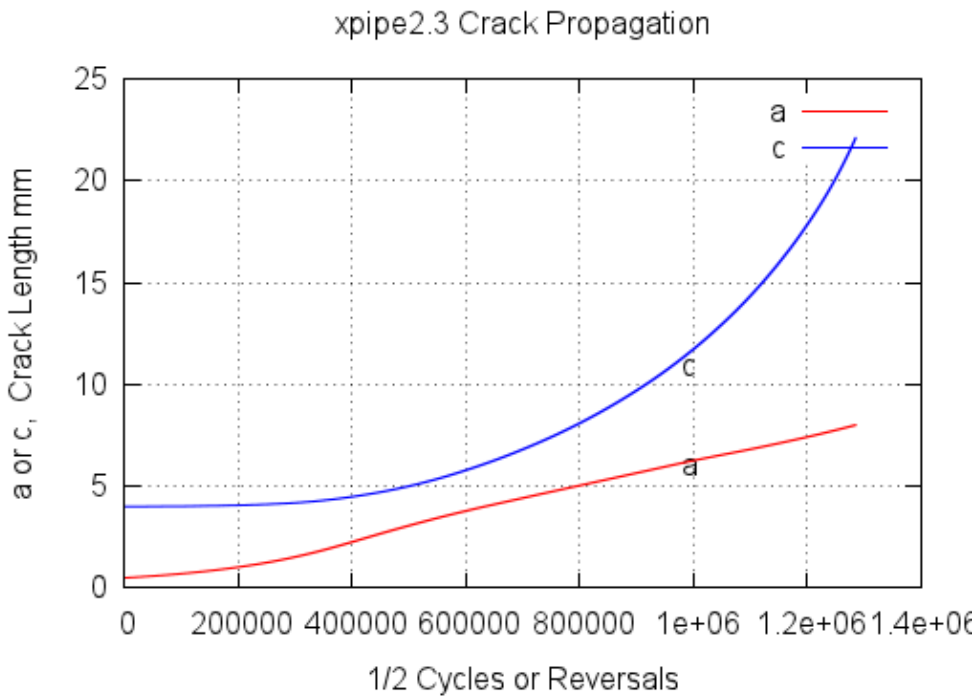
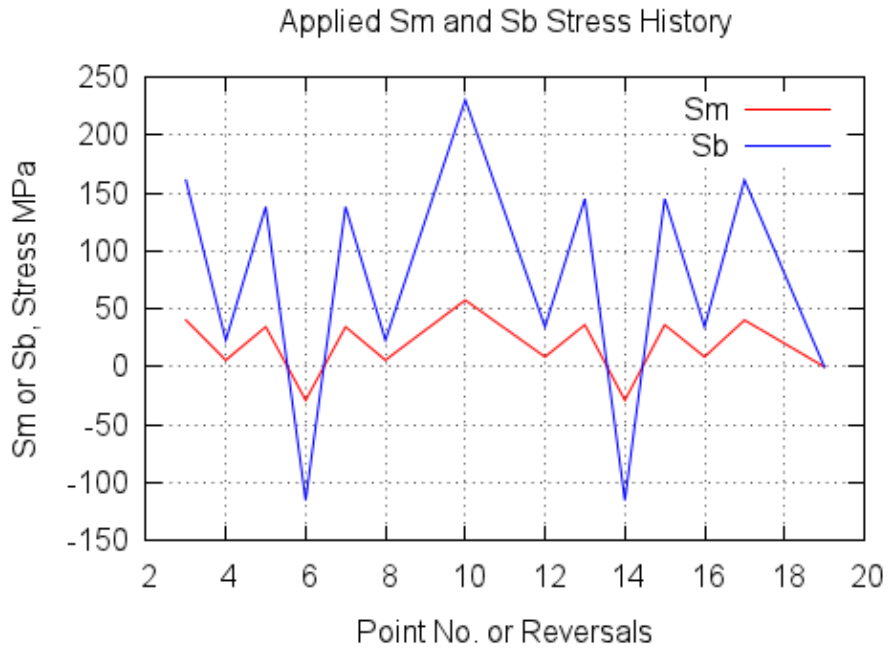
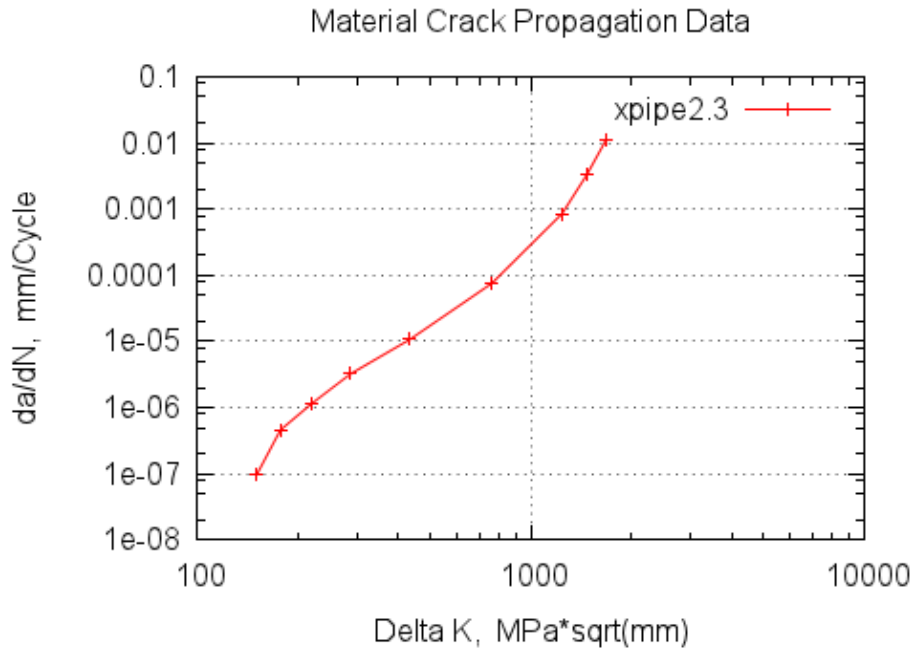
Simulation input data:
B= 10.0 mm
r_i= 50. mm
a_0= 0.5 mm
c_0= 4.0 mm
#MATERIAL= merged_a36_fitted.html
#TYPE= pipe_inside_surface_flaw
#ACTIVATE_MmMb= 1 _____#ACTIVATE_MkmMkb= 0 _____#ACTIVATE_fw= 0

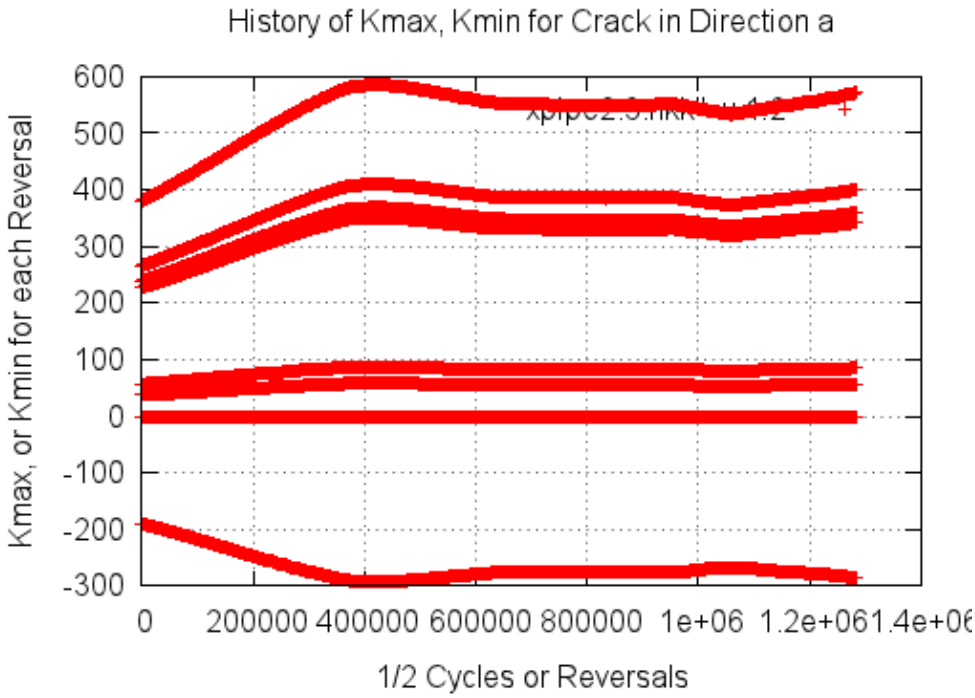
Crack Propagation Results:

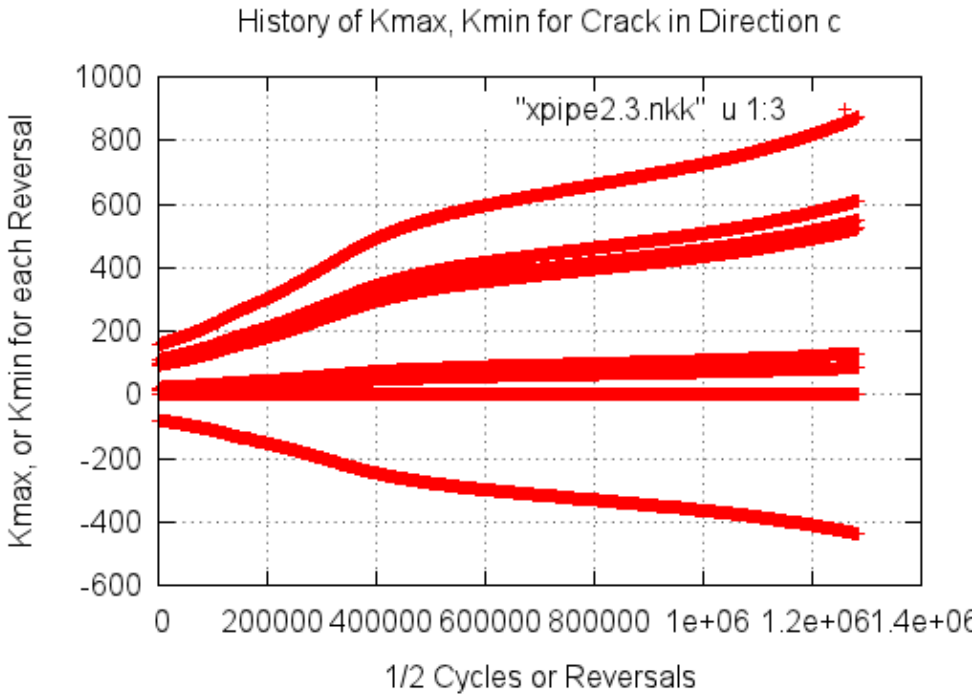
- No. of Reversals= 1284776 revs. or 642388 cycles
- Final _____ **a** = 0.7999976E+01 mm
- Final _____ **c** = 0.2209251E+02 mm
- No. of History Reps.= 91770 reps. + 10 revs.

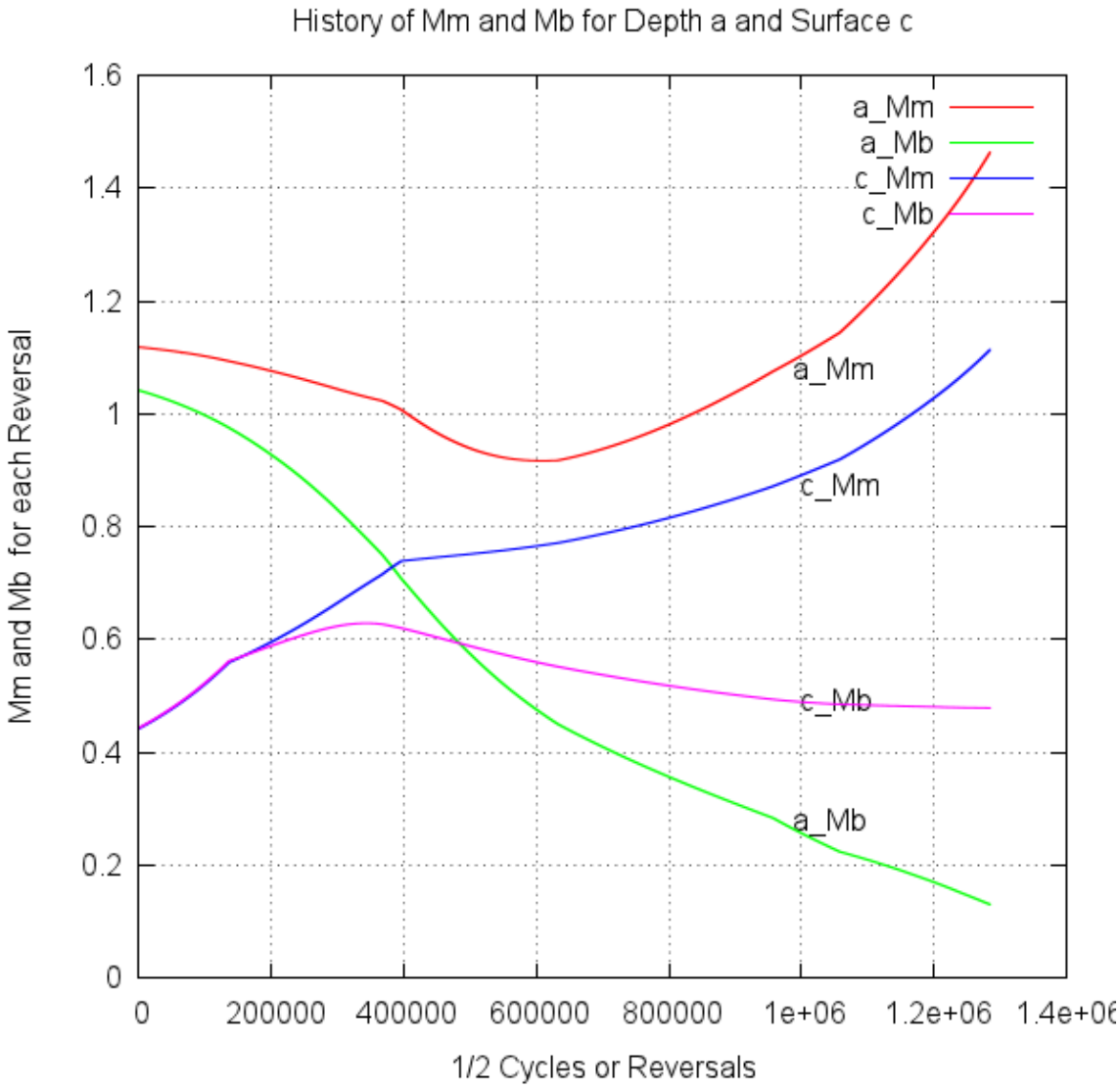



Applied Sm and Sb Stress History
Sm
Sb
Sm or Sb, Stress MPa
250
200
150
100
50
0
-50
-100
-150
2
4
6
8
10
12
14
16
18
20
Point No. or Reversals


Material Crack Propagation Data
xpipe2.3
da/dN, mm/Cycle
0.1
0.01
0.001
0.0001
1e-05
1e-06
1e-07
1e-08
100
1000
10000
Delta K, MPa*sqrt(mm)


History of Kmax, Kmin for Crack in Direction a
Kmax, or Kmin for each Reversal
600
500
400
300
200
100
0
-100
-200
-300
0
200000
400000
600000
800000
1e+06
1.2e+06
1.4e+06
1/2 Cycles or Reversals


History of Kmax, Kmin for Crack in Direction c
"xpipe2.3.nkk" u 1:3
Kmax, or Kmin for each Reversal
1000
800
600
400
200
0
-200
-400
-600
0
200000
400000
600000
800000
1e+06
1.2e+06
1.4e+06
1/2 Cycles or Reversals


History of Mm and Mb for Depth a and Surface c
Mm and Mb for each Reversal
1/2 Cycles or Reversals
a_Mm
a_Mb
c_Mm
c_Mb
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
0
200000
400000
600000
800000
1e+06
1.2e+06
1.4e+06

Crack Initiation Life Results for xpipe2.3

Files Used:

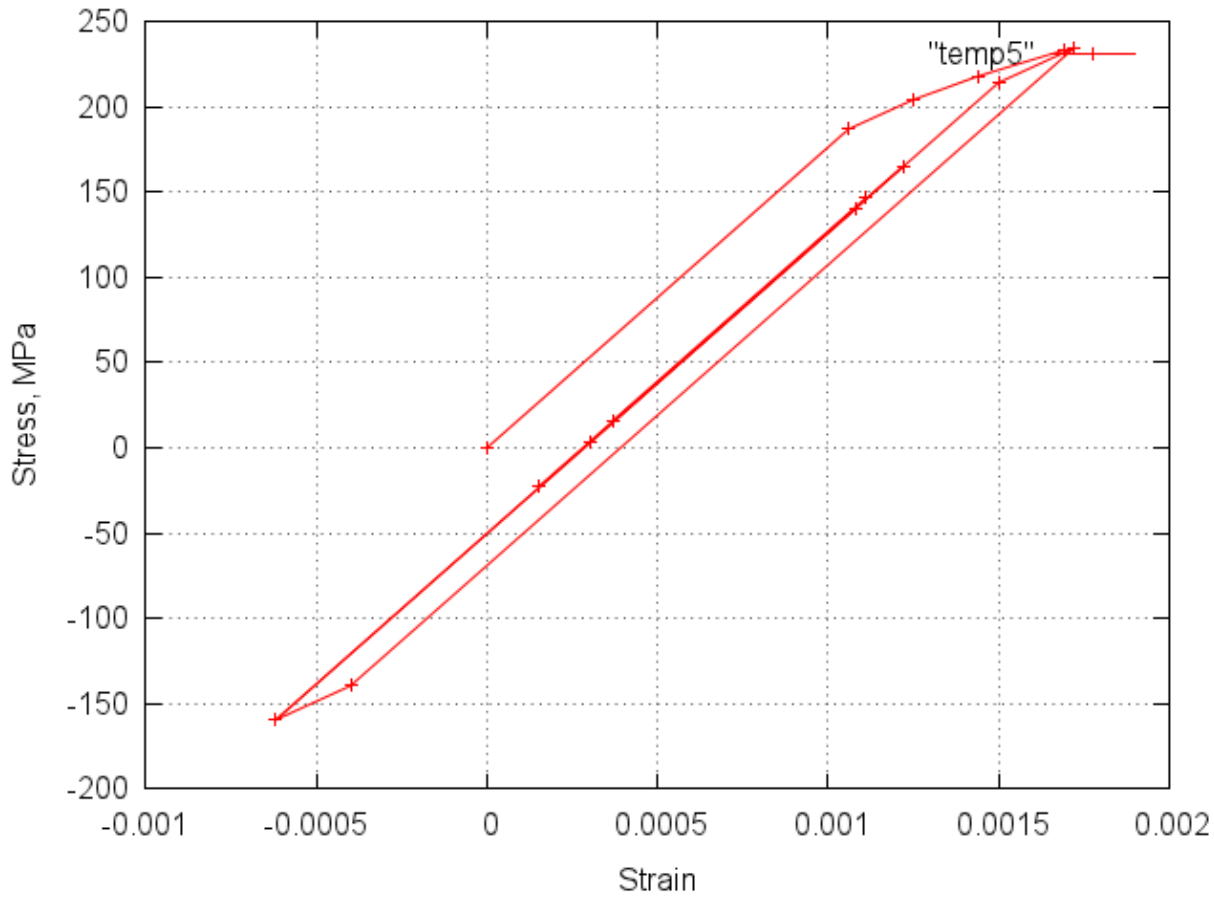
- Stress History (Sb+Sm)
- Rainflow File
- Material File

Loop	Smax	Smin	N	Sigmax	Sigmin	Delta	Epsmax	Epsmin	DeltaEps	%Eps	%SWaT	%Sts	%Morr
1	286.0	-147.0	1.0	234.	-160.	394.	0.00172	-.00062	0.00234	100.0	100.0	100.0	100.0
2	202.0	-147.0	1.0	165.	-160.	325.	0.00122	-.00062	0.00184	0.0	0.0	0.0	0.0
3	202.0	-0.0	1.0	165.	-23.	188.	0.00122	0.00015	0.00107	0.0	0.0	0.0	0.0
4	175.0	27.9	2.0	140.	3.	137.	0.00108	0.00030	0.00078	0.0	0.0	0.0	0.0
5	182.0	41.9	2.0	147.	16.	130.	0.00111	0.00037	0.00074	0.0	0.0	0.0	0.0

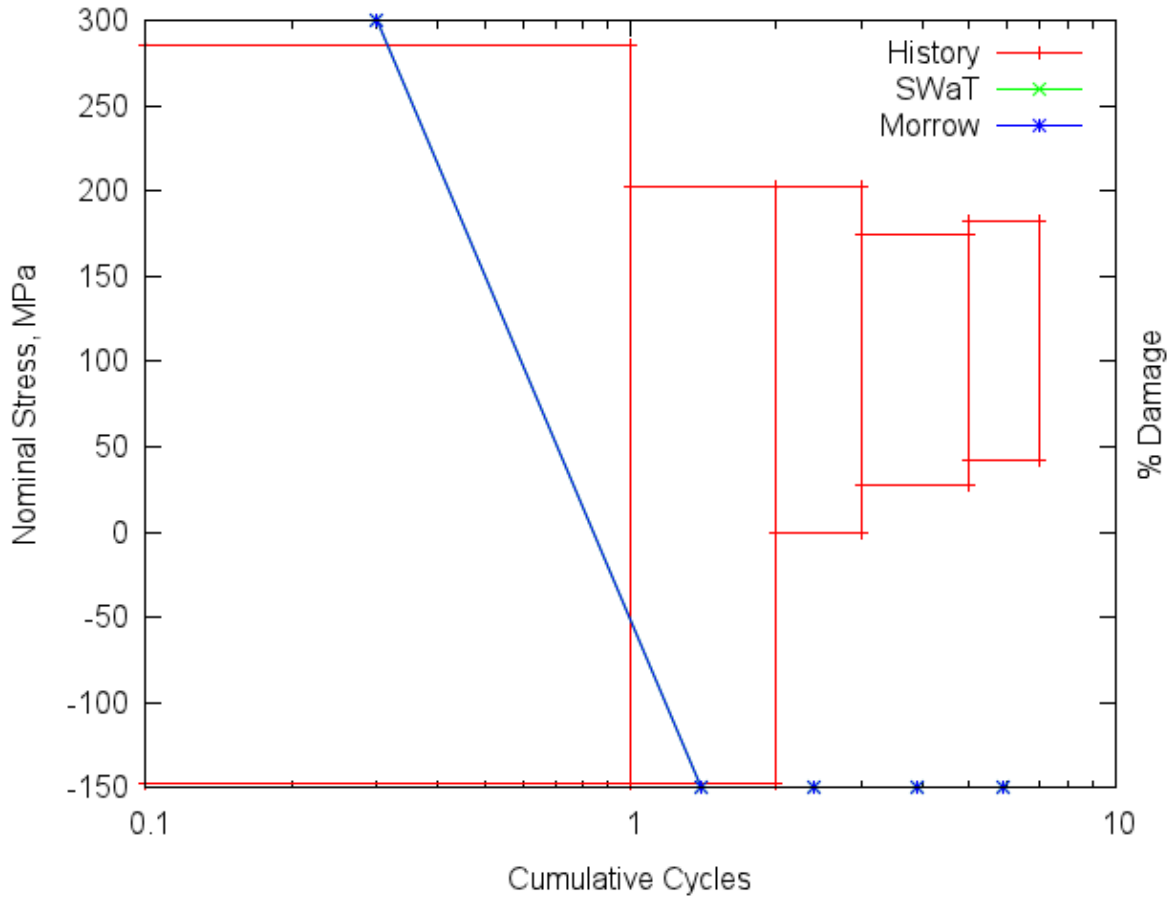
Predicted History Repetitions to Initiation:

StrainLife_Reps	SWaT_Life_Reps	StressLife_Reps	Morrow_Reps	Goodman_Reps (Reps= Repetions)
1449787.9	788522.9	1449786.4	877723.0	614678.0

Local Stress and Strain Response:



Cumulative Cycle Plot of History and Damage:



(Rectangles are Rainflow Cycle Sets: Sorted by Range: largest on Left)

Appendix 1: Print of "pdprop.env" Simulation Control file

```
# This file contains the starting filenames, variables etc
# for the Crack Propagation  programs.   It should be edited by the
# user before each simulation run. It can also be generated from web
# page at:  to be determined
#

#TYPE= pipe_inside_surface_flaw     #with or without weld using ACTIVATEs:
#ACTIVATE_MmMb=     1    #  Deactivate  = 0
#ACTIVATE_MkmMkb=   0    #  Set to off for inside surf. flaw.( not available )
#ACTIVATE_fw=       0    #  Set to off for inside surf. flaw.( fw=1.0 )

#                               #Other      #TYPE=  options:
#                               # plate_long_surface_flaw
#                               # plate_tru_flaw
#                               # plate_embedded_flaw
#                               # plate_edge_flaw
#                               #
#                               # pipe_inside_surface_flaw
#                               # pipe_long_inside_surface_flaw
#                               # pipe_full_inside_flaw
#                               # pipe_full_outside_flaw
#                               #
```

```
#                               # rod_surface_flaw
#                               # rod_full_outside_flaw

#                               # These problem types are used to pull in the
#                               # appropriate Fw, Mm, Mb, files etc.

# The factors described in this section may be ignored if not applicable to
# the particular problem type described above.
# (All dimensions in mm)
#B= 10.0   # plate (or pipe wall) thickness
#W=  0.0   # plate width
#ri= 50.    # Internal diameter if pipe problem
#azero= 0.5  # initial crack depth
#czero= 4.0  # initial 1/2 crack width at surface
#L= 0.      # Weld Feature width.  Set to 0.0 if no Mkm or Mkb (weld)

#HISTORYFILE=  load1.txt    # historyFileName
#           # Adjustments to load file variables:
#           # Note that the MEANADD (below) is added AFTER the MAGFACTOR is applied.
#MAGFACTOR_m= 1.0     # Multiply factor on membrane load. Result should be MPa
#MAGFACTOR_b= 1.0     # Multiply factor on bending load term. Result should be MPa
#MEANADD_m=   0.0     # Mean shift in MPa added to membrane stress.
#MEANADD_b=   0.0     # Mean shift in MPa added to bending stress.

#MAXREPS=  100000     # Max no. history repeats in simulation.
#                     # One repetition or application of the load history is
#                     # also called a "block" of cycles.
#                     # Normally this would be some large number.
#
#MATERIAL=  merged_a36_fitted.html   #File name of material fitted data
#                                 This file is used to define the cyclic
#                                 stress-strain curve, and the Neuber Product curve.
#
#DADN= table                      # Can be "table" or "Paris"
#DADN_PARIS= 0.0 0.0 0.0 0.0 mpa_mm    # Kth  a  m  Kc units (ignored if #DADN= table )
#                              !! specify:   mpa_m   or   ksi_in  or  mpa_mm
#                             ksi_in: ksi stress, inch crack length, inches in delta_K
#                             mpa_m:  mpa stress,    m crack length, meters in delta_K
#                             mpa_mm: mpa stress,   mm crack length, mm in delta_K
#                                     same as N/(mm**(3/2))
#DADN_TABLE= a36+1015.dadn    # da/dN digitized da/dN curve for material,
#                                 including the threshold, and KIc.
#                                 If a threshold exists, put in a vertical line
#                                 (with two identical X-axis points).
#                                 If the threshold needs to be "turned off" then
#                                 do NOT put in a vertical line at low da/dN.
#                                 (Ignored when #DADN= PARIS )
#
#BLOCKSKIP=   1.0 percent       # At the end of each block check if the previous
#                                 two blocks of cycles had similar damage (crack
#                                 extension) within this percentage.  If TRUE then
#                                 simply skip the simulation of the next block,
#                                 but just add the expected damage.  Continue by
#                                 simulating the block after the skip.
#                                 A value of 0.0 will disallow skipping blocks.
#SAVELEVEL=  3               #Amout of output saved to disk:
#                            #   3=lots  2=medium  1=minimal
#                            #  (not programed yet)
```

Appendix 2: Print of da/dn vs DeltaK Table in file xpipe2.3

Delta_K	da/dN					
0.1502160E+03	0.9620540E-07	0.2176716E+01	-0.7016800E+01	0.0000000E+00	0.0000000E+00	1
0.1769830E+03	0.4562300E-06	0.2247931E+01	-0.6340816E+01	0.7121539E-01	0.6759844E+00	2
0.2202350E+03	0.1160170E-05	0.2342886E+01	-0.5935478E+01	0.9495497E-01	0.4053378E+00	3
0.2874840E+03	0.3224090E-05	0.2458614E+01	-0.5491593E+01	0.1157272E+00	0.4438853E+00	4
0.4331670E+03	0.1069760E-04	0.2636655E+01	-0.4970714E+01	0.1780417E+00	0.5208793E+00	5
0.7637410E+03	0.7556810E-04	0.2882946E+01	-0.4121662E+01	0.2462907E+00	0.8490520E+00	6
0.1240590E+04	0.8520410E-03	0.3093628E+01	-0.3069540E+01	0.2106822E+00	0.1052122E+01	7
0.1471680E+04	0.3307300E-02	0.3167813E+01	-0.2480526E+01	0.7418513E-01	0.5890131E+00	8
0.1675690E+04	0.1074680E-01	0.3224194E+01	-0.1968721E+01	0.5638027E-01	0.5118057E+00	9

Appendix 3: Print of Stress-Strain-Init.Life file: "matfile"

```
#SAE Standard Fatigue Data File format
```

# #

Pick one: #FDE_plot #FDE_fit # #

```
#
#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.
#You should have received a copy of the GNU General PUblic License
#along with this program - if not, write to the Free Software
#Foundation, Inc., 59 Temple Place - Suite 330, Boston, MA 02111-1307, USA
#Try also their web site: http://www.gnu.org/copyleft/gpl.html
#
# NOTE:  Fitted Data !!
# A36 Steel Merged Data Sets from Refs. 1 and 2:
# Ref.1: P.Dindinger report to Fat.Des.+Eval. Comm. Apr.2012
# Ref.2: G.A.Miller and H.S.Reemsnyder, "Strain-Cycle Fatigue of Sheet and
# Plate Steels I:  Test Method Development and Data Presentation,"
# SAE Paper 830175, Detroit MI, Feb28-Mar.4, 1983
#
# NOTE that original test data ends at  2Nf = 1.3million.
#
#FileType= strain_life
#DataType= fitted
#TIMEcol= 0
#NAME=  ASTM-A36
#NAME=  Structural
#NAME=  Steel
#Stress_units= ksi
#Strain_units= strain
#Sy=    38.4 0.2pc offset, 265  mpa
#Su=  69.  ksi from Miller/Reemsnyder = 475 mpa
#eu=       0   #strain at Su not reported
#E= 29528. ksi  = 203600 mpa
#FractureStrain=  0 not reported
```

```
#FractureStress=  0. not reported
#monotonic_K= 0  not reported
#monotonic_n= 0  not reported
#BHN= 138.
#%RA= 0. %  not reported
#
#saedigcurve_v2.2.f starts.
# NOTE!! The Following Points are FITTED DATA:#NOTE!! Fitted Stress computed using Experm.
# Total Strain   2Nf  Stress  Mean   Plastic Strain   Initial
#    Amp              Amp   Stress      Amp        Elastic Mod.
   0.88485          1   115.3      0.   0.88095     29528. #Fitted_point
   0.00914       5000    52.1      0.   0.00737     29528. #Fitted_point
   0.00665      10000    48.8      0.   0.00499     29528. #Fitted_point
   0.00493      20000    45.7      0.   0.00338     29528. #Fitted_point
   0.00344      50000    42.0      0.   0.00202     29528. #Fitted_point
   0.00270     100000    39.3      0.   0.00136     29528. #Fitted_point
   0.00217     200000    36.8      0.   0.00092     29528. #Fitted_point
   0.00169     500000    33.8      0.   0.00055     29528. #Fitted_point
   0.00144    1000000    31.6      0.   0.00037     29528. #Fitted_point
#Original test data ends at  2Nf = 1.3million.
#Points below are extrapolation:
   0.00125    2000000    29.6      0.   0.00025     29528. #Fitted_point
   0.00106    5000000    27.1      0.   0.00014     29528. #Fitted_point
#
#
```