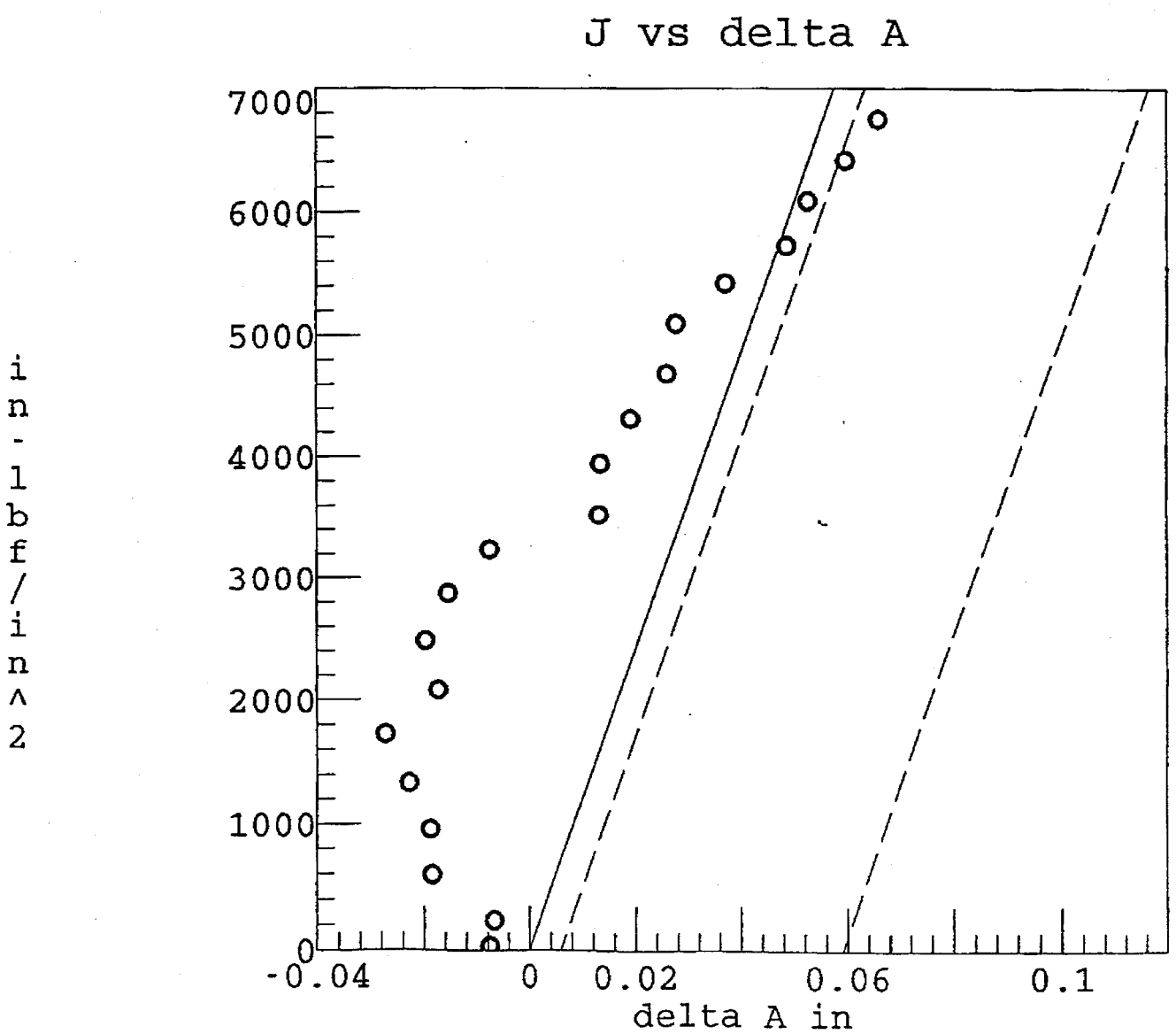
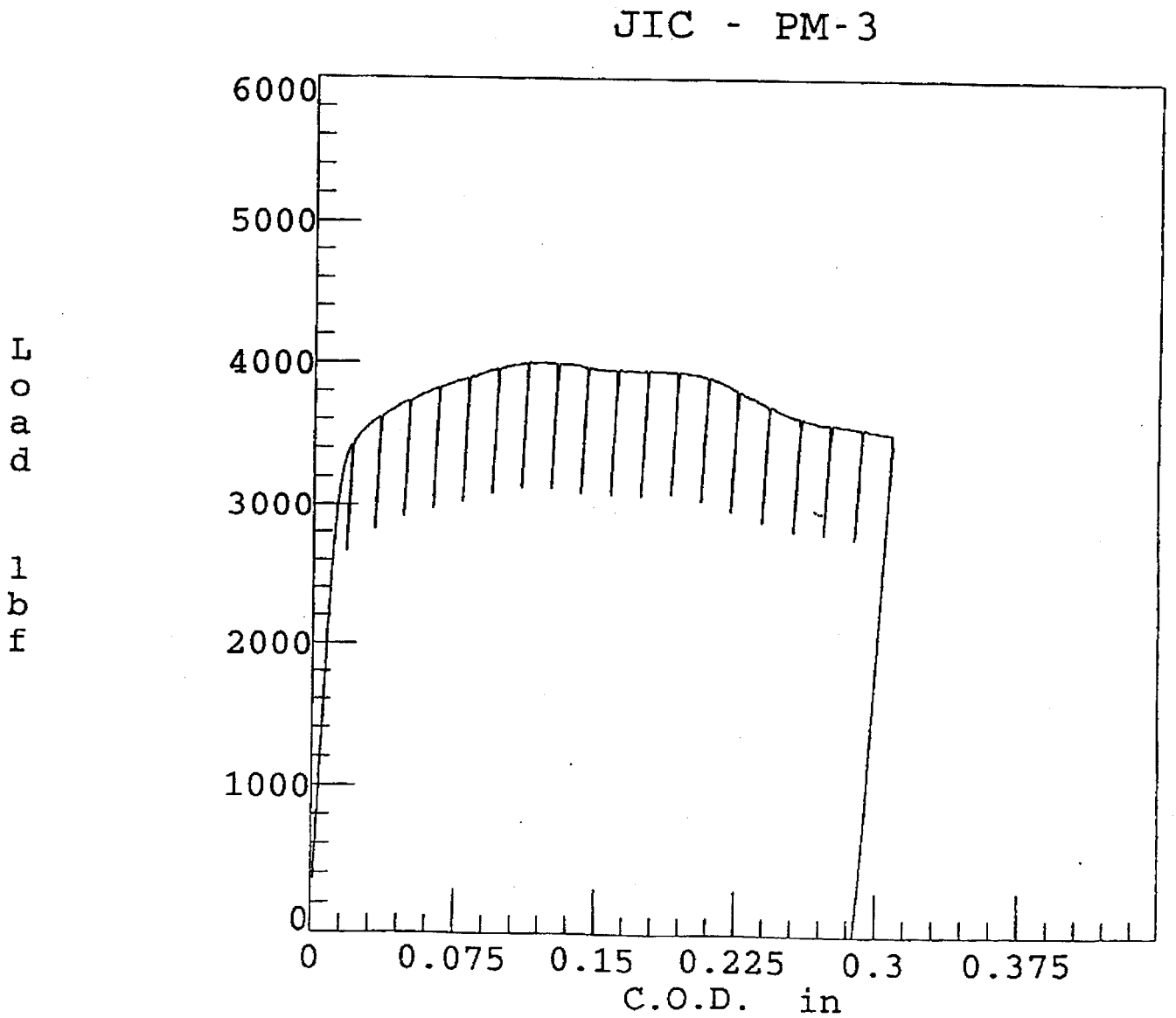
Template: JIC Fracture Toughness
Procedure: ATR95
Batch: 81095
Specimen: PM-2
Run Time Execute Data Table

Step Number	Crack Length in	J in-lbf/in^2	Delta a in	Corr. (none)
1	0.879788	28.9634	0.022488	0.997848
2	0.857509	192.438	0.000209	0.995857
3	0.844400	459.559	-0.012900	0.989458
4	0.840311	744.269	-0.016989	0.991375
5	0.834802	1031.55	-0.022498	0.995627
6	0.834300	1317.89	-0.023000	0.996708
7	0.832383	1611.27	-0.024917	0.997745
8	0.831640	1911.85	-0.025660	0.997348
9	0.833326	2206.56	-0.023974	0.997472
10	0.836831	2497.48	-0.020469	0.997180
11	0.837736	2800.61	-0.019564	0.997396
12	0.839690	3111.90	-0.017610	0.998206
13	0.841253	3414.27	-0.016047	0.998699
14	0.840261	3743.98	-0.017039	0.998419
15	0.841985	4052.21	-0.015315	0.998444
16	0.845723	4351.95	-0.011577	0.998425
17	0.857495	4595.35	0.000195	0.998880
18	0.860238	4907.91	0.002938	0.998547
19	0.865136	5198.34	0.007836	0.999049
20	0.871648	5475.61	0.014348	0.998400
21	0.870720	5821.54	0.013420	0.998641
22	0.876760	6094.07	0.019460	0.998518
23	0.880948	6381.62	0.023648	0.998765
24	0.885745	6666.92	0.028445	0.998473
25	0.887725	6975.21	0.030425	0.998626
26	0.889406	7300.58	0.032106	0.998676
27	0.894968	7560.32	0.037668	0.998396
28	0.895202	7897.11	0.037902	0.998612
29	0.901371	8148.00	0.044071	0.998497
30	0.907305	8398.64	0.050005	0.997933

PM-3.

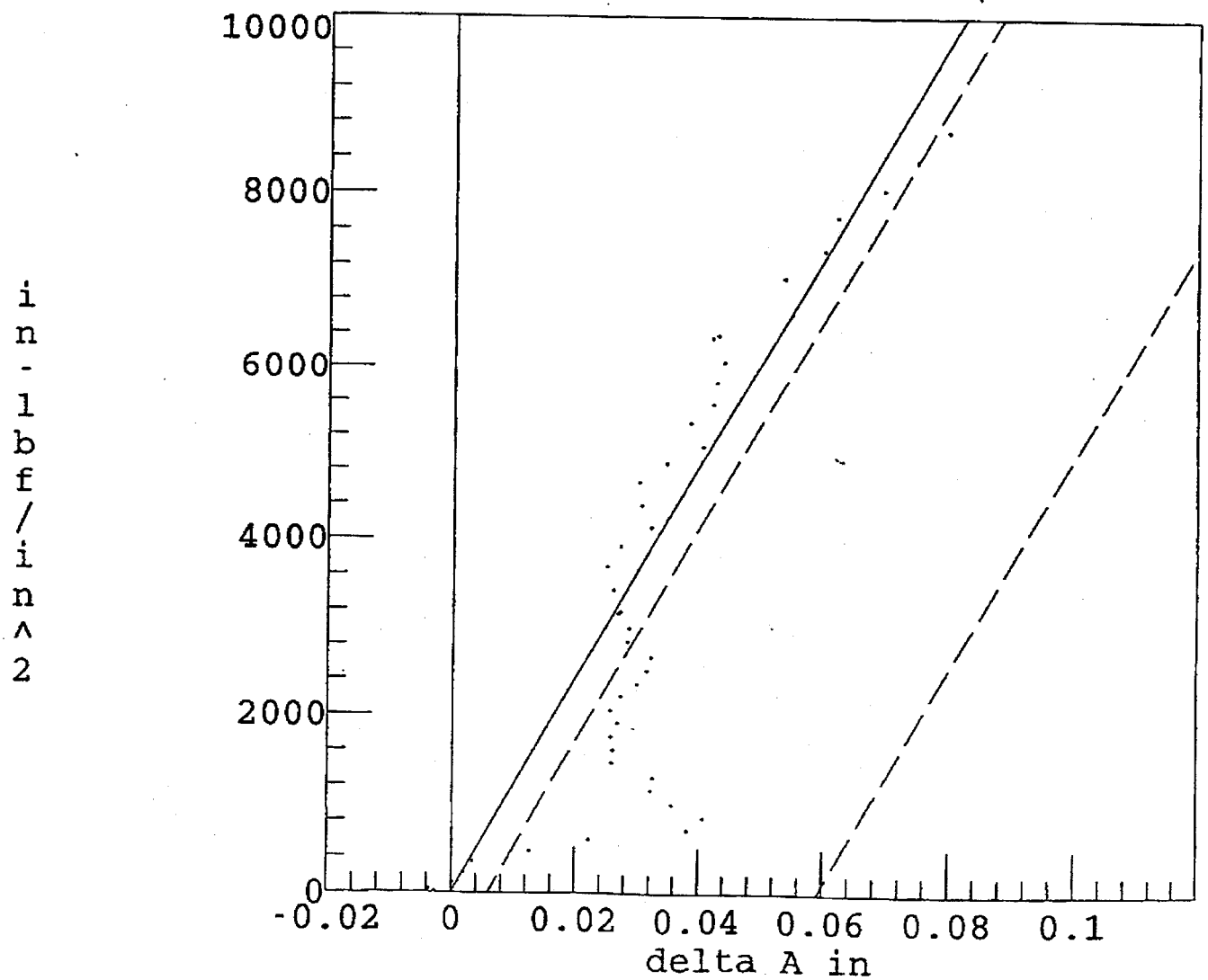

J vs delta A
7000
6000
5000
4000
3000
2000
1000
0
in-lbf/in^2
-0.04
0
0.02
0.06
0.1
delta A in


JIC - PM-3
6000
5000
4000
3000
2000
1000
0
Load lbf
0
0.075
0.15
0.225
0.3
0.375
C.O.D. in

Template: JIC Fracture Toughness
Procedure: ATR95
Batch: 81095
Specimen: PM-3
In Time Execute Data Table

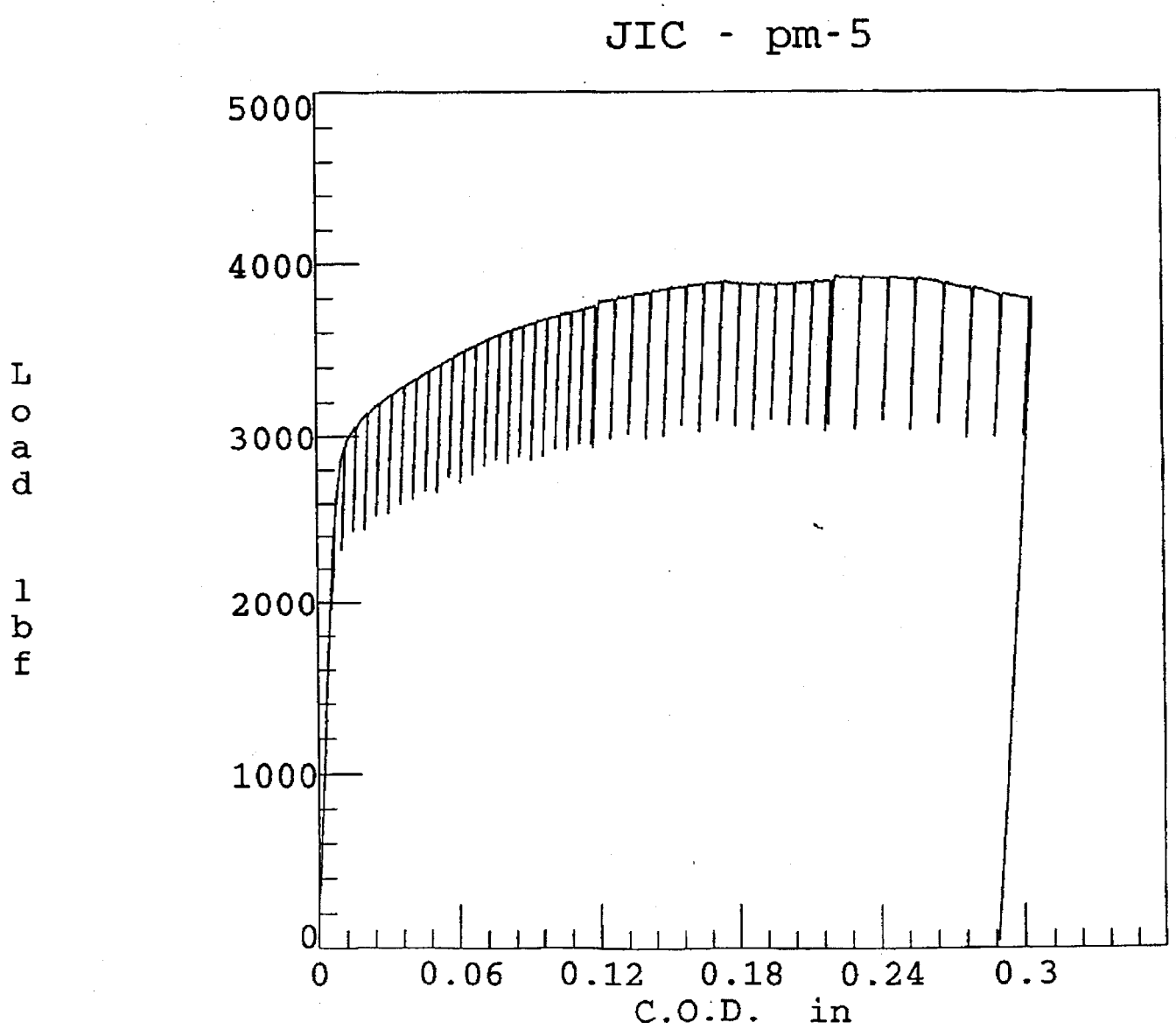
Step Number	Crack Length in	J in-lbf/in^2	Delta a in	Corr. (none)
1	0.848874	29.7798	-0.007626	0.997419
2	0.849729	233.996	-0.006771	0.988551
3	0.837933	593.251	-0.018567	0.987057
4	0.837596	957.512	-0.018904	0.991156
5	0.833596	1334.91	-0.022904	0.996294
6	0.829232	1726.13	-0.027268	0.997845
7	0.839106	2081.38	-0.017394	0.997633
8	0.836717	2488.47	-0.019783	0.998049
9	0.840902	2871.20	-0.015598	0.998442
10	0.848831	3236.53	-0.007669	0.998326
11	0.869458	3530.84	0.012958	0.997829
12	0.869782	3945.84	0.013282	0.997274
13	0.875488	4320.16	0.018988	0.997647
14	0.882304	4689.06	0.025804	0.997484
15	0.884094	5098.45	0.027594	0.998252
16	0.893389	5433.05	0.036889	0.998541
17	0.904965	5733.03	0.048465	0.998559
18	0.908926	6093.45	0.052426	0.998308
19	0.916051	6418.97	0.059551	0.998297
20	0.922282	6750.52	0.065782	0.998550

J vs delta A PM-5

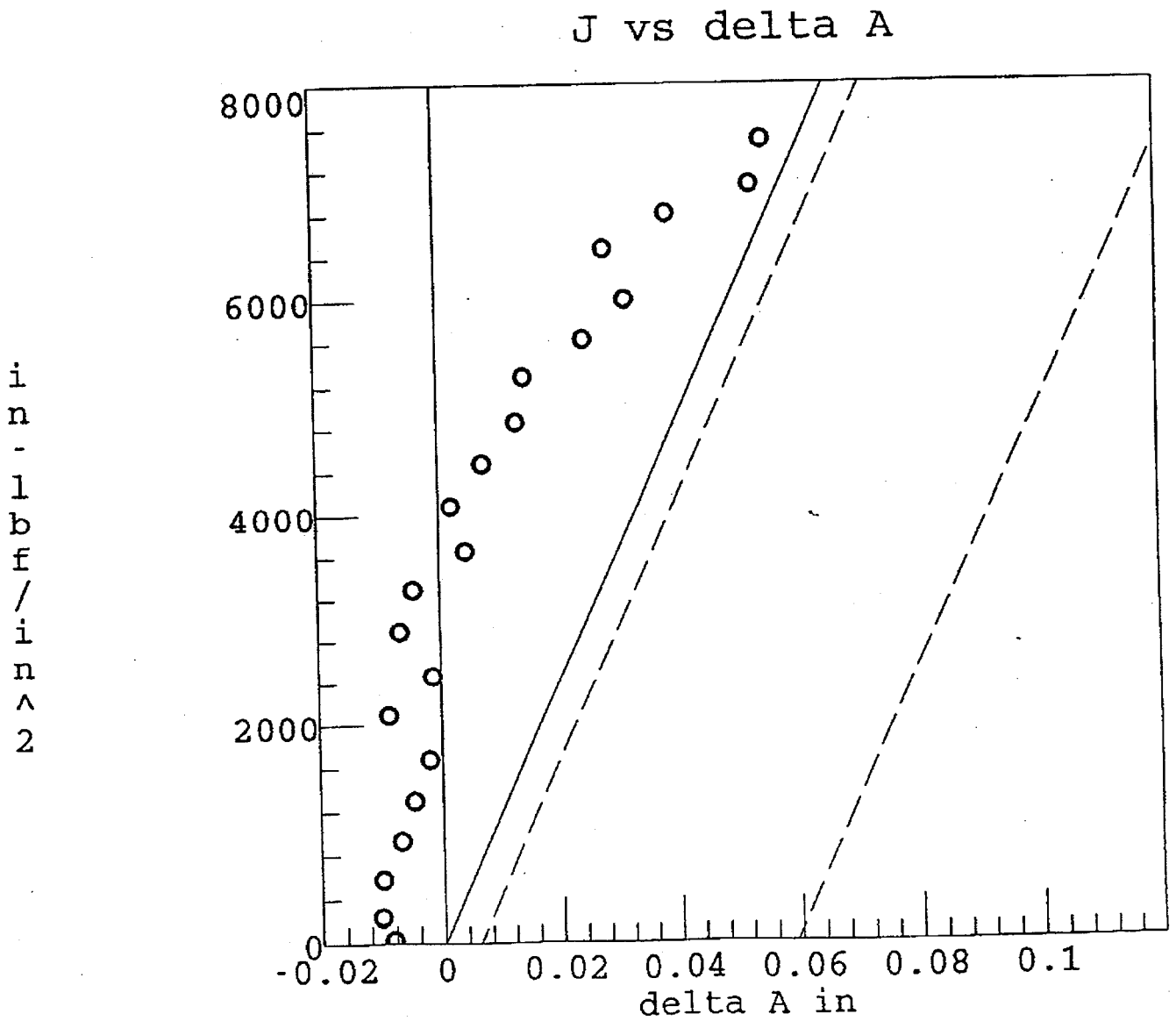


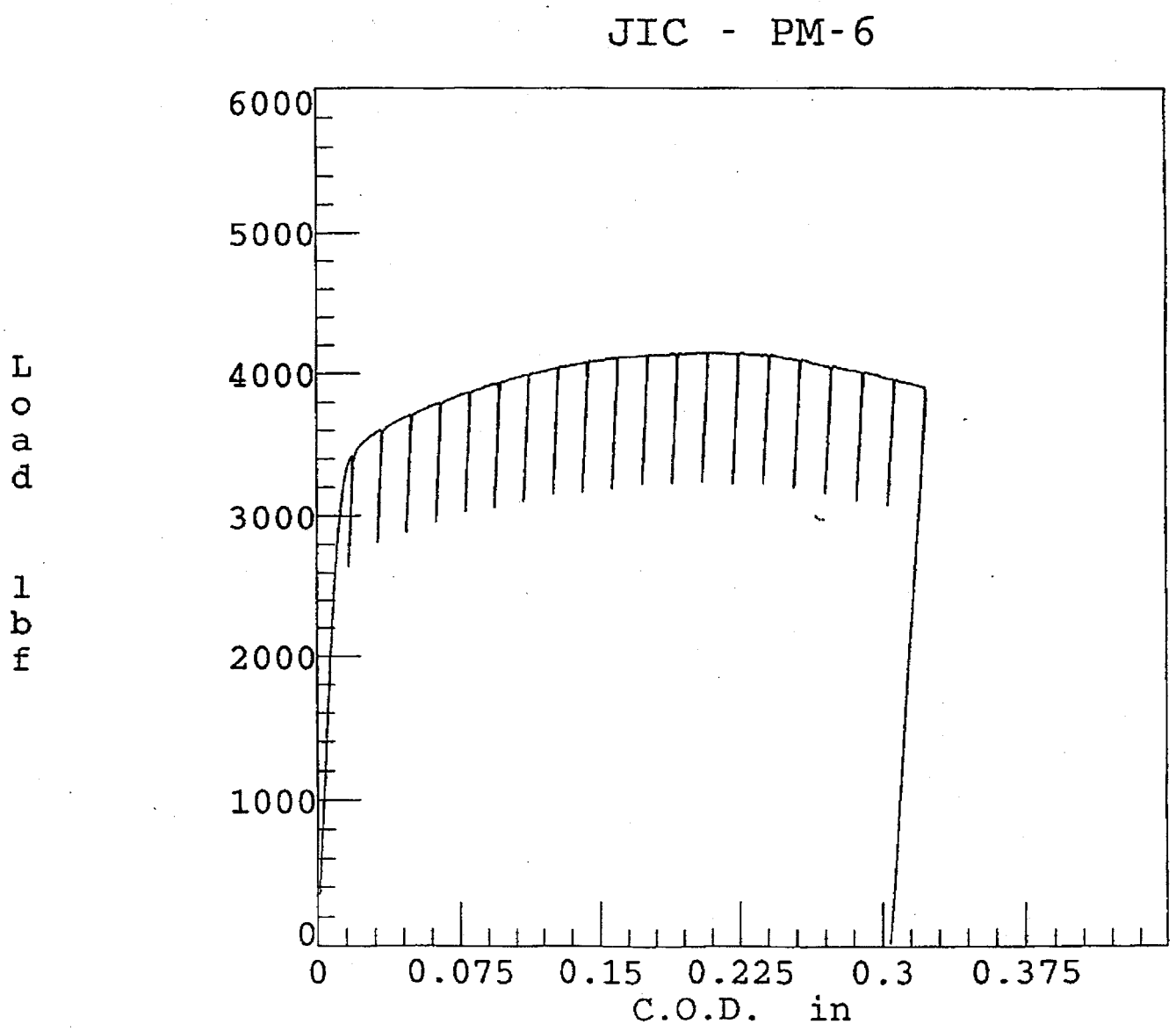
Template: JIC Fracture Toughness
Procedure: SE(B)
Batch: ATRlrgbendBASElow
Specimen: pm-5
Run Time Execute Data Table

Step Number	Crack Length in	J in-lbf/in^2	Delta a in	Corr. (none)
1	0.859351	11.0139	-0.002749	0.997190
2	0.858355	32.2703	-0.003745	0.998481
3	0.862228	111.415	0.000128	0.998940
4	0.864069	225.820	0.001968	0.999148
5	0.865493	345.064	0.003393	0.999043
6	0.874711	464.031	0.012611	0.999355
7	0.884370	587.736	0.022270	0.999359
8	0.900302	704.075	0.038202	0.998861
9	0.902880	844.381	0.040780	0.997389
10	0.897750	993.316	0.035650	0.997726
11	0.894354	1149.64	0.032254	0.998016
12	0.894692	1293.39	0.032592	0.997033
13	0.887974	1461.76	0.025874	0.995188
14	0.888099	1607.14	0.025999	0.995681
15	0.887807	1756.56	0.025707	0.994399
16	0.888948	1909.68	0.026848	0.994707
17	0.887691	2057.58	0.025591	0.995866
18	0.889404	2216.88	0.027304	0.994197
19	0.892039	2356.17	0.029939	0.993938
20	0.893644	2507.95	0.031544	0.994315
21	0.894317	2661.41	0.032217	0.992368
22	0.890510	2842.02	0.028410	0.994025
23	0.890739	2996.40	0.028639	0.993062
24	0.888947	3170.78	0.026847	0.991899
25	0.889251	3188.80	0.027151	0.991471
26	0.888180	3434.17	0.026080	0.990279
27	0.887061	3688.66	0.024961	0.989967
28	0.889278	3919.17	0.027178	0.992723
29	0.894176	4135.01	0.032076	0.990426
30	0.892656	4392.62	0.030556	0.992543
31	0.892293	4655.05	0.030193	0.991700
32	0.896723	4873.66	0.034623	0.992429
33	0.902549	5079.19	0.040449	0.992733
34	0.900487	5352.35	0.038387	0.992612
35	0.904110	5573.76	0.042010	0.992740
36	0.904701	5828.26	0.042601	0.992078
37	0.905834	6073.93	0.043734	0.992818
38	0.903950	6355.21	0.041850	0.992187
39	0.904860	6383.50	0.042760	0.993269
40	0.916817	6639.74	0.054717	0.993731
41	0.915518	7050.61	0.053418	0.993231
42	0.921952	7366.46	0.059852	0.995992
43	0.923913	7747.37	0.061813	0.995054
44	0.931373	8048.74	0.069273	0.996470
45	0.936682	8378.82	0.074582	0.997552
46	0.941739	8706.73	0.079639	0.998280


JIC - pm-5
5000
4000
3000
2000
1000
0
Load lbf
0
0.06
0.12
0.18
0.24
0.3
C.O.D. in

PM-6.


J vs delta A
8000
6000
4000
2000
0
in-lbf/in^2
-0.02
0
0.02
0.04
0.06
0.08
0.1
delta A in


JIC - PM-6
6000
5000
4000
3000
2000
1000
0
Load lbf
0
0.075
0.15
0.225
0.3
0.375
C.O.D. in

Template: JIC Fracture Toughness
Procedure: ATR95
Batch: 81195
Specimen: PM-6
Run Time Execute Data Table

Step Number	Crack Length in	J in-lbf/in^2	Delta a in	Corr. (none)
1	0.842832	28.9174	-0.008368	0.996964
2	0.840961	237.695	-0.010239	0.998846
3	0.841228	580.366	-0.009972	0.997969
4	0.844349	934.231	-0.006851	0.998207
5	0.846494	1304.09	-0.004706	0.997682
6	0.849086	1681.79	-0.002114	0.998590
7	0.842559	2099.25	-0.008641	0.999148
8	0.849809	2468.09	-0.001391	0.998925
9	0.844618	2897.61	-0.006582	0.998730
10	0.846881	3294.09	-0.004319	0.999036
11	0.855544	3662.71	0.004344	0.998951
12	0.853282	4097.13	0.002082	0.998966
13	0.858607	4483.20	0.007407	0.999171
14	0.864354	4865.07	0.013154	0.998702
15	0.865728	5293.86	0.014529	0.998854
16	0.875848	5632.45	0.024648	0.998946
17	0.883002	6004.35	0.031802	0.998892
18	0.879523	6478.88	0.028323	0.998563
19	0.890177	6801.60	0.038977	0.998987
20	0.904357	7068.55	0.053157	0.998533
21	0.906311	7487.41	0.055111	0.998734

APPENDIX D

Photographs for Bend Specimen Fracture Surfaces

APPENDIX E

Nomenclature for Fracture Toughness Test Report

Final K_{max}

The maximum stress intensity desired for the final portion of precracking. This value, the current precrack length, the final crack length, and the load ratio are used by the software to determine the precrack command loads.

Load Ratio (R)

The ratio of the minimum to maximum load used during precracking. The minimum load will be determined by this value.

Test Frequency (5 to 50 Hz)

Frequency used in the precracking process.

Final Crack Length

The desired crack length achieved through precracking. When this is reached, precracking stops.

Cycle Limited

Check for precracking to stop after a specified number of cycles. If selected, the precracking stops when "Maximum Number of Cycles" is reached.

Maximum Number of Cycles

The number of cycles at which precracking stops, if "Cycle Limited" is selected.

Crack Length Monitoring

There are two methods. The manual/visual method relies on the operator to periodically stop the test, measure the crack length, enter the crack length at the appropriate prompt, and then continue running the test. The compliance method relies on a gauge attached to the specimen to measure the specimen compliance. Since the compliance of the specimen is proportional to the crack length, the measured compliance is used to estimate and record the crack length automatically.

Upper LSF Data Range

The percentage of the measured load range to be used as the upper limit for linear least squares fit compliance determination.

Automatic Inspection Hold

Check for precracking to hold every "Inspection Interval" to allow crack length measurement.

Inspection Interval

The number of cycles after which precracking should Hold. This is only active if "Automatic Inspection Hold" is selected.

Precycle Load

The precycle option is provided to minimize the non-linearity in acquired data at the start of the test.

Test Control (COD or Displacement)

The control mode for the Ramp-To-Next and Crack-Propagation-Hold phases of the J_{IC} test. The choices are COD and Displacement. The Unload and Reload segments of the J_{IC} test will always be in Load control.

Ramp Rate

This is the rate at which the system should ramp to the next end level in the Ramp (to next) segment of the J_{IC} test.

Unload on Load Step

Check for unload to take place on Load Step if the other step increments have not triggered first.

Load Step

This is the load increment that will be added to the current load level at the beginning of each Ramp (to next) segment to determine a maximum load for this step.

Unload on COD Step

Check for unload to take place on COD Step if the other step increments have not triggered first.

COD Step

This is the COD increment that will be added to the current COD level at the beginning of each Ramp (to next) segment to determine a maximum COD for this step.

Unload on Displacement Step

Check for unload to take place on Displacement Step if the other step increments have not triggered first.

Displacement Step

This is the displacement increment that will be added to the current displacement level at the beginning of each Ramp (to next) segment to determine a maximum displacement for this step.

Unload on Pct of Current Load

Check for unload to take place as a percent of the load at the end of the Hold (crack propagation) segment. If both percent unload and absolute unload are chosen, the smaller of the two resulting values will be used.

Percent Unload

The amount of force to unload as a percentage of the step peak load. If both percent unload and absolute unload are chosen, the smaller of the two resulting values will be used.

Unload Absolute

Check for a maximum unload to take place regardless of the percentage of the step peak load. If both percent unload and absolute unload are chosen, the smaller of the two resulting values will be used.

Absolute Unload

The amount to unload in both the Unload and Reload segments in force units. If both percent unload and absolute unload are chosen, the smaller of the two resulting values will be used.

Number of Unloads

The number of unload and reload segment pairs to perform in each step of the J_{IC} test.

Crack Propagation Hold Time

The length of time to hold at constant COD or Displacement in the Hold (crack propagation) segment of the J_{IC} test. If this time is zero, the Hold (crack propagation) segment of the test will be bypassed.

Unload Rate

The rate at which the system will unload the specimen in the Unload segments in each step.

Reload Rate

The rate at which the system will reload the specimen to the load value at the beginning of the first Unload segment in each step.

Ramp to Initial Load

Check if the first step should ramp in load control to a particular load. The load is based on a percentage of the final precrack load. This allows the user to start with loads closer to loads of the final precrack load for the specimen. This option helps speed the test and eliminates step data which may not be desired.

Pct of Final Precrack Load

This specifies the percentage of the load of the final precrack cycle which should be used as the load for the end of the first Ramp (to next) segment. This is only active if "Ramp To Initial Load" is selected.

Load Ramp Rate

The ramp rate for the initial Ramp (to next) segment when it is done in load control. This is only active if "Ramp To Initial Load" is selected.

Frame Stiffness

The inverse of the compliance of the test system. This term is used to determine the displacement due to load frame deflection, and deformation of fixtures. The resulting displacement is subtracted from the measured displacement when calculating the energy absorbed by the specimen. This is particularly important when using SE(B) specimens.

Specimen Geometry [FFC(T), LLC(T), DC(T), or SE(B)]

Use the list box to select the appropriate geometry. All specimens in a batch must have the same geometry. Once a batch is created, the geometry can not change unless all the existing specimens in that batch are deleted.

Event Logging

Check if the events during test execution should be recorded.

Event Log Filename

Name the file where events during the test will be listed.

Upper LSF Data Range

Enter the percentage of the measured load range, in a loading/unloading sequence, that is used as the upper limit for linear least squares fit compliance determination.

Lower LSF Data Range

Enter the percentage of the measured load range, in a loading/unloading sequence, that is used as the lower limit for linear least squares fit compliance determination.

End on Maximum Load

Check if the test should end when the "Maximum Load" specified is reached.

Maximum Load

Test completes at the load entered if "End on maximum load" is checked.

End on Maximum COD

Check if the test should terminate when the "Maximum COD" specified is reached.

Maximum COD

Test completes at the COD entered if "End on Maximum COD" is checked.

End on Maximum Displacement

Check if the test should terminate when the "Maximum Displacement" specified is reached.

Maximum Displacement

Test completes at the displacement entered if "End on Maximum Displacement" is checked.

End on Maximum Crack Length

Check if the test should terminate when the "Maximum Crack Length" specified is reached.

Maximum Crack Length

Test completes when crack length reaches the length entered if "End on Maximum Crack Length" is reached.

End on Crack Length Extension

Check if the test should end when the maximum amount of crack extension beyond the test initial crack length.

Maximum Crack Length Extension

Test completes when the crack extension reaches the amount specified if End on Crack Length Extension is checked.

Termination Type

If immediate is chosen to end the test, the test will shut down immediately upon reaching a termination criteria. If Controlled is chosen, the test will end after the next hold, unload, reload sequence.

Hydraulic Shutdown

Check if hydraulics should be turned off when the test is ended.

Width (W)

For C(T) specimens, enter the distance from the center of the loading pin holes to the back face of the specimen. For SE(B) specimens, enter the distance from the notched side to the opposite side of the specimen.

Notch Length

For C(T) specimens, enter the length of the specimen's machined notch measured from the center of the loading pin holes to the tip of the notch. For SE(B) specimens, enter the length of the specimen's machined notch measured from the notched side to the tip of the notch.

Thickness (B)

Enter the thickness of the specimen.

Net Thickness (B_n)

For ungrooved specimens Net Thickness should have the same value as Thickness. All tests where net thickness is not equal to thickness are listed as invalid since ASTM E647-93 does not discuss grooved specimens.

Span (S)

This is only used for SE(B) specimens. Span is the distance between the two supports on the same side of the specimen.

Modulus of Elasticity

Modulus is an estimate of the materials initial stiffness below its elastic limit. This value can be changed, either in the Assign Modulus window or here in the Batch Editor.

Yield Strength

Yield Strength as determined by ASTM E* or EN 10002. Typically the value is determined as 0.2% offset yield point.

Ultimate Tensile Strength

Ultimate Tensile Strength is the maximum tensile stress that a material is capable of sustaining. This is also known as "Ultimate Strength" or "Tensile Strength."

Poisson's Ratio

Poisson's Ratio is the absolute value of the ratio of transverse strain to the corresponding axial strain resulting from uniformly distributed axial stress below the proportional limit of the material.

Crack Plane Orientation

Enter up to 32 characters. This is an identification of the plane and direction of a fracture in relation to product geometry. This identification is designed by a hyphenated code. See ASTM E 399-90 3.1.3.3 and Figures 1 through 3.

Pin Center from Crack Plane

Enter the distance that is one half the span between the load points (center of pin holes). It is used by the software in correction calculations for specimen rotation of C(T) specimens.

COD Half-Gage Length

Enter the distance that is one half the distance between the displacement measurement points (COD attachment edges). It is used by the software in correction calculations for specimen rotation of C(T) specimens.

COD Distance From Load Line

Enter the distance between the displace measurement points and load points (center of pin holes). For LLC(T) specimens this is zero.

Test Temperature

Enter the test temperature as required by ASTM 813. The J_{IC} test method covers the determination of J with a loading rate that is slow and environmentally assisted cracking is assumed to be negligible.

Number of Cycles

The number of cycles executed during precracking.

Final Precrack Length

The final crack length reached during precracking.

Final P_{max}

The maximum loading during the final precracking cycle.

Precrack P_{max}

The maximum loading during the entire precracking process.

Final K_{max}

The maximum stress intensity on the final cycle of precracking.

Precrack K_{max}

The maximum stress intensity during the entire precracking process.

Comment

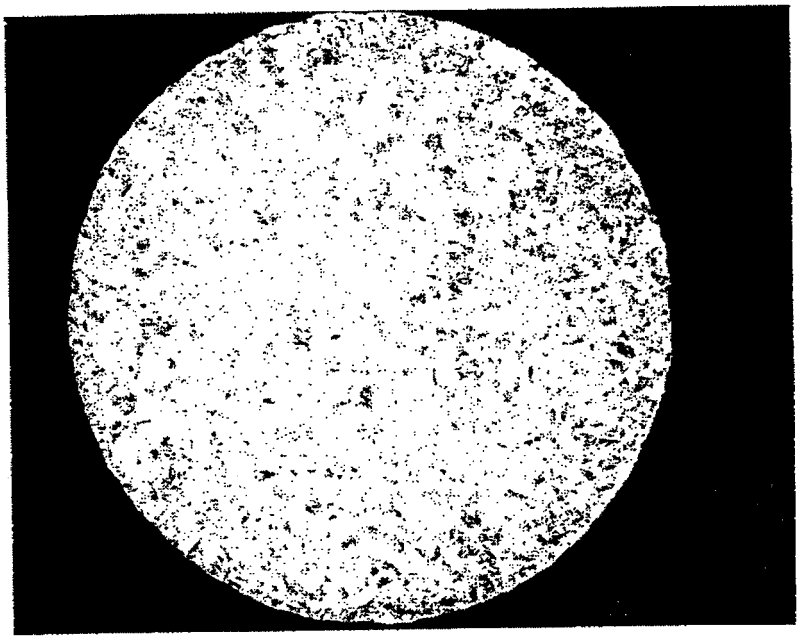
This field allows you to enter a short comment up to 32 characters which is displayed in the final Test Results Report Summary.

OK Button

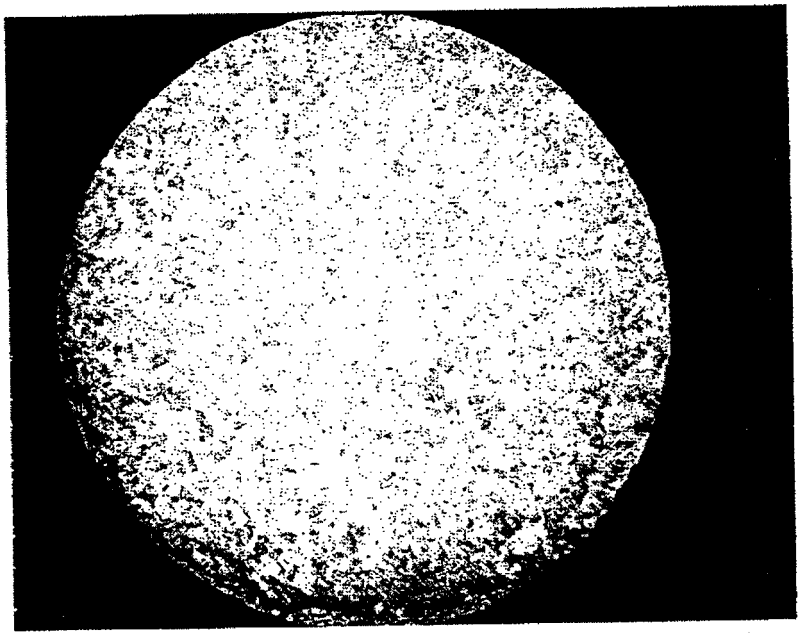
Saves these values for the current specimen. Switches the test mode to J_{IC} Test Control.

APPENDIX F

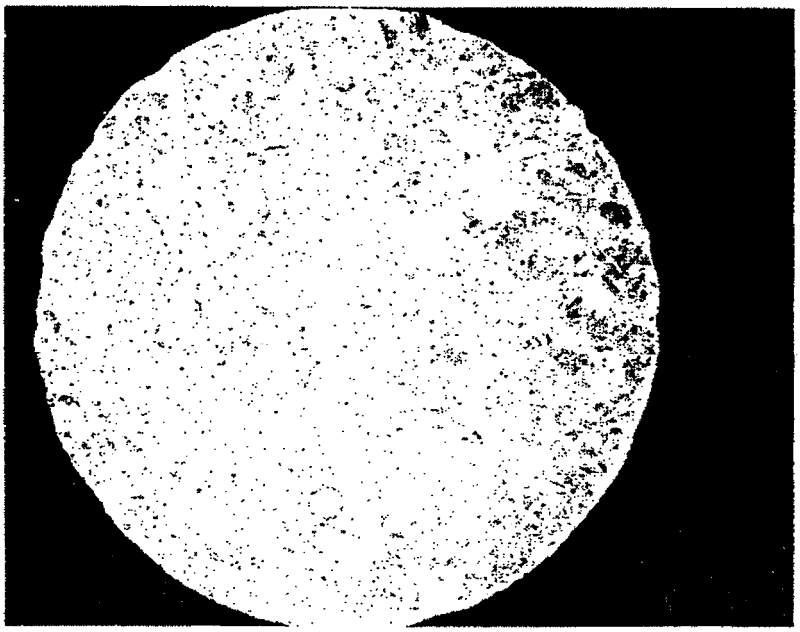
Metallography for HAZ Tensile Specimens



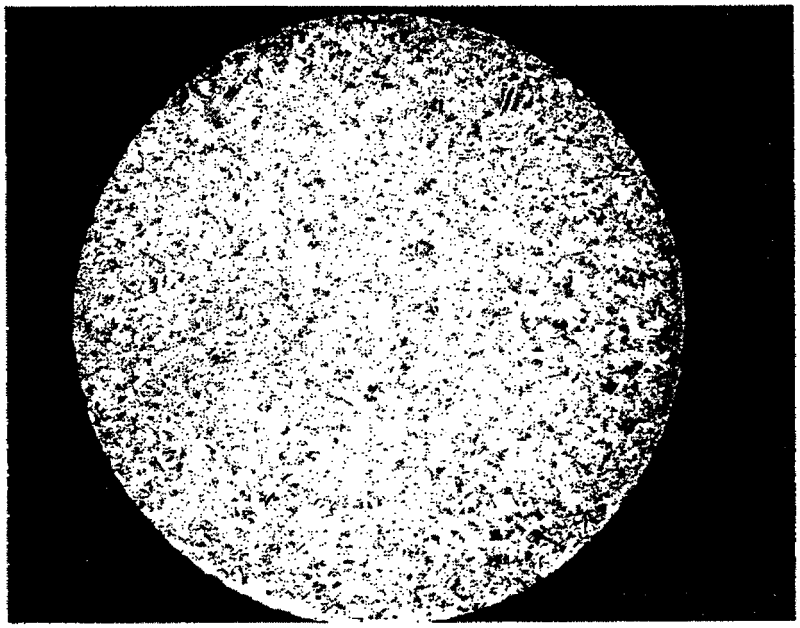
HAZ-1



HAZ-2



HAZ-3



HAZ-4

DISTRIBUTION

ATR

J. Dwight (3)
W. Reuter
R. Loyld

B&W NESI

G. O. Hayner
K. Y. Hour
K. R. Redmond
Project File (2)