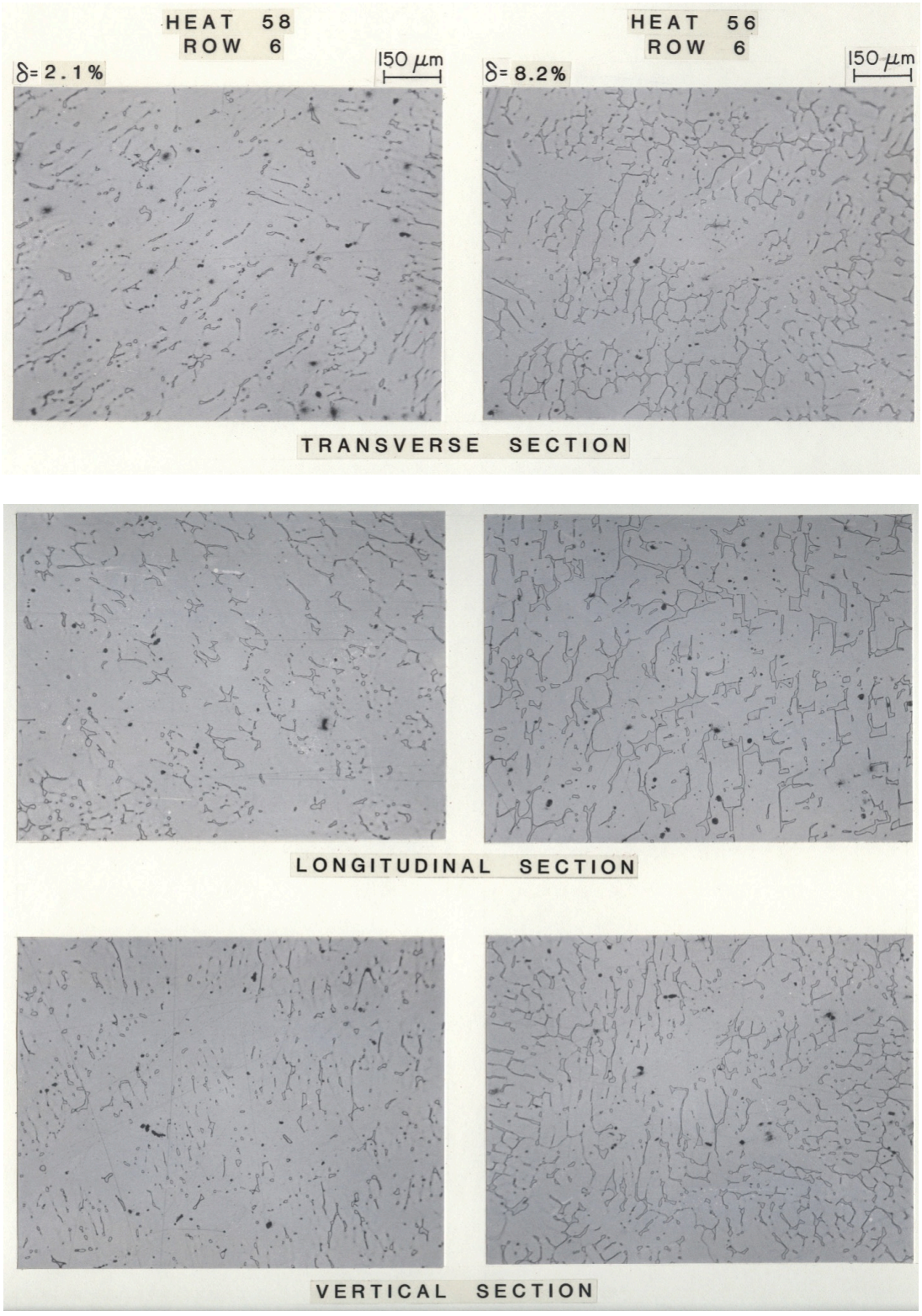
Appendix A

Ferrite Morphology

Various experimental and commercial heats of cast stainless steel were characterized to determine the morphology and distribution of the ferrite phase in the duplex structure. The materials were examined in three orientations (i.e., axial, circumferential, and radial planes for pipes or longitudinal, transverse, and vertical sections for keel blocks), as well as different locations, namely, material near the center and the inner and outer surfaces of pipes, and top and bottom regions (i.e., Rows 6 and 3, respectively, in Figs. A–1 to A–3) of keel blocks. Material from vanes, shroud, and hub of a pump impeller was also examined. Orientation of the material had little or no effect on the ferrite content and morphology. Typical microstructures for the various heats are shown in Figs. A–1 to A–9. The ferrite content measured for each location is given in the figures.

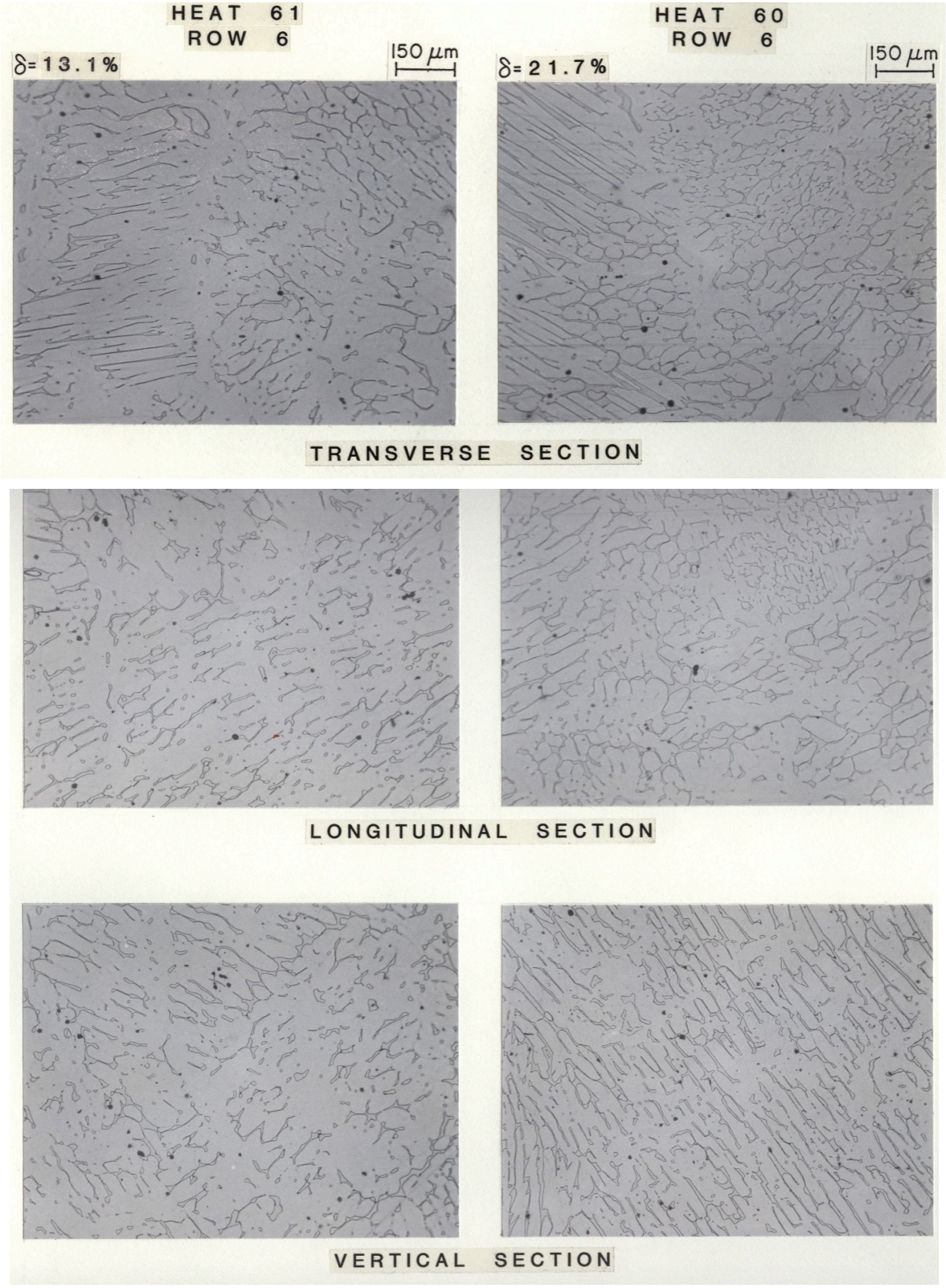
The ferrite morphology in the static–cast keel blocks is different from that in the centrifugally cast pipes. For the same ferrite content, the mean ferrite spacing in the keel blocks is smaller than that in the pipe material. Such differences may be attributed to differences in the section thickness of the castings. In general, the ferrite morphology is globular for ferrite contents <5% and lacy or acicular for larger amounts of ferrite. The lacy form of ferrite is characterized by an interlaced network of ferrite islands, whereas the acicular morphology represents fine needle–like ferrite distributed in the austenite matrix. All morphologies have a random arrangement within the casting.

Some differences in the ferrite content are observed for materials from different locations of the cast products. The ferrite content is always lower toward the top of the keel blocks and the inner surface of the cast pipes (for centrifugal casting, the inner surface corresponds to the bottom of the casting). This condition appears to be related to the nickel content in the material, i.e., the concentration of nickel was higher near the top of the keel blocks and inner surface of the pipes.



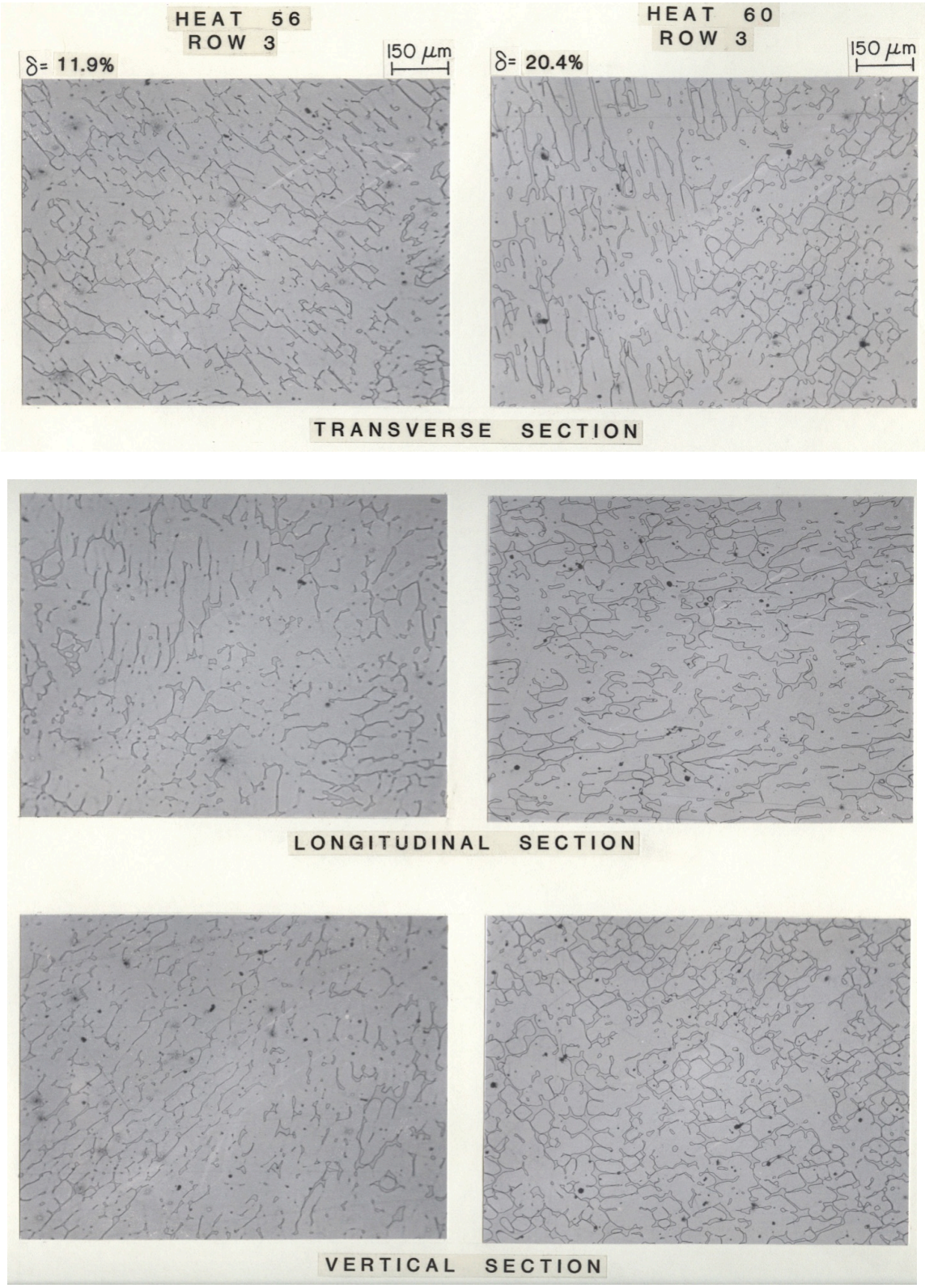
(a)

Figure A–1. Microstructures Along the Three Orientations of Static–Cast Keel Blocks of CF–8 Stainless Steel. (a) and (b) top region and (c) bottom region of keel block.



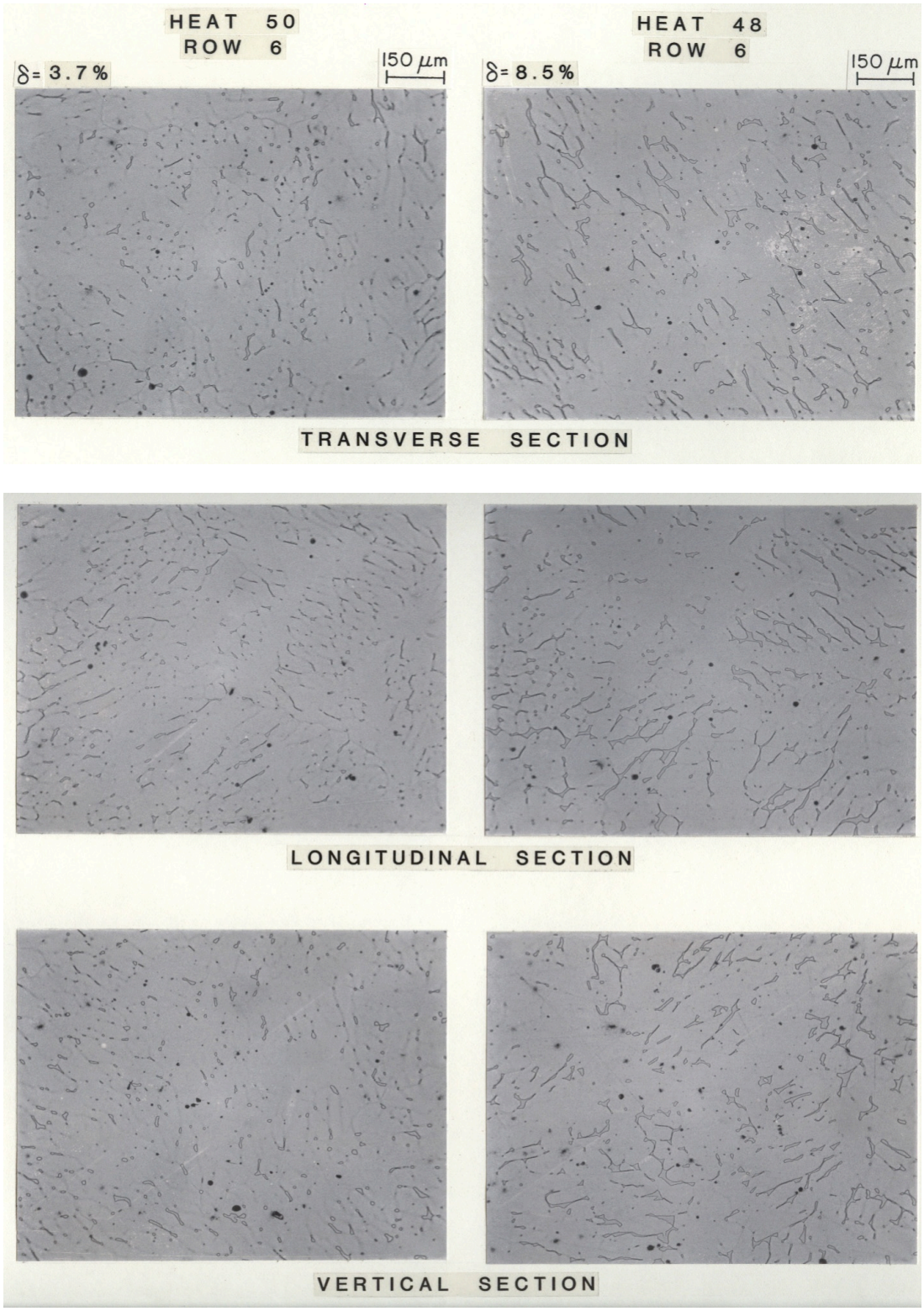
(b)

Figure A–1. (Contd.)



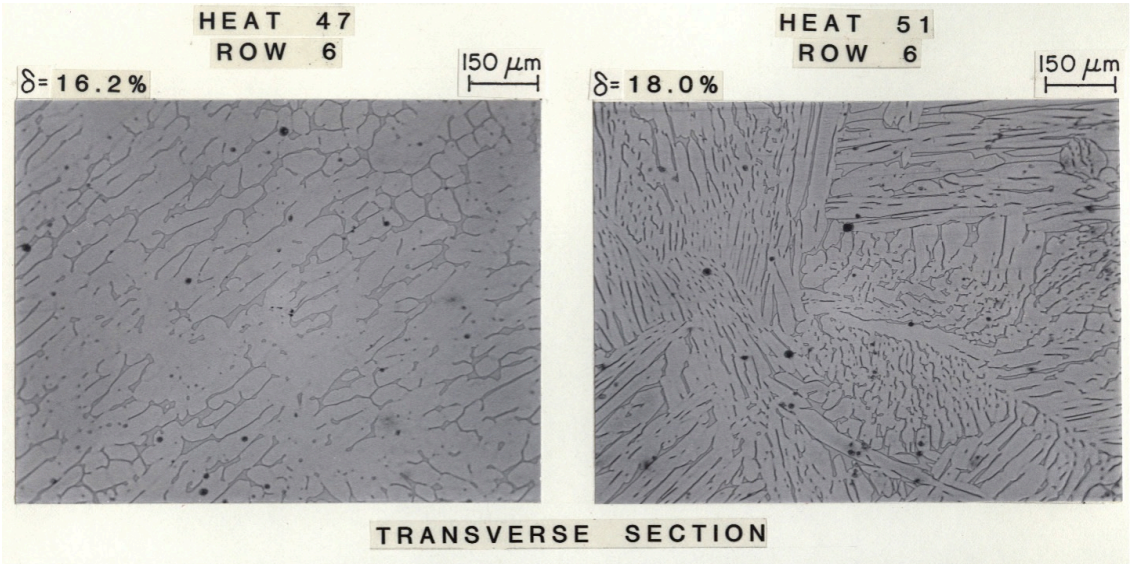
(c)

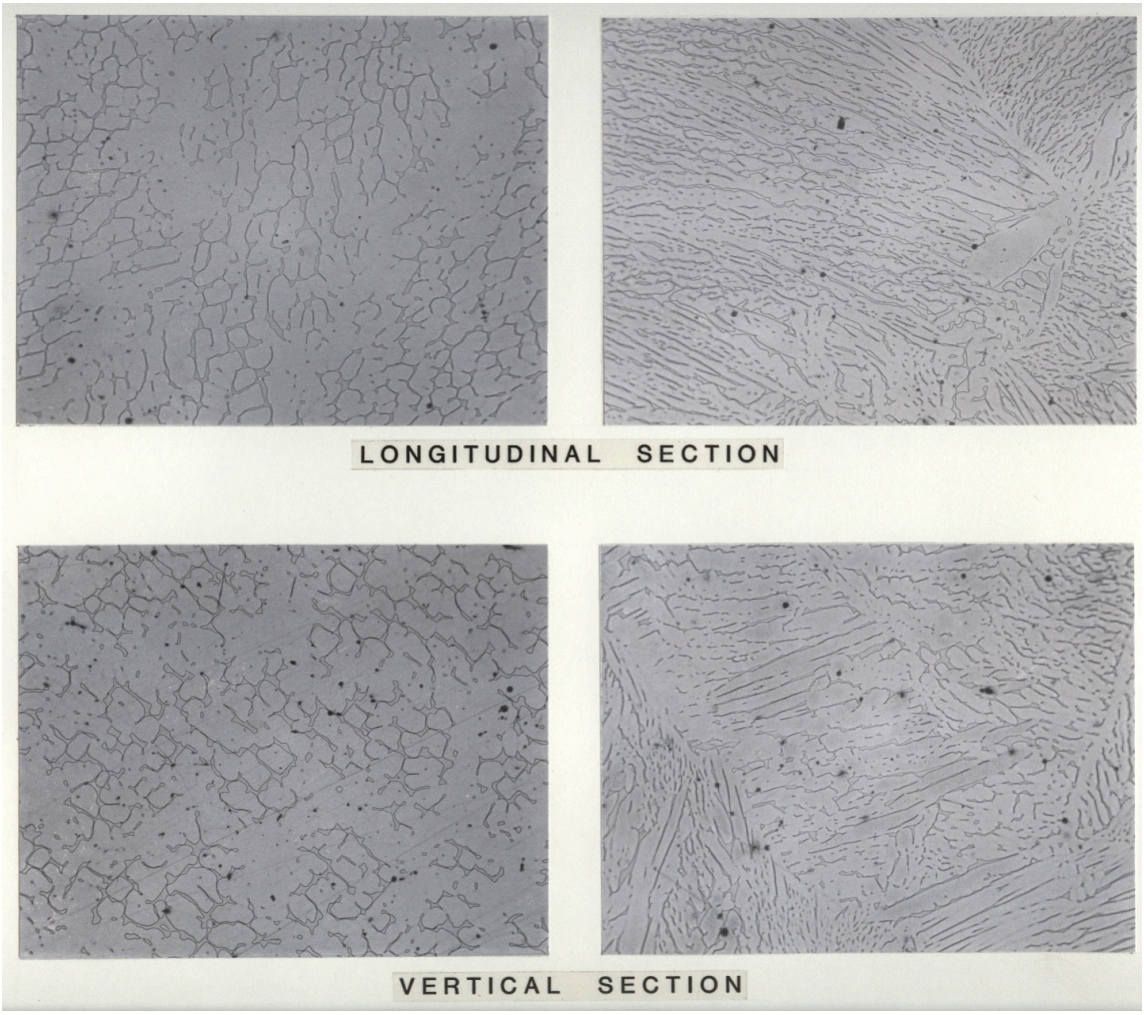
Figure A–1. (Contd.)



(a)

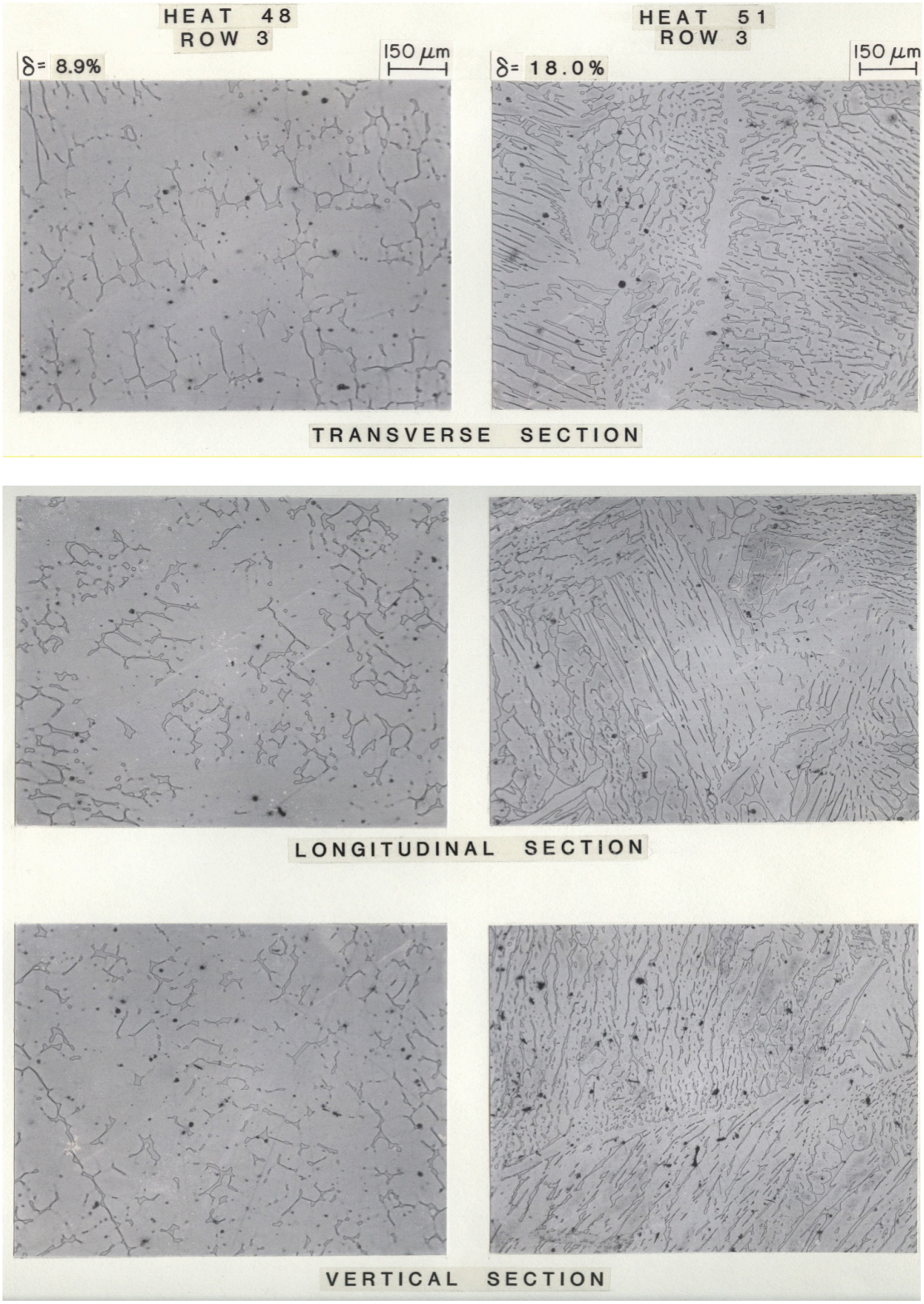
Figure A–2. Microstructures Along the Three Orientations of Static–Cast Keel Blocks of CF–3 Stainless Steel. (a) and (b) top region and (c) bottom region of keel block.





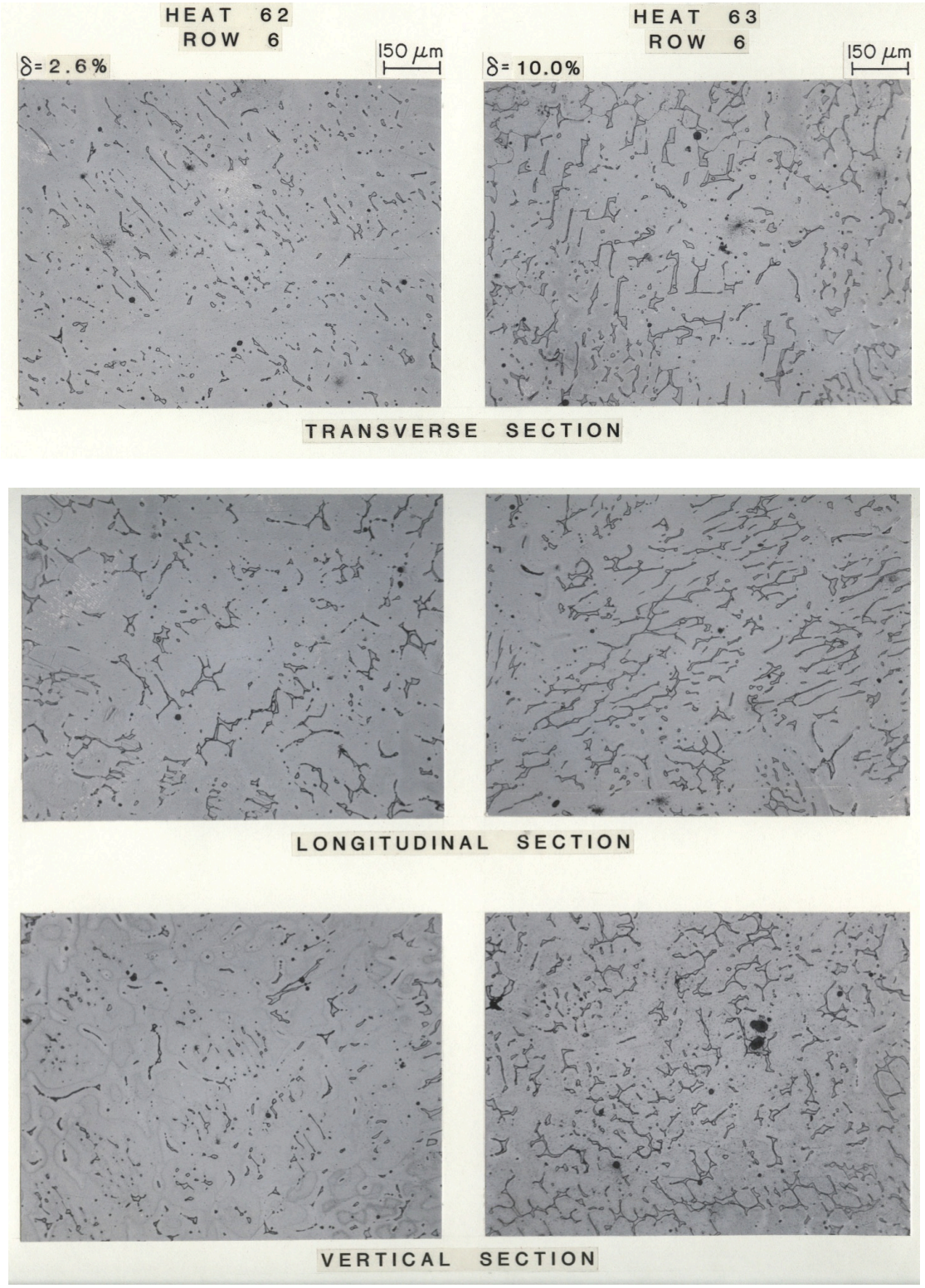
(b)

Figure A–2. (Contd.)



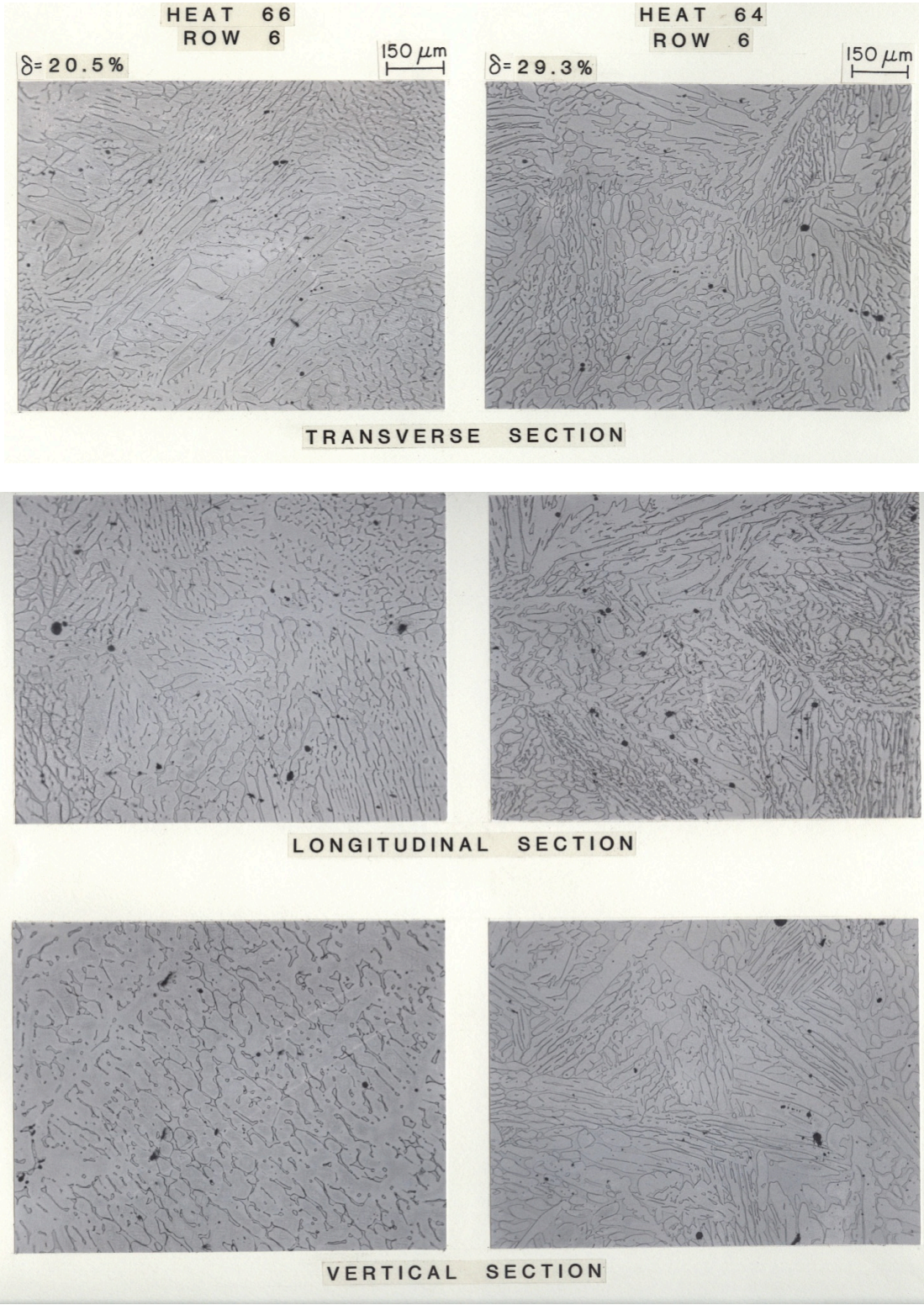
(c)

Figure A–2. (Contd.)



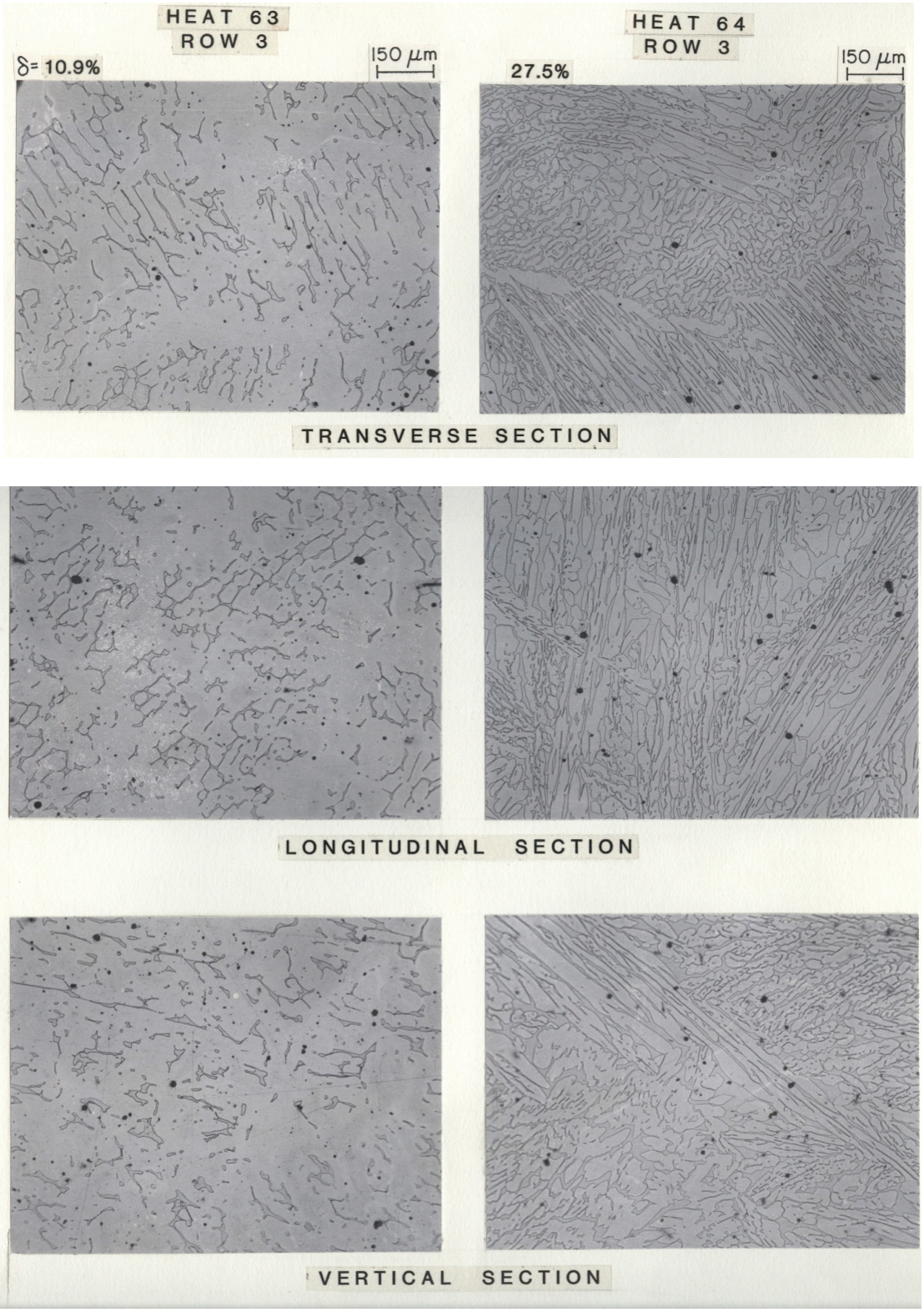
(a)

Figure A–3. Microstructures Along the Three Orientations of Static=Cast Keel Blocks of CF–8M Stainless Steel. (a) and (b) top region and (c) bottom region of keel block.



(b)

Figure A–3. (Contd.)



(c)

Figure A–3. (Contd.)

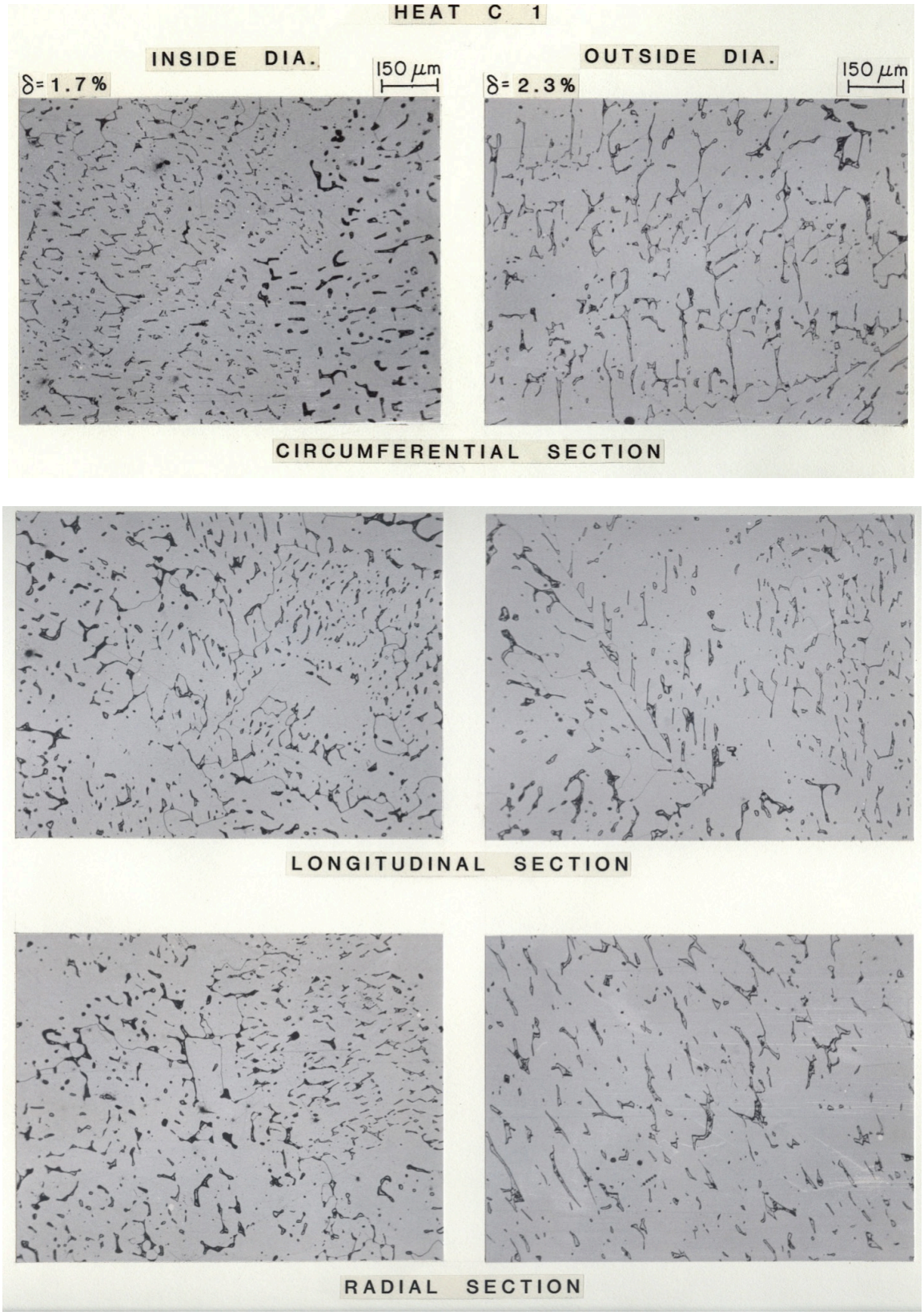


Figure A–4. Microstructures Along the Three Orientations of the Static–Cast Pump Casing Ring of CF–8 Stainless Steel.

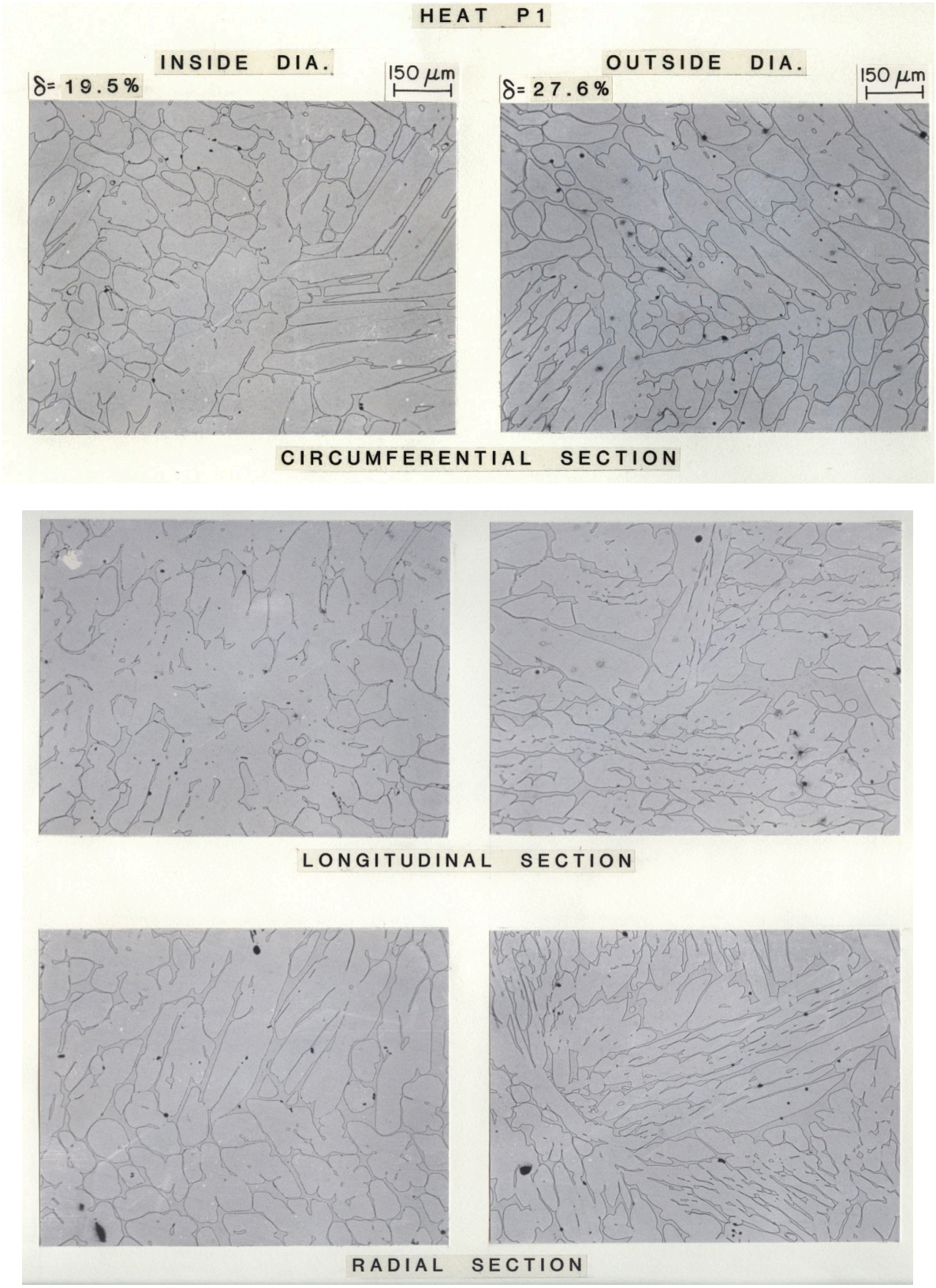
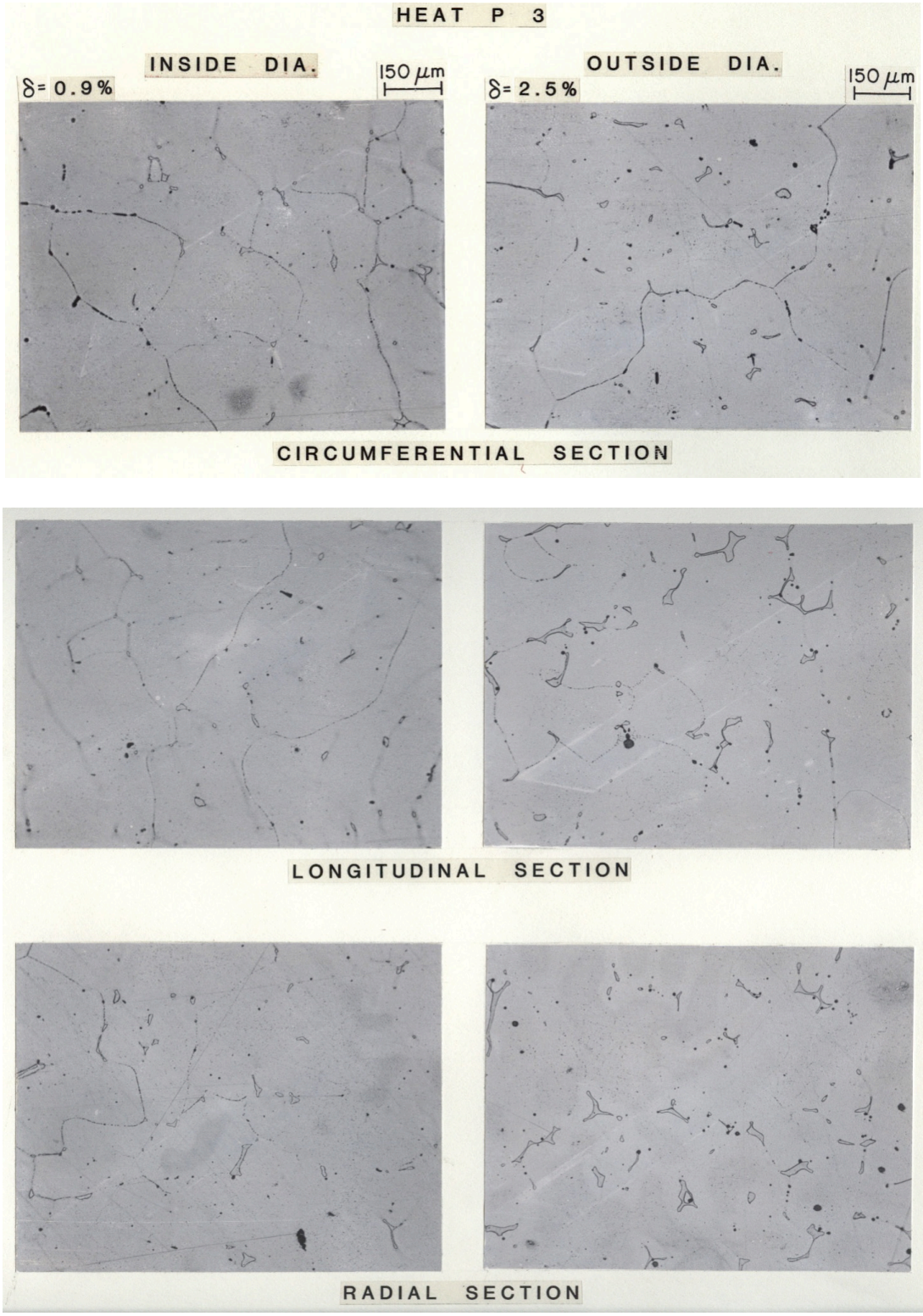
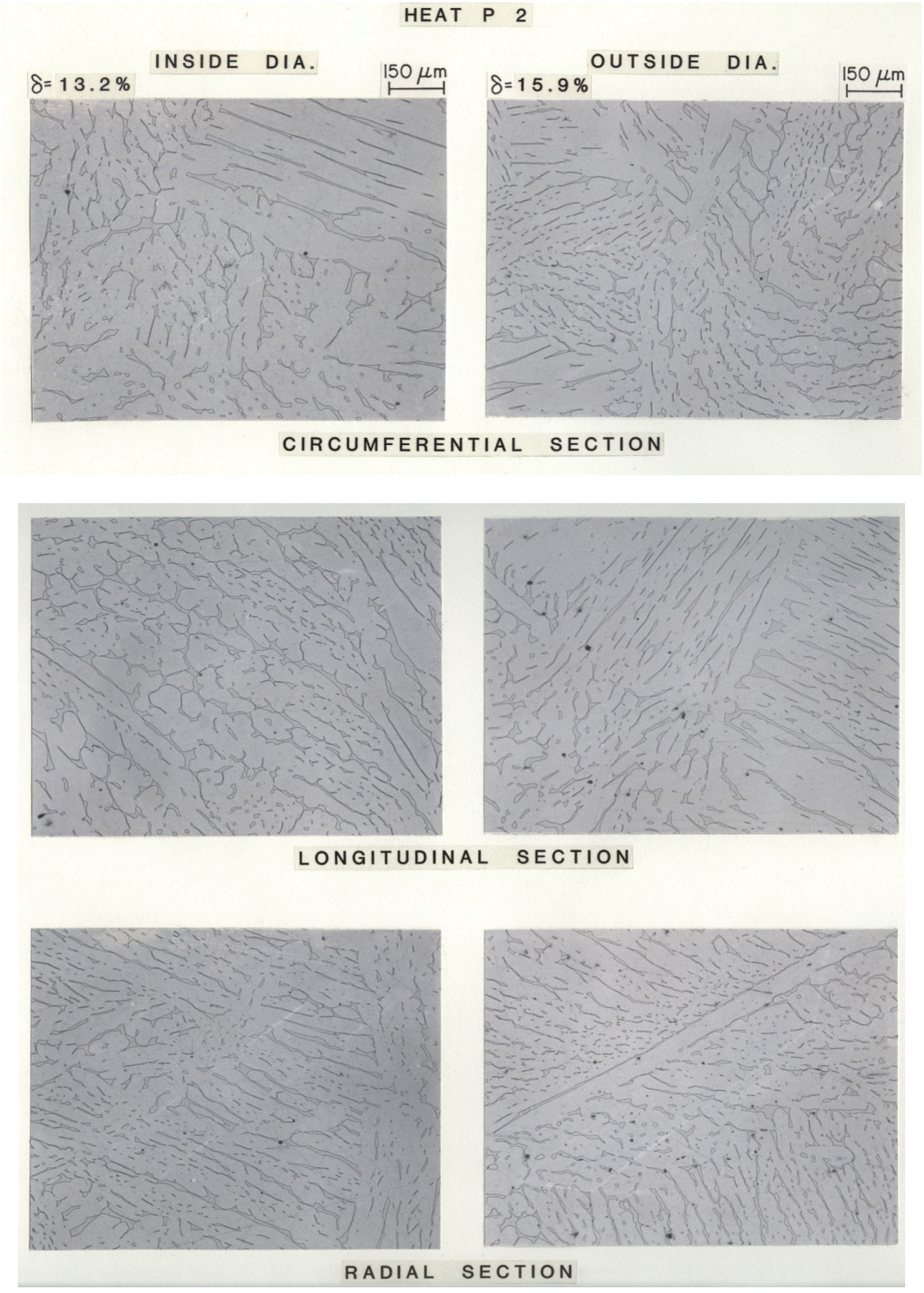


Figure A–5. Microstructures Along the Three Orientations of the Centrifugally Cast Pipe of CF–8 Stainless Steel.



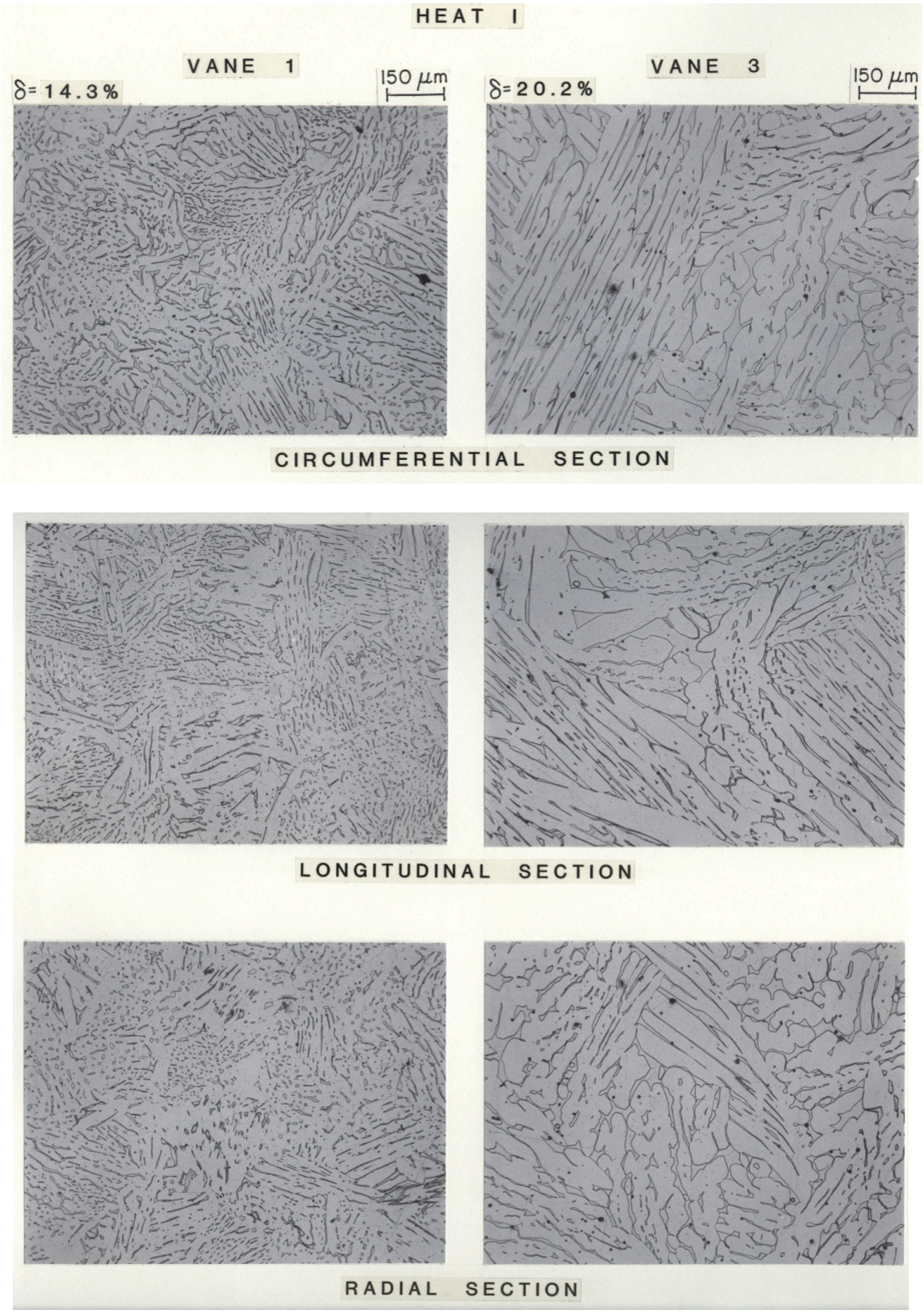
(a)

Figure A–6. Microstructures Along the Three Orientations of the Centrifugally Cast Pipe of CF–3 Stainless Steel. (a) Heat P3 and (b) Heat P2.



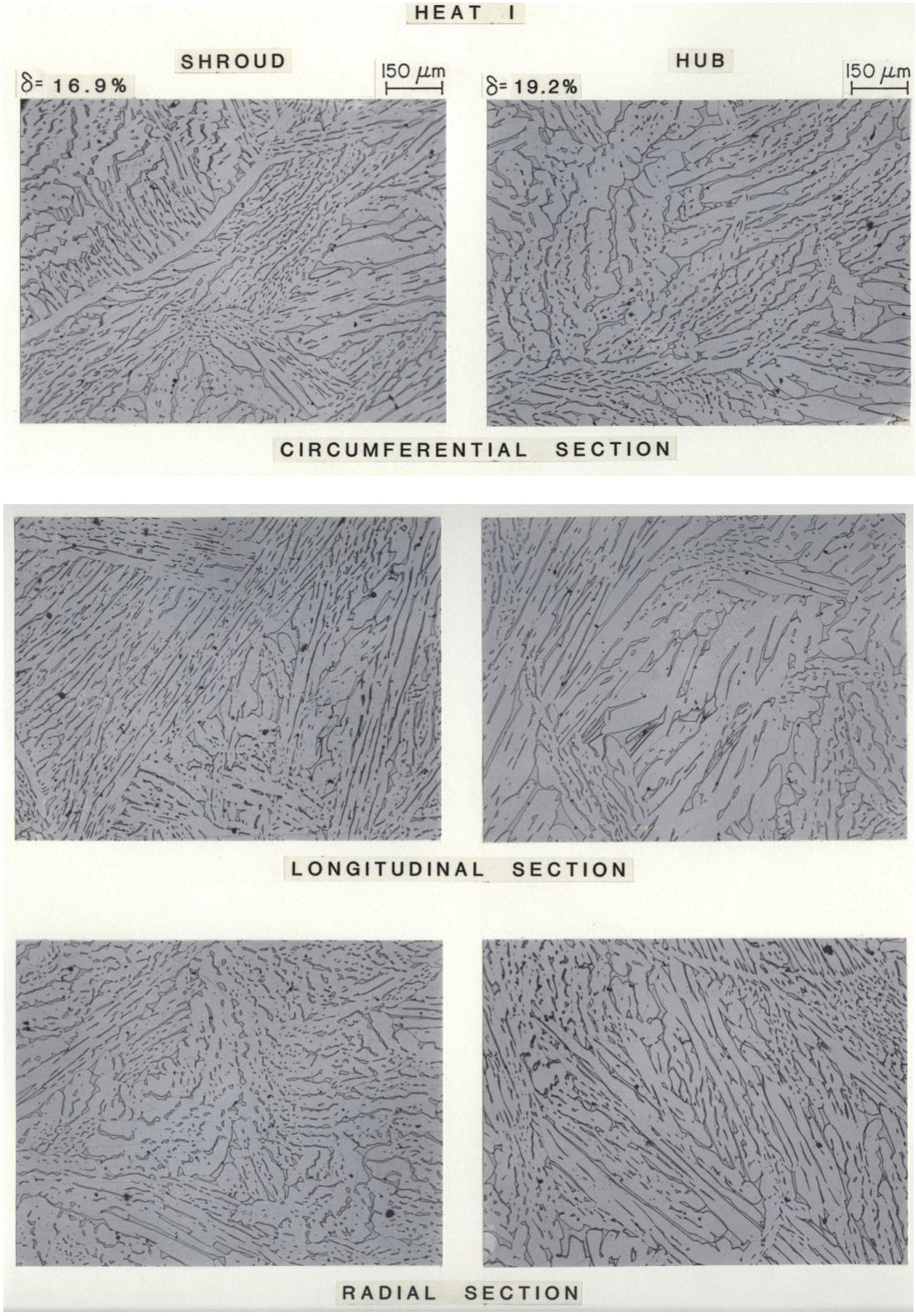
(b)

Figure A–6. (Contd.)



(a)

Figure A–7. Microstructures Along the Three Orientations of the Static–Cast Pump Impeller of CF–3 Stainless Steel. (a) Vanes and (b) Shroud and Hub Section of the Impeller.



(b)

Figure A–7. (Contd.)

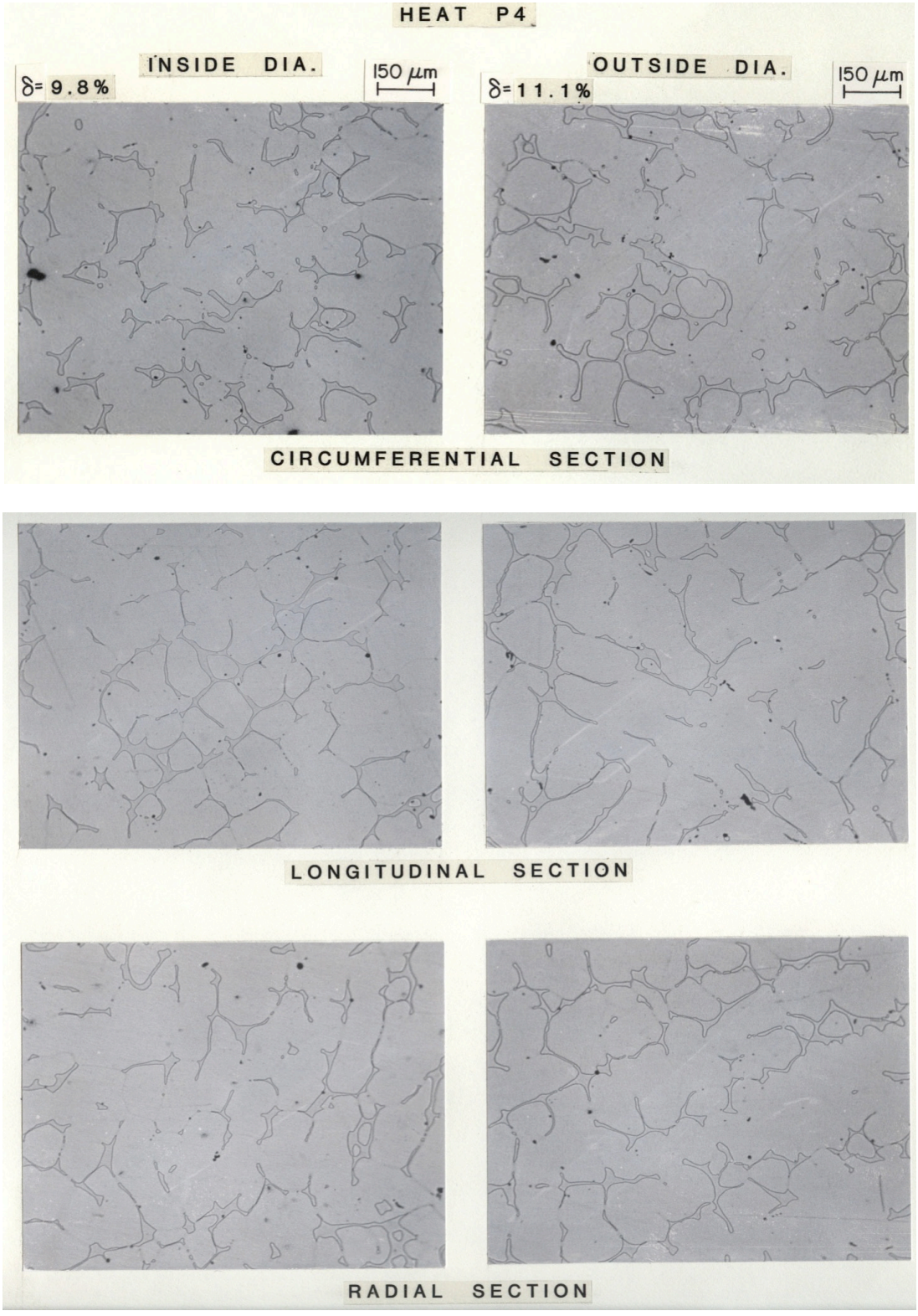
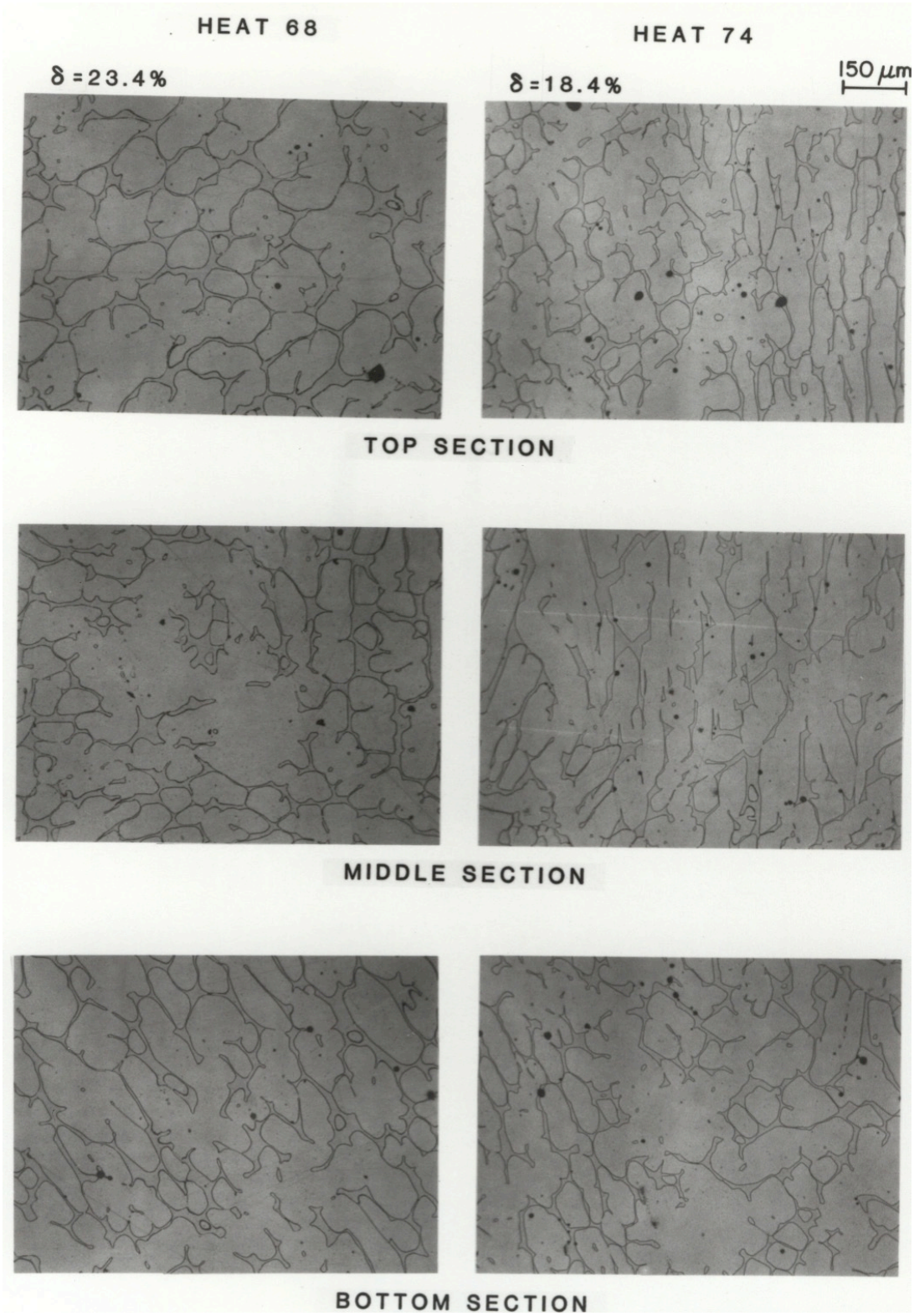
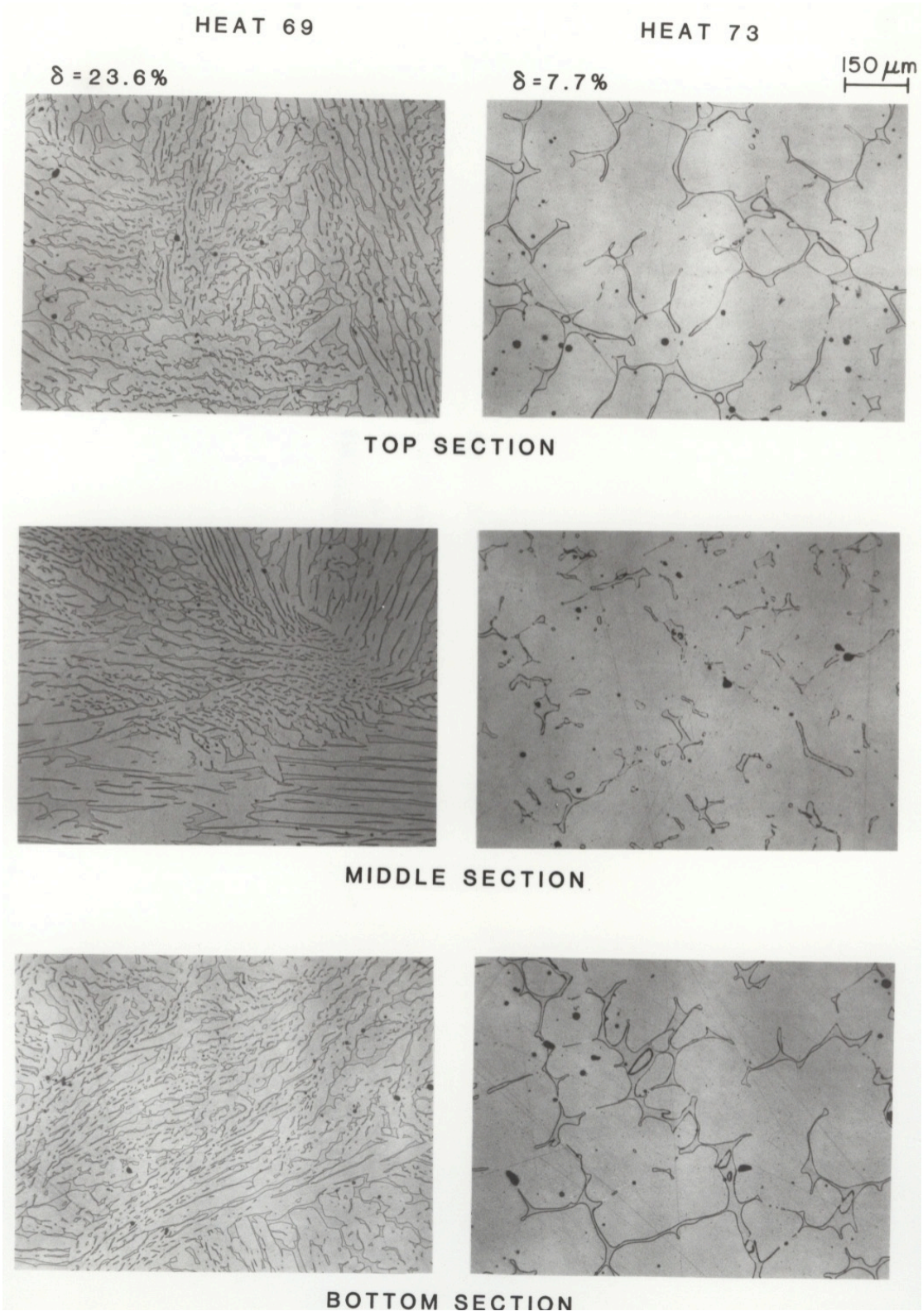


Figure A–8. Microstructures Along the Three Orientations of the Centrifugally Cast Pipe of CF–8M Stainless Steel.



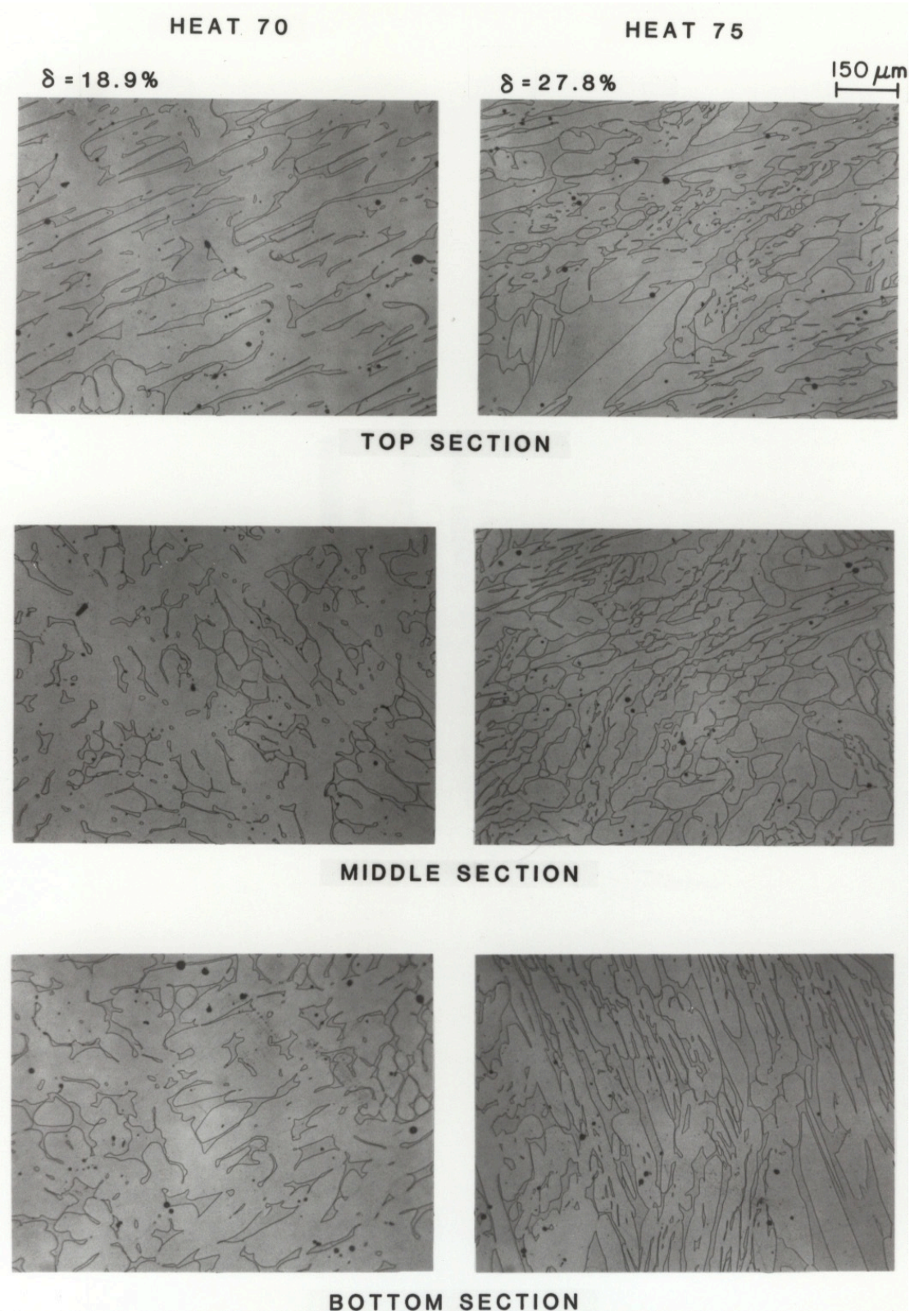
(a)

Figure A–9. Microstructures from Three Locations in Static–Cast Slabs of CF–8 (Heats 68 and 73), CF–3 (Heat 69), and CF–8M (Heats 70, 74, and 75) Stainless Steel.



(b)

Figure A–9. (Contd.)



(c)

Figure A–9. (Contd.)

Appendix B

Charpy–Impact Properties

The Charpy–impact tests were conducted on a Dynatup Model 8000A drop–weight impact machine with an instrumented tup and data readout system. The load–time traces from each test were digitized and stored on a floppy disk. The total impact energy was computed from the load–time traces. The data for the various experimental and commercial heats as well as the KRB pump cover material are given in Tables B–1 to B–4. The impact energies are normalized with respect to the cross sectional area of the specimens (impact energy in ft·lb can be obtained from J/cm^2 by multiplying by 0.59). The aging temperatures in Table B–4 for the KRB pump cover plate during reactor service represent the temperatures at specific locations of the specimens. The temperatures were calculated for the following temperature boundary conditions: reactor operating temperature, 284.5°C (545°F); ambient temperature, 50°C (122°F); and temperature of the cooling jacket for the pump shaft, 31°C (88°F).

The values of 0.2% yield and maximum load for each test are also listed. Deviation from linearity in the load–time trace occurred at 125 to 150 μs for the various heats and aging conditions. The load at 200 μs was estimated to represent 0.2% yield. The actual time for 0.2% yield varies with the strain hardening rate of the material; the load at 0.2% yield can be obtained from a power law fit of the data. The error in the estimated values was <5% for the various tests.

Table B–1. Charpy–Impact Test Results for the Small Experimental Heats of Cast Stainless Steel.

Specimen ID	Heat	Aging Temp. (°C)	Aging Time (h)	Test Temp. (°C)	Impact Energy (J/cm^2)	Yield Load (kN)	Max. Load (kN)
			CF–3 Grade				
473–S15	47	–	–	–196	133.3	12.400	23.000
476–S15	47	–	–	–196	131.9	12.320	22.961
473–S13	47	–	–	25	235.3	9.681	15.552
473–S14	47	–	–	25	203.9	10.202	15.035
476–S13	47	–	–	25	224.9	9.337	14.563
476–S14	47	–	–	25	250.3	8.984	14.805
472–S01	47	290	3000	25	196.4	10.200	15.922
472–S02	47	290	3000	25	234.7	10.069	15.866
472–S03	47	290	3000	25	213.4	9.655	15.638
472–S04	47	290	9980	25	203.3	9.586	15.665
472–S05	47	290	9980	25	223.3	9.160	15.791
472–S06	47	290	9980	25	208.9	9.287	15.209
472–S08	47	290	30000	25	263.5	9.276	15.682
472–S09	47	290	30000	25	268.0	9.227	15.672
474–S10	47	320	3000	25	224.4	12.669	17.834
474–S11	47	320	3000	25	202.1	10.954	15.930
474–S12	47	320	3000	25	411.1	10.640	18.648
474–S13	47	320	9980	25	183.6	9.160	15.431
474–S14	47	320	9980	25	233.3	9.270	15.658
474–S15	47	320	9980	25	187.5	9.586	15.855
474–S16	47	320	30000	25	202.4	9.618	16.316
474–S17	47	320	30000	25	186.9	9.598	16.209
474–S18	47	320	30000	25	190.5	10.155	16.219
474–S01	47	350	355	25	228.5	9.787	15.698
474–S02	47	350	355	25	236.8	10.320	16.569
474–S03	47	350	355	25	185.8	10.836	16.075
474–S04	47	350	1000	25	206.6	9.270	15.594
474–S05	47	350	1000	25	194.0	9.554	15.968
474–S06	47	350	1000	25	196.3	10.571	15.344
475–S07	47	350	3000	25	232.3	8.872	15.439
475–S08	47	350	3000	25	234.9	9.203	15.456
475–S09	47	350	3000	25	204.1	9.110	15.027
475–S13	47	350	30000	25	165.9	9.647	16.492
475–S14	47	350	30000	25	154.2	9.950	15.496
475–S15	47	350	30000	25	161.3	10.175	16.512
476–S16	47	400	30	25	314.7	9.672	15.421
476–S17	47	400	30	25	264.0	10.053	16.270
476–S18	47	400	30	25	378.2	9.448	16.768
476–S01	47	400	111	25	221.5	8.679	15.261
476–S02	47	400	111	25	268.2	8.772	15.379
476–S03	47	400	111	25	207.7	9.276	15.573
475–S01	47	400	303	25	394.4	10.537	18.560
475–S02	47	400	303	25	265.1	7.924	15.785
475–S03	47	400	303	25	164.0	10.202	16.518
475–S04	47	400	1000	25	206.9	9.251	16.073
475–S05	47	400	1000	25	116.4	10.454	15.363
475–S06	47	400	1000	25	178.7	9.738	16.133
476–S05	47	400	3017	25	179.4	9.654	15.556
476–S06	47	400	3017	25	200.2	9.218	15.693
476–S07	47	400	9980	25	153.0	10.166	16.343
476–S08	47	400	9980	25	174.9	10.273	16.170
476–S09	47	400	9980	25	174.7	9.440	16.145
476–S10	47	400	30000	25	177.1	9.555	15.792
476–S11	47	400	30000	25	173.8	9.575	16.338

Table B–1. (Contd.)

Specimen ID	Heat	Aging Temp. (°C)	Aging Time (h)	Test Temp. (°C)	Impact Energy (J/cm²)	Yield Load (kN)	Max. Load (kN)
472–S16	47	450	10	25	265.9	9.653	16.328
472–S17	47	450	10	25	312.8	9.516	16.426
472–S18	47	450	10	25	280.7	9.701	16.387
473–S16	47	450	50	25	281.7	0.000	0.000
473–S17	47	450	50	25	205.8	10.165	16.941
473–S18	47	450	50	25	209.5	9.794	16.746
477–S01	47	450	100	25	235.9	9.740	15.767
477–S02	47	450	100	25	214.0	9.730	15.993
477–S03	47	450	100	25	178.4	9.309	15.324
477–S04	47	450	310	25	177.9	10.160	16.259
477–S05	47	450	310	25	186.3	10.000	16.057
477–S06	47	450	310	25	197.7	10.403	16.706
477–S07	47	450	1000	25	144.3	9.702	14.715
477–S08	47	450	1000	25	234.3	9.148	16.263
477–S09	47	450	1000	25	173.1	9.375	15.771
477–S10	47	450	2998	25	175.3	9.102	15.479
477–S11	47	450	2998	25	178.7	8.801	15.487
477–S12	47	450	2998	25	167.2	8.885	14.629
483–S15	48	–	–	–196	157.1	13.920	23.020
486–S15	48	–	–	–196	215.7	14.556	24.717
483–S13	48	–	–	25	218.4	–	–
483–S14	48	–	–	25	200.3	–	–
486–S13	48	–	–	25	186.2	–	–
486–S14	48	–	–	25	247.6	–	–
486–S01	48	400	111	25	298.4	–	–
486–S02	48	400	111	25	296.3	–	–
486–S03	48	400	111	25	266.3	–	–
486–C01	48	400	3017	–196	68.4	14.000	19.173
487–S01	48	450	100	25	373.9	–	–
487–S02	48	450	100	25	252.1	–	–
487–S03	48	450	100	25	228.0	–	–
493–S15	49	–	–	–196	177.0	14.000	24.303
496–S15	49	–	–	–196	202.8	13.310	22.959
493–S13	49	–	–	25	183.5	–	–
493–S14	49	–	–	25	188.4	–	–
496–S13	49	–	–	25	178.0	–	–
496–S14	49	–	–	25	182.1	–	–
496–S01	49	400	111	25	371.3	–	–
496–S02	49	400	111	25	245.9	–	–
496–S03	49	400	111	25	345.7	–	–
497–S01	49	450	100	25	224.1	–	–
497–S02	49	450	100	25	272.6	–	–
497–S03	49	450	100	25	270.7	–	–
503–S15	50	–	–	–196	150.1	12.619	25.248
506–S15	50	–	–	–196	124.9	12.357	23.563
503–S13	50	–	–	25	217.2	–	–
503–S14	50	–	–	25	225.6	–	–
506–S13	50	–	–	25	196.5	–	–
506–S14	50	–	–	25	286.0	–	–
506–S01	50	400	111	25	317.6	–	–
506–S02	50	400	111	25	342.3	–	–
506–S03	50	400	111	25	296.6	–	–
507–S01	50	450	100	25	300.0	–	–
507–S03	50	450	100	25	365.5	–	–

Table B–1. (Contd.)

Specimen ID	Heat	Aging Temp. (°C)	Aging Time (h)	Test Temp. (°C)	Impact Energy (J/cm^2)	Yield Load (kN)	Max. Load (kN)
513–C15	51	–	–	–196	138.3	13.797	23.330
516–S15	51	–	–	–196	139.9	14.369	24.454
515–C07	51	–	–	25	251.2	11.000	17.451
515–C08	51	–	–	25	239.3	10.951	17.519
513–S13	51	–	–	25	188.8	10.670	16.645
513–S14	51	–	–	25	220.5	10.463	16.565
516–S13	51	–	–	25	213.5	10.177	16.480
516–S14	51	–	–	25	187.3	10.546	16.865
512–S01	51	290	3000	25	171.4	12.348	17.916
512–S02	51	290	3000	25	209.7	10.930	16.977
512–S03	51	290	3000	25	178.8	11.925	17.256
512–S04	51	290	9980	25	219.0	10.646	16.522
512–S05	51	290	9980	25	264.8	10.449	16.593
512–S06	51	290	9980	25	263.2	10.343	16.549
512–S07	51	290	30000	25	236.4	10.331	16.805
512–S08	51	290	30000	25	263.0	10.477	17.234
512–S09	51	290	30000	25	259.0	10.634	16.893
514–S10	51	320	3000	25	165.4	12.360	17.707
514–S11	51	320	3000	25	175.1	12.000	17.747
514–S12	51	320	3000	25	192.6	11.887	17.727
514–S13	51	320	9980	25	206.4	10.578	17.289
514–S14	51	320	9980	25	227.0	11.071	17.358
514–S15	51	320	9980	25	165.6	11.571	17.268
514–S16	51	320	30000	25	195.1	11.171	17.889
514–S17	51	320	30000	25	237.4	11.424	18.562
514–S18	51	320	30000	25	251.1	11.454	19.099
514–S01	51	350	355	25	204.8	10.626	17.609
514–S02	51	350	355	25	210.4	12.000	17.929
514–S03	51	350	355	25	213.4	11.840	17.968
514–S04	51	350	1000	25	201.2	11.680	18.178
514–S05	51	350	1000	25	210.2	12.680	18.011
514–S06	51	350	1000	25	207.4	11.480	17.609
515–S07	51	350	3000	25	196.2	10.994	16.873
515–S08	51	350	3000	25	190.8	10.234	16.555
515–S09	51	350	3000	25	231.4	10.295	16.951
515–S10	51	350	9980	25	159.7	12.023	17.719
515–S11	51	350	9980	25	164.7	12.164	18.196
515–S12	51	350	9980	25	188.6	12.096	18.088
515–S13	51	350	30000	25	194.7	11.620	18.338
515–S14	51	350	30000	25	197.5	11.249	17.947
515–S15	51	350	30000	25	180.1	11.415	18.084
516–S16	51	400	30	25	315.7	10.677	18.085
516–S17	51	400	30	25	262.4	11.087	18.095
516–S18	51	400	30	25	268.4	10.785	17.773
516–S01	51	400	111	25	235.9	10.308	17.313
516–S02	51	400	111	25	235.7	10.367	17.168
516–S03	51	400	111	25	235.8	10.706	17.320
515–S01	51	400	303	25	208.7	12.393	18.226
515–S02	51	400	303	25	191.5	11.840	18.230
515–S03	51	400	303	25	204.2	11.840	18.717
515–S04	51	400	1000	25	177.7	10.936	17.793
515–S05	51	400	1000	25	165.7	11.143	17.091
515–S06	51	400	1000	25	184.1	10.290	17.352
516–C01	51	400	3017	–196	43.1	15.218	18.898
516–S04	51	400	3017	25	138.9	10.659	16.602

Table B–1. (Contd.)

Specimen ID	Heat	Aging Temp. (°C)	Aging Time (h)	Test Temp. (°C)	Impact Energy (J/cm^2)	Yield Load (kN)	Max. Load (kN)
516–S05	51	400	3017	25	192.3	10.697	17.785
516–S06	51	400	3017	25	164.6	10.653	17.307
516–C04	51	400	9980	–196	35.9	14.804	16.647
516–S07	51	400	9980	25	120.0	11.600	18.073
516–S08	51	400	9980	25	159.8	11.647	18.736
516–S09	51	400	9980	25	140.4	11.082	17.522
516–S10	51	400	30000	25	171.2	11.653	18.720
516–S11	51	400	30000	25	158.9	11.507	18.437
512–S16	51	450	10	25	206.5	11.000	17.919
512–S17	51	450	10	25	200.2	10.990	18.271
512–S18	51	450	10	25	216.2	10.980	18.241
513–S16	51	450	50	25	207.7	11.063	17.986
513–S17	51	450	50	25	214.6	11.083	18.601
513–S18	51	450	50	25	262.9	14.401	23.283
517–S01	51	450	100	25	191.3	10.021	17.591
517–S02	51	450	100	25	227.8	10.341	17.865
517–S03	51	450	100	25	183.3	10.824	17.391
517–S04	51	450	310	25	134.3	12.480	17.680
517–S05	51	450	310	25	168.3	11.840	18.226
517–S06	51	450	310	25	157.8	12.000	18.259
517–C01	51	450	1000	25	170.8	10.387	17.873
517–C02	51	450	1000	25	134.1	11.203	17.250
517–C03	51	450	1000	25	131.2	10.675	16.503
517–S07	51	450	1000	25	154.1	11.429	17.727
517–S08	51	450	1000	25	186.1	10.828	18.543
517–S09	51	450	1000	25	170.3	11.026	17.764
517–S10	51	450	2998	25	149.6	10.637	16.740
517–S11	51	450	2998	25	171.3	10.641	17.417
517–S12	51	450	2998	25	147.1	10.395	16.606
517–C04	51	450	9980	–196	66.6	14.735	20.658
517–S13	51	450	9980	25	136.0	11.562	17.695
517–S14	51	450	9980	25	155.9	11.440	18.374
517–S15	51	450	9980	25	159.9	12.080	18.995
523–S15	52	–	–	–196	175.1	12.273	24.344
526–S15	52	–	–	–196	126.6	14.640	22.020
525–C09	52	–	–	25	245.2	10.141	16.729
523–S13	52	–	–	25	206.2	10.288	15.533
523–S14	52	–	–	25	241.3	10.136	16.150
526–S13	52	–	–	25	244.9	8.565	14.593
526–S14	52	–	–	25	295.2	9.135	15.739
522–S01	52	290	3000	25	178.6	11.155	16.270
522–S02	52	290	3000	25	193.7	10.367	16.262
522–S03	52	290	3000	25	187.2	10.785	16.121
522–S04	52	290	9980	25	231.4	9.040	15.588
522–S05	52	290	9980	25	239.4	10.234	16.402
522–S06	52	290	9980	25	397.0	9.360	15.084
522–S07	52	290	30000	25	237.1	9.618	16.258
522–S08	52	290	30000	25	291.5	9.696	16.258
522–S09	52	290	30000	25	248.8	9.882	16.482
524–S10	52	320	3000	25	209.9	10.360	16.067
524–S11	52	320	3000	25	257.0	10.353	16.403
524–S12	52	320	3000	25	185.4	11.600	16.340
524–S13	52	320	9980	25	209.9	10.240	16.283
524–S14	52	320	9980	25	266.7	10.154	16.571
524–S15	52	320	9980	25	191.9	10.603	16.284

Table B–1. (Contd.)

Specimen ID	Heat	Aging Temp. (°C)	Aging Time (h)	Test Temp. (°C)	Impact Energy (J/cm^2)	Yield Load (kN)	Max. Load (kN)
524–S16	52	320	30000	25	242.5	10.428	16.980
524–S17	52	320	30000	25	283.5	10.321	17.439
524–S18	52	320	30000	25	262.2	10.389	17.303
524–S01	52	350	355	25	211.9	10.227	16.471
524–S02	52	350	355	25	195.2	11.186	16.499
524–S03	52	350	355	25	191.6	10.781	17.209
524–S05	52	350	1000	25	240.1	11.072	16.339
524–S06	52	350	1000	25	188.6	10.400	15.958
525–S07	52	350	3000	25	261.8	9.115	15.919
525–S08	52	350	3000	25	226.3	9.686	15.727
525–S09	52	350	3000	25	219.4	–	–
525–S10	52	350	9980	25	225.3	11.553	17.228
525–S11	52	350	9980	25	207.0	11.452	16.905
525–S12	52	350	9980	25	184.0	11.232	17.200
525–S13	52	350	30000	25	259.2	9.999	17.156
525–S14	52	350	30000	25	270.9	9.813	17.225
525–S15	52	350	30000	25	254.5	10.067	17.166
526–S01	52	400	111	25	278.6	9.054	16.035
526–S02	52	400	111	25	290.4	9.904	16.084
526–S03	52	400	111	25	288.1	10.319	15.967
525–S01	52	400	303	25	205.5	10.120	17.021
525–S02	52	400	303	25	186.4	10.780	16.174
525–S03	52	400	303	25	187.9	11.557	16.587
525–S04	52	400	1000	25	196.6	10.508	16.348
525–S05	52	400	1000	25	231.8	10.016	16.369
525–S06	52	400	1000	25	253.3	9.389	16.886
526–C01	52	400	3017	–196	77.1	13.556	20.974
526–S04	52	400	3017	25	192.3	10.296	16.589
526–S05	52	400	3017	25	223.9	9.113	15.895
526–S06	52	400	3017	25	237.6	10.074	17.016
526–C04	52	400	9980	–196	36.7	13.376	17.377
526–S07	52	400	9980	25	187.4	10.379	16.944
526–S08	52	400	9980	25	156.7	10.880	16.295
526–S09	52	400	9980	25	158.5	10.911	17.164
526–S10	52	400	30000	25	213.7	10.590	17.461
526–S11	52	400	30000	25	337.5	12.794	22.887
522–S16	52	450	10	25	270.7	10.365	17.217
522–S17	52	450	10	25	267.9	10.150	17.060
522–S18	52	450	10	25	296.6	10.394	17.392
523–S16	52	450	50	25	245.9	9.657	17.088
523–S17	52	450	50	25	255.1	9.970	17.098
523–S18	52	450	50	25	242.8	10.243	17.293
527–S01	52	450	100	25	236.6	9.513	16.495
527–S02	52	450	100	25	226.3	10.081	16.218
527–S03	52	450	100	25	276.9	9.506	16.029
527–S04	52	450	310	25	187.6	10.760	16.623
527–S05	52	450	310	25	175.3	12.006	17.514
527–S06	52	450	310	25	219.8	11.120	17.849
527–C01	52	450	1000	25	214.5	–	–
527–C02	52	450	1000	25	204.4	–	–
527–C03	52	450	1000	25	157.7	–	–
527–S07	52	450	1000	25	190.2	9.662	16.083
527–S08	52	450	1000	25	177.5	9.387	14.577
527–S09	52	450	1000	25	186.5	9.640	16.622
527–S10	52	450	2998	25	192.0	9.722	16.224

Table B–1. (Contd.)

Specimen ID	Heat	Aging Temp. (°C)	Aging Time (h)	Test Temp. (°C)	Impact Energy (J/cm²)	Yield Load (kN)	Max. Load (kN)
527–S11	52	450	2998	25	105.6	–	–
527–S12	52	450	2998	25	170.8	–	–
527–C04	52	450	9980	–196	138.2	11.840	24.312
527–S13	52	450	9980	25	211.1	10.880	17.621
527–S14	52	450	9980	25	193.6	10.449	17.158
527–S15	52	450	9980	25	189.9	10.784	17.571
			CF–8 Grade				
533–S15	53	–	–	–196	95.4	14.055	20.775
536–S15	53	–	–	–196	69.8	16.118	19.825
533–S13	53	–	–	25	178.1	–	–
533–S14	53	–	–	25	219.2	–	–
536–S14	53	–	–	25	175.7	–	–
536–S01	53	400	111	25	211.4	–	–
536–S02	53	400	111	25	217.5	–	–
536–S03	53	400	111	25	236.9	–	–
536–C01	53	400	3017	–196	29.1	16.554	18.142
537–S01	53	450	100	25	119.6	–	–
537–S02	53	450	100	25	197.1	–	–
537–S03	53	450	100	25	175.5	–	–
543–S15	54	–	–	–196	90.6	17.019	22.994
546–S15	54	–	–	–196	59.0	16.320	19.518
543–S13	54	–	–	25	211.7	–	–
543–S14	54	–	–	25	171.2	–	–
546–S13	54	–	–	25	195.1	–	–
546–S14	54	–	–	25	170.9	–	–
546–S01	54	400	111	25	253.7	–	–
546–S02	54	400	111	25	250.7	–	–
546–S03	54	400	111	25	243.5	–	–
546–C01	54	400	3017	–196	64.6	17.054	21.864
547–S01	54	450	100	25	279.3	–	–
547–S02	54	450	100	25	279.3	–	–
547–S03	54	450	100	25	276.2	–	–
563–S15	56	–	–	–196	81.0	13.281	20.566
566–S15	56	–	–	–196	95.1	12.641	20.766
563–S13	56	–	–	25	212.0	9.811	15.848
563–S14	56	–	–	25	211.7	9.737	15.731
566–S13	56	–	–	25	196.0	10.440	16.750
566–S14	56	–	–	25	205.8	9.764	15.386
562–S01	56	290	3000	25	190.2	9.979	15.882
562–S02	56	290	3000	25	166.1	10.897	16.277
562–S03	56	290	3000	25	194.3	9.971	15.884
562–S04	56	290	9980	25	232.7	8.793	15.931
562–S05	56	290	9980	25	241.1	9.414	15.796
562–S06	56	290	9980	25	349.9	9.154	14.933
562–S07	56	290	30000	25	223.0	9.852	15.633
562–S08	56	290	30000	25	260.2	9.911	15.936
562–S09	56	290	30000	25	249.6	10.057	16.248
564–S10	56	320	3000	25	195.4	11.120	16.393
564–S11	56	320	3000	25	182.3	11.050	16.750
564–S12	56	320	3000	25	184.2	10.653	16.489
564–S13	56	320	9980	25	173.6	10.400	16.181
564–S14	56	320	9980	25	183.6	10.080	16.112
564–S15	56	320	9980	25	197.7	10.520	16.733
564–S16	56	320	30000	25	240.0	10.116	16.502
564–S17	56	320	30000	25	208.7	10.380	16.395

Table B–1. (Contd.)

Specimen ID	Heat	Aging Temp. (°C)	Aging Time (h)	Test Temp. (°C)	Impact Energy (J/cm^2)	Yield Load (kN)	Max. Load (kN)
564–S18	56	320	30000	25	219.0	10.350	16.951
564–S01	56	350	355	25	221.5	10.320	16.291
564–S02	56	350	355	25	229.1	10.240	16.675
564–S03	56	350	355	25	207.6	10.483	16.194
564–S04	56	350	1000	25	200.8	8.568	15.859
564–S05	56	350	1000	25	192.1	10.214	16.572
564–S06	56	350	1000	25	183.4	11.743	16.465
565–S07	56	350	3000	25	197.6	–	–
565–S09	56	350	3000	25	168.5	–	–
565–S13	56	350	30000	25	203.6	10.302	16.590
565–S14	56	350	30000	25	232.1	10.067	17.000
565–S15	56	350	30000	25	247.7	9.989	17.088
566–S01	56	400	111	25	196.3	–	–
566–S02	56	400	111	25	208.4	–	–
566–S03	56	400	111	25	231.0	–	–
565–S01	56	400	303	25	162.9	10.937	16.320
565–S03	56	400	303	25	151.6	11.480	17.355
565–S04	56	400	1000	25	162.3	10.246	16.073
565–S05	56	400	1000	25	177.3	9.241	15.301
565–S06	56	400	1000	25	196.0	–	–
566–S04	56	400	3017	25	177.5	–	–
566–S05	56	400	3017	25	158.7	–	–
566–S06	56	400	3017	25	165.3	–	–
566–S07	56	400	9980	25	137.6	10.057	16.588
566–S08	56	400	9980	25	168.4	10.480	17.230
566–S09	56	400	9980	25	138.6	10.240	16.069
566–S10	56	400	30000	25	140.3	10.404	16.572
566–S11	56	400	30000	25	161.7	9.838	16.436
562–S16	56	450	10	25	274.2	10.492	16.836
562–S17	56	450	10	25	215.3	10.599	16.348
562–S18	56	450	10	25	216.1	10.531	16.904
563–S16	56	450	50	25	224.2	10.302	16.736
563–S17	56	450	50	25	192.9	10.155	15.945
563–S18	56	450	50	25	221.9	9.794	16.473
567–S01	56	450	100	25	211.5	–	–
567–S02	56	450	100	25	187.8	–	–
567–S03	56	450	100	25	199.8	–	–
567–S04	56	450	310	25	150.0	10.480	16.681
567–S05	56	450	310	25	179.6	11.120	17.082
567–S06	56	450	310	25	168.6	11.063	17.158
567–S07	56	450	1000	25	127.1	–	–
567–S08	56	450	1000	25	172.4	–	–
567–S09	56	450	1000	25	174.8	–	–
567–S10	56	450	2998	25	133.4	–	–
567–S11	56	450	2998	25	129.1	–	–
567–S13	56	450	9980	25	105.0	10.510	16.126
567–S14	56	450	9980	25	110.4	10.240	16.770
567–S15	56	450	9980	25	110.3	10.559	15.918
573–S15	57	–	–	–196	140.0	12.160	22.858
576–S15	57	–	–	–196	97.4	12.320	20.687
573–S13	57	–	–	25	202.4	–	–
573–S14	57	–	–	25	164.3	–	–
576–S13	57	–	–	25	183.3	–	–
576–S14	57	–	–	25	204.7	–	–
576–S01	57	400	111	25	224.9	–	–

Table B–1. (Contd.)

Specimen ID	Heat	Aging Temp. (°C)	Aging Time (h)	Test Temp. (°C)	Impact Energy (J/cm²)	Yield Load (kN)	Max. Load (kN)
576–S02	57	400	111	25	271.1	–	–
576–S03	57	400	111	25	246.6	–	–
577–S01	57	450	100	25	270.0	–	–
577–S02	57	450	100	25	237.4	–	–
583–S15	58	–	–	–196	126.9	14.111	23.055
586–S15	58	–	–	–196	116.3	14.880	22.533
583–S13	58	–	–	25	245.0	0,000	0,000
583–S14	58	–	–	25	316.3	0,000	0,000
586–S13	58	–	–	25	327.9	–	–
586–S14	58	–	–	25	256.6	–	–
586–S01	58	400	111	25	234.2	–	–
586–S02	58	400	111	25	204.7	–	–
586–S03	58	400	111	25	188.3	–	–
587–S01	58	450	100	25	234.2	–	–
587–S02	58	450	100	25	201.8	–	–
587–S03	58	450	100	25	186.3	–	–
593–S15	59	–	–	–196	75.3	16.459	21.763
596–S15	59	–	–	–196	30.0	16.352	16.160
593–S13	59	–	–	25	247.1	10.549	15.948
593–S14	59	–	–	25	219.1	10.452	16.114
596–S13	59	–	–	25	210.5	10.998	15.826
596–S14	59	–	–	25	231.7	10.324	15.885
592–S01	59	290	3000	25	165.9	11.649	16.847
592–S02	59	290	3000	25	186.9	11.312	16.290
592–S03	59	290	3000	25	197.8	10.400	16.332
592–S04	59	290	9980	25	241.1	10.672	16.610
592–S05	59	290	9980	25	213.2	10.283	16.350
592–S06	59	290	9980	25	193.0	11.582	16.423
592–S07	59	290	30000	25	258.6	10.477	16.854
592–S08	59	290	30000	25	254.5	10.389	16.512
592–S09	59	290	30000	25	298.6	10.116	17.010
594–S10	59	320	3000	25	207.8	11.269	17.162
594–S11	59	320	3000	25	191.6	11.760	17.346
594–S12	59	320	3000	25	199.8	11.411	17.787
594–S13	59	320	9980	25	183.5	11.005	16.532
594–S14	59	320	9980	25	219.5	10.504	16.308
594–S15	59	320	9980	25	193.1	9.886	15.729
594–S17	59	320	30000	25	190.9	11.239	18.201
594–S18	59	320	30000	25	219.1	11.366	17.820
594–S16	59	320	30000	25	217.6	10.868	17.449
594–S02	59	350	355	25	196.8	11.387	16.681
594–S03	59	350	355	25	242.7	10.771	16.998
594–S04	59	350	1000	25	189.3	10.720	16.778
594–S06	59	350	1000	25	172.6	11.774	17.557
595–S07	59	350	3000	25	183.3	–	–
595–S08	59	350	3000	25	129.0	–	–
595–S09	59	350	3000	25	190.7	–	–
595–S10	59	350	9980	25	166.2	10.800	17.218
595–S11	59	350	9980	25	184.7	10.833	17.523
595–S12	59	350	9980	25	194.1	11.565	17.060
595–S13	59	350	30000	25	146.4	11.551	17.303
595–S14	59	350	30000	25	173.6	11.239	16.756
595–S15	59	350	30000	25	175.2	11.473	17.498
596–S16	59	400	30	25	276.1	10.863	17.383
596–S17	59	400	30	25	267.0	10.834	17.392

Table B–1. (Contd.)

Specimen ID	Heat	Aging Temp. (°C)	Aging Time (h)	Test Temp. (°C)	Impact Energy (J/cm^2)	Yield Load (kN)	Max. Load (kN)
596–S18	59	400	30	25	362.4	11.058	17.373
596–S01	59	400	111	25	144.6	–	–
596–S02	59	400	111	25	151.7	–	–
596–S03	59	400	111	25	151.1	–	–
595–S01	59	400	303	25	412.0	10.417	15.949
595–S02	59	400	303	25	159.4	11.280	17.018
595–S03	59	400	303	25	178.7	11.241	17.574
595–S04	59	400	1000	25	152.6	10.467	16.653
595–S05	59	400	1000	25	134.0	10.650	16.227
595–S06	59	400	1000	25	157.4	9.817	16.557
596–C01	59	400	3017	–196	16.7	14.655	14.655
596–S04	59	400	3017	25	196.5	–	–
596–S05	59	400	3017	25	183.4	–	–
596–S06	59	400	3017	25	115.0	–	–
596–C04	59	400	9980	–196	13.5	14.768	14.768
596–S07	59	400	9980	25	106.3	11.240	16.531
596–S08	59	400	9980	25	119.7	10.560	16.582
596–S09	59	400	9980	25	95.8	10.880	15.742
596–S10	59	400	30000	25	87.4	10.882	15.577
596–S11	59	400	30000	25	175.4	12.843	21.896
592–S16	59	450	10	25	245.1	11.478	17.910
592–S17	59	450	10	25	233.1	10.531	16.563
592–S18	59	450	10	25	203.0	11.263	17.480
593–S16	59	450	50	25	209.5	10.760	16.873
593–S17	59	450	50	25	214.6	10.760	17.967
593–S18	59	450	50	25	163.1	10.839	16.648
597–S01	59	450	100	25	65.7	–	–
597–S02	59	450	100	25	188.4	–	–
597–S03	59	450	100	25	131.4	–	–
597–S04	59	450	310	25	113.3	11.742	16.315
597–S05	59	450	310	25	121.2	11.912	17.283
597–S06	59	450	310	25	137.5	11.828	17.843
597–C01	59	450	1000	25	134.9	–	–
597–C02	59	450	1000	25	69.2	–	–
597–C03	59	450	1000	25	127.6	–	–
597–S07	59	450	1000	25	122.6	–	–
597–S08	59	450	1000	25	161.9	–	–
597–S09	59	450	1000	25	137.0	–	–
597–S10	59	450	2998	25	123.8	–	–
597–S11	59	450	2998	25	108.2	–	–
597–S12	59	450	2998	25	124.6	–	–
597–C04	59	450	9980	–196	13.8	14.862	14.895
597–S13	59	450	9980	25	96.6	8.074	17.735
597–S14	59	450	9980	25	91.0	10.989	15.851
597–S15	59	450	9980	25	102.0	11.742	16.410
603–S15	60	–	–	–196	25.4	14.771	14.771
606–S15	60	–	–	–196	21.7	15.569	15.569
605–C09	60	–	–	25	213.6	11.702	18.076
603–S13	60	–	–	25	187.6	11.455	16.452
603–S14	60	–	–	25	200.3	10.509	16.180
606–S13	60	–	–	25	200.7	10.728	16.532
606–S14	60	–	–	25	196.5	11.194	17.397
602–S01	60	290	3000	25	183.1	11.709	17.075
602–S02	60	290	3000	25	143.8	12.280	16.934
602–S03	60	290	3000	25	176.6	12.092	17.668

Table B–1. (Contd.)

Specimen ID	Heat	Aging Temp. (°C)	Aging Time (h)	Test Temp. (°C)	Impact Energy (J/cm^2)	Yield Load (kN)	Max. Load (kN)
602–S04	60	290	9980	25	204.4	11.140	17.700
602–S05	60	290	9980	25	231.2	11.658	17.378
602–S06	60	290	9980	25	220.1	10.880	17.118
602–S07	60	290	30000	25	229.2	11.376	17.488
602–S08	60	290	30000	25	258.8	11.053	17.937
602–S09	60	290	30000	25	240.7	11.317	17.752
604–S10	60	320	3000	25	181.2	12.033	17.829
604–S11	60	320	3000	25	204.1	11.760	18.367
604–S12	60	320	3000	25	175.8	11.978	17.515
604–S13	60	320	9980	25	165.1	11.040	16.797
604–S14	60	320	9980	25	180.9	11.840	17.660
604–S15	60	320	9980	25	169.4	11.800	17.328
604–S16	60	320	30000	25	149.2	12.001	18.133
604–S17	60	320	30000	25	219.9	12.030	18.865
604–S18	60	320	30000	25	200.6	12.333	18.963
604–S01	60	350	355	25	167.1	12.400	18.187
604–S02	60	350	355	25	137.7	12.480	17.394
604–S03	60	350	355	25	189.4	11.920	17.955
604–S04	60	350	1000	25	150.0	12.560	17.939
604–S05	60	350	1000	25	150.9	12.486	17.559
604–S06	60	350	1000	25	161.7	12.520	17.681
605–S08	60	350	3000	25	195.5	11.685	18.055
605–S09	60	350	3000	25	180.9	10.867	17.327
605–S10	60	350	9980	25	113.9	11.648	17.679
605–S11	60	350	9980	25	159.7	11.557	17.776
605–S12	60	350	9980	25	130.5	11.639	17.508
605–S13	60	350	30000	25	117.4	11.786	18.240
605–S14	60	350	30000	25	96.0	12.274	17.605
605–S15	60	350	30000	25	56.8	12.362	13.104
606–S16	60	400	30	25	262.2	12.034	18.407
606–S17	60	400	30	25	221.7	11.732	18.261
606–S18	60	400	30	25	209.8	11.605	17.988
606–S01	60	400	111	25	169.1	10.366	17.233
606–S02	60	400	111	25	163.6	10.847	17.433
606–S03	60	400	111	25	175.6	11.061	16.982
605–S01	60	400	303	25	136.7	12.125	17.700
605–S02	60	400	303	25	115.0	12.240	18.033
605–S03	60	400	303	25	146.4	12.760	17.973
605–S04	60	400	1000	25	87.6	11.270	15.222
605–S05	60	400	1000	25	123.6	10.839	17.651
605–S06	60	400	1000	25	89.7	11.846	15.971
606–C01	60	400	3017	–196	11.4	15.094	15.094
606–S04	60	400	3017	25	67.1	12.035	15.491
606–S05	60	400	3017	25	105.3	11.414	17.301
606–S06	60	400	3017	25	70.2	11.775	15.501
606–C04	60	400	9980	–196	8.0	14.910	14.910
606–S07	60	400	9980	25	57.1	12.320	14.901
606–S08	60	400	9980	25	64.5	12.560	16.140
606–S09	60	400	9980	25	45.1	12.400	14.173
606–S10	60	400	30000	25	55.7	12.766	16.250
606–S11	60	400	30000	25	75.8	12.795	17.031
602–S16	60	450	10	25	210.3	12.239	18.280
602–S17	60	450	10	25	216.3	11.780	18.603
602–S18	60	450	10	25	232.5	12.161	19.100
603–S16	60	450	50	25	132.3	11.883	17.703

Table B–1. (Contd.)

Specimen ID	Heat	Aging Temp. (°C)	Aging Time (h)	Test Temp. (°C)	Impact Energy (J/cm^2)	Yield Load (kN)	Max. Load (kN)
603–S17	60	450	50	25	116.9	12.381	17.713
603–S18	60	450	50	25	161.3	15.824	22.392
607–S01	60	450	100	25	106.9	10.750	16.507
607–S02	60	450	100	25	120.8	11.853	17.555
607–S03	60	450	100	25	110.5	11.787	18.026
607–S04	60	450	310	25	72.2	12.800	15.759
607–S05	60	450	310	25	156.4	11.360	16.258
607–S06	60	450	310	25	78.2	13.360	16.245
607–C01	60	450	1000	25	94.7	11.135	16.693
607–C02	60	450	1000	25	94.2	12.147	17.238
607–C03	60	450	1000	25	85.7	12.041	16.387
607–S07	60	450	1000	25	74.4	11.831	15.775
607–S08	60	450	1000	25	85.7	11.879	16.315
607–S09	60	450	1000	25	80.8	12.104	16.461
607–S10	60	450	2998	25	41.3	11.045	13.374
607–S11	60	450	2998	25	68.1	11.521	15.272
607–S12	60	450	2998	25	79.7	12.061	17.086
607–C04	60	450	9980	–196	10.4	13.139	13.139
607–S13	60	450	9980	25	42.6	12.583	14.828
607–S14	60	450	9980	25	54.7	12.495	15.782
607–S15	60	450	9980	25	32.8	12.639	14.167
613–S15	61	–	–	–196	29.8	17.689	18.351
616–S15	61	–	–	–196	53.8	18.160	19.571
613–S13	61	–	–	25	253.4	10.580	16.424
613–S14	61	–	–	25	238.7	10.456	16.652
616–S13	61	–	–	25	252.4	10.709	16.700
616–S14	61	–	–	25	255.7	10.945	16.943
612–S01	61	290	3000	25	164.9	12.248	17.609
612–S02	61	290	3000	25	189.8	13.006	17.934
612–S03	61	290	3000	25	200.8	10.960	16.828
612–S04	61	290	9980	25	247.3	10.600	16.718
612–S05	61	290	9980	25	221.7	11.760	17.429
612–S06	61	290	9980	25	204.6	11.720	17.460
612–S07	61	290	30000	25	259.1	11.073	17.195
612–S08	61	290	30000	25	292.0	11.717	16.717
612–S09	61	290	30000	25	266.4	10.819	17.703
614–S10	61	320	3000	25	196.7	12.123	17.362
614–S11	61	320	3000	25	171.7	12.785	17.703
614–S12	61	320	3000	25	210.6	12.214	18.240
614–S13	61	320	9980	25	213.6	11.793	17.510
614–S14	61	320	9980	25	253.0	11.858	17.777
614–S16	61	320	30000	25	225.0	11.464	17.683
614–S17	61	320	30000	25	262.9	11.971	18.533
614–S18	61	320	30000	25	236.8	12.108	18.631
614–S01	61	350	355	25	239.4	13.787	18.389
614–S02	61	350	355	25	224.2	11.920	17.442
614–S03	61	350	355	25	218.3	12.080	16.965
614–S04	61	350	1000	25	216.3	12.000	17.388
614–S05	61	350	1000	25	223.3	12.380	17.426
614–S06	61	350	1000	25	187.8	11.768	17.180
615–S08	61	350	3000	25	148.6	10.552	17.130
615–S09	61	350	3000	25	234.4	10.301	16.630
615–S10	61	350	9980	25	176.5	12.609	17.946
615–S11	61	350	9980	25	139.1	12.162	17.457
615–S12	61	350	9980	25	148.9	12.296	17.269

Table B–1. (Contd.)

Specimen ID	Heat	Aging Temp. (°C)	Aging Time (h)	Test Temp. (°C)	Impact Energy (J/cm²)	Yield Load (kN)	Max. Load (kN)
615–S13	61	350	30000	25	202.8	11.620	18.055
615–S14	61	350	30000	25	189.2	11.727	18.035
615–S15	61	350	30000	25	197.9	11.473	18.055
616–S01	61	400	111	25	256.8	10.796	17.234
616–S02	61	400	111	25	233.8	11.014	16.597
616–S03	61	400	111	25	320.0	10.934	17.131
615–S01	61	400	303	25	182.5	12.294	17.721
615–S02	61	400	303	25	170.9	11.680	17.626
615–S03	61	400	303	25	172.9	12.720	18.817
615–S04	61	400	1000	25	161.1	11.256	16.849
615–S05	61	400	1000	25	157.4	11.361	16.263
615–S06	61	400	1000	25	169.0	11.142	17.066
616–S04	61	400	3017	25	150.3	11.628	16.929
616–S05	61	400	3017	25	152.7	10.907	17.090
616–S06	61	400	3017	25	253.4	10.725	17.550
616–S07	61	400	9980	25	125.2	12.134	17.495
616–S08	61	400	9980	25	171.4	11.807	19.295
616–S09	61	400	9980	25	139.0	12.128	17.658
616–S10	61	400	30000	25	137.2	11.761	17.724
616–S11	61	400	30000	25	159.9	11.341	18.115
617–S01	61	450	100	25	182.1	10.501	17.519
617–S02	61	450	100	25	184.9	11.531	17.730
617–S03	61	450	100	25	186.6	10.671	17.425
617–S04	61	450	310	25	123.0	12.902	17.803
617–S05	61	450	310	25	359.4	11.924	18.626
617–S06	61	450	310	25	197.5	12.937	19.339
617–S07	61	450	1000	25	139.1	11.829	17.370
617–S08	61	450	1000	25	128.1	11.098	16.760
617–S09	61	450	1000	25	146.9	11.285	17.331
617–S10	61	450	2998	25	134.6	11.442	17.667
617–S11	61	450	2998	25	112.5	10.835	16.182
617–S12	61	450	2998	25	126.4	11.288	16.681
617–S10	61	450	9980	25	114.4	12.003	17.623
617–S14	61	450	9980	25	73.9	12.400	14.391
617–S15	61	450	9980	25	89.6	12.078	15.747
			CF–8M Grade				
623–S15	62	–	–	–196	188.5	14.720	22.886
626–S15	62	–	–	–196	186.3	11.840	24.265
623–S13	62	–	–	25	195.9	–	–
623–S14	62	–	–	25	243.1	–	–
626–S13	62	–	–	25	234.0	–	–
626–S14	62	–	–	25	239.3	–	–
626–S01	62	400	111	25	175.7	–	–
626–S02	62	400	111	25	202.0	–	–
626–S03	62	400	111	25	193.2	–	–
627–S01	62	450	100	25	191.0	–	–
627–S02	62	450	100	25	237.2	–	–
627–S03	62	450	100	25	254.7	–	–
627–S07	62	450	1000	25	219.2	9.745	15.213
627–S09	62	450	1000	25	229.7	10.028	16.004
633–S15	63	–	–	–196	167.4	15.560	24.060
636–S15	63	–	–	–196	227.8	16.880	25.206
635–C07	63	–	–	25	229.6	9.565	15.460
633–S13	63	–	–	25	233.9	9.793	15.088
633–S14	63	–	–	25	293.2	9.585	15.493
636–S13	63	–	–	25	221.9	10.112	15.519

Table B–1. (Contd.)

Specimen ID	Heat	Aging Temp. (°C)	Aging Time (h)	Test Temp. (°C)	Impact Energy (J/cm^2)	Yield Load (kN)	Max. Load (kN)
636–S14	63	–	–	25	245.4	9.546	15.189
632–S01	63	290	3000	25	189.6	11.251	17.021
632–S02	63	290	3000	25	434.0	11.280	17.911
632–S04	63	290	9980	25	221.2	9.394	15.573
632–S05	63	290	9980	25	225.8	9.808	15.011
632–S06	63	290	9980	25	172.4	10.121	14.987
632–S07	63	290	30000	25	195.7	9.696	15.701
632–S08	63	290	30000	25	215.0	9.755	15.506
632–S09	63	290	30000	25	235.4	9.979	16.531
634–S10	63	320	3000	25	148.3	11.200	15.597
634–S11	63	320	3000	25	158.1	11.280	16.557
634–S12	63	320	3000	25	203.7	10.600	16.063
634–S13	63	320	9980	25	156.7	10.416	15.349
634–S14	63	320	9980	25	228.9	9.633	15.900
634–S15	63	320	9980	25	148.5	10.317	15.109
634–S16	63	320	30000	25	152.6	10.829	15.975
634–S17	63	320	30000	25	171.0	10.262	16.365
634–S18	63	320	30000	25	187.2	10.282	16.482
634–S01	63	350	355	25	192.4	10.175	15.723
634–S02	63	350	355	25	301.2	9.760	15.688
634–S03	63	350	355	25	139.2	11.591	16.609
634–S04	63	350	1000	25	166.7	10.289	15.388
634–S05	63	350	1000	25	181.2	10.240	15.992
634–S06	63	350	1000	25	241.8	10.640	16.402
635–S07	63	350	3000	25	192.1	9.383	15.236
635–S08	63	350	3000	25	209.2	9.646	14.770
635–S09	63	350	3000	25	220.8	9.389	15.551
635–S10	63	350	9980	25	109.3	10.801	15.339
635–S11	63	350	9980	25	123.1	10.195	15.192
635–S12	63	350	9980	25	132.4	10.345	16.164
635–S13	63	350	30000	25	137.6	10.389	15.594
635–S14	63	350	30000	25	100.6	10.341	14.237
635–S15	63	350	30000	25	178.1	10.360	16.502
636–S16	63	400	30	25	368.8	10.004	16.397
636–S17	63	400	30	25	317.7	9.223	16.143
636–S18	63	400	30	25	306.1	10.336	16.182
636–S01	63	400	111	25	215.8	9.683	15.835
636–S02	63	400	111	25	220.0	9.795	15.620
636–S03	63	400	111	25	277.6	9.653	15.866
635–S01	63	400	303	25	168.6	10.640	16.872
635–S02	63	400	303	25	172.8	10.640	16.048
635–S03	63	400	303	25	172.8	10.720	16.273
635–S04	63	400	1000	25	183.9	9.191	15.698
635–S05	63	400	1000	25	164.0	10.044	15.633
635–S06	63	400	1000	25	181.2	10.375	16.171
636–C01	63	400	3017	–196	58.0	16.782	20.807
636–S04	63	400	3017	25	146.6	–	–
636–S05	63	400	3017	25	148.6	–	–
636–S06	63	400	3017	25	175.2	–	–
636–C04	63	400	9980	–196	42.0	16.179	19.694
636–S07	63	400	9980	25	123.5	10.480	15.770
636–S08	63	400	9980	25	130.7	9.897	16.760
636–S09	63	400	9980	25	135.2	9.915	15.835
636–S10	63	400	30000	25	191.9	10.043	17.187
636–S11	63	400	30000	25	152.1	10.258	15.694

Table B–1. (Contd.)

Specimen ID	Heat	Aging Temp. (°C)	Aging Time (h)	Test Temp. (°C)	Impact Energy (J/cm^2)	Yield Load (kN)	Max. Load (kN)
632–S16	63	450	10	25	225.9	10.204	16.102
632–S17	63	450	10	25	243.6	9.950	16.531
632–S18	63	450	10	25	212.2	9.608	15.438
633–S16	63	450	50	25	195.2	10.292	16.482
633–S17	63	450	50	25	221.0	9.667	16.541
633–S18	63	450	50	25	209.7	9.452	16.258
637–S01	63	450	100	25	182.0	9.323	16.216
637–S02	63	450	100	25	188.1	9.555	15.508
637–S03	63	450	100	25	170.5	10.056	15.640
637–S04	63	450	310	25	154.1	11.738	16.936
637–S05	63	450	310	25	162.4	11.480	16.871
637–S06	63	450	310	25	183.4	11.476	16.833
637–C01	63	450	1000	25	160.9	10.048	15.999
637–C02	63	450	1000	25	153.8	9.570	14.918
637–C03	63	450	1000	25	151.1	9.889	15.414
637–S07	63	450	1000	25	147.5	10.437	15.698
637–S08	63	450	1000	25	175.8	8.894	15.290
637–S09	63	450	1000	25	151.5	10.158	16.631
637–S10	63	450	2998	25	157.0	9.251	15.656
637–S11	63	450	2998	25	159.2	9.444	16.069
637–C04	63	450	9980	–196	32.0	14.649	17.170
637–S13	63	450	9980	25	119.0	10.137	16.101
637–S14	63	450	9980	25	106.7	10.915	15.368
637–S15	63	450	9980	25	109.4	10.000	14.753
643–S15	64	–	–	–196	74.2	19.572	21.541
646–S15	64	–	–	–196	90.6	18.880	25.636
645–C09	64	–	–	25	62.6	10.394	15.753
643–S13	64	–	–	25	165.5	11.326	17.238
643–S14	64	–	–	25	225.4	11.644	18.345
646–S13	64	–	–	25	220.2	–	–
646–S14	64	–	–	25	187.7	11.620	17.441
642–S01	64	290	3000	25	164.6	12.514	19.079
642–S02	64	290	3000	25	164.2	12.514	19.079
642–S03	64	290	3000	25	176.1	12.274	18.485
642–S04	64	290	9980	25	173.5	12.368	18.667
642–S05	64	290	9980	25	211.1	12.371	18.796
642–S06	64	290	9980	25	229.3	12.319	18.687
642–S07	64	290	30000	25	198.1	12.010	18.748
642–S08	64	290	30000	25	214.8	12.518	19.138
642–S09	64	290	30000	25	213.6	12.674	19.236
644–S10	64	320	3000	25	166.9	13.200	19.383
644–S11	64	320	3000	25	179.8	13.320	19.635
644–S12	64	320	3000	25	177.0	12.590	19.421
644–S13	64	320	9980	25	117.1	13.667	19.538
644–S14	64	320	9980	25	92.9	13.330	17.726
644–S15	64	320	9980	25	99.5	13.528	17.910
644–S16	64	320	30000	25	66.4	14.041	17.879
644–S17	64	320	30000	25	67.9	13.817	16.941
644–S18	64	320	30000	25	67.8	13.963	18.240
644–S01	64	350	355	25	176.4	13.280	19.211
644–S02	64	350	355	25	166.3	13.360	19.230
644–S03	64	350	355	25	170.4	13.721	20.119
644–S04	64	350	1000	25	139.6	13.600	19.040
644–S05	64	350	1000	25	172.4	13.680	19.974
644–S06	64	350	1000	25	155.1	14.120	19.434

Table B–1. (Contd.)

Specimen ID	Heat	Aging Temp. (°C)	Aging Time (h)	Test Temp. (°C)	Impact Energy (J/cm^2)	Yield Load (kN)	Max. Load (kN)
645–S07	64	350	3000	25	147.0	12.703	18.879
645–S08	64	350	3000	25	154.5	12.577	18.733
645–S09	64	350	3000	25	148.2	12.115	19.068
645–S10	64	350	9980	25	67.7	13.556	19.039
645–S11	64	350	9980	25	80.8	13.299	18.171
645–S12	64	350	9980	25	111.4	13.836	21.139
645–S13	64	350	30000	25	59.3	13.827	18.191
645–S14	64	350	30000	25	51.3	13.866	17.654
645–S15	64	350	30000	25	54.0	13.914	16.951
646–S16	64	400	30	25	217.6	12.922	19.705
646–S17	64	400	30	25	222.4	12.971	19.940
646–S18	64	400	30	25	211.9	12.893	20.262
646–S01	64	400	111	25	161.7	11.927	19.841
646–S02	64	400	111	25	192.6	12.210	19.527
646–S03	64	400	111	25	177.8	10.343	19.427
645–S01	64	400	303	25	78.6	13.680	17.510
645–S02	64	400	303	25	123.0	14.040	20.099
645–S03	64	400	303	25	115.8	14.087	19.836
645–S04	64	400	1000	25	70.2	12.036	17.008
645–S05	64	400	1000	25	82.9	12.344	17.650
645–S06	64	400	1000	25	63.2	12.659	16.750
646–C01	64	400	3017	–196	8.9	16.110	16.110
646–S04	64	400	3017	25	56.3	12.268	17.554
646–S05	64	400	3017	25	56.3	12.182	16.366
646–S06	64	400	3017	25	38.8	12.079	14.205
646–C04	64	400	9980	–196	9.6	16.364	16.378
646–S07	64	400	9980	25	47.5	14.271	17.474
646–S08	64	400	9980	25	50.1	14.240	17.140
646–S09	64	400	9980	25	57.0	14.640	17.557
646–S10	64	400	30000	25	34.9	13.479	15.675
646–S11	64	400	30000	25	44.0	13.566	16.846
642–S16	64	450	10	25	219.9	–	–
642–S17	64	450	10	25	193.7	12.899	20.496
642–S18	64	450	10	25	180.3	13.123	20.408
643–S16	64	450	50	25	99.0	13.797	19.080
643–S17	64	450	50	25	131.8	12.957	20.447
643–S18	64	450	50	25	116.3	13.231	20.027
647–S01	64	450	100	25	98.8	12.177	19.170
647–S02	64	450	100	25	102.2	12.182	18.007
647–S03	64	450	100	25	110.8	12.492	19.328
647–S04	64	450	310	25	93.8	14.600	20.113
647–S05	64	450	310	25	70.8	14.413	19.196
647–S06	64	450	310	25	66.4	14.413	17.690
647–C01	64	450	1000	25	68.5	13.044	17.715
647–C02	64	450	1000	25	57.0	14.538	17.168
647–C03	64	450	1000	25	53.5	14.396	17.509
647–S07	64	450	1000	25	61.7	13.185	16.508
647–S08	64	450	1000	25	82.0	13.618	19.106
647–S09	64	450	1000	25	86.4	13.324	19.052
647–S11	64	450	2998	25	50.3	13.187	16.166
647–S12	64	450	2998	25	53.2	12.876	16.436
647–C04	64	450	9980	–196	8.2	14.467	14.467
647–S13	64	450	9980	25	49.4	13.920	17.182
647–S14	64	450	9980	25	41.8	14.160	17.084
647–S15	64	450	9980	25	43.4	14.373	15.782

Table B–1. (Contd.)

Specimen ID	Heat	Aging Temp. (°C)	Aging Time (h)	Test Temp. (°C)	Impact Energy (J/cm^2)	Yield Load (kN)	Max. Load (kN)
653–S15	65	–	–	–196	60.3	20.240	22.247
656–S15	65	–	–	–196	99.6	20.464	26.942
653–S13	65	–	–	25	199.1	12.247	18.151
653–S14	65	–	–	25	238.5	11.245	18.247
656–S13	65	–	–	25	226.1	11.829	17.632
656–S14	65	–	–	25	222.5	11.554	18.139
652–S01	65	290	3000	25	198.1	12.827	18.726
652–S02	65	290	3000	25	149.3	12.560	18.516
652–S03	65	290	3000	25	227.4	12.053	18.676
652–S04	65	290	9980	25	209.8	12.280	18.551
652–S05	65	290	9980	25	204.4	12.476	18.677
652–S06	65	290	9980	25	162.3	13.227	18.543
652–S07	65	290	30000	25	190.4	12.459	18.181
652–S08	65	290	30000	25	217.1	12.274	18.748
652–S09	65	290	30000	25	217.6	12.918	18.904
654–S10	65	320	3000	25	168.3	12.640	18.938
654–S11	65	320	3000	25	195.4	13.038	18.995
654–S12	65	320	3000	25	185.1	12.640	19.419
654–S13	65	320	9980	25	164.2	12.800	19.063
654–S14	65	320	9980	25	193.8	12.780	19.696
654–S15	65	320	9980	25	175.1	12.144	19.089
654–S16	65	320	30000	25	115.1	13.700	20.066
654–S17	65	320	30000	25	100.2	13.231	18.797
654–S18	65	320	30000	25	94.6	13.729	18.963
654–S01	65	350	355	25	162.0	13.040	19.009
654–S02	65	350	355	25	207.3	12.509	18.518
654–S03	65	350	355	25	141.9	12.985	18.583
654–S04	65	350	1000	25	185.7	13.239	19.679
654–S05	65	350	1000	25	183.0	12.960	19.303
654–S06	65	350	1000	25	182.5	13.577	19.954
655–S07	65	350	3000	25	177.2	–	–
655–S08	65	350	3000	25	184.0	–	–
655–S09	65	350	3000	25	164.6	–	–
655–S10	65	350	9980	25	173.4	11.568	18.597
655–S11	65	350	9980	25	159.6	11.000	18.280
655–S12	65	350	9980	25	140.3	12.453	18.121
655–S13	65	350	30000	25	97.1	13.856	19.734
655–S14	65	350	30000	25	126.0	13.895	20.037
655–S15	65	350	30000	25	79.7	13.202	17.449
656–S16	65	400	30	25	223.3	12.659	19.705
656–S17	65	400	30	25	246.2	12.795	19.823
656–S18	65	400	30	25	209.7	12.288	19.256
656–S01	65	400	111	25	145.7	–	–
656–S02	65	400	111	25	161.1	–	–
656–S03	65	400	111	25	171.6	–	–
655–S01	65	400	303	25	162.4	12.720	20.299
655–S02	65	400	303	25	141.8	12.667	18.486
655–S03	65	400	303	25	141.9	12.800	19.391
655–S04	65	400	1000	25	92.7	–	–
655–S05	65	400	1000	25	104.8	–	–
655–S06	65	400	1000	25	115.0	–	–
656–S04	65	400	3017	25	60.0	–	–
656–S05	65	400	3017	25	69.3	–	–
656–S06	65	400	3017	25	62.4	–	–
656–S07	65	400	9980	25	49.4	13.616	16.580

Table B–1. (Contd.)

Specimen ID	Heat	Aging Temp. (°C)	Aging Time (h)	Test Temp. (°C)	Impact Energy (J/cm^2)	Yield Load (kN)	Max. Load (kN)
656–S08	65	400	9980	25	79.7	13.631	18.184
656–S09	65	400	9980	25	56.4	14.480	17.682
656–S10	65	400	30000	25	92.9	13.440	19.979
656–S11	65	400	30000	25	61.3	13.361	17.129
652–S16	65	450	10	25	227.0	12.889	20.271
652–S17	65	450	10	25	209.1	13.163	20.047
652–S18	65	450	10	25	185.6	12.997	19.968
653–S16	65	450	50	25	189.5	12.694	20.593
653–S17	65	450	50	25	124.9	12.674	19.368
653–S18	65	450	50	25	159.2	13.289	20.535
657–S01	65	450	100	25	130.2	–	–
657–S02	65	450	100	25	199.2	–	–
657–S03	65	450	100	25	149.3	–	–
657–S04	65	450	310	25	87.7	14.640	19.143
657–S05	65	450	310	25	69.6	14.625	17.771
657–S06	65	450	310	25	80.7	14.921	19.105
657–S07	65	450	1000	25	84.8	–	–
657–S08	65	450	1000	25	92.2	–	–
657–S09	65	450	1000	25	90.3	–	–
657–S10	65	450	2998	25	52.1	–	–
657–S11	65	450	2998	25	70.5	–	–
657–S12	65	450	2998	25	66.7	–	–
657–S13	65	450	9980	25	47.3	13.054	16.843
657–S14	65	450	9980	25	66.1	13.280	18.111
657–S15	65	450	9980	25	56.9	12.558	17.355
663–S15	66	–	–	–196	136.8	16.480	25.748
666–S15	66	–	–	–196	172.2	16.010	26.435
663–S13	66	–	–	25	168.0	10.640	16.774
663–S14	66	–	–	25	259.6	11.116	16.925
666–S13	66	–	–	25	202.3	9.716	15.014
666–S14	66	–	–	25	251.9	10.650	16.545
662–S01	66	290	3000	25	182.2	10.560	16.994
662–S02	66	290	3000	25	161.4	11.641	16.523
662–S03	66	290	3000	25	215.2	11.240	17.130
662–S04	66	290	9980	25	185.0	10.477	16.747
662–S05	66	290	9980	25	0.0	10.680	17.136
662–S06	66	290	9980	25	222.1	10.859	17.557
662–S07	66	290	30000	25	222.3	10.995	17.889
662–S08	66	290	30000	25	248.2	9.823	17.752
662–S09	66	290	30000	25	228.6	10.966	17.810
664–S10	66	320	3000	25	187.8	11.360	17.444
664–S11	66	320	3000	25	333.3	11.320	17.151
664–S12	66	320	3000	25	241.5	11.280	17.155
664–S13	66	320	9980	25	160.3	11.106	17.086
664–S14	66	320	9980	25	155.7	11.812	18.032
664–S15	66	320	9980	25	156.5	11.963	17.839
664–S16	66	320	30000	25	145.9	11.483	17.840
664–S17	66	320	30000	25	208.5	11.854	18.787
664–S18	66	320	30000	25	188.3	12.225	19.607
664–S01	66	350	355	25	178.4	11.571	17.405
664–S02	66	350	355	25	208.0	12.114	17.954
664–S03	66	350	355	25	220.6	11.470	17.933
664–S04	66	350	1000	25	171.2	11.693	18.601
664–S06	66	350	1000	25	161.5	11.885	17.766
665–S07	66	350	3000	25	183.7	–	–

Table B–1. (Contd.)

Specimen ID	Heat	Aging Temp. (°C)	Aging Time (h)	Test Temp. (°C)	Impact Energy (J/cm^2)	Yield Load (kN)	Max. Load (kN)
665–S09	66	350	3000	25	254.4	–	–
665–S13	66	350	30000	25	144.2	11.405	18.553
665–S14	66	350	30000	25	156.1	11.747	18.035
665–S15	66	350	30000	25	147.9	11.630	18.357
666–S16	66	400	30	25	245.8	11.341	18.349
666–S17	66	400	30	25	270.6	11.039	18.359
666–S18	66	400	30	25	241.5	11.146	18.251
666–S01	66	400	111	25	155.6	–	–
666–S02	66	400	111	25	151.1	–	–
666–S03	66	400	111	25	173.9	–	–
665–S01	66	400	303	25	161.3	11.920	17.574
665–S02	66	400	303	25	192.3	11.520	18.259
665–S03	66	400	303	25	208.1	11.520	18.361
665–S04	66	400	1000	25	143.2	11.977	17.418
665–S05	66	400	1000	25	174.4	10.717	17.365
665–S06	66	400	1000	25	122.7	12.830	18.554
666–C01	66	400	3017	–196	16.9	15.445	15.445
666–S04	66	400	3017	25	134.7	–	–
666–S05	66	400	3017	25	146.8	–	–
666–S06	66	400	3017	25	138.5	–	–
666–C04	66	400	9980	–196	16.2	16.208	16.208
666–S07	66	400	9980	25	96.0	12.019	18.057
666–S08	66	400	9980	25	111.2	11.720	18.477
666–S09	66	400	9980	25	112.2	12.572	17.979
666–S10	66	400	30000	25	135.5	11.556	18.934
666–S11	66	400	30000	25	129.8	11.312	18.300
662–S16	66	450	10	25	268.0	10.887	18.455
662–S17	66	450	10	25	231.9	11.249	18.611
662–S18	66	450	10	25	208.7	11.385	18.406
663–S16	66	450	50	25	175.4	11.083	18.074
663–S17	66	450	50	25	195.4	11.034	18.357
663–S18	66	450	50	25	172.7	11.415	17.937
667–S01	66	450	100	25	170.1	–	–
667–S02	66	450	100	25	207.4	–	–
667–S03	66	450	100	25	167.4	–	–
667–S04	66	450	310	25	119.8	12.249	18.127
667–S05	66	450	310	25	164.6	12.505	19.342
667–S06	66	450	310	25	157.8	12.846	19.376
667–C02	66	450	1000	25	101.5	13.123	17.264
667–C03	66	450	1000	25	90.1	13.163	16.805
667–S07	66	450	1000	25	120.2	–	–
667–S08	66	450	1000	25	123.8	–	–
667–S10	66	450	2998	25	97.7	–	–
667–S11	66	450	2998	25	92.5	–	–
667–S12	66	450	2998	25	124.8	–	–
667–C04	66	450	9980	–196	25.6	16.120	17.215
667–S13	66	450	9980	25	111.3	12.063	17.718
667–S14	66	450	9980	25	106.7	12.072	17.804
667–S15	66	450	9980	25	104.1	11.600	17.447

Table B–2. Charpy–Impact Test Results for the Commercial Heats of Cast Stainless Steel.

Specimen ID	Heat	Aging Temp. (°C)	Aging Time (h)	Test Temp. (°C)	Impact Energy (J/cm^2)	Yield Load (kN)	Max. Load (kN)
			CF–3 Grade				
I1V–006	I	–	–	–196	163.1	12.884	25.873
I1V–007	I	–	–	–196	152.5	12.696	25.239
I3V–008	I	–	–	–196	176.5	12.448	25.252
I1V–008	I	–	–	–120	203.0	11.760	22.271
I2V–005	I	–	–	–120	100.5	14.151	20.819
I2V–004	I	–	–	–50	177.7	12.942	21.081
I3C–005	I	–	–	–50	205.3	12.566	20.573
I3C–004	I	–	–	–20	225.0	13.260	19.793
I1V–004	I	–	–	25	189.4	8.930	15.295
I1V–005	I	–	–	25	194.9	9.201	15.365
I3C–003	I	–	–	25	143.5	11.309	16.961
I3V–001	I	–	–	25	179.2	9.331	14.877
I3V–002	I	–	–	25	191.4	9.280	15.481
I3V–006	I	–	–	75	172.5	9.932	14.710
I3V–005	I	–	–	125	177.7	9.128	13.086
I1V–009	I	–	–	200	175.4	7.983	11.746
I3V–003	I	–	–	290	144.2	7.969	11.195
I3V–004	I	–	–	290	137.1	6.532	10.114
I3C–019	I	290	9980	25	231.4	9.547	16.178
I3V–046	I	290	9980	25	177.9	10.838	16.486
I3V–047	I	290	9980	25	206.5	10.169	16.568
I3C–022	I	290	30000	25	301.4	9.686	17.098
I3V–049	I	290	30000	25	240.5	9.960	16.883
I3V–050	I	290	30000	25	195.5	10.116	15.565
IC3–006	I	320	3000	25	170.9	11.000	16.564
I3C–007	I	320	3000	25	211.1	10.995	16.553
I3V–030	I	320	3000	25	191.0	9.844	16.274
I3V–031	I	320	3000	25	188.3	9.902	17.074
I3C–008	I	320	9980	25	210.5	10.371	16.967
I3C–009	I	320	9980	25	241.5	10.359	16.607
I3V–033	I	320	9980	25	152.7	10.880	16.599
I3V–034	I	320	9980	25	188.1	10.459	16.559
I3V–036	I	320	9980	25	179.9	10.793	17.550
I1V–038	I	320	30000	–197	128.0	12.293	23.864
I1V–039	I	320	30000	–100	169.7	12.098	22.224
I1V–041	I	320	30000	–50	184.9	12.186	21.677
I1V–042	I	320	30000	–20	217.9	11.229	20.525
I1V–043	I	320	30000	0	195.9	10.858	18.260
I1V–047	I	320	30000	25	220.9	10.214	17.244
I2V–025	I	320	30000	25	222.7	10.018	17.420
I2V–026	I	320	30000	25	199.7	10.223	16.863
I1V–044	I	320	30000	75	227.4	9.306	15.379
I1V–045	I	320	30000	125	204.8	8.603	14.061
I1V–046	I	320	30000	290	194.1	6.503	11.366
I1V–025	I	350	3000	25	185.3	9.353	16.410
I3V–019	I	350	3000	25	220.2	9.432	16.720
I3V–020	I	350	3000	25	175.5	9.691	16.164
I1V–031	I	350	9980	–196	71.8	12.234	19.463
I1V–035	I	350	9980	–196	64.0	11.934	18.456
I1V–030	I	350	9980	–120	84.2	12.320	18.974
I1V–033	I	350	9980	–100	131.9	12.381	20.213
I3V–024	I	350	9980	–80	170.1	12.479	21.980
I1V–034	I	350	9980	–50	162.1	7.360	19.993
I1V–036	I	350	9980	–20	174.4	11.520	19.756

Table B–2. (Contd.).

Specimen ID	Heat	Aging Temp. (°C)	Aging Time (h)	Test Temp. (°C)	Impact Energy (J/cm^2)	Yield Load (kN)	Max. Load (kN)
I2V–021	I	350	9980	25	136.7	11.406	16.972
I2V–022	I	350	9980	25	158.8	11.566	17.374
I3V–022	I	350	9980	25	128.0	11.539	17.349
I1V–032	I	350	9980	75	175.5	8.960	15.506
I3V–023	I	350	9980	125	127.3	8.454	12.888
I1V–037	I	350	9980	290	130.1	7.003	11.241
I3V–025	I	350	30000	25	170.8	10.692	17.644
I3V–026	I	350	30000	25	177.1	10.428	17.791
I3V–027	I	350	30000	25	180.8	11.835	19.256
I1V–010	I	400	1000	25	138.9	9.630	15.552
I3V–010	I	400	1000	25	146.3	8.991	15.482
I3V–011	I	400	1000	25	147.8	9.949	16.161
I1V–012	I	400	9980	–196	54.3	12.193	19.335
I1V–013	I	400	9980	–196	43.1	12.004	16.180
I1V–015	I	400	9980	–120	92.3	12.401	20.037
I1V–017	I	400	9980	–120	103.8	12.240	19.992
I1V–019	I	400	9980	–80	157.7	12.215	22.624
I1V–023	I	400	9980	–50	108.1	11.952	19.510
I3V–014	I	400	9980	–50	84.3	12.919	17.124
I1V–022	I	400	9980	–20	111.3	12.626	19.459
I1V–014	I	400	9980	25	156.1	9.600	16.872
I1V–016	I	400	9980	25	159.0	10.000	17.434
I3V–013	I	400	9980	25	152.0	10.242	17.473
I1V–020	I	400	9980	75	147.1	9.840	16.145
I1V–021	I	400	9980	125	148.7	8.538	14.295
I1V–016	I	400	9980	290	122.3	6.377	11.762
I1V–018	I	400	9980	290	126.9	6.600	11.966
I3V–016	I	400	30000	25	122.9	10.931	16.114
I3V–017	I	400	30000	25	153.1	10.941	18.232
I2V–007	I	450	1000	25	122.8	10.813	15.389
I2V–008	I	450	1000	25	133.9	9.623	15.304
I2V–009	I	450	1000	25	149.1	9.463	16.474
I2V–010	I	450	2998	25	137.1	10.508	16.505
I2V–011	I	450	2998	25	131.2	10.049	16.272
I2V–012	I	450	2998	25	126.9	9.241	15.386
I2V–013	I	450	9980	25	140.7	10.720	17.706
I2V–014	I	450	9980	25	158.9	11.031	17.685
I2V–015	I	450	9980	25	160.0	10.640	18.110
P22–A04	P2	–	–	–196	174.8	12.560	25.260
P22–T02	P2	–	–	–196	208.6	12.761	26.220
P23–A07	P2	–	–	–196	195.1	11.840	24.495
P24–T01	P2	–	–	–196	187.3	12.400	24.711
P25–A01	P2	–	–	–196	181.0	12.729	25.333
P21–A04	P2	–	–	–120	419.2	12.800	23.634
P22–A05	P2	–	–	–50	395.7	13.203	21.031
P23–T05	P2	–	–	–50	429.2	12.558	21.329
P22–A06	P2	–	–	–20	495.7	11.200	19.458
P23–T07	P2	–	–	–20	493.8	10.960	19.102
P23–T08	P2	–	–	–20	533.8	11.200	19.719
P21–A01	P2	–	–	25	412.0	9.079	15.338
P21–T03	P2	–	–	25	342.6	10.016	15.475
P22–A03	P2	–	–	25	414.7	8.830	15.018
P22–T01	P2	–	–	25	346.1	9.404	15.110

Table B–2. (Contd.).

Specimen ID	Heat	Aging Temp. (°C)	Aging Time (h)	Test Temp. (°C)	Impact Energy (J/cm^2)	Yield Load (kN)	Max. Load (kN)
P23–A03	P2	–	–	25	341.3	9.795	15.559
P23–A05	P2	–	–	25	435.8	9.982	17.216
P23–T03	P2	–	–	25	407.9	9.070	15.287
P22–A07	P2	–	–	75	421.6	9.200	14.826
P23–T06	P2	–	–	75	184.4	10.740	15.431
P21–A03	P2	–	–	125	361.2	8.044	13.517
P22–T18	P2	–	–	125	353.2	7.901	13.015
P21–T04	P2	–	–	200	219.5	8.239	13.013
P25–A02	P2	–	–	200	334.1	6.801	12.340
P21–A05	P2	–	–	290	311.5	6.235	11.507
P23–A06	P2	–	–	290	299.3	5.920	11.115
P24–T02	P2	–	–	290	290.8	5.725	10.900
P21–A25	P2	290	3000	25	438.6	10.120	16.687
P21–A26	P2	290	3000	25	466.0	10.005	16.633
P21–A28	P2	290	9980	25	462.5	9.360	16.544
P21–A29	P2	290	9980	25	454.0	9.200	16.774
P21–T15	P2	290	9980	25	464.2	8.743	16.769
P22–A16	P2	320	3000	25	432.5	9.717	16.339
P22–A17	P2	320	3000	25	428.8	8.827	16.849
P22–A18	P2	320	3000	25	446.0	7.319	16.543
P21–A08	P2	320	9980	25	372.2	10.253	17.126
P21–A09	P2	320	9980	25	466.4	9.600	17.060
P21–T09	P2	320	9980	25	452.3	9.760	16.556
P22–A19	P2	320	9980	25	473.7	8.687	17.590
P21–A11	P2	320	30000	–197	69.2	12.430	16.512
P21–A13	P2	320	30000	–120	130.6	13.475	22.439
P22–A22	P2	320	30000	–80	174.7	12.176	21.931
P22–A23	P2	320	30000	–50	148.5	12.196	18.640
P22–A24	P2	320	30000	–20	266.2	11.532	19.812
P22–A25	P2	320	30000	0	292.8	11.132	18.972
P21–T12	P2	320	30000	25	369.8	9.901	16.980
P22–A21	P2	320	30000	25	491.3	10.009	17.771
P22–A27	P2	320	30000	25	374.6	9.862	17.010
P22–A28	P2	320	30000	25	493.9	9.813	17.186
P22–A26	P2	320	30000	75	458.1	9.413	15.897
P21–T11	P2	320	30000	125	412.1	8.192	14.549
P21–A12	P2	320	30000	290	351.3	6.562	12.479
P25–T11	P2	320	30000	290	339.7	6.679	11.932
P21–T05	P2	350	3000	25	389.0	9.367	16.364
P21–T06	P2	350	3000	25	349.8	9.955	16.122
P23–A11	P2	350	3000	25	199.1	9.800	16.008
P23–A12	P2	350	3000	25	430.8	10.000	16.702
P23–A13	P2	350	3000	25	433.2	9.680	16.627
P24–A14	P2	350	3000	290	347.4	7.200	12.845
P24–A15	P2	350	3000	290	347.5	7.897	13.035
P23–A21	P2	350	9980	–196	86.5	13.840	23.508
P24–A17	P2	350	9980	–196	79.1	12.044	20.211
P23–A20	P2	350	9980	–120	113.0	13.040	21.001
P23–A24	P2	350	9980	–50	131.5	10.699	18.934
P24–A24	P2	350	9980	–50	197.3	11.680	20.509
P24–A18	P2	350	9980	–20	283.5	11.855	19.835
P22–T07	P2	350	9980	25	441.6	11.200	17.368

Table B–2. (Contd.).

Specimen ID	Heat	Aging Temp. (°C)	Aging Time (h)	Test Temp. (°C)	Impact Energy (J/cm^2)	Yield Load (kN)	Max. Load (kN)
P22–T09	P2	350	9980	25	318.2	9.800	17.525
P23–A16	P2	350	9980	25	275.1	11.480	17.083
P23–A17	P2	350	9980	25	181.2	11.920	17.676
P23–A18	P2	350	9980	25	171.0	11.680	17.270
P23–A19	P2	350	9980	25	419.0	9.753	16.428
P24–A22	P2	350	9980	25	200.9	11.181	16.853
P24–A16	P2	350	9980	75	405.8	8.641	16.118
P23–A23	P2	350	9980	125	383.8	7.640	13.751
P23–A25	P2	350	9980	200	320.5	6.456	11.915
P23–A22	P2	350	9980	290	322.3	5.957	11.883
P24–A19	P2	350	9980	290	320.8	5.698	11.857
P23–A28	P2	350	30000	−196	58.4	12.997	18.318
P23–A29	P2	350	30000	−196	55.7	12.674	16.609
P23–T11	P2	350	30000	−196	61.5	12.333	17.732
P23–A30	P2	350	30000	−120	104.6	11.385	20.505
P23–T12	P2	350	30000	−120	112.6	11.415	21.121
P23–A31	P2	350	30000	−100	115.9	12.538	20.847
P23–T13	P2	350	30000	−100	101.5	12.342	19.480
P23–A32	P2	350	30000	−78	89.4	12.479	19.207
P23–T14	P2	350	30000	−78	115.3	12.313	19.871
P23–A33	P2	350	30000	−50	91.8	11.669	17.186
P23–T15	P2	350	30000	−50	182.3	11.561	20.847
P23–A34	P2	350	30000	−20	159.6	11.200	19.275
P23–T16	P2	350	30000	−20	234.2	10.868	20.183
P23–A34	P2	350	30000	0	204.4	10.878	18.406
P23–T17	P2	350	30000	0	198.7	10.809	18.250
P23–T22	P2	350	30000	25	233.2	10.165	17.186
P24–A27	P2	350	30000	25	227.1	10.126	17.283
P25–A21	P2	350	30000	25	212.6	10.155	16.531
P23–T23	P2	350	30000	50	307.2	9.706	16.736
P25–A22	P2	350	30000	50	215.7	9.491	16.043
P23–A36	P2	350	30000	75	349.1	9.286	15.281
P23–T18	P2	350	30000	75	434.5	8.700	15.174
P23–A37	P2	350	30000	125	387.5	7.880	13.621
P23–T19	P2	350	30000	125	391.0	7.343	13.729
P23–A20	P2	350	30000	200	301.4	6.962	13.280
P23–A38	P2	350	30000	290	342.6	6.034	11.776
P23–A39	P2	350	30000	290	340.8	6.279	11.825
P23–T21	P2	350	30000	290	350.1	6.269	12.010
P24–T03	P2	400	1000	25	204.8	9.511	15.876
P24–T04	P2	400	1000	25	232.6	10.297	16.436
P25–A15	P2	400	1000	25	243.9	–	–
P25–A16	P2	400	1000	25	224.7	9.814	15.991
P25–A17	P2	400	1000	25	210.6	10.016	16.161
P24–A15	P2	400	3017	25	219.9	9.668	16.299
P24–A16	P2	400	3017	25	263.2	8.926	16.412
P24–A17	P2	400	3017	25	313.8	9.453	16.766
P24–A06	P2	400	9980	−196	42.9	13.075	16.688
P24–A07	P2	400	9980	25	135.6	10.360	16.883
P24–A08	P2	400	9980	25	166.0	10.280	17.191
P24–A09	P2	400	9980	25	174.0	10.740	17.570
P24–T07	P2	400	9980	25	128.7	10.680	16.280
P24–T08	P2	400	9980	25	193.2	10.985	17.682
P24–T09	P2	400	30000	25	209.1	10.043	17.265

Table B–2. (Contd.).

Specimen ID	Heat	Aging Temp. (°C)	Aging Time (h)	Test Temp. (°C)	Impact Energy (J/cm^2)	Yield Load (kN)	Max. Load (kN)
P25–A18	P2	400	30000	25	175.9	10.277	16.856
P25–A19	P2	400	30000	25	139.5	9.994	16.192
P25–A03	P2	450	1000	25	253.2	9.812	16.445
P25–A04	P2	450	1000	25	229.8	10.293	16.772
P25–A05	P2	450	1000	25	279.0	9.532	16.998
P25–T02	P2	450	1000	25	155.0	9.822	16.276
P25–T03	P2	450	1000	25	190.9	9.383	15.718
P25–A06	P2	450	2998	25	200.6	10.063	16.736
P25–A07	P2	450	2998	25	182.0	10.108	16.125
P25–A08	P2	450	2998	25	208.6	9.610	16.639
P25–T04	P2	450	2998	25	137.8	9.501	15.448
P25–T05	P2	450	2998	25	127.3	9.912	15.096
P25–A06	P2	450	9980	25	162.8	10.231	16.931
P25–A07	P2	450	9980	25	188.6	10.792	17.735
P25–A08	P2	450	9980	25	193.8	10.480	17.712
P25–T06	P2	450	9980	25	132.3	10.995	16.880
P25–T07	P2	450	9980	25	121.8	10.610	16.408
P32–A02	P3	–	–	–196	87.4	17.280	21.306
P32–A03	P3	–	–	–196	113.5	17.280	22.628
P33–A02	P3	–	–	–196	119.4	17.600	23.509
P33–A06	P3	–	–	–196	114.7	18.320	23.220
P32–A04	P3	–	–	–120	199.3	17.680	22.818
P33–A52	P3	–	–	–50	256.5	12.938	20.216
P33–A05	P3	–	–	–20	255.5	14.536	18.603
P31–A01	P3	–	–	25	269.0	10.556	15.458
P32–A01	P3	–	–	25	329.0	9.962	15.316
P33–A01	P3	–	–	25	301.3	9.014	14.799
P31–A02	P3	–	–	75	327.4	9.976	13.966
P31–A05	P3	–	–	125	320.4	8.520	13.738
P33–A03	P3	–	–	290	272.2	5.745	10.789
P33–A04	P3	–	–	290	220.7	5.920	10.140
P31–A11	P3	320	3000	25	325.1	11.473	16.178
P31–A12	P3	320	3000	25	359.4	10.129	15.773
P31–A13	P3	320	3000	25	302.7	10.781	16.936
P32–A08	P3	350	3000	25	293.9	10.348	15.360
P33–A43	P3	350	3000	25	265.9	10.780	16.006
P32–A23	P3	350	9980	–196	87.0	16.640	21.256
P32–A24	P3	350	9980	–196	64.6	18.422	22.136
P33–A47	P3	350	9980	–120	110.9	15.421	19.009
P32–A11	P3	350	9980	–50	192.0	13.600	18.908
P32–A12	P3	350	9980	–20	293.8	13.762	17.891
P32–A20	P3	350	9980	25	361.7	10.443	16.776
P32–A21	P3	350	9980	25	384.2	9.938	15.532
P32–A22	P3	350	9980	25	345.9	10.571	15.438
P32–A13	P3	350	9980	75	372.5	9.360	14.633
P32–A18	P3	350	9980	125	314.2	7.520	12.740
P32–A17	P3	350	9980	200	307.3	6.446	12.028
P32–A16	P3	350	9980	290	230.6	4.938	8.824
P33–A48	P3	350	9980	290	268.4	4.663	10.178
P33–A32	P3	400	1000	25	341.3	10.466	15.374
P33–A33	P3	400	1000	25	282.9	10.452	15.448
P33–A34	P3	400	1000	25	369.6	9.926	15.018
P33–A29	P3	400	3017	25	341.2	–	–

Table B–2. (Contd.).

Specimen ID	Heat	Aging Temp. (°C)	Aging Time (h)	Test Temp. (°C)	Impact Energy (J/cm²)	Yield Load (kN)	Max. Load (kN)
P33–A31	P3	400	3017	25	389.2	10.679	15.520
P33–A08	P3	450	100	25	345.0	–	–
P33–A09	P3	450	100	25	366.3	–	–
P33–A10	P3	450	100	25	401.1	–	–
P33–A14	P3	450	1000	25	461.3	11.610	17.068
P33–A16	P3	450	1000	25	462.1	11.288	17.449
P33–A17	P3	450	2998	25	374.9	10.290	15.648
P33–A18	P3	450	2998	25	400.2	10.291	15.957
P33–A19	P3	450	2998	25	384.5	10.671	16.111
			CF–8 Grade				
C1–A10	C1	–	–	–196	24.0	12.320	13.921
C1–A11	C1	–	–	–196	17.0	12.940	13.060
C1–A07	C1	–	–	25	61.8	8.617	11.780
C1–A08	C1	–	–	25	55.8	–	–
C1–A09	C1	–	–	25	61.2	8.162	11.143
C1–A49	C1	350	3000	25	47.1	–	–
C1–A50	C1	350	3000	25	52.6	–	–
C1–A51	C1	350	3000	25	54.6	–	–
C1–A31	C1	400	1000	25	46.2	–	–
C1–A32	C1	400	1000	25	34.7	–	–
C1–A33	C1	400	1000	25	49.0	–	–
C1–A28	C1	400	3017	25	44.1	–	–
C1–A29	C1	400	3017	25	70.1	–	–
C1–A30	C1	400	3017	25	59.7	–	–
C1–A16	C1	450	1000	25	63.1	–	–
C1–A17	C1	450	1000	25	51.5	–	–
C1–A18	C1	450	1000	25	45.0	–	–
C1–A19	C1	450	2998	25	56.6	–	–
C1–A20	C1	450	2998	25	60.5	–	–
C1–A21	C1	450	2998	25	60.8	–	–
P12–A03	P1	–	–	–196	26.9	14.583	15.087
P12–T02	P1	–	–	–196	26.1	16.483	17.070
P14–A02	P1	–	–	–196	61.7	15.550	19.841
P11–A03	P1	–	–	25	199.3	10.313	15.929
P12–A01	P1	–	–	25	241.0	9.809	16.503
P12–A02	P1	–	–	25	236.6	10.601	15.260
P12–A05	P1	–	–	25	198.1	10.639	17.066
P12–T01	P1	–	–	25	209.0	10.779	16.058
P13–T04	P1	–	–	25	169.8	9.220	14.735
P13–T05	P1	–	–	25	338.3	11.261	16.123
P14–A01	P1	–	–	25	234.1	10.492	16.380
P12–A04	P1	–	–	290	171.4	8.732	12.418
P13–T06	P1	–	–	290	340.2	7.965	12.694
P11–A14	P1	290	3000	25	260.8	11.440	16.916
P11–A15	P1	290	3000	25	261.0	11.676	16.455
P11–A16	P1	290	3000	25	258.5	11.263	16.882
P11–A17	P1	290	9980	25	301.9	10.480	16.325
P11–A18	P1	290	9980	25	182.3	10.867	16.108
P11–T07	P1	290	9980	25	245.7	10.851	16.216
P11–A20	P1	290	30000	25	183.6	10.448	16.443
P11–A21	P1	290	30000	25	200.2	11.327	16.121
P11–T09	P1	290	30000	25	232.8	11.532	16.395

Table B–2. (Contd.).

Specimen ID	Heat	Aging Temp. (°C)	Aging Time (h)	Test Temp. (°C)	Impact Energy (J/cm^2)	Yield Load (kN)	Max. Load (kN)
P11–A04	P1	320	3000	25	231.0	10.820	16.347
P11–A05	P1	320	3000	25	182.0	10.829	16.258
P12–A18	P1	320	3000	25	225.0	11.113	17.519
P11–A06	P1	320	9980	25	176.8	10.800	16.198
P11–A07	P1	320	9980	25	183.2	10.964	16.750
P11–T01	P1	320	9980	25	228.8	11.781	17.343
P11–T03	P1	320	30000	25	168.4	11.376	17.254
P12–A20	P1	320	30000	25	225.5	11.835	18.640
P12–A21	P1	320	30000	25	228.1	11.620	18.943
P12–T03	P1	350	3000	25	157.6	10.947	16.908
P12–T04	P1	350	3000	25	200.9	11.219	17.419
P13–A13	P1	350	3000	25	168.8	11.490	17.490
P13–A14	P1	350	3000	25	237.5	10.988	16.846
P13–A15	P1	350	3000	25	185.3	10.464	16.808
P13–A16	P1	350	9980	25	96.0	12.240	17.175
P13–A17	P1	350	9980	25	145.6	12.480	18.734
P13–A18	P1	350	9980	25	227.5	11.800	18.094
P13–A19	P1	350	9980	290	288.2	8.088	12.937
P13–A20	P1	350	9980	290	201.2	8.782	13.348
P12–T09	P1	350	30000	25	73.4	11.835	15.272
P13–A23	P1	350	30000	25	103.4	11.844	16.795
P13–A24	P1	350	30000	25	86.2	11.962	15.565
P13–A03	P1	400	1000	25	67.7	10.802	14.296
P13–A04	P1	400	1000	25	82.3	10.782	15.197
P14–A16	P1	400	1000	25	80.4	11.412	15.779
P13–A03	P1	400	3017	25	60.7	–	–
P13–A04	P1	400	3017	25	50.2	11.384	13.804
P14–A15	P1	400	3017	25	57.4	11.500	14.249
P13–A09	P1	400	9980	–196	8.9	12.538	12.546
P14–A17	P1	400	9980	25	53.8	12.720	15.838
P14–A18	P1	400	9980	25	47.6	12.080	15.892
P14–A19	P1	400	9980	25	53.8	12.421	16.335
P14–A09	P1	400	9980	290	133.5	9.200	14.830
P13–A11	P1	400	30000	25	57.9	12.063	15.284
P13–T10	P1	400	30000	25	69.7	11.939	18.293
P14–A20	P1	400	30000	25	91.1	16.765	20.267
P14–A03	P1	450	1000	25	61.8	11.980	14.059
P14–A04	P1	450	1000	25	68.7	12.292	14.196
P14–A05	P1	450	1000	25	109.4	11.528	16.463
P14–A06	P1	450	2998	25	75.9	12.144	16.237
P14–A07	P1	450	2998	25	64.0	11.176	16.187
P14–A08	P1	450	2998	25	61.3	11.694	14.765
P14–T02	P1	450	2998	25	62.3	10.941	14.292
P14–T03	P1	450	2998	25	60.5	11.454	15.167
P14–A10	P1	450	9980	25	63.4	12.323	16.387
P14–A11	P1	450	9980	25	47.6	13.459	15.395
P14–T04	P1	450	9980	25	87.1	12.807	17.906
P14–T05	P1	450	9980	25	65.0	12.730	15.389
			CF–8M Grade				
P42–A04	P4	–	–	–196	37.5	17.800	19.703
P42–A05	P4	–	–	–196	31.0	19.472	19.472
P41–A01	P4	–	–	25	228.2	11.933	16.448
P42–A01	P4	–	–	25	226.4	11.335	15.724

Table B–2. (Contd.).

Specimen ID	Heat	Aging Temp. (°C)	Aging Time (h)	Test Temp. (°C)	Impact Energy (J/cm^2)	Yield Load (kN)	Max. Load (kN)
P42–A02	P4	–	–	25	190.3	11.792	15.631
P42–A03	P4	–	–	25	265.8	12.360	18.380
P41–A32	P4	290	3000	25	173.3	13.160	17.723
P41–A33	P4	290	3000	25	270.6	12.218	17.457
P41–A34	P4	290	3000	25	212.2	12.564	16.915
P41–A35	P4	290	9980	25	248.3	11.781	16.599
P41–A36	P4	290	9980	25	–	12.200	16.400
P41–A41	P4	290	30000	25	288.4	11.971	17.986
P41–A42	P4	290	30000	25	280.7	12.098	17.283
P41–A20	P4	320	3000	25	269.8	11.960	17.777
P41–A21	P4	320	3000	25	222.7	12.520	17.834
P41–A22	P4	320	3000	25	222.8	12.669	17.834
P41–A23	P4	320	9980	25	148.2	12.129	16.161
P41–A24	P4	320	9980	25	178.9	12.720	17.322
P41–A26	P4	320	30000	25	86.7	12.567	15.643
P41–A27	P4	320	30000	25	88.1	12.528	15.106
P41–A04	P4	350	355	25	171.0	12.911	17.118
P41–A05	P4	350	355	25	268.9	12.000	17.148
P41–A06	P4	350	1000	25	251.5	11.960	18.278
P41–A07	P4	350	1000	25	189.4	12.306	17.112
P42–A47	P4	350	1000	25	154.1	13.160	17.085
P41–A08	P4	350	3000	25	124.1	11.491	15.525
P41–A09	P4	350	3000	25	146.2	12.118	16.491
P42–A48	P4	350	3000	25	135.0	11.616	16.379
P41–A10	P4	350	9980	25	83.4	11.880	14.943
P41–A11	P4	350	9980	25	77.3	12.484	14.974
P41–A12	P4	350	9980	25	100.9	11.930	15.877
P42–A49	P4	350	30000	25	57.7	12.459	14.803
P42–A50	P4	350	30000	25	68.5	9.130	18.297
P42–A25	P4	400	100	25	221.2	11.460	16.780
P42–A26	P4	400	100	25	210.7	12.268	16.907
P42–A27	P4	400	100	25	165.0	11.918	16.368
P42–A28	P4	400	303	25	153.3	12.400	17.112
P42–A29	P4	400	303	25	150.7	11.920	17.011
P42–A30	P4	400	303	25	120.6	12.320	16.663
P42–A34	P4	400	1000	25	129.3	11.478	16.325
P42–A35	P4	400	1000	25	121.4	11.812	15.738
P42–A36	P4	400	1000	25	129.2	11.596	16.507
P42–A31	P4	400	3017	25	78.1	11.825	13.922
P42–A32	P4	400	3017	25	78.5	11.221	15.167
P42–A33	P4	400	3017	25	143.0	11.917	16.415
P42–A37	P4	400	9980	25	72.6	13.283	15.854
P42–A38	P4	400	9980	25	64.7	12.920	14.802
P42–A39	P4	400	9980	25	56.8	12.520	14.771
P42–A40	P4	400	30000	25	57.3	12.424	13.303
P42–A41	P4	400	30000	25	68.4	15.021	–
P42–A07	P4	450	100	25	191.6	11.278	17.468
P42–A08	P4	450	100	25	194.8	11.553	17.317
P42–A09	P4	450	100	25	208.2	12.177	17.852
P42–A10	P4	450	310	25	–	14.962	18.020
P42–A11	P4	450	310	25	159.8	12.658	18.790
P42–A12	P4	450	310	25	119.1	12.600	15.960

Table B–2. (Contd.).

Specimen ID	Heat	Aging Temp. (^{o}C)	Aging Time (h)	Test Temp. (^{o}C)	Impact Energy (J/cm^{2})	Yield Load (kN)	Max. Load (kN)
P42–A13	P4	450	1000	25	78.7	11.330	14.181
P42–A14	P4	450	1000	25	74.1	11.826	15.276
P42–A15	P4	450	1000	25	123.7	12.119	16.989
P42–A16	P4	450	2998	25	50.2	11.404	12.031
P42–A17	P4	450	2998	25	39.5	10.890	10.890
P42–A20	P4	450	9980	25	73.2	12.000	16.281
P42–A21	P4	450	9980	25	40.0	12.443	13.382

Table B–3. Charpy–Impact Test Results for the Large Experimental Heats of Cast Stainless STeel.

Specimen Id.	Heat	Aging Temp. (°C)	Aging Time (h)	Test Temp. (°C)	Impact Energy (J/cm^2)	Yield Load (kN)	Max. Load (kN)
			CF–3 Grade				
69.3–45	69	–	–	–196	145.5	11.520	24.120
69.4–45	69	–	–	–196	170.2	11.763	24.709
69–248	69	–	–	–196	172.6	11.840	25.116
69.3–44	69	–	–	–120	232.3	13.280	26.389
69.4–43	69	–	–	–120	213.8	10.720	22.550
69–266	69	–	–	–120	231.1	13.600	26.462
69.1–42	69	–	–	–50	253.5	11.411	21.416
69–265	69	–	–	–50	186.1	12.800	20.921
69.1–43	69	–	–	–20	292.6	10.880	19.537
69.1–45	69	–	–	25	159.0	10.678	16.009
69.2–45	69	–	–	25	187.1	11.124	16.746
69.3–43	69	–	–	25	264.9	9.770	16.446
69–264	69	–	–	25	217.2	10.776	16.836
69.2–44	69	–	–	75	402.3	8.320	14.882
69–249	69	–	–	75	303.7	7.680	14.143
69.1–41	69	–	–	125	360.6	7.437	13.490
69–121	69	–	–	125	340.7	7.392	13.674
69.1–44	69	–	–	200	330.1	5.920	11.729
69.1–40	69	–	–	290	293.0	5.600	10.507
69.4–44	69	–	–	290	199.2	7.155	11.103
69–267	69	–	–	290	280.9	6.682	10.967
69.3–28	69	290	30000	–196	71.0	11.454	17.869
69.4–28	69	290	30000	–196	81.3	11.268	19.656
69–131	69	290	30000	–120	226.2	11.991	23.357
69.3–29	69	290	30000	–120	213.4	10.731	24.372
69.4–29	69	290	30000	–100	202.4	11.034	21.912
69.3–30	69	290	30000	–80	240.7	11.922	22.273
69.4–34	69	290	30000	–50	248.1	10.243	20.310
69–132	69	290	30000	–20	295.9	11.483	20.027
69.3–31	69	290	30000	10	205.0	11.313	18.375
69–133	69	290	30000	25	246.9	10.594	17.810
69.3–32	69	290	30000	25	205.4	10.292	17.791
69.4–35	69	290	30000	75	192.6	8.769	14.940
69.3–33	69	290	30000	175	168.1	7.314	12.733
69–134	69	290	30000	290	196.2	5.263	10.653
69.3–34	69	290	30000	290	200.4	5.478	10.936
69–442	69	320	300	25	290.2	10.487	17.615
69–443	69	320	300	25	320.9	10.165	17.635
69–445	69	320	1000	25	260.5	9.979	16.756
69–446	69	320	1000	25	292.3	10.077	17.430
69–448	69	320	3000	25	314.5	10.341	17.625
69–449	69	320	3000	25	298.9	9.989	17.410
69.4–19	69	320	10000	–196	62.4	12.986	19.590
69.3–20	69	320	10000	–78	237.5	13.798	25.229
69.3–27	69	320	10000	–50	216.5	13.978	24.156
69.4–20	69	320	10000	–20	218.1	13.496	21.726
69.3–24	69	320	10000	25	186.7	12.398	19.913
69.3–25	69	320	10000	25	201.7	11.410	17.990
69.3–21	69	320	10000	75	163.3	11.326	17.004
69.3–19	69	320	10000	175	193.1	9.186	13.939
69.3–22	69	320	10000	290	160.0	7.911	12.756
69.1–37	69	320	30000	–197	50.1	12.420	18.221
69.1–38	69	320	30000	–96	113.2	12.811	20.710
69.1–39	69	320	30000	–50	135.9	12.098	20.310

Table B–3. (Contd.)

Specimen Id.	Heat	Aging Temp. (°C)	Aging Time (h)	Test Temp. (°C)	Impact Energy (J/cm^2)	Yield Load (kN)	Max. Load (kN)
69–237	69	320	30000	–20	220.5	11.971	20.720
69.2–27	69	320	30000	0	175.5	11.210	18.748
69.2–38	69	320	30000	25	194.1	10.897	17.449
69–238	69	320	30000	25	179.8	10.204	17.332
69.2–39	69	320	30000	75	248.9	9.296	15.877
69–239	69	320	30000	100	222.6	8.241	14.705
69.3–37	69	320	30000	290	223.8	7.128	12.391
69–240	69	320	30000	290	202.2	6.982	12.254
69–333	69	350	100	25	295.3	10.126	17.312
69–334	69	350	100	25	257.3	9.989	17.078
69–336	69	350	300	25	292.9	10.311	17.449
69–337	69	350	300	25	272.7	10.272	17.205
69–339	69	350	1000	25	246.8	10.448	17.742
69–340	69	350	1000	25	224.8	10.380	17.449
69.1–20	69	350	2570	–196	49.0	13.912	18.014
69.2–20	69	350	2570	–120	102.7	14.852	23.055
69.2–21	69	350	2570	–120	78.8	14.120	18.616
69.1–27	69	350	2570	–50	194.2	12.000	21.708
69.1–25	69	350	2570	25	156.9	11.863	17.590
69.2–19	69	350	2570	25	151.3	10.560	17.908
69.1–19	69	350	2570	75	195.8	9.520	15.763
69.1–26	69	350	2570	125	186.7	9.534	14.336
69.1–21	69	350	2570	290	261.2	6.240	11.886
69.4–04	69	350	10000	–196	32.5	14.626	14.822
69–113	69	350	10000	–120	78.8	13.480	20.106
69.3–06	69	350	10000	–100	48.8	14.646	16.987
69.3–04	69	350	10000	–70	40.9	14.364	15.937
69.4–05	69	350	10000	–50	94.7	13.920	20.522
69–115	69	350	10000	–50	87.6	13.262	19.260
69.3–01	69	350	10000	–40	144.6	12.323	20.974
69.3–05	69	350	10000	–20	61.5	13.554	17.207
69.3–03	69	350	10000	–10	187.3	12.186	20.564
69.3–07	69	350	10000	0	161.3	12.176	19.363
69.3–08	69	350	10000	25	175.3	12.233	19.496
69.3–09	69	350	10000	25	194.6	11.840	19.886
69–116	69	350	10000	25	196.0	11.480	19.567
69.4–01	69	350	10000	75	158.3	10.758	16.763
69–111	69	350	10000	75	213.6	10.743	16.141
69–114	69	350	10000	175	199.6	9.129	14.962
69.3–02	69	350	10000	290	191.3	8.918	13.839
69–112	69	350	10000	290	147.2	9.680	13.690
69.3–10	69	350	30000	–196	39.3	12.762	16.570
69.3–11	69	350	30000	–97	56.6	12.987	18.172
69.3–16	69	350	30000	–50	87.6	12.567	19.841
69.3–17	69	350	30000	–20	106.5	12.001	18.845
69.4–10	69	350	30000	0	98.8	10.604	17.010
69–125	69	350	30000	25	108.7	10.194	16.316
69.3–18	69	350	30000	25	131.4	10.214	17.137
69.4–11	69	350	30000	75	135.7	9.628	15.428
69.4–12	69	350	30000	100	157.5	9.335	15.106
69.4–13	69	350	30000	175	147.7	8.700	14.315
69–126	69	350	30000	290	178.6	7.372	12.870
69.4–14	69	350	30000	290	141.0	7.724	12.948
69–321	69	400	50	25	231.3	10.546	17.586
69–322	69	400	50	25	221.6	10.741	17.928
69–324	69	400	100	25	236.2	10.800	17.849
69–325	69	400	100	25	272.2	10.712	18.260

Table B–3. (Contd.)

Specimen Id.	Heat	Aging Temp. (°C)	Aging Time (h)	Test Temp. (°C)	Impact Energy (J/cm²)	Yield Load (kN)	Max. Load (kN)
69.327	69	400	300	25	197.2	10.770	18.435
69–328	69	400	300	25	164.1	10.907	18.670
69–330	69	400	1000	25	163.3	11.258	18.816
69–331	69	400	1000	25	159.0	10.692	17.273
69.1–11	69	400	2570	–196	34.0	12.851	16.175
69–253	69	400	2570	–196	36.8	12.794	17.989
69.1–18	69	400	2570	–100	97.5	13.827	20.213
69.2–12	69	400	2570	–50	90.1	13.076	18.979
69–252	69	400	2570	–50	90.0	12.371	19.426
69.1–16	69	400	2570	25	143.4	10.479	17.075
69.2–11	69	400	2570	25	134.0	11.297	18.497
69–251	69	400	2570	25	147.4	11.368	19.150
69.1–12	69	400	2570	75	142.2	9.280	16.417
69–250	69	400	2570	75	151.9	9.600	16.559
69.2–10	69	400	2570	125	133.7	7.800	15.114
69–254	69	400	2570	125	181.8	9.084	16.040
69.1–10	69	400	2570	290	139.8	7.605	13.195
69–255	69	400	2570	290	141.3	7.412	12.800
69.1–15	69	400	10000	–196	35.2	14.638	16.449
69.2–14	69	400	10000	–196	28.2	14.800	17.025
69–103	69	400	10000	–196	32.0	14.597	16.271
69.1–22	69	400	10000	–100	65.6	14.061	19.002
69.2–04	69	400	10000	–50	71.9	14.772	19.261
69–102	69	400	10000	–50	91.3	14.991	22.928
69.1–24	69	400	10000	–10	120.3	13.045	18.943
69.1–13	69	400	10000	25	94.1	12.874	17.927
69.2–06	69	400	10000	25	88.4	12.440	17.800
69.3–56	69	400	10000	25	115.3	11.258	17.644
69–105	69	400	10000	25	108.2	12.963	19.876
69.1–14	69	400	10000	75	162.4	11.551	17.926
69.2–05	69	400	10000	75	130.3	11.347	17.769
69–101	69	400	10000	75	138.8	11.280	17.709
69.1–23	69	400	10000	125	161.0	10.960	17.214
69–104	69	400	10000	125	160.6	10.851	16.941
69.2–13	69	400	10000	290	127.6	8.502	13.801
69–106	69	400	10000	290	142.3	8.640	14.720
69.1–07	69	450	2570	–196	50.8	13.023	17.438
69.2–08	69	450	2570	–196	57.4	13.757	20.200
69.1–02	69	450	2570	–120	95.5	15.307	23.776
69.1–03	69	450	2570	–120	68.1	14.963	21.024
69.2–03	69	450	2570	–80	71.1	13.397	20.691
69.1–09	69	450	2570	–50	123.9	13.209	20.982
69.1–01	69	450	2570	25	124.7	11.240	18.067
69.2–02	69	450	2570	25	117.5	11.341	17.418
69.2–07	69	450	2570	75	116.0	8.960	15.110
69.1–08	69	450	2570	125	176.5	8.800	15.422
69.2–01	69	450	2570	290	123.8	7.280	12.468
			CF–8 Grade				
68.3–45	68	–	–	–196	48.4	16.121	18.867
68.4–45	68	–	–	–196	24.2	14.361	15.145
68–134	68	–	–	–196	29.4	13.800	13.800
68.4–44	68	–	–	–120	139.8	13.200	22.685
68.2–43	68	–	–	–50	125.4	13.040	20.251
68–131	68	–	–	–50	145.9	12.080	20.385
68.1–41	68	–	–	–20	161.4	12.135	19.613
68.1–40	68	–	–	25	317.4	14.054	21.906
68.1–45	68	–	–	25	221.9	10.754	15.610

Table B–3. (Contd.)

Specimen Id.	Heat	Aging Temp. (°C)	Aging Time (h)	Test Temp. (°C)	Impact Energy (J/cm^2)	Yield Load (kN)	Max. Load (kN)
68.2–45	68	–	–	25	365.0	9.600	16.699
68–265	68	–	–	25	197.0	11.680	17.162
68.3–43	68	–	–	75	195.7	10.137	15.666
68–266	68	–	–	75	304.0	9.460	15.024
68.2–44	68	–	–	125	371.5	8.000	13.939
68–267	68	–	–	125	336.6	8.600	13.645
68.1–42	68	–	–	200	172.8	7.200	11.731
68.3–44	68	–	–	290	282.8	6.763	11.168
68.4–43	68	–	–	290	308.7	6.400	11.535
68–274	68	–	–	290	269.7	6.951	11.436
68.3–28	68	290	30000	–196	44.5	16.473	18.084
68.3–29	68	290	30000	–120	39.7	14.901	16.395
68.4–28	68	290	30000	–100	109.9	14.100	19.461
68.3–30	68	290	30000	–80	62.4	13.934	17.234
68.4–29	68	290	30000	–50	91.5	12.704	19.246
68–141	68	290	30000	–20	192.6	12.254	19.041
68.3–31	68	290	30000	0	222.5	11.776	18.640
68.4–30	68	290	30000	10	209.2	11.913	18.113
68–142	68	290	30000	25	281.6	11.317	17.557
68.3–32	68	290	30000	25	171.8	11.005	16.199
68.3–34	68	290	30000	50	309.1	10.760	17.137
68–143	68	290	30000	75	299.7	9.921	16.072
68.4–34	68	290	30000	125	411.9	8.388	14.217
68.3–36	68	290	30000	175	373.5	7.362	13.211
68.4–35	68	290	30000	200	346.9	7.636	12.782
68–144	68	290	30000	290	335.9	6.591	11.874
68.3–35	68	290	30000	290	341.4	6.601	11.864
68–352	68	320	300	25	217.3	10.946	16.902
68–353	68	320	300	25	230.9	10.819	16.775
68–355	68	320	1000	25	255.1	10.536	16.512
68–356	68	320	1000	25	232.9	10.887	16.775
68–358	68	320	3000	25	195.4	10.712	16.707
68–359	68	320	3000	25	199.9	10.458	16.053
68.4–19	68	320	10000	–196	19.3	15.344	15.344
68.3–19	68	320	10000	–78	54.4	16.465	18.014
68.4–20	68	320	10000	–50	87.3	16.117	21.041
68.3–23	68	320	10000	–20	155.5	14.626	22.190
68.3–22	68	320	10000	25	222.0	13.456	18.579
68.3–27	68	320	10000	25	175.0	13.503	19.202
68.3–26	68	320	10000	75	237.6	11.095	16.848
68.3–21	68	320	10000	175	216.3	10.230	15.695
68.3–20	68	320	10000	290	175.6	8.527	12.668
68.1–37	68	320	30000	–197	25.5	14.969	14.969
68.1–38	68	320	30000	–96	95.5	15.145	21.414
68–247	68	320	30000	–50	67.5	13.895	17.908
68.1–39	68	320	30000	–20	99.1	12.420	18.191
68–248	68	320	30000	0	111.5	12.098	17.088
68.2–37	68	320	30000	25	128.1	11.630	16.648
68–249	68	320	30000	25	142.1	11.561	17.820
68.2–38	68	320	30000	50	191.4	10.653	16.922
68–258	68	320	30000	50	185.6	10.682	16.209
68.2–39	68	320	30000	100	200.4	9.804	15.711
68–259	68	320	30000	175	246.0	8.046	14.217
68.3–37	68	320	30000	290	187.9	7.411	12.723
68–260	68	320	30000	290	254.4	6.728	11.747
68–333	68	350	100	25	245.9	12.167	17.615
68–334	68	350	100	25	360.9	12.040	17.576

Table B–3. (Contd.)

Specimen Id.	Heat	Aging Temp. (°C)	Aging Time (h)	Test Temp. (°C)	Impact Energy (J/cm²)	Yield Load (kN)	Max. Load (kN)
68–336	68	350	300	25	231.7	11.610	17.791
68–337	68	350	300	25	263.5	11.688	17.869
68–339	68	350	1000	25	168.1	11.747	18.240
68–340	68	350	1000	25	174.5	12.186	18.230
68.1–19	68	350	5780	–196	16.5	14.551	14.551
68.1–21	68	350	5780	–100	31.3	14.744	14.744
68.1–26	68	350	5780	–50	59.1	16.380	16.940
68.2–21	68	350	5780	–10	80.1	12.860	16.072
68.1–25	68	350	5780	25	236.9	11.480	30.128
68.2–19	68	350	5780	25	149.0	11.686	17.544
68.1–20	68	350	5780	75	160.9	10.400	16.314
68.1–20	68	350	5780	125	194.4	9.520	14.680
68.1–27	68	350	5780	290	147.5	7.040	12.140
68.4–02	68	350	10000	–196	14.3	15.979	15.979
68–122	68	350	10000	–120	9.9	14.630	14.634
68.3–09	68	350	10000	–100	39.3	15.477	16.878
68.3–04	68	350	10000	–70	21.1	15.107	15.107
68.3–05	68	350	10000	–50	15.5	12.365	12.365
68–126	68	350	10000	–50	30.7	14.480	14.773
68.4–03	68	350	10000	–20	73.0	14.310	14.310
68.3–01	68	350	10000	0	81.6	12.928	14.198
68.3–03	68	350	10000	25	100.3	13.707	19.246
68.3–07	68	350	10000	25	133.5	13.479	19.642
68–125	68	350	10000	25	66.2	12.720	16.016
68.3–06	68	350	10000	75	208.3	11.743	17.604
68–121	68	350	10000	75	150.7	11.817	18.219
68.3–02	68	350	10000	125	186.5	9.882	15.565
68–124	68	350	10000	175	212.6	9.852	15.579
68.4–05	68	350	10000	290	227.5	9.237	14.076
68–123	68	350	10000	290	187.7	8.560	13.654
68.3–10	68	350	30000	–196	15.6	12.791	12.791
68.3–11	68	350	30000	–50	33.0	13.924	15.272
68.3–12	68	350	30000	0	56.1	12.713	15.037
68–135	68	350	30000	25	96.0	12.088	16.326
68.3–13	68	350	30000	25	65.1	12.098	15.789
68.3–14	68	350	30000	50	56.6	11.229	13.787
68.3–15	68	350	30000	75	154.4	10.214	16.492
68.3–16	68	350	30000	100	137.9	10.087	15.809
68–136	68	350	30000	125	165.9	9.345	15.252
68.3–17	68	350	30000	175	168.0	9.677	14.295
68.4–13	68	350	30000	225	187.1	8.620	13.829
68–137	68	350	30000	290	195.5	7.636	12.674
68.3–18	68	350	30000	290	179.8	7.851	13.329
68–321	68	400	50	25	289.2	12.293	18.230
68–322	68	400	50	25	211.0	11.766	17.098
68–324	68	400	100	25	249.5	11.942	18.523
68–325	68	400	100	25	240.8	11.883	18.045
68–327	68	400	300	25	168.1	12.108	18.113
68–328	68	400	300	25	158.3	12.098	17.771
68–330	68	400	1000	25	100.6	12.254	15.701
68–331	68	400	1000	25	94.4	12.157	15.662
68.2–10	68	400	2570	–196	12.4	14.529	14.529
68–253	68	400	2570	–196	9.3	13.217	13.217
68.1–12	68	400	2570	–100	24.9	13.983	13.983
68.1–18	68	400	2570	–50	48.0	14.880	17.119
68–255	68	400	2570	–50	30.9	14.571	15.296
68.2–12	68	400	2570	–10	62.7	13.114	15.115

Table B–3. (Contd.)

Specimen Id.	Heat	Aging Temp. (°C)	Aging Time (h)	Test Temp. (°C)	Impact Energy (J/cm²)	Yield Load (kN)	Max. Load (kN)
68.1–16	68	400	2570	25	76.7	12.143	16.295
68.2–11	68	400	2570	25	55.7	12.415	16.102
68–251	68	400	2570	25	89.9	12.478	15.675
68.1–10	68	400	2570	75	116.6	10.360	15.153
68–254	68	400	2570	75	103.7	10.188	15.729
68.1–11	68	400	2570	125	176.3	8.766	14.845
68–252	68	400	2570	125	168.5	9.520	15.166
68.1–17	68	400	2570	290	132.4	7.254	11.875
68–250	68	400	2570	290	146.7	8.076	12.810
68.2–04	68	400	10000	–196	9.0	13.459	13.459
68.2–06	68	400	10000	–196	6.1	13.277	13.277
68–116	68	400	10000	–196	9.1	13.882	13.882
68.2–05	68	400	10000	–50	29.4	15.873	15.873
68.1–13	68	400	10000	25	58.3	13.713	15.857
68.1–56	68	400	10000	25	79.6	12.079	15.604
68.2–13	68	400	10000	25	44.7	14.056	15.849
68–111	68	400	10000	25	27.4	15.032	15.032
68–115	68	400	10000	25	55.2	14.014	16.974
68.1–23	68	400	10000	75	65.4	12.444	15.873
68.1–24	68	400	10000	75	110.3	12.160	17.774
68–113	68	400	10000	75	107.5	12.760	18.063
68.1–14	68	400	10000	100	121.8	9.813	14.627
68.2–14	68	400	10000	125	85.6	12.116	15.844
68–114	68	400	10000	125	174.8	11.681	17.866
68.1–15	68	400	10000	175	170.7	8.329	13.680
68.1–22	68	400	10000	290	138.5	8.427	13.507
68–112	68	400	10000	290	149.5	8.504	14.171
68.1–02	68	450	2570	–196	99.0	13.249	13.249
68.2–08	68	450	2570	–196	11.0	12.719	12.719
68.1–03	68	450	2570	–100	36.7	15.633	18.103
68.2–07	68	450	2570	–50	23.7	13.171	14.194
68.2–03	68	450	2570	–20	33.5	13.573	13.778
68.1–09	68	450	2570	0	69.9	13.143	15.203
68.1–01	68	450	2570	25	40.3	12.612	14.047
68.2–02	68	450	2570	25	68.1	12.869	17.498
68.2–01	68	450	2570	75	109.3	10.383	15.777
68.1–07	68	450	2570	125	107.1	9.406	15.158
68.1–08	68	450	2570	290	124.8	7.356	12.587
			CF–8M Grade				
70.1–42	70	–	–	–196	50.2	16.651	17.861
70–267	70	–	–	–196	70.7	16.836	22.214
70.1–41	70	–	–	–125	224.2	16.006	24.293
70.2–43	70	–	–	–125	204.9	14.972	22.311
70–264	70	–	–	–125	170.6	15.431	22.331
70.3–44	70	–	–	–100	221.5	14.181	21.892
70.4–44	70	–	–	–75	204.0	14.455	22.321
70.3–45	70	–	–	–50	197.0	13.186	19.823
70–122	70	–	–	–50	233.1	13.196	19.881
70.1–44	70	–	–	–20	279.6	12.073	18.398
70.2–44	70	–	–	0	267.3	12.259	18.232
70.1–40	70	–	–	25	395.0	10.677	16.885
70.3–45	70	–	–	25	325.2	10.189	16.485
70.4–43	70	–	–	75	212.7	9.711	15.548
70.2–45	70	–	–	125	325.8	8.364	13.791
70.1–43	70	–	–	290	248.7	6.227	11.175
70.4–45	70	–	–	290	172.3	6.412	11.224
70–265	70	–	–	290	139.2	5.993	10.258

Table B–3. (Contd.)

Specimen Id.	Heat	Aging Temp. (°C)	Aging Time (h)	Test Temp. (°C)	Impact Energy (J/cm²)	Yield Load (kN)	Max. Load (kN)
70.1–19	70	350	2570	–196	22.6	15.040	15.040
70.2–21	70	350	2570	–125	62.2	11.692	18.144
70.1–27	70	350	2570	–100	67.1	14.650	15.977
70.1–26	70	350	2570	–75	103.1	14.513	20.613
70.2–20	70	350	2570	–50	195.3	13.371	21.365
70.1–20	70	350	2570	–20	224.1	12.893	19.774
70.1–25	70	350	2570	0	266.8	12.005	18.495
70.1–21	70	350	2570	25	221.9	11.849	18.271
70.2–19	70	350	2570	290	177.4	6.812	11.468
70.3–03	70	350	10000	–196	16.5	16.494	16.494
70.4–04	70	350	10000	–125	28.1	14.991	16.553
70.3–06	70	350	10000	–100	23.0	15.128	15.128
70.4–02	70	350	10000	–75	40.2	14.962	16.865
70–113	70	350	10000	–75	65.6	13.420	18.329
70.3–07	70	350	10000	–50	69.7	13.596	16.709
70.4–01	70	350	10000	–20	64.3	13.703	16.006
70–111	70	350	10000	–20	66.6	13.254	15.938
70.3–02	70	350	10000	0	121.9	12.473	18.056
70–115	70	350	10000	0	55.2	12.639	16.084
70.3–09	70	350	10000	25	76.4	11.468	15.157
70–114	70	350	10000	25	112.8	11.097	16.612
70.3–04	70	350	10000	125	178.3	9.906	15.967
70.3–01	70	350	10000	290	218.3	7.310	12.825
70–112	70	350	10000	290	158.3	6.969	11.204
70.1–10	70	400	2570	–196	18.7	15.294	15.294
70–250	70	400	2570	–125	42.0	15.372	16.651
70.2–11	70	400	2570	–100	51.9	14.728	18.310
70–254	70	400	2570	–100	36.9	14.718	16.153
70.1–11	70	400	2570	–75	62.6	14.484	18.241
70.1–17	70	400	2570	–50	75.3	14.250	19.139
70.1–18	70	400	2570	–20	121.3	13.635	17.744
70–252	70	400	2570	–20	75.0	12.678	17.021
70.1–16	70	400	2570	0	75.8	12.366	16.455
70.1–12	70	400	2570	25	114.1	11.429	17.656
70–251	70	400	2570	25	103.1	11.351	17.119
70.2–12	70	400	2570	75	145.8	11.000	16.729
70–253	70	400	2570	125	237.4	9.370	15.606
70.2–10	70	400	2570	290	194.1	8.764	13.742
70–255	70	400	2570	290	147.5	8.677	13.459
70.1–22	70	400	10000	–196	9.9	12.054	12.054
70–103	70	400	10000	–125	33.7	15.138	16.895
70.2–04	70	400	10000	–100	34.0	14.972	16.221
70–106	70	400	10000	–75	80.2	14.367	20.359
70.1–13	70	400	10000	–50	32.3	14.152	15.235
70.1–23	70	400	10000	–20	42.7	13.498	14.825
70–101	70	400	10000	–20	50.6	13.566	14.162
70.2–14	70	400	10000	0	78.5	12.151	16.807
70.1–15	70	400	10000	25	81.2	12.161	15.880
70.2–05	70	400	10000	25	83.5	11.390	16.045
70–104	70	400	10000	25	123.7	11.292	18.241
70.1–24	70	400	10000	75	164.1	11.097	16.973
70.2–06	70	400	10000	125	122.0	9.155	15.352
70.2–13	70	400	10000	200	193.7	8.286	14.425
70.1–14	70	400	10000	290	127.4	7.720	12.464
70–105	70	400	10000	290	153.2	7.535	12.337
74.3–45	74	–	–	–196	99.5	16.786	21.479
74.4–45	74	–	–	–196	87.4	16.669	22.275

Table B–3. (Contd.)

Specimen Id.	Heat	Aging Temp. (°C)	Aging Time (h)	Test Temp. (°C)	Impact Energy (J/cm²)	Yield Load (kN)	Max. Load (kN)
74–124	74	–	–	–196	87.0	16.026	23.107
74.4–43	74	–	–	–120	158.2	16.165	22.792
74.1–40	74	–	–	–50	161.9	14.690	20.563
74–121	74	–	–	–50	135.0	14.160	19.158
74.1–42	74	–	–	–20	160.4	11.840	17.695
74.1–45	74	–	–	25	267.9	11.400	16.404
74.2–45	74	–	–	25	157.0	12.095	16.743
74–264	74	–	–	25	205.6	11.996	17.551
74.3–43	74	–	–	75	202.9	9.200	14.829
74–266	74	–	–	75	291.0	8.918	14.842
74.2–44	74	–	–	125	132.3	9.000	13.426
74–122	74	–	–	125	213.9	9.189	14.269
74.1–44	74	–	–	200	154.3	8.148	12.934
74.1–43	74	–	–	290	236.7	6.880	11.643
74.4–44	74	–	–	290	156.1	6.960	10.866
74–265	74	–	–	290	152.8	6.995	10.316
74.3–28	74	290	30000	–196	35.5	16.883	16.883
74.4–28	74	290	30000	–196	34.1	16.658	18.416
74.3–29	74	290	30000	–120	139.6	15.223	21.511
74.4–29	74	290	30000	–100	116.2	13.651	18.299
74.3–30	74	290	30000	–80	256.5	12.977	22.224
74.4–30	74	290	30000	–50	308.5	13.973	21.072
74–131	74	290	30000	–20	286.4	11.717	18.308
74.3–31	74	290	30000	0	273.9	11.835	18.738
74.4–31	74	290	30000	10	335.5	10.516	17.273
74–132	74	290	30000	25	326.6	10.702	18.133
74.3–32	74	290	30000	25	344.9	10.594	17.078
74.4–32	74	290	30000	75	261.1	8.605	13.174
74.3–33	74	290	30000	175	235.6	7.773	13.133
74–133	74	290	30000	290	283.3	6.698	11.971
74.3–34	74	290	30000	290	289.0	6.386	11.678
74.3–22	74	320	10000	–196	18.2	17.147	17.147
74.4–19	74	320	10000	–78	150.6	15.862	23.164
74.3–24	74	320	10000	–50	120.2	15.230	19.900
74.3–19	74	320	10000	–20	188.2	14.731	21.097
74.3–20	74	320	10000	25	188.6	13.175	18.648
74.3–21	74	320	10000	25	224.0	12.405	19.060
74.3–25	74	320	10000	75	258.0	11.838	17.235
74.3–27	74	320	10000	175	182.6	11.346	15.697
74.4–20	74	320	10000	175	135.1	8.112	12.458
74.1–37	74	320	30000	–197	15.4	14.285	14.285
74.1–38	74	320	30000	–96	65.1	15.692	20.418
74–237	74	320	30000	–50	53.8	14.451	15.604
74.1–39	74	320	30000	–20	75.8	12.606	15.018
74–238	74	320	30000	0	122.5	12.264	17.508
74.2–37	74	320	30000	25	95.4	10.800	15.692
74–239	74	320	30000	25	156.1	11.649	17.537
74.2–38	74	320	30000	50	154.3	11.200	16.356
74–240	74	320	30000	75	207.2	10.712	16.395
74.2–39	74	320	30000	100	160.5	9.393	15.701
74–241	74	320	30000	175	201.4	8.017	14.051
74.3–37	74	320	30000	290	176.0	7.773	12.997
74–292	74	320	30000	290	179.8	7.812	12.909
74.1–20	74	350	2570	–196	31.1	17.160	17.227
74.1–19	74	350	2570	–120	56.3	18.602	21.137
74.1–27	74	350	2570	–120	48.3	17.153	18.283
74.2–21	74	350	2570	–50	175.4	12.862	20.450

Table B–3. (Contd.)

Specimen Id.	Heat	Aging Temp. (°C)	Aging Time (h)	Test Temp. (°C)	Impact Energy (J/cm²)	Yield Load (kN)	Max. Load (kN)
74.1–25	74	350	2570	25	152.2	11.962	17.069
74.2–19	74	350	2570	25	165.9	12.727	17.350
74.2–26	74	350	2570	75	169.2	10.280	16.185
74.1–21	74	350	2570	125	192.0	10.009	15.342
74.2–20	74	350	2570	290	155.2	7.603	11.610
74.3–04	74	350	10000	–196	16.0	16.484	16.484
74–115	74	350	10000	–120	36.9	15.600	16.596
74.4–02	74	350	10000	–100	62.2	17.513	20.829
74.4–05	74	350	10000	–70	43.5	15.633	16.659
74.3–08	74	350	10000	–50	98.0	15.408	21.498
74–114	74	350	10000	–50	66.5	14.800	17.935
74.3–05	74	350	10000	–20	73.6	15.107	18.884
74.3–01	74	350	10000	–10	114.8	12.879	18.152
74.3–03	74	350	10000	0	105.9	12.713	17.234
74.3–07	74	350	10000	10	90.7	13.407	17.400
74.3–02	74	350	10000	25	124.1	12.807	17.927
74.3–06	74	350	10000	25	103.7	12.840	17.203
74–112	74	350	10000	25	208.9	12.120	18.850
74.4–01	74	350	10000	75	148.1	11.648	18.267
74–113	74	350	10000	75	157.9	10.883	17.425
74–116	74	350	10000	175	163.8	10.338	16.145
74.3–09	74	350	10000	290	153.2	8.840	14.505
74–111	74	350	10000	290	140.5	7.900	13.437
74.3–10	74	350	30000	–196	15.1	14.735	14.735
74.3–11	74	350	30000	–97	20.6	14.149	14.149
74.3–12	74	350	30000	–50	49.6	13.592	15.281
74.3–16	74	350	30000	–20	58.6	12.157	15.574
74.3–17	74	350	30000	0	76.6	11.913	15.965
74.125	74	350	30000	25	56.9	11.590	13.953
74.3–18	74	350	30000	25	69.1	11.727	14.578
74.4–10	74	350	30000	50	89.8	10.878	15.233
74.4–11	74	350	30000	75	93.3	10.155	14.910
74.4–12	74	350	30000	100	87.0	10.321	14.686
74–126	74	350	30000	125	127.7	9.481	15.311
74.4–13	74	350	30000	175	141.6	8.788	14.207
74–127	74	350	30000	290	168.7	6.200	10.985
74.4–14	74	350	30000	290	160.4	8.446	13.895
74.2–10	74	400	2570	–196	13.3	16.558	16.558
74–255	74	400	2570	–196	15.2	14.894	14.894
74.1–10	74	400	2570	–50	75.0	13.360	16.490
74–253	74	400	2570	–50	47.0	12.593	15.794
74.1–16	74	400	2570	25	139.1	11.407	17.995
74.2–11	74	400	2570	25	153.1	11.399	17.897
74–251	74	400	2570	25	94.4	11.118	17.082
74.1–12	74	400	2570	75	131.1	9.920	16.232
74–250	74	400	2570	75	140.0	10.518	16.049
74.1–18	74	400	2570	125	142.8	9.440	15.109
74–254	74	400	2570	125	141.2	8.240	14.289
74.1–11	74	400	2570	290	138.7	7.280	12.549
74–252	74	400	2570	290	131.6	7.389	12.564
74.1–14	74	400	10000	–196	9.0	14.433	14.433
74.2–05	74	400	10000	–196	7.6	11.794	11.794
74–106	74	400	10000	–196	9.3	12.454	12.454
74.1–24	74	400	10000	–50	52.4	15.289	18.133
74–103	74	400	10000	–50	66.0	16.060	18.597
74.1–23	74	400	10000	25	50.9	13.160	15.167
74.2–06	74	400	10000	25	102.2	13.604	19.223

Table B–3. (Contd.)

Specimen Id.	Heat	Aging Temp. (°C)	Aging Time (h)	Test Temp. (°C)	Impact Energy (J/cm²)	Yield Load (kN)	Max. Load (kN)
74–105	74	400	10000	25	76.3	13.151	17.194
74.1–22	74	400	10000	75	113.4	12.794	17.558
74.2–14	74	400	10000	75	107.4	11.600	17.157
74–101	74	400	10000	75	108.4	13.179	19.241
74.1–15	74	400	10000	125	116.5	11.351	16.244
74–104	74	400	10000	125	143.5	11.440	17.512
74.2–04	74	400	10000	290	161.8	9.120	14.211
74–102	74	400	10000	290	123.9	8.520	13.668
74.1–07	74	450	2570	–196	8.4	12.860	12.860
74.2–01	74	450	2570	–196	9.3	12.095	12.095
74.1–03	74	450	2570	–50	53.8	14.048	17.088
74.1–01	74	450	2570	25	81.6	11.996	16.369
74.2–02	74	450	2570	25	87.6	12.278	17.238
74.2–08	74	450	2570	75	91.3	9.515	14.187
74.2–03	74	450	2570	125	94.4	7.760	14.202
74.1–02	74	450	2570	290	94.4	7.920	12.106
75.1–42	75	–	–	–196	45.0	19.404	20.335
75.4–43	75	–	–	–196	46.1	18.650	21.991
75–246	75	–	–	–196	32.8	18.002	18.989
75.2–45	75	–	–	–120	198.0	18.720	27.858
75–122	75	–	–	–120	140.2	19.339	27.274
75.3–45	75	–	–	–50	204.1	14.577	21.300
75–123	75	–	–	–50	194.5	14.651	20.610
75.2–44	75	–	–	–20	209.9	13.440	19.808
75.1–40	75	–	–	25	260.6	12.047	18.096
75.1–45	75	–	–	25	247.5	12.464	19.003
75.3–44	75	–	–	25	237.6	12.128	18.365
75–247	75	–	–	25	201.8	12.520	18.263
75.2–43	75	–	–	75	196.0	10.691	16.605
75–121	75	–	–	75	217.0	10.000	16.475
75.1–45	75	–	–	125	151.7	10.139	15.118
75–257	75	–	–	125	189.2	9.585	14.702
75.4–44	75	–	–	200	178.4	9.256	14.339
75.1–44	75	–	–	290	153.6	7.264	12.261
75.3–43	75	–	–	290	193.1	7.822	12.282
75–124	75	–	–	290	147.6	7.388	11.703
75.3–28	75	290	30000	–196	25.7	18.308	18.308
75.4–31	75	290	30000	–120	56.7	15.945	19.500
75–131	75	290	30000	–100	89.7	11.268	21.677
75.3–29	75	290	30000	–80	117.5	15.535	19.002
75.4–32	75	290	30000	–50	196.6	14.627	21.960
75–132	75	290	30000	–20	229.2	13.680	20.623
75.3–31	75	290	30000	–20	234.7	13.358	20.867
75.4–33	75	290	30000	0	249.0	13.582	20.378
753–32	75	290	30000	10	262.5	12.538	19.529
75–133	75	290	30000	25	284.6	12.850	19.656
75.4–34	75	290	30000	25	247.4	12.362	19.441
75.3–33	75	290	30000	50	250.1	11.815	17.898
75.4–35	75	290	30000	125	275.7	9.608	16.297
75.3–34	75	290	30000	200	258.1	8.153	14.207
75–134	75	290	30000	290	235.5	7.665	13.231
75.3–35	75	290	30000	290	239.5	7.558	12.782
75–442	75	320	300	25	235.2	12.323	18.221
75–443	75	320	300	25	218.2	12.245	18.611
75–445	75	320	1000	25	238.9	12.372	18.396
75–446	75	320	1000	25	222.1	12.079	17.810

Table B–3. (Contd.)

Specimen Id.	Heat	Aging Temp. (°C)	Aging Time (h)	Test Temp. (°C)	Impact Energy (J/cm^2)	Yield Load (kN)	Max. Load (kN)
75–448	75	320	3000	25	290.3	12.450	19.256
75–449	75	320	3000	25	230.9	12.616	18.914
75.3–27	75	320	10000	–196	16.3	18.737	18.737
75.3–20	75	320	10000	–78	46.6	18.627	19.566
75.4–19	75	320	10000	–50	50.1	16.886	18.217
75.3–24	75	320	10000	–20	81.3	16.238	19.654
75.3–20	75	320	10000	25	160.6	14.943	21.218
75.3–26	75	320	10000	25	209.7	15.275	22.477
75.3–22	75	320	10000	75	219.9	13.102	19.663
75.3–19	75	320	10000	175	168.4	10.011	15.521
75.3–21	75	320	10000	175	187.8	11.759	17.667
75.1–37	75	320	30000	–197	9.3	12.811	12.811
75.1–38	75	320	30000	–96	25.5	17.225	18.181
75–237	75	320	30000	–50	37.6	15.496	17.332
75.1–39	75	320	30000	–20	49.6	14.696	17.234
75–238	75	320	30000	0	62.2	13.993	16.522
75.2–37	75	320	30000	25	52.7	13.358	15.916
75–239	75	320	30000	25	75.9	13.485	16.883
75.2–38	75	320	30000	50	46.5	12.665	14.657
75–240	75	320	30000	75	125.9	12.420	17.683
75.2–39	75	320	30000	100	65.6	11.385	14.471
75–241	75	320	30000	175	160.8	10.038	16.190
75.3–37	75	320	30000	290	155.8	8.212	14.988
75–242	75	320	30000	290	164.2	9.237	14.393
75–333	75	350	100	25	286.9	12.912	19.656
75–334	75	350	100	25	257.3	12.323	19.324
75–336	75	350	300	25	197.6	12.641	18.738
75–337	75	350	300	25	259.0	12.850	19.881
75–339	75	350	1000	25	205.8	13.104	19.978
75–340	75	350	1000	25	212.0	13.104	19.578
75.1–19	75	350	2570	–196	15.3	16.105	16.105
75.1–21	75	350	2570	–100	37.9	16.025	18.330
75.2–19	75	350	2570	–50	48.1	14.792	15.995
75.1–27	75	350	2570	–10	132.0	14.510	19.929
75.1–25	75	350	2570	25	88.6	12.943	16.921
75.2–21	75	350	2570	25	73.1	12.869	17.773
75.1–20	75	350	2570	75	155.8	11.200	17.405
75.1–26	75	350	2570	125	154.6	10.680	16.463
75.2–20	75	350	2570	290	147.8	8.850	13.626
75.3–09	75	350	10000	–196	11.1	16.922	16.922
75–114	75	350	10000	–120	18.1	16.840	17.221
75.3–01	75	350	10000	–100	20.1	17.501	17.501
75.3–06	75	350	10000	–70	31.2	17.480	18.569
75.4–04	75	350	10000	–50	22.1	16.132	16.132
75–112	75	350	10000	–50	21.3	15.331	15.331
75.3–08	75	350	10000	–20	35.2	16.160	16.458
75.3–04	75	350	10000	25	53.6	15.360	16.967
75.3–07	75	350	10000	25	51.2	15.266	18.135
75–111	75	350	10000	25	33.0	14.140	15.313
75.4–01	75	350	10000	75	70.0	14.494	17.125
75–115	75	350	10000	75	60.2	14.322	17.082
75.3–02	75	350	10000	100	112.8	11.307	16.307
75.3–05	75	350	10000	150	171.2	10.887	16.922
75–113	75	350	10000	175	136.0	11.032	16.637
75.4–02	75	350	10000	200	147.7	10.721	16.522
75.4–03	75	350	10000	290	159.9	10.640	16.780
75–116	75	350	10000	290	146.8	10.720	17.172

Table B–3. (Contd.)

Specimen Id.	Heat	Aging Temp. (°C)	Aging Time (h)	Test Temp. (°C)	Impact Energy (J/cm²)	Yield Load (kN)	Max. Load (kN)
75.4–10	75	350	30000	–196	10.5	15.291	15.291
75.4–11	75	350	30000	–50	23.9	14.774	14.988
75.4–13	75	350	30000	0	30.2	13.924	15.272
75–125	75	350	30000	25	31.2	13.338	14.783
75.3–13	75	350	30000	25	29.7	12.518	13.436
75.3–14	75	350	30000	50	24.7	12.733	13.221
75.3–15	75	350	30000	75	46.6	11.932	13.924
75.3–16	75	350	30000	100	56.8	12.362	15.418
75–126	75	350	30000	125	45.2	11.786	13.983
75.3–17	75	350	30000	175	70.2	11.620	14.998
75.4–14	75	350	30000	225	90.1	10.604	14.871
75–127	75	350	30000	290	118.9	9.872	15.662
75.3–18	75	350	30000	290	104.8	9.598	14.188
75–321	75	400	50	25	214.3	13.192	19.636
75–322	75	400	50	25	211.6	13.231	19.461
75–324	75	400	100	25	209.4	13.338	19.705
75–325	75	400	100	25	198.1	13.114	19.578
75–327	75	400	300	25	150.9	13.309	20.183
75–328	75	400	300	25	142.0	13.612	19.890
75–330	75	400	1000	25	100.4	13.231	18.679
75–331	75	400	1000	25	80.1	13.621	16.805
75.1–10	75	400	2570	–196	7.6	14.691	14.691
75.2–12	75	400	2570	–196	11.6	14.768	14.768
75.1–12	75	400	2570	–100	18.2	14.647	14.647
75.1–17	75	400	2570	–50	41.6	14.800	17.196
75–252	75	400	2570	–50	33.7	14.800	15.403
75–251	75	400	2570	–10	44.5	15.037	16.775
75.1–16	75	400	2570	25	57.5	13.680	17.243
75.2–10	75	400	2570	25	40.3	12.328	14.119
75–255	75	400	2570	25	41.2	12.971	15.544
75.2–11	75	400	2570	75	103.9	12.279	17.257
75–254	75	400	2570	75	73.4	12.221	16.712
75.1–11	75	400	2570	125	120.6	10.720	16.153
75–250	75	400	2570	125	105.2	10.730	15.878
75.1–18	75	400	2570	290	114.1	8.692	13.773
75–255	75	400	2570	290	116.9	9.038	14.445
75.1–14	75	400	10000	–196	8.1	14.001	14.001
75.2–13	75	400	10000	–196	8.4	14.251	14.251
75–106	75	400	10000	–196	8.5	14.440	14.440
75.2–04	75	400	10000	–50	19.5	14.950	14.950
75–105	75	400	10000	–50	20.7	16.608	16.608
75.1–13	75	400	10000	25	32.5	15.431	16.981
75.2–05	75	400	10000	25	42.2	15.760	17.164
75.3–56	75	400	10000	25	29.3	13.465	15.008
75–104	75	400	10000	25	32.72	15.160	16.406
75.1–23	75	400	10000	75	47.9	14.154	17.197
75.2–06	75	400	10000	75	51.3	14.310	16.571
75–102	75	400	10000	75	62.5	12.160	18.877
75.1–15	75	400	10000	125	67.5	13.280	18.174
75–101	75	400	10000	125	84.0	13.649	18.696
75.1–22	75	400	10000	175	96.7	11.239	16.697
75.2–14	75	400	10000	200	100.6	10.878	15.740
75.1–24	75	400	10000	290	143.5	10.793	16.534
75–103	75	400	10000	290	127.8	10.597	16.625
75.1–03	75	450	2570	–196	14.5	16.448	16.448
75.1–07	75	450	2570	–196	9.1	14.141	14.141
75.1–02	75	450	2570	–100	23.7	17.254	18.592

Table B–3. (Contd.)

Specimen Id.	Heat	Aging Temp. (°C)	Aging Time (h)	Test Temp. (°C)	Impact Energy (J/cm^2)	Yield Load (kN)	Max. Load (kN)
75.1–08	75	450	2570	–80	26.2	16.326	16.326
75.2–02	75	450	2570	–50	29.3	15.120	16.592
75.2–03	75	450	2570	–10	33.4	14.930	15.604
75.1–01	75	450	2570	25	39.7	13.920	14.796
75.2–08	75	450	2570	25	62.5	12.998	16.396
75.2–01	75	450	2570	75	67.2	12.392	16.316
75.1–09	75	450	2570	125	75.7	11.480	16.112
75.2–07	75	450	2570	290	82.0	9.469	13.392

Table B–4. Charpy–Impact Test Results for the KRB Pump Cover Plate Material.

Specimen ID	Heat	Aging Temp. (°C)	Aging Time (h)	Test Temp. (°C)	Impact Energy (J/cm²)	Yield Load (kN)	Max. Load (kN)
			Reannealed				
08–11R	KRB	–	–	–196	19.4	15.946	15.946
10–11R	KRB	–	–	–196	17.3	15.759	15.759
10–12R	KRB	–	–	–196	16.4	14.897	14.940
12–22R	KRB	–	–	–120	26.6	14.724	15.225
09–22R	KRB	–	–	–50	77.8	13.168	16.798
12–12R	KRB	–	–	–50	114.6	13.164	18.156
08–22R	KRB	–	–	–20	170.2	12.360	18.362
09–12R	KRB	–	–	–20	231.1	12.835	18.754
08–12R	KRB	–	–	25	230.6	12.157	16.863
10–21R	KRB	–	–	25	232.6	11.676	16.548
10–22R	KRB	–	–	25	214.1	11.978	16.384
12–11R	KRB	–	–	25	192.3	12.218	17.093
C5–02R	KRB	–	–	25	217.0	12.649	17.832
C5–03R	KRB	–	–	25	303.0	11.790	18.017
09–21R	KRB	–	–	75	389.4	9.642	15.116
08–21R	KRB	–	–	125	285.1	8.318	13.581
12–21R	KRB	–	–	125	315.7	7.970	12.292
09–11R	KRB	–	–	290	329.7	7.343	11.596
C6–05R	KRB	320	3000	25	120.9	12.034	16.943
C6–06R	KRB	320	3000	25	178.6	11.517	18.085
C4–04R	KRB	320	10000	25	97.1	11.239	15.369
C4–05R	KRB	320	10000	25	97.4	11.756	16.453
C6–03R	KRB	350	300	25	125.7	13.615	18.710
C6–04R	KRB	350	300	25	184.9	16.654	23.330
C4–01R	KRB	350	1000	25	82.6	12.766	17.070
C4–02R	KRB	350	1000	25	88.8	12.678	15.704
C3–01R	KRB	350	3000	25	68.9	12.786	15.928
C3–02R	KRB	350	3000	25	63.2	13.332	16.904
C3–04R	KRB	350	10000	25	38.3	11.805	12.440
C3–05R	KRB	350	10000	25	33.1	11.385	11.854
C6–01R	KRB	400	100	25	108.7	12.571	17.949
C6–02R	KRB	400	100	25	109.2	16.810	22.560
C2–01R	KRB	400	300	25	59.6	12.698	15.821
C2–02R	KRB	400	300	25	70.0	13.020	15.333
C2–04R	KRB	400	1000	25	34.0	11.527	11.527
C2–05R	KRB	400	1000	25	29.3	11.390	11.390
C1–01R	KRB	400	3000	25	19.5	12.698	12.698
C1–02R	KRB	400	3000	25	20.0	12.220	12.220
C1–04R	KRB	400	10000	25	25.7	11.571	11.571
C1–05R	KRB	400	10000	25	27.9	11.620	11.620
			Reactor Service				
11–11	KRB	279	68000	–196	9.5	10.615	10.615
11–12	KRB	273	68000	–196	7.5	12.929	12.929
11–21	KRB	271	68000	–196	9.9	10.417	10.417
11–22	KRB	254	68000	–196	11.1	12.629	12.629
03–11	KRB	279	68000	–120	29.5	20.250	20.250
03–12	KRB	273	68000	–120	12.1	12.383	12.383
04–11	KRB	279	68000	–50	35.6	14.470	15.537
04–12	KRB	273	68000	–50	26.8	14.365	14.535
04–21	KRB	271	68000	–50	22.7	10.651	10.651
04–22	KRB	254	68000	–50	34.6	13.149	13.149
03–21	KRB	271	68000	–20	67.0	12.737	14.811
03–22	KRB	254	68000	–20	26.9	12.316	12.316
01–11	KRB	279	68000	25	121.6	13.272	17.039

Table B–4. (Contd.)

Specimen ID	Heat	Aging Temp. (°C)	Aging Time (h)	Test Temp. (°C)	Impact Energy (J/cm^2)	Yield Load (kN)	Max. Load (kN)
01–12	KRB	273	68000	25	168.4	12.521	18.494
01–21	KRB	271	68000	25	132.2	12.832	18.429
01–22	KRB	254	68000	25	146.3	11.400	16.955
07–11	KRB	279	68000	25	90.6	12.437	17.124
07–12	KRB	273	68000	25	103.0	12.856	18.588
07–21	KRB	271	68000	25	59.6	11.514	14.298
07–22	KRB	254	68000	25	105.5	12.209	16.752
C5–01	KRB	275	68000	25	186.7	15.117	23.778
C5–06	KRB	275	68000	25	125.9	12.268	16.992
06–11	KRB	279	68000	75	168.0	10.859	16.826
06–12	KRB	273	68000	75	177.5	10.490	16.690
05–11	KRB	279	68000	125	206.5	11.251	15.583
05–12	KRB	273	68000	125	200.6	11.385	15.730
05–21	KRB	271	68000	125	196.8	10.196	14.547
05–22	KRB	254	68000	125	224.7	9.779	15.362
06–21	KRB	271	68000	200	366.9	8.034	13.832
06–22	KRB	254	68000	200	276.4	8.021	13.234
02–11	KRB	279	68000	290	321.2	7.630	12.293
02–12	KRB	273	68000	290	152.0	8.382	12.773
02–21	KRB	271	68000	290	233.9	8.257	12.258
02–22	KRB	254	68000	290	174.5	7.697	12.317

Appendix C

Tensile Properties

Tensile tests were performed according to ASTM Standards E–8 and E–21 on cylindrical specimens with 5.08–mm (0.2–in.) diameter and 20.3–mm (0.8–in.) gauge length. The tests were conducted at Materials Engineering Associates (MEA) and at Argonne National Laboratory (ANL). The results from four commercial and seven experimental heats aged at temperatures between 320 and 450°C for times up to 30,000 h, as well as the KRB pump cover plate material, are given in Table C.1. The data from the MEA tests have been presented in a report entitled "Compilation of Tensile and J–R Curve Data from Thermally–Aged Stainless Steel," by A. L. Hiser, MEA–2239, Vols. I – III, October 1987.

The true fracture stress was obtained from the fracture load and cross sectional area at fracture. The total elongation was determined from crosshead as well as extensometer displacements. Machine compliance was determined and subtracted from the crosshead displacement to obtain the specimen elongation. For most tests, machine compliance was ~36% of the crosshead displacement. The values obtained by the two methods showed good agreement.

Table C–1. Tensile Test Results for Cast Stainless Steels.

Specimen Number	Heat	Orientation	Test Temp. (°C)	Engineering 0.2% Yield Stress (MPa)	Engineering Ultimate Stress (MPa)	True Fracture Stress (MPa)	Elongation (%)	Red. in Area (%)	Aging Condition Temp. (°C)	Aging Condition Time (h)	Ref.[a]
					CF–3 Grade						
I1V–01	I	L	25	264.8	598.8	1636.6	84.6	79.3	Unaged		2
I1V–02	I	L	25	242.1	583.4	1698.5	78.4	79.5	Unaged		2
I2V–01	I	L	25	251.0	579.9	1274.6	77.4	74.3	Unaged		2
I2V–02	I	L	25	257.7	578.1	1671.8	75.0	80.2	Unaged		2
I3C–01	I	L	25	239.7	517.6	1274.8	66.2	69.5	Unaged		2
I2V–23	I	L	25	235.8	637.3	1387.7	71.4	66.7	320	30000	1
I3C–14	I	L	25	278.2	633.9	1411.7	59.4	68.2	320	30000	1
I3V–39	I	L	25	282.5	452.7	–	17.5	50.5	320	30000	1
I1V–26	I	L	25	281.3	615.4	1897.6	60.6	77.4	350	10000	2
I1V–27	I	L	25	303.4	644.7	1445.0	–	62.2	350	10000	2
I2V–19	I	L	25	314.7	642.0	1296.9	72.0	68.4	350	10000	2
I2V–03	I	L	290	169.2	409.2	756.1	–	58.9	Unaged		2
I2V–06	I	L	290	178.5	402.4	837.8	39.4	64.6	Unaged		2
I3C–02	I	L	290	158.6	387.3	819.5	33.0	66.2	Unaged		2
I2V–24	I	L	290	178.6	445.9	710.7	40.4	57.2	320	30000	1
I3C–15	I	L	290	163.6	427.2	810.4	39.5	67.2	320	30000	1
I3V–40	I	L	290	–	470.5	828.9	27.1	54.7	320	30000	1
I1V–28	I	L	290	192.4	381.1	503.0	–	36.0	350	10000	2
I1V–29	I	L	290	189.0	442.8	780.5	34.2	59.7	350	10000	2
I2V–20	I	L	290	179.1	437.8	756.0	39.0	51.6	350	10000	2
P21T–01	P2	C	25	216.3	538.3	1000.4	72.6	59.9	Unaged		2
P23T–01	P2	C	25	238.1	556.8	1568.6	106.0	84.4	Unaged		2
P22A–01	P2	L	25	206.4	561.7	1094.5	73.7	75.7	Unaged		2
P23A–01	P2	L	25	216.7	536.9	887.4	62.4	75.1	Unaged		2
P22T–16	P2	C	25	247.0	580.1	1547.8	66.1	79.9	290	30000	1
P21A–31	P2	L	25	242.6	571.1	2017.1	66.5	84.7	290	30000	1
P25A–28	P2	L	25	223.9	548.3	1797.3	59.8	87.0	290	30000	1
P24T–14	P2	C	25	229.4	600.0	1944.4	71.9	82.3	320	30000	1
P25T–10	P2	C	25	258.1	581.8	1535.3	58.2	75.5	320	30000	1
P22A–32	P2	L	25	225.4	617.2	1799.8	68.9	79.0	320	30000	1
P22A–36	P2	L	25	237.4	603.0	1487.0	75.3	80.5	320	30000	1
P22T–04	P2	C	25	252.3	601.8	2162.5	–	85.3	350	10000	2
P23A–14	P2	L	25	249.2	594.3	2783.2	73.6	88.5	350	10000	2
P23A–26	P2	L	25	265.2	608.5	1830.3	76.6	78.8	350	10000	2
P22T–11	P2	C	25	249.3	628.4	1235.0	66.9	64.4	350	30000	1
P22A–13	P2	L	25	245.5	615.4	1598.5	66.1	76.2	350	30000	1
P24T–05	P2	C	25	233.5	603.1	1268.2	–	68.8	400	10000	2
P24A–04	P2	L	25	236.2	616.8	2384.5	–	78.0	400	10000	2
P21T–02	P2	C	290	161.3	387.1	819.1	44.6	72.2	Unaged		2
P23T–02	P2	C	290	154.2	405.0	688.2	42.4	65.9	Unaged		2
P22A–02	P2	L	290	137.9	406.9	755.7	47.2	65.9	Unaged		2
P23A–02	P2	L	290	144.0	385.1	538.7	39.9	59.6	Unaged		2
P21A–33	P2	L	290	155.2	405.9	740.8	48.3	73.7	290	30000	1
P21A–14	P2	L	290	153.2	428.9	968.4	44.0	73.0	320	30000	1
P21A–16	P2	L	290	152.6	407.7	870.6	41.0	71.9	320	30000	1
P21T–08	P2	C	290	155.6	423.5	876.3	49.8	70.7	350	10000	2
P22T–05	P2	C	290	153.8	399.0	696.5	43.0	66.9	350	10000	2
P23A–15	P2	L	290	161.0	415.4	900.5	–	69.7	350	10000	2
P23A–27	P2	L	290	154.1	419.4	970.7	39.6	72.9	350	10000	2
P22T–12	P2	C	290	167.0	436.2	740.2	39.9	56.0	350	30000	1
P24A–30	P2	L	290	142.4	432.1	828.0	52.1	60.9	350	30000	1
P24T–06	P2	C	290	160.4	447.1	818.5	40.2	56.4	400	10000	2
P24A–05	P2	L	290	146.6	430.6	655.0	40.2	53.8	400	10000	2

Table C–1. (Contd.)

Specimen Number	Heat	Orientation	Test Temp. (°C)	Engineering 0.2% Yield Stress (MPa)	Engineering Ultimate Stress (MPa)	True Fracture Stress (MPa)	Elongation (%)	Red. in Area (%)	Aging Condition Temp. (°C)	Aging Condition Time (h)	Ref.[a]
693–40	69	H	25	278.8	606.0	1070.1	57.1	48.9	Unaged		2
693–41	69	H	25	273.4	583.6	1093.4	54.1	54.4	Unaged		2
694–21	69	H	25	286.7	624.6	1757.0	58.4	76.1	320	10000	1
694–25	69	H	25	232.1	585.4	1428.3	71.1	75.2	320	10000	1
692–25	69	H	25	285.4	633.4	1483.2	67.7	76.2	350	2570	2
692–26	69	H	25	302.6	648.2	1364.3	62.5	72.4	350	2570	2
694–06	69	H	25	292.1	652.0	1902.3	59.7	76.0	350	10000	1
694–07	69	H	25	266.2	635.5	1480.4	56.6	71.6	350	10000	1
69–119	69	V	25	249.6	617.3	1811.6	56.0	78.4	350	10000	1
692–16	69	H	25	253.6	638.8	1358.9	52.4	72.4	400	2570	2
692–17	69	H	25	300.9	683.2	1309.9	44.3	60.6	400	2570	2
692–15	69	H	25	287.8	673.9	1409.6	49.0	56.8	400	10000	1
692–22	69	H	25	278.6	699.1	1727.1	49.2	68.3	400	10000	1
69–109	69	V	25	276.7	688.0	1796.6	67.5	73.5	400	10000	1
691–04	69	H	25	271.3	691.9	1476.9	36.5	71.4	450	2570	2
691–05	69	H	25	263.1	664.6	1528.2	56.6	73.2	450	2570	2
693–42	69	H	290	190.8	420.9	908.2	35.9	63.4	Unaged		2
694–40	69	H	290	177.0	417.0	809.0	33.6	59.7	Unaged		2
694–26	69	H	290	174.4	408.7	697.5	32.4	60.5	320	10000	1
694–27	69	H	290	183.5	422.8	973.7	31.0	65.3	320	10000	1
692–27	69	H	290	173.1	451.3	752.6	32.3	53.8	350	2570	2
684–09	69	H	290	156.4	413.1	720.9	42.0	52.7	350	10000	1
69–120	69	V	290	179.8	429.8	875.1	33.7	68.8	350	10000	1
692–18	69	H	290	163.9	444.8	556.4	21.8	33.2	400	2570	2
692–24	69	H	290	173.3	494.5	785.1	33.4	44.8	400	10000	1
69–110	69	V	290	196.9	481.6	802.3	36.7	51.5	400	10000	1
691–06	69	H	290	177.7	479.7	683.6	28.5	44.9	450	2570	2
692–09	69	H	290	175.7	477.1	793.4	27.4	51.0	450	2570	2
					CF–8 Grade						
18–11	KRB	R	25	306.2	554.9	1348.9	59.2	67.0	280	68000	1
18–12	KRB	R	25	288.5	555.9	1426.1	40.4	70.2	280	68000	1
18–22	KRB	R	25	291.9	568.9	1162.3	45.3	59.2	280	68000	1
13–12	KRB	R	25	317.3	567.4	1285.7	59.8	67.7	Reannealed		1
13–21	KRB	R	25	289.2	575.2	1209.1	48.0	67.0	Reannealed		1
13–22	KRB	R	25	287.7	531.2	1370.6	48.5	69.5	Reannealed		1
15–11	KRB	R	290	214.0	469.0	924.1	44.8	62.4	280	68000	1
15–12	KRB	R	290	208.4	444.5	774.1	39.9	51.1	280	68000	1
15–21	KRB	R	290	199.6	482.5	842.1	50.6	53.3	280	68000	1
15–22	KRB	R	290	180.2	434.0	710.1	48.8	51.1	280	68000	1
16–21	KRB	R	290	184.0	405.0	605.4	37.5	41.5	Reannealed		1
17–21	KRB	R	290	171.5	416.2	875.3	56.0	66.3	Reannealed		1
P13T–01	P1	C	25	244.7	584.5	1221.5	56.5	68.8	Unaged		2
P13T–03	P1	C	25	245.9	579.9	1206.6	54.6	65.9	Unaged		2
P11A–01	P1	L	25	–	584.9	1127.0	57.7	64.0	Unaged		2
P13A–01	P1	L	25	248.5	584.5	1579.5	62.4	72.9	Unaged		2
P14T–09	P1	C	25	266.2	596.2	1561.8	72.9	74.4	290	30000	1
P11A–25	P1	L	25	285.7	595.2	1660.1	69.7	71.7	290	30000	1
P14A–26	P1	L	25	276.5	575.7	993.2	47.4	61.6	290	30000	1
P11T–06	P1	C	25	–	569.3	1676.7	52.0	79.6	320	30000	1
P14T–08	P1	C	25	–	–	–	–	78.3	320	30000	1
P12T–05	P1	C	25	276.8	610.8	1315.5	67.2	58.9	350	10000	2
P12T–06	P1	C	25	263.4	608.7	864.7	87.2	76.1	350	10000	2
P12A–08	P1	L	25	290.5	652.9	1625.9	–	75.2	350	10000	2
P12A–09	P1	L	25	271.2	618.0	2322.0	–	80.2	350	10000	2
P12T–11	P1	C	25	266.6	617.0	1240.0	79.3	61.0	350	30000	1
P12A–13	P1	L	25	285.0	637.0	1068.7	71.1	55.8	350	30000	1

Table C–1. (Contd.)

Specimen Number	Heat	Orientation	Test Temp. (°C)	Engineering 0.2% Yield Stress (MPa)	Engineering Ultimate Stress (MPa)	True Fracture Stress (MPa)	Elongation (%)	Red. in Area (%)	Aging Condition Temp. (°C)	Aging Condition Time (h)	Ref.[a]
P13T–07	P1	C	25	285.0	660.0	1351.8	46.8	55.8	400	10000	2
P13A–07	P1	L	25	286.3	677.7	1429.8	68.6	56.4	400	10000	2
P13T–02	P1	C	290	148.5	408.8	642.2	33.3	43.9	Unaged		2
P14T–01	P1	C	290	157.0	437.5	622.3	32.6	46.4	Unaged		2
P11A–02	P1	L	290	159.9	442.7	497.0	35.5	36.7	Unaged		2
P13A–02	P1	L	290	155.0	424.4	850.8	43.0	67.2	Unaged		2
P14A–27	P1	L	290	167.8	421.6	812.5	41.8	60.1	290	30000	1
P11A–09	P1	L	290	175.5	435.1	934.6	41.1	59.1	320	30000	1
P12A–19	P1	L	290	174.8	456.9	731.1	39.3	51.6	320	30000	1
P12A–22	P1	L	290	175.4	418.7	629.7	35.8	46.6	320	30000	1
P12T–08	P1	C	290	180.2	454.2	981.5	–	63.4	350	10000	2
P12A–10	P1	L	290	173.7	451.3	919.6	43.4	62.8	350	10000	2
P12A–11	P1	L	290	180.7	457.7	823.2	42.4	55.8	350	10000	2
P12T–12	P1	C	290	194.9	472.7	786.5	35.5	58.0	350	30000	1
P14A–22	P1	L	290	185.3	462.3	719.2	35.3	44.5	350	30000	1
P14A–23	P1	L	290	198.6	475.6	735.1	35.6	42.0	350	30000	1
P13T–08	P1	C	290	167.3	502.2	791.0	–	49.6	400	10000	2
P13A–08	P1	L	290	162.9	485.6	881.0	35.6	51.0	400	10000	2
683–40	68	H	25	274.1	530.0	996.8	45.4	53.4	Unaged		2
683–41	68	H	25	279.4	517.2	811.9	36.4	49.2	Unaged		2
684–21	68	H	25	304.5	614.1	1291.8	67.8	61.9	320	10000	1
684–22	68	H	25	281.0	571.2	1880.1	75.9	80.7	320	10000	1
682–25	68	H	25	281.5	601.6	1647.2	64.1	75.2	350	5780	2
682–26	68	H	25	294.8	599.4	1620.7	62.0	73.5	350	5780	2
684–06	68	H	25	264.5	606.5	2014.0	57.8	78.3	350	10000	1
684–07	68	H	25	299.7	601.1	1953.4	52.1	76.7	350	10000	1
68–129	68	V	25	287.6	595.8	1688.6	63.7	73.5	350	10000	1
682–16	68	H	25	294.1	657.8	1534.6	75.0	64.0	400	2570	2
682–17	68	H	25	289.8	629.5	1313.0	–	64.6	400	2570	2
682–15	68	H	25	313.4	641.0	1526.3	42.8	64.4	400	10000	1
682–22	68	H	25	299.3	650.4	1019.0	45.8	49.4	400	10000	1
68–119	68	V	25	–	624.3	1926.8	48.6	72.9	400	10000	1
681–04	68	H	25	291.3	653.1	1030.9	41.5	38.7	450	2570	2
681–05	68	H	25	309.4	632.9	1447.0	–	68.7	450	2570	2
683–42	68	H	290	162.7	397.3	815.4	29.2	57.8	Unaged		2
684–40	68	H	290	156.4	412.3	792.0	37.9	60.6	Unaged		2
684–23	68	H	290	173.4	416.6	1048.7	39.1	72.7	320	10000	1
684–24	68	H	290	164.4	442.8	869.9	45.7	58.2	320	10000	1
682–27	68	H	290	185.1	452.4	826.3	41.7	57.8	350	5780	2
684–09	68	H	290	164.3	500.3	765.7	42.1	51.9	350	10000	1
68–130	68	V	290	168.9	447.2	765.4	38.7	49.9	350	10000	1
682–18	68	H	290	161.3	463.1	711.3	32.1	47.1	400	2570	2
682–24	68	H	290	176.7	475.6	800.8	46.3	47.6	400	10000	1
68–120	68	V	290	193.9	484.4	734.0	38.8	37.1	400	10000	1
681–06	68	H	290	169.7	486.8	700.4	–	36.8	450	2570	2
682–09	68	H	290	191.6	503.8	769.0	35.5	42.6	450	2570	2
733–40	73	H	25	254.3	557.0	882.9	52.9	41.3	Unaged		1
733–41	73	H	25	249.5	530.8	988.8	61.6	55.1	Unaged		1
732–25	73	H	25	244.0	526.5	1453.0	64.0	74.2	350	2570	1
732–26	73	H	25	244.4	528.4	1109.6	51.9	65.4	350	2570	1
732–16	73	H	25	240.8	541.8	1390.9	66.3	72.4	400	2570	1
732–17	73	H	25	252.6	555.7	1419.0	52.7	72.1	400	2570	1
731–04	73	H	25	256.5	493.1	944.5	39.9	53.1	450	2570	1
731–05	73	H	25	234.0	570.4	1511.4	81.9	69.3	450	2570	1
733–42	73	H	290	138.9	366.6	970.1	48.9	75.8	Unaged		1
734–40	73	H	290	133.9	365.0	599.5	43.8	54.0	Unaged		1

Table C–1. (Contd.)

Specimen Number	Heat	Orientation	Test Temp. (°C)	Engineering 0.2% Yield Stress (MPa)	Engineering Ultimate Stress (MPa)	True Fracture Stress (MPa)	Elongation (%)	Red. in Area (%)	Aging Condition Temp. (°C)	Aging Condition Time (h)	Ref.[a]
732–27	73	H	290	139.6	419.8	833.9	57.8	62.0	350	2570	1
732–18	73	H	290	–	444.1	700.7	50.1	59.3	400	2570	1
731–06	73	H	290	144.1	411.2	596.6	33.4	39.2	450	2570	1
732–09	73	H	290	136.2	436.1	730.6	56.9	51.2	450	2570	1
					CF–8M Grade						
205–26	205	L	25	248.5	670.6	1227.7	41.6	65.0	400	18000	1
205–25	205	L	290	179.4	505.9	744.1	33.9	44.6	400	18000	1
205–28	205	L	290	177.3	507.8	790.3	38.0	49.2	400	18000	1
205–29	205	L	290	168.2	495.1	700.7	35.2	44.2	400	18000	1
743–40	74	H	25	273.5	542.4	1356.5	0.0	65.4	Unaged		1
743–41	74	H	25	273.0	531.3	1362.7	64.1	68.3	Unaged		1
742–25	74	H	25	269.0	575.1	1380.5	60.9	68.1	350	2570	1
742–26	74	H	25	261.0	536.8	1517.5	63.8	72.0	350	2570	1
742–16	74	H	25	268.6	602.3	1409.4	48.6	70.8	400	2570	1
742–17	74	H	25	267.7	579.7	1308.7	46.5	71.8	400	2570	1
741–04	74	H	25	257.5	620.5	1293.5	48.1	60.5	450	2570	1
741–05	74	H	25	259.1	616.7	1176.2	60.8	52.9	450	2570	1
744–40	74	H	290	171.8	412.3	557.7	37.5	58.7	Unaged		1
742–27	74	H	290	174.9	454.3	787.2	43.8	65.9	350	2570	1
742–18	74	H	290	166.2	485.1	695.0	39.7	57.1	400	2570	1
741–06	74	H	290	172.0	500.7	678.6	33.0	45.5	450	2570	1
742–09	74	H	290	170.3	485.2	697.5	31.0	35.8	450	2570	1
753–40	75	H	25	313.5	610.4	1056.6	51.5	67.9	Unaged		1
753–41	75	H	25	330.5	589.8	931.7	44.9	74.9	Unaged		1
752–17	75	H	25	353.1	731.5	1441.4	44.7	64.0	400	2570	1
754–21	75	H	25	355.9	693.7	1822.9	61.9	75.0	320	10000	1
754–25	75	H	25	406.3	706.0	1763.9	50.6	71.2	320	10000	1
752–25	75	H	25	–	667.8	1677.6	42.7	68.4	350	2570	1
752–26	75	H	25	346.5	688.9	1522.3	42.8	64.6	350	2570	1
754–06	75	H	25	332.7	741.1	1543.1	46.7	59.6	350	10000	1
754–07	75	H	25	352.5	728.5	1159.6	45.4	54.2	350	10000	1
75–119	75	V	25	354.0	742.8	1437.7	49.7	53.6	350	10000	1
752–16	75	H	25	326.7	703.6	1531.0	43.6	64.3	400	2570	1
752–15	75	H	25	405.3	777.1	1305.1	42.4	45.0	400	10000	1
752–22	75	H	25	–	749.1	1093.5	30.7	37.6	400	10000	1
75–109	75	V	25	355.9	736.8	1171.8	44.0	46.3	400	10000	1
751–04	75	H	25	311.7	721.2	1094.2	30.6	38.4	450	2570	1
751–05	75	H	25	314.7	746.4	1217.2	37.5	41.6	450	2570	1
753–42	75	H	290	191.5	474.8	620.7	42.1	45.0	Unaged		1
754–40	75	H	290	196.8	470.8	652.0	37.0	63.1	Unaged		1
754–26	75	H	290	205.6	538.0	945.5	39.8	64.7	320	10000	1
754–27	75	H	290	212.2	534.3	957.8	40.2	64.6	320	10000	1
752–27	75	H	290	204.7	528.8	843.9	36.1	49.4	350	2570	1
754–09	75	H	290	219.8	614.1	918.6	34.6	44.8	350	10000	1
75–120	75	V	290	209.9	595.6	854.7	44.0	35.4	350	10000	1
752–18	75	H	290	203.2	591.1	799.6	36.9	41.0	400	2570	1
752–24	75	H	290	208.2	630.4	858.4	33.6	31.4	400	10000	1
75–110	75	V	290	206.7	593.1	884.1	35.5	42.4	400	10000	1
751–06	75	H	290	218.7	598.2	749.6	34.4	24.7	450	2570	1
752–09	75	H	290	197.7	606.2	888.1	35.8	33.0	450	2570	1

[a] 1 = Argonne National Laboratory; 2 = Materials Engineering Associates.

Appendix D

J–R Curve Characterization

The J–R curve tests were conducted according to ASTM Specifications E 813 Rev. 85 and E 1152. Compact–tension (CT) specimens, 25.4 mm (1 in.) thick with 10% side grooves, were used for the tests. The tests were conducted at MEA and at ANL. The results for four commercial and four experimental heats, aged at 350, 400, and 450°C for times up to 10,000 h, as well as the KBR pump cover plate material, are given in Table D–1. The data from the MEA tests have been presented in a report entitled "Compilation of Tensile and J–R Curve Data from Thermally–Aged Stainless Steel," by A. L. Hiser, MEA–2239, Vols. I–III, October 1987.

Both deformation theory and modified forms of J integral are listed in Table D–1. The J_{IC} and tearing modulus were determined in accordance with ASTM E 813 Rev. 85. For all tests, the J vs Δa data did not follow the blunting line expressed by $J = 2\sigma_f \Delta a$, where σ_f is the flow stress defined by the mean of yield and ultimate stress. The data were always to the left of the blunting line. A better fit of the data was obtained by changing the slope of the blunting line to $4\sigma_f$ instead of $2\sigma_f$. Examples are shown in Figs. D–1 and D–2 for the J–R curve test data obtained for the KRB pump cover plate and Heat 205. Consequently, fracture toughness J_{IC} values were determined with the $4\sigma_f$ slope for the blunting and offset lines.

The J_{IC} and tearing modulus were also determined according to the procedure used by MEA. Fracture toughness J_{IC} is defined as the intersection of the 0.15–offset line with the power–law fit of the data between the exclusion lines.

The experimental data and analyses for the ANL tests are included. The various validity criteria specified in ASTM E–813 for J_{IC} and E 5112 for the J–R curve were used to qualify the test data. The validity criteria for J_{IC} or J–R curve were not met for all the tests. The reasons for the discrepancy are data point spacing, shape of the final crack front, or size of the uncracked ligament. In general, the size of the uncracked ligament or the specimen thickness was inadequate for the unaged or short–term–aged specimens because of the relatively high toughness of the material. The J_{max} limit for the J vs Δa data was ignored in most tests to obtain a good power law fit of the test data.

All tests showed significant load relaxation during the unloading/reloading cycle for estimating the crack length by elastic compliance. The unloading curves for the KRB pump cover plate, tested at room temperature and 290°C, are shown in Fig. D–3. All unloadings were 25% of the load. The load at the end of the unloading/reloading cycle is always lower than it was at the start of the unloading cycle. The difference is appreciable for the room temperature test. Consequently, the initial 20–30% of the unloading curve, marked by horizontal dashes in Fig. D–3, was ignored in estimating the crack length.

The shape of the crack front was also very irregular for most cast stainless steels. This may be attributed to the coarse grain structure of the cast material. Cast stainless steels with large columnar grains, in particular, showed significant variation in crack length along the width of a specimen. Furthermore, the crack front always had a leading crack near the edges of the specimen. Consequently, the near–surface measurements of the final physical crack length were often >±1.02 mm, the maximum value allowed for data qualification.

The fracture surfaces often showed uncracked ridges or ligaments along the direction of crack extension. The uncracked ligaments add significant error to the estimation of crack length by compliance. Therefore, the difference between the crack extension predicted from elastic compliance and the average measured physical crack extension is more than the maximum value allowed by ASTM E 1152.

Table D–1. J–R Curve Results for Cast Stainless Steels.

Specimen		Orien-	Test		Δa Final[a]		Deformation J[b]				Modified J[b]				Flow	Impact	Condition	
Number	Heat	tation	Temp.		Comp.	Opt.	J_{IC}		C		J_{IC}		C		Stress	Energy[c]	Temp.	Time
			(°C)	a/W	(mm)	(mm)	(kJ/m²)	T_{av}	(kJ/m²)	n	(kJ/m²)	T_{av}	(kJ/m²)	n	(MPa)	(J/cm²)	(°C)	(h)
									CF-3									
I1S-03	I	C-L	25	0.530	13.50	12.90	475.9	604	781.5	0.694	435.2	712	796.0	0.788	411.2	179.7	Unaged	
I1S-01	I	L-C	25	0.538	15.20	13.77	623.9	541	861.5	0.591	639.2	610	896.5	0.638	411.2	179.7	Unaged	
I2S-01	I	L-C	25	0.534	12.18	13.66	478.2	675	811.6	0.743	483.6	741	840.7	0.784	411.2	179.7	Unaged	
I1S-07	I	L-C	25	0.561	6.44	6.75	453.5	353	707.5	0.560	473.3	380	739.7	0.580	450.6	214.4	320	30000
I1S-06	I	C-L	25	0.527	12.69	14.72	497.8	336	741.1	0.522	506.7	373	771.1	0.558	466.8	141.2	350	10000
I1S-04	I	L-C	25	0.535	12.86	14.04	455.9	334	705.8	0.539	462.9	369	733.9	0.574	466.8	141.2	350	10000
I2S-03	I	L-C	25	0.544	12.93	14.17	330.2	463	684.2	0.747	333.6	501	710.1	0.778	466.8	141.2	350	10000
I1S-02	I	L-C	290	0.525	13.18	14.83	386.1	491	512.6	0.459	393.4	563	534.3	0.506	284.2	140.7	Unaged	
I2S-02	I	L-C	290	0.532	6.21	7.23	376.7	633	536.9	0.561	393.0	670	557.0	0.576	284.2	140.7	Unaged	
I1S-05	I	L-C	290	0.541	12.45	13.62	249.9	367	385.5	0.480	252.9	411	402.2	0.518	303.7	130.1	350	10000
I2S-04	I	L-C	290	0.538	12.65	13.91	274.5	425	425.0	0.512	277.5	476	443.2	0.552	303.7	130.1	350	10000
P2B-03	I	C-L	25	0.538	6.92	7.95	1271.7	1194	1250.6	0.817	1301.3	1393	1256.5	0.898	381.0	385.8	Unaged	
P2B-01	I	L-C	25	0.541	6.25	7.18	1300.1	1400	1241.6	0.890	1245.6	1592	1225.2	0.961	381.0	385.8	Unaged	
P2T-01	I	L-C	25	0.539	3.18	2.92	1365.3	1104	1274.3	0.754	1480.4	1113	1315.3	0.747	381.0	385.8	Unaged	
P2T-06	I	L-C	25	0.791	3.31	4.17	935.4	988	1178.3	0.820	1025.5	1140	1236.9	0.879	421.7	360.4	350	3000
P2T-08	I	L-C	25	0.531	9.52	10.76	913.3	1091	1221.9	0.897	989.9	1154	1261.8	0.913	436.8	286.7	350	10000
P2T-10	I	L-C	25	0.531	8.53	8.39	1468.0	903	1426.5	0.728	1647.8	1000	1487.1	0.767	436.8	286.7	350	10000
P2B-11	I	C-L	25	0.556	2.58	4.00	688.4	575	960.6	0.643	710.3	639	998.1	0.686	434.7	224.2	350	30000
P2B-06	I	L-C	25	0.527	11.83	13.04	747.1	808	1053.6	0.765	787.2	893	1097.5	0.804	426.4	159.5	400	10000
P2T-04	I	L-C	25	0.528	11.26	12.18	820.2	681	1059.3	0.666	849.6	758	1096.7	0.711	426.4	159.5	400	10000
P2B-02	I	L-C	290	0.531	6.51	8.03	1483.5	1435	1080.9	0.691	1749.4	1682	1102.3	0.765	268.5	300.5	Unaged	
P2T-02	I	L-C	290	0.534	3.62	3.98	892.3	1272	873.7	0.694	949.6	1524	891.5	0.782	268.5	300.5	Unaged	
P2T-07	I	L-C	290	0.525	8.36	9.50	1060.3	1208	980.8	0.689	1154.4	1397	1004.8	0.756	288.2	347.5	350	3000
P2T-09	I	L-C	290	0.529	8.44	10.47	1033.8	1272	964.9	0.717	1182.9	1382	1013.5	0.743	286.8	321.5	350	10000
P2T-05	I	L-C	290	0.515	11.85	13.63	874.6	732	893.1	0.484	917.2	866	920.0	0.548	288.6	-	400	10000
692-08B	69	H	25	0.530	13.72	16.07	204.4	263	405.4	0.597	205.3	287	421.6	0.628	435.5	207.1	Unaged	
692-08T	69	H	25	0.537	13.34	14.60	267.0	408	552.9	0.700	268.8	438	571.9	0.728	435.5	207.1	Unaged	
691-04B	69	H	25	0.519	12.47	13.61	702.9	307	888.8	0.425	720.9	350	925.5	0.466	467.7	154.1	350	3000
691-01T	69	H	25	0.552	10.97	10.33	480.1	416	762.0	0.604	489.0	459	793.3	0.641	452.1	188.6	350	10000

Table D–1. (Contd.)

Specimen Number	Heat	Orientation	Test Temp. (°C)	a/W	Δa Final[a] Comp. (mm)	Δa Final[a] Opt. (mm)	Deformation J[b] J_{IC} (kJ/m²)	Deformation J[b] T_{av}	Deformation J[b] C (kJ/m²)	Deformation J[b] n	Modified J[b] J_{IC} (kJ/m²)	Modified J[b] T_{av}	Modified J[b] C (kJ/m²)	Modified J[b] n	Flow Stress (MPa)	Impact Energy[c] (J/cm²)	Condition Temp. (°C)	Condition Time (h)
691-03B	69	H	25	0.514	12.86	13.65	454.9	200	614.2	0.368	459.3	229	639.4	0.408	469.1	141.6	400	3000
696-01T	69	H	25	0.566	5.11	5.90	323.1	244	548.3	0.527	328.9	268	573.1	0.558	484.0	96.9	400	10000
691-05B	69	H	25	0.517	12.85	14.04	495.1	212	661.4	0.375	503.7	243	690.3	0.413	472.7	121.1	450	3000
693-07T	69	H	290	0.532	12.87	14.50	700.1	378	756.3	0.312	723.6	467	785.8	0.370	301.4	257.6	Unaged	
693-01V	69	V	290	0.582	12.53	13.56	266.3	423	424.8	0.540	252.3	504	439.5	0.621	301.4	257.6	Unaged	
691-06T	69	H	290	0.530	12.97	14.17	450.9	231	523.7	0.259	465.1	280	550.0	0.301	312.2	261.1	350	3000
691-05T	69	H	290	0.526	12.47	13.42	255.0	301	368.5	0.412	256.5	345	384.7	0.456	304.4	140.6	450	3000
691-03T	69	H	290	0.519	12.77	13.75	261.9	256	376.0	0.395	264.3	291	392.3	0.433	327.6	123.8	450	3000
									CF-8									
C1B-03	C1	C-L	25	0.531	13.47	15.20	306.3	557	549.0	0.664	310.3	606	569.8	0.696	356.2	59.7	Unaged	
C1B-01	C1	L-C	25	0.526	12.87	14.45	291.9	230	404.6	0.361	295.2	264	422.5	0.399	356.2	59.7	Unaged	
C1B-02	C1	L-C	25	0.537	11.60	12.65	185.3	455	416.5	0.724	186.1	489	431.3	0.752	356.2	59.7	Unaged	
C1B-04	C1	L-C	290	0.529	12.89	14.44	–	–	–	–	254.0	625	384.5	0.539	241.1	–	Unaged	
C1B-05	C1	L-C	290	0.529	132.1	14.95	236.4	583	362.4	0.527	254.3	600	380.3	0.523	241.1	–	Unaged	
KRB-01	KRB	R-C	25	0.553	6.58	6.49	396.2	403	657.1	0.602	400.4	447	684.6	0.642	428.4	115.4	284	68000
KRB-04	KRB	R-C	25	0.576	6.69	7.29	531.6	626	843.9	0.687	536.9	698	875.9	0.734	428.0	217.4	Reannealed	
KRB-05	KRB	C-R	290	0.609	9.10	10.58	681.1	337	764.3	0.346	707.5	420	802.1	0.411	329.0	321.2	284	68000
P1B-03	P1	C-L	25	0.526	10.27	12.53	592.2	603	866.5	0.652	602.6	670	898.0	0.697	413.8	228.3	Unaged	
P1B-01	P1	L-C	25	0.524	8.42	9.07	413.3	678	776.1	0.785	419.8	733	803.4	0.818	416.5	228.3	Unaged	
P1T-01	P1	L-C	25	0.537	9.25	10.42	560.3	1124	1017.4	0.958	610.7	1132	1045.3	0.946	416.5	228.3	Unaged	
P1B-11	P1	L-C	25	0.551	–	8.28	1002.3	407	1105.6	0.429	1069.2	465	1163.1	0.468	420.7	207.3	320	30000
P1T-08	P1	C-L	25	0.519	13.90	13.07	209.1	445	526.3	0.808	202.0	493	546.4	0.861	439.8	156.4	350	10000
P1B-06	P1	L-C	25	0.523	3.88	3.07	707.3	437	945.8	0.544	720.2	497	982.0	0.594	458.1	156.4	350	10000
P1T-06	P1	L-C	25	0.525	12.58	13.79	468.0	565	837.6	0.740	468.4	622	866.5	0.783	458.1	156.4	350	10000
P1B-09	P1	L-C	25	0.562	7.70	9.78	409.0	420	708.2	0.644	414.7	460	735.7	0.679	451.4	87.7	350	30000
P1B-05	P1	L-C	25	0.535	12.35	14.13	228.7	231	445.0	0.582	230.8	249	462.2	0.609	481.8	51.7	400	10000
P1T-04	P1	L-C	25	0.558	11.75	12.22	186.8	187	368.0	0.558	188.1	203	382.7	0.586	481.8	51.7	400	10000
P1B-02	P1	L-C	290	0.522	12.79	14.84	554.7	534	664.1	0.448	571.2	624	691.7	0.501	295.8	255.8	Unaged	
P1T-02	P1	L-C	290	0.533	12.38	14.46	630.9	630	733.8	0.488	674.5	688	771.2	0.512	295.8	255.8	Unaged	

Table D–1. (Contd.)

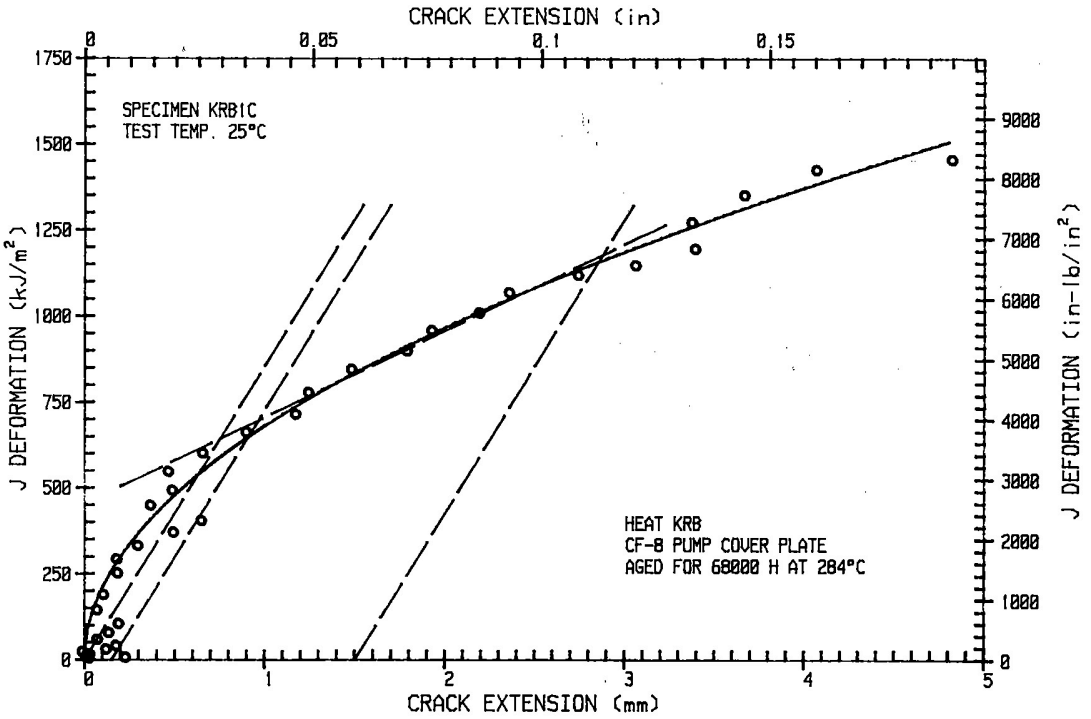
Specimen		Orien-	Test		Δa Final[a]		Deformation J[b]				Modified J[b]				Flow	Impact	Condition	
Number	Heat	tation	Temp. (°C)	a/W	Comp. (mm)	Opt. (mm)	J_{IC} (kJ/m²)	T_{av}	C (kJ/m²)	n	J_{IC} (kJ/m²)	T_{av}	C (kJ/m²)	n	Stress (MPa)	Energy[c] (J/cm²)	Temp. (°C)	Time (h)
P1B-07	P1	L-C	290	0.527	7.19	9.63	400.7	384	529.9	0.424	428.2	410	559.7	0.434	315.8	244.7	350	10000
P1T-07	P1	L-C	290	0.526	12.36	14.10	542.1	469	663.3	0.435	558.4	537	691.7	0.484	315.8	244.7	350	10000
P1T-05	P1	L-C	290	0.513	12.48	13.47	293.7	391	451.7	0.505	298.7	431	470.0	0.538	324.2	133.5	400	10000
683-05B	68	H	25	0.527	13.04	14.68	324.4	396	552.8	0.586	327.0	432	572.9	0.619	400.2	245.4	Unaged	
683-05T	68	H	25	0.519	13.88	16.29	282.3	335	485.5	0.554	284.0	369	504.1	0.590	400.2	245.4	Unaged	
683-03V	68	V	25	0.528	12.81	15.00	311.8	364	526.0	0.562	315.5	398	546.3	0.594	400.2	245.4	Unaged	
681-04B	68	H	25	0.543	10.22	11.65	798.0	560	1037.7	0.608	832.0	607	1075.5	0.636	444.3	192.9	350	3000
682-02T	68	H	25	0.560	8.08	8.35	285.3	511	641.6	0.796	287.8	551	665.2	0.826	442.5	100.0	350	10000
681-03B	68	H	25	0.548	10.73	12.13	408.4	307	648.6	0.531	412.6	338	673.6	0.566	467.8	74.1	400	3000
681-11T	68	H	25	0.553	7.08	6.85	260.5	253	487.6	0.578	266.1	265	502.6	0.590	472.5	46.4	400	10000
681-04T	68	H	25	0.531	12.92	14.52	294.7	193	467.7	0.448	296.6	214	486.1	0.480	471.7	54.2	450	3000
681-05B	68	H	25	0.540	–	–	252.6	330	532.9	0.680	253.2	356	551.9	0.711	471.7	54.2	450	3000
683-07T	68	H	290	0.536	12.59	14.50	753.1	368	783.0	0.271	752.5	545	795.3	0.384	282.2	287.1	Unaged	
681-06T	68	H	290	0.544	13.40	15.28	406.3	573	592.8	0.575	413.7	642	617.0	0.619	318.8	147.5	350	3000
681-05T	68	H	290	0.550	12.69	14.66	335.4	362	464.9	0.431	343.1	414	487.9	0.473	312.2	139.6	450	3000
681-03T	68	H	290	0.529	12.69	13.77	312.2	319	454.9	0.446	316.5	361	475.1	0.486	338.5	124.8	450	3000
									Weld									
205-23C	205	L-C	290	0.511	15.71	16.36	185.0	149	328.1	0.482	186.7	161	339.7	0.506	440.2	123.5	400	18000
									CF-8M									
205-25C	205	L-C	25	0.569	10.45	11.65	275.8	248	493.9	0.555	274.9	274	513.4	0.593	461.1	113.8	400	18000
205-24C	205	L-C	290	0.581	9.93	11.14	207.2	256	340.0	0.475	208.1	285	354.3	0.512	339.0	116.3	400	18000
207-09C	205	L-C	290	0.564	10.76	11.09	615.1	409	718.8	0.405	642.9	483	755.8	0.456	320.5	271.6	Unaged	
207-10C	205	L-C	290	0.573	9.47	10.78	473.9	508	637.0	0.526	484.5	578	663.9	0.574	320.5	271.6	Unaged	
743-05B	74	H	25	0.528	12.61	14.71	610.3	415	795.4	0.481	633.5	451	826.1	0.505	405.1	210.1	Unaged	
743-05T	74	H	25	0.523	12.44	14.04	577.1	276	710.6	0.355	595.4	323	746.0	0.398	405.1	210.1	Unaged	
741-06T	74	H	25	0.532	12.55	14.31	692.1	385	852.6	0.439	724.7	437	895.6	0.476	410.5	159.1	350	3000
741-03B	74	H	25	0.514	12.35	15.18	389.0	248	556.5	0.420	394.0	277	578.7	0.455	429.6	128.9	400	3000
741-03T	74	H	25	0.522	13.08	14.57	238.8	210	404.0	0.483	241.7	226	418.0	0.505	438.5	84.6	450	3000
741-03B	74	H	25	0.533	12.91	13.74	289.4	288	502.9	0.548	296.2	297	514.8	0.554	438.5	84.6	450	3000

Table D–1. (Contd.)

Specimen Number	Heat	Orientation	Test Temp. (°C)	a/W	Δa Final[a] Comp. (mm)	Δa Final[a] Opt. (mm)	Deformation J[b] J_{IC} (kJ/m²)	Deformation J[b] T_{av}	Deformation J[b] C (kJ/m²)	Deformation J[b] n	Modified J[b] J_{IC} (kJ/m²)	Modified J[b] T_{av}	Modified J[b] C (kJ/m²)	Modified J[b] n	Flow Stress (MPa)	Impact Energy[c] (J/cm²)	Condition Temp. (°C)	Condition Time (h)
752-08T	75	H	25	0.584	10.80	11.92	463.2	226	639.4	0.405	471.9	259	670.1	0.447	461.0	236.9	Unaged	
752-02T	75	H	25	0.548	11.92	12.16	274.2	164	478.0	0.496	276.6	178	495.9	0.523	542.8	46.0	350	10000
751-01T	75	H	25	0.565	11.39	13.13	78.8	117	233.5	0.751	78.7	124	240.8	0.772	561.9	35.8	400	10000
752-08B	75	H	290	0.579	7.83	8.49	436.8	386	583.3	0.453	448.2	444	611.6	0.498	333.5	164.8	Unaged	
753-03V	75	V	290	0.565	8.32	9.21	493.4	289	600.0	0.347	500.4	365	630.5	0.418	333.5	164.8	Unaged	
758-02C	758	L-C	25	0.582	10.84	10.39	91.2	101	209.0	0.591	91.5	108	216.6	0.613	501.0	69.6	400	18000
758-03C	758	L-C	25	0.568	11.57	13.56	103.4	116	239.1	0.607	103.4	124	247.3	0.632	501.0	69.6	400	18000
758-01C	758	L-C	290	0.567	11.90	12.37	167.4	128	268.8	0.400	167.8	142	279.8	0.432	397.1	118.1	400	18000

[a] *According to ASTM E-813 but with a slope of 4 times the flow stress for the blunting line.*

[b] *Final crack extension: Comp. Determined from computer and Opt. Measured optically.*



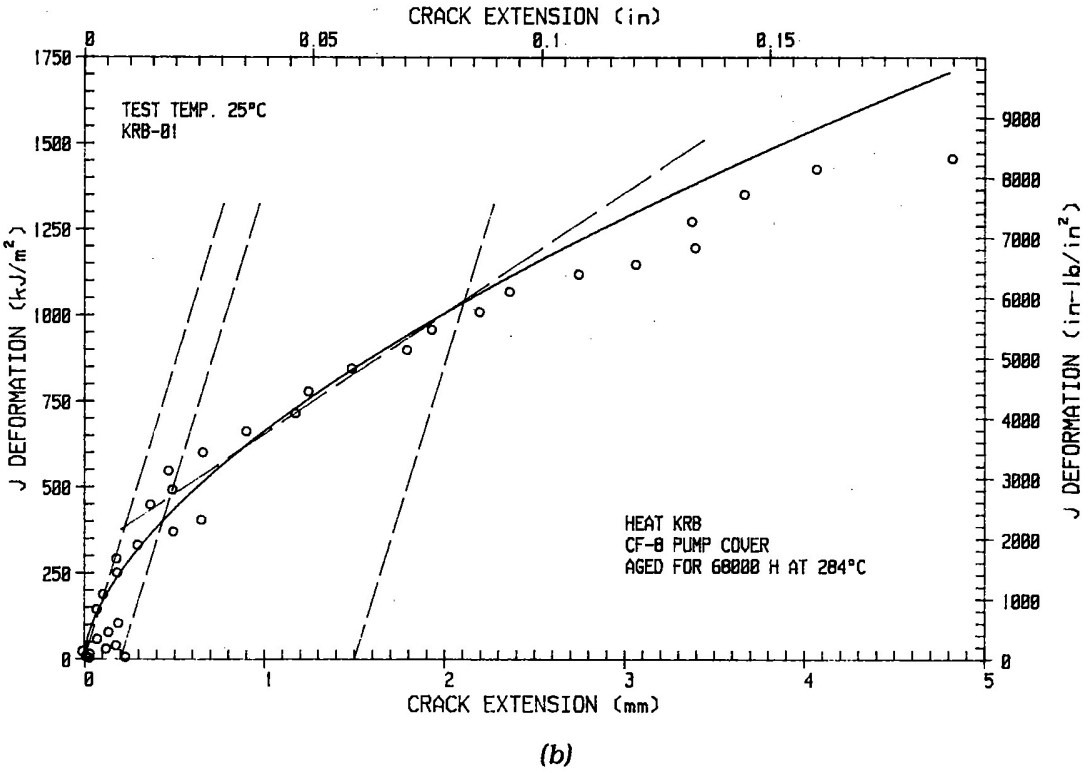
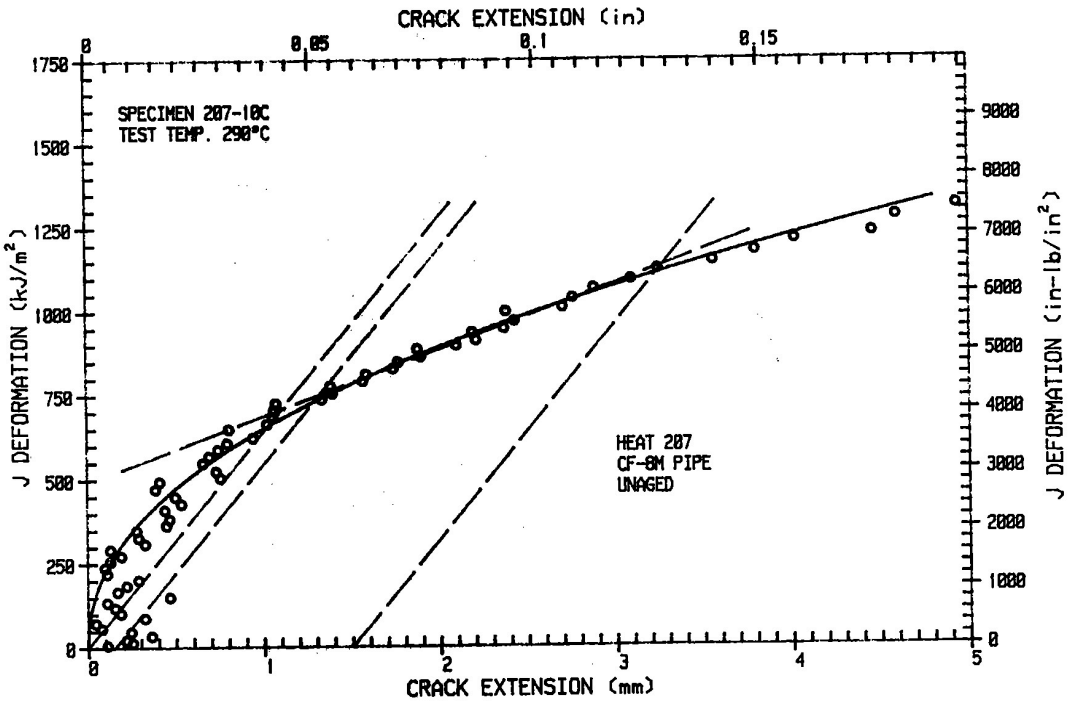
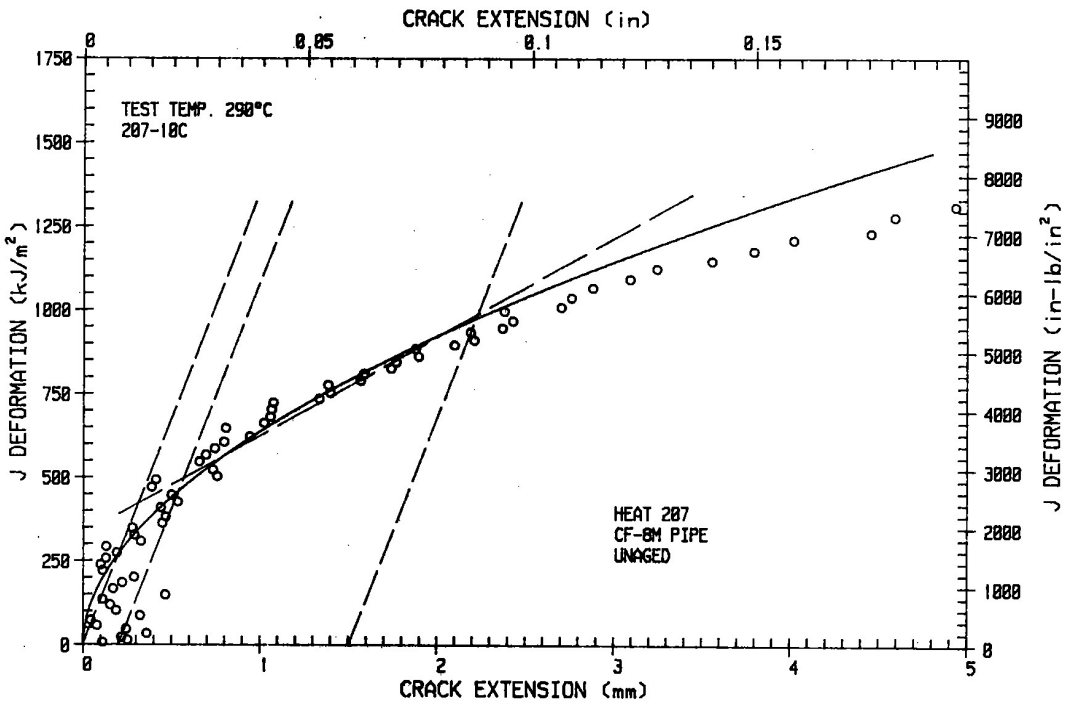


Figure D–1. Analysis of the J vs Δa Data for the KRB Material Using a Slope of (a) $2\sigma_f$ and (b) $4\sigma_f$ for the Blunting Line.

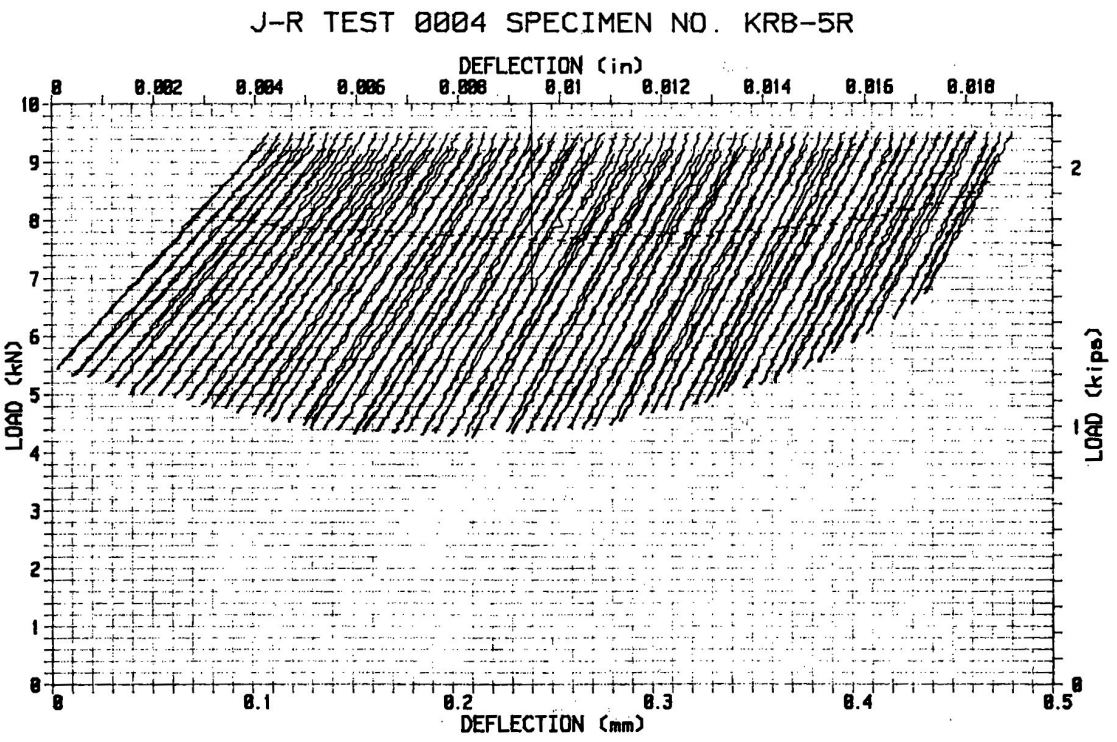


(a)

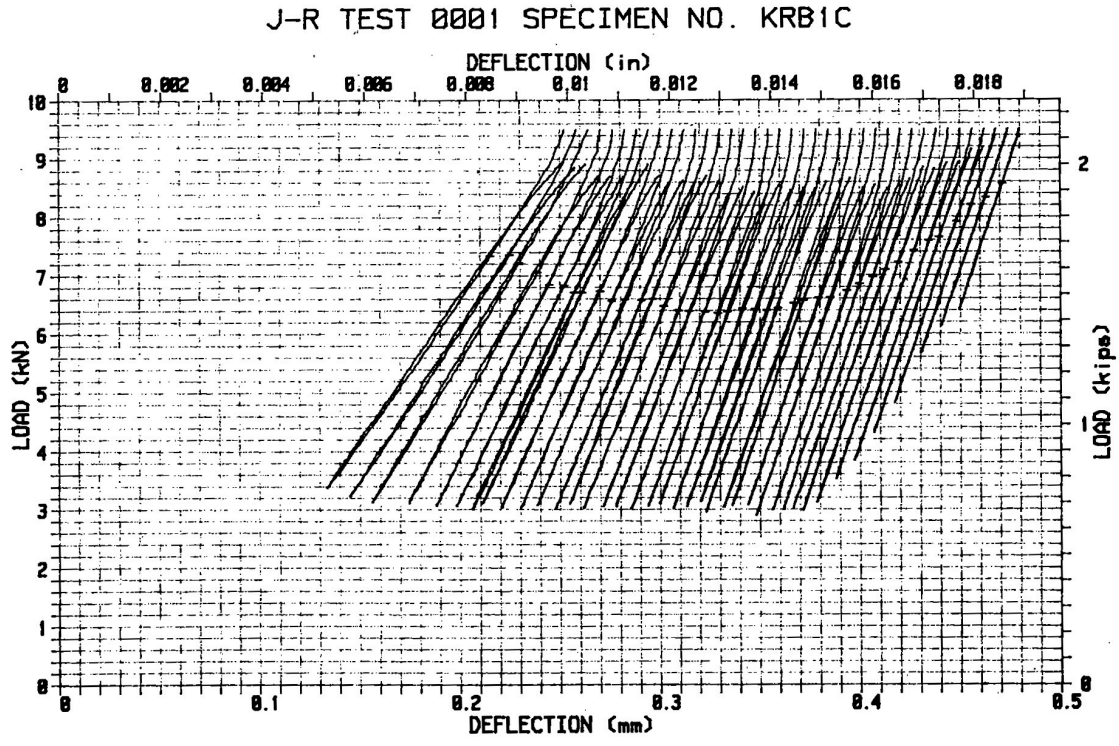


(b)

Figure D–2. Analysis of the J vs Δa Data for Heat 207 Using a Slope of (a) $2\sigma_f$ and (b) $4\sigma_f$ for the Blunting Line.



(a)



(b)

Figure D–3. Unloading Curves for the KRB Material Tested at (a) Room Temperature and (b) 290°C.

J–R CURVE TEST DATA

Table D–2. Test Data for Specimen 693–01V

Test Number	:	0003	Test Temp	:	290°C
Material Type	:	CF–3 Slab	Heat Number	:	69
Aging Temp	:	25°C	Aging Time	:	0 h
Spec. Thickness	:	25.40 mm	Net Thickness	:	20.33 mm
Spec. Width	:	50.82 mm	Flow Stress σ_f	:	301.40 MPa

Unload Number	J_d (kJ/m^2)	J_m (kJ/m^2)	Δa (mm)	Load (kN)	Deflection (mm)
1	8.83	8.81	−0.0656	12.966	0.242
2	19.25	19.20	−0.1113	14.949	0.386
3	32.98	33.08	−0.0143	16.207	0.556
4	48.19	48.21	−0.0493	17.193	0.734
5	63.78	63.98	0.0060	17.880	0.905
6	80.63	80.81	0.0029	18.463	1.085
7	101.04	100.75	−0.0830	19.103	1.292
8	129.15	129.35	−0.0153	19.912	1.571
9	152.38	155.33	0.3017	20.430	1.812
10	175.93	177.81	0.1955	20.992	2.031
11	199.11	202.09	0.2914	21.311	2.244
12	220.29	224.24	0.3662	21.669	2.441
13	250.37	252.02	0.2094	22.063	2.689
14	273.76	279.95	0.4900	22.487	2.915
15	299.28	303.87	0.3994	22.766	3.127
16	326.23	330.92	0.4045	22.975	3.348
17	352.53	362.11	0.6360	23.212	3.597
18	375.95	391.90	0.9149	23.399	3.837
19	403.75	421.03	0.9689	23.552	4.075
20	432.96	449.92	0.9569	23.609	4.304
21	461.90	483.44	1.1179	23.710	4.558
22	486.30	513.17	1.2939	23.623	4.788
23	518.15	547.52	1.3713	23.584	5.057
24	541.57	579.10	1.6104	23.629	5.294
25	567.52	606.67	1.6553	23.541	5.512
26	588.78	635.94	1.8683	23.364	5.729
27	610.32	662.42	1.9940	23.264	5.935
28	628.05	691.96	2.2832	23.137	6.155
29	650.69	718.11	2.3658	23.046	6.362
30	675.51	748.72	2.4963	22.874	6.592
31	696.38	776.46	2.6453	22.848	6.802
32	718.76	810.41	2.8861	22.681	7.055
33	741.17	846.48	3.1584	22.366	7.326
34	763.20	882.56	3.4269	21.920	7.600
35	804.05	926.16	3.4765	21.510	7.942
36	832.81	970.23	3.7402	21.185	8.270
37	853.37	1015.84	4.1530	20.621	8.621
38	876.04	1061.81	4.5208	20.064	8.985
39	891.30	1109.09	5.0059	19.468	9.359
40	916.86	1152.33	5.2629	19.045	9.715
41	943.28	1203.76	5.6101	18.691	10.119
42	957.92	1252.84	6.0692	17.856	10.514
43	986.55	1312.76	6.4656	17.225	11.010
44	1023.97	1385.02	6.8805	16.455	11.609
45	1029.17	1466.57	7.7406	15.087	12.308
46	1068.17	1542.23	8.1283	14.249	13.007
47	1091.99	1632.08	8.7829	13.305	13.808
48	1123.29	1716.53	9.2772	12.377	14.610
49	1118.89	1797.04	10.0281	11.301	15.408
50	1110.71	1871.70	10.7261	10.061	16.209
51	1118.49	1943.67	11.2403	9.270	17.006
52	1111.15	2013.64	11.8313	8.332	17.806
53	1072.85	2076.08	12.5740	7.308	18.608

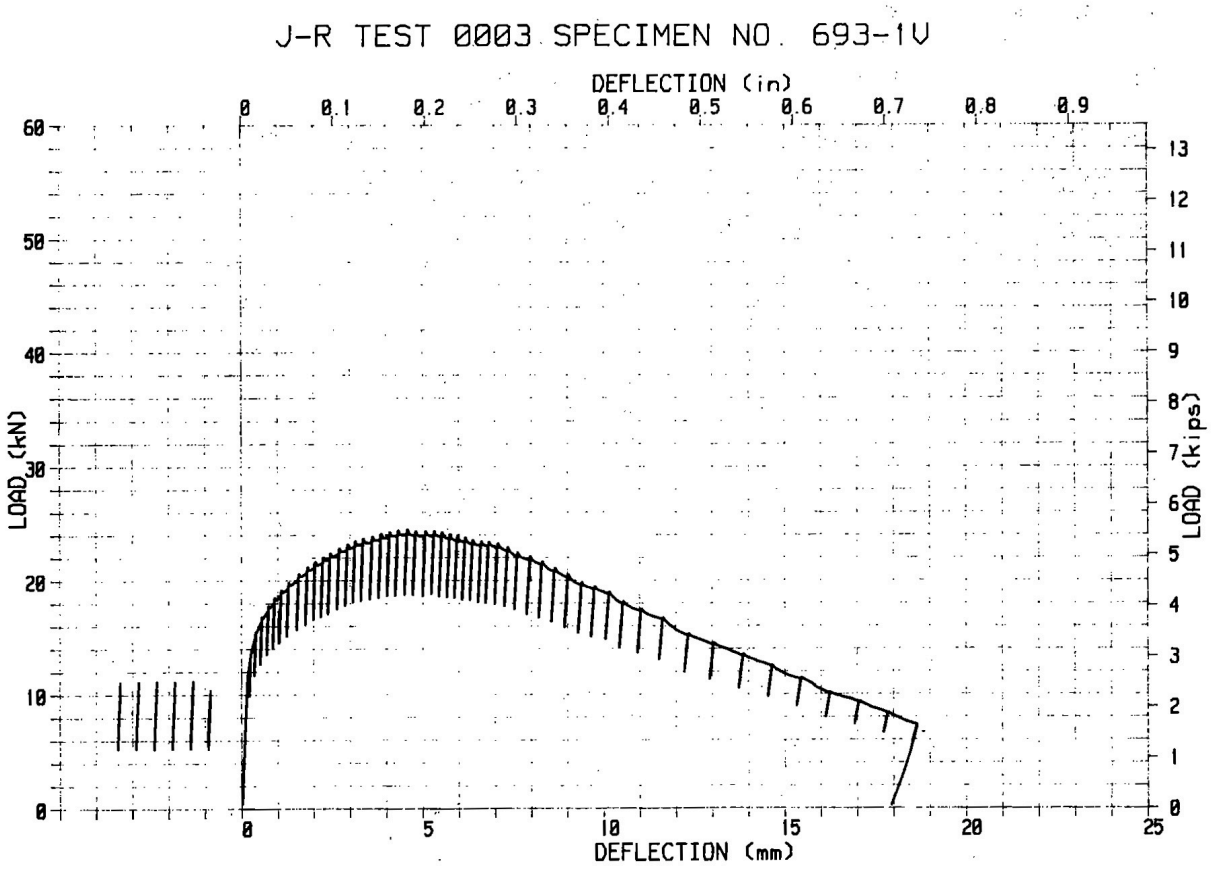


Figure D–4. Load vs Load Line Displacement Curve for Unaged Heat 69 Tested at 290°C.

Table D–3. Deformation J_{IC} and J–R Curve Results for Specimen 693–01V

Test Number	:	0003	Test Temp	:	290°C
Material Type	:	CF–3 Slab	Heat Number	:	69
Aging Temp	:	25°C	Aging Time	:	0 h
Spec. Thickness	:	25.40 mm	Net Thickness	:	20.33 mm
Spec. Width	:	50.82 mm	Flow Stress σ_f	:	301.40 MPa
Modulus E	:	177.49 GPa	(Effective)		
Modulus E	:	168.90 GPa	(Nominal)		
Initial Crack	:	29.5594 mm	Initial a/w	:	0.5816 (Measured)
Final Crack	:	43.1563 mm	Final a/w	:	0.8492 (Measured)
Final Crack	:	42.1334 mm	Final a/w	:	0.8291 (Compliance)

LINEAR FIT J = B+M(Δa)

Intercept B	=	188.161 kJ/m^2	Slope M	=	223.66
Fit Coeff R	=	0.9808	(14 Data Points)		
J_{IC}	=	231.0 kJ/m^2	(1319.2 in·lb/in^2)		
Δa (J_{IC})	=	0.192 mm	(0.0075 in)		
T Average	=	437.0	(J_{IC} at 0.15)		

POWER LAW FIT J=C(Δa)^n

Coeff C	=	424.77 kJ/m^2	Exponent N	=	0.5395
Fit Coeff R	=	0.9793	(14 Data Points)		
J_{IC} (0.20)	=	266.3 kJ/m^2	(1520.7 in·lb/in^2)		
Δa (J_{IC})	=	0.421 mm	(0.0166 in)		
T Average	=	422.7	(J_{IC} at 0.20)		
J_{IC} (0.15)	=	241.1 kJ/m^2	(1376.6 in·lb/in^2)		
Δa (J_{IC})	=	0.350 mm	(0.0138 in)		
T Average	=	431.1	(J_{IC} at 0.15)		
Kjc	=	331.7 MPa·m$^{0.5}$			

J_{IC} VALIDITY & DATA QUALIFICATION (E 813–85)

Jmax Allowed	:	427.20 kJ/m^2	(Jmax = $b_o\sigma_f$/15)
Data Limit	:	Jmax	Ignored
Δa (max) Allowed	:	2.014 mm	(at 1.5 exclusion line)
Data Limit	:	1.5 Exclusion line	
Data Points	:	Zone A = 4	Zone B = 4
Data Point Spacing	:	OK	
B_{net} and b_o Size	:	OK	
dJ/da at J_{IC}	:	OK	
Initial Crack Shape	:	OK	
Final Crack Shape	:	OK	
Crack Size Estimate	:	Inadequate	(by compliance)
E Effective	:	OK	
J_{IC} Estimate	:	INVALID	

J–R CURVE VALIDITY & DATA QUALIFICATION (E 1152–87)

Jmax Allowed	:	306.37 kJ/m^2	(Jmax = $B_{net}\sigma_f$/20)
Δa (max) Allowed	:	2.126 mm	(Δa = 0.1 b_o)
Δa (max) Allowed	:	4.949 mm	(Omega = 5)
Data Points	:	Zone A = 15	Zone B = 6
Data Point Spacing	:	Inadequate	
J–R Curve Data	:	INVALID	

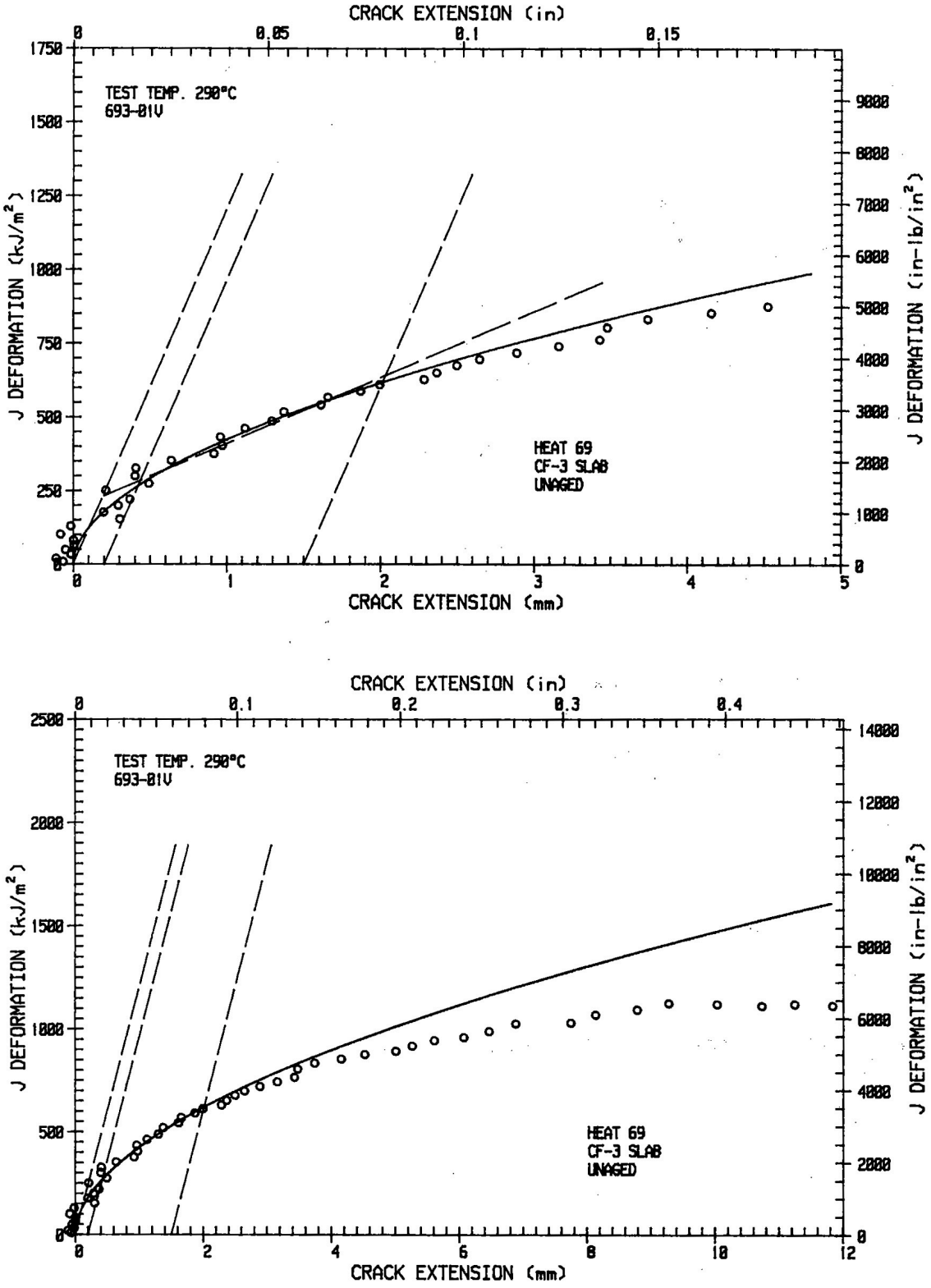


Figure D–5. Deformation J_{IC} and J–R Curve for Unaged Heat 69 Tested at 290°C.

Table D–4. Modified J_{IC} and J–R Curve Results for Specimen 693–01V

Test Number	:	0003	Test Temp	:	290°C
Material Type	:	CF–3 Slab	Heat Number	:	69
Aging Temp	:	25°C	Aging Time	:	0 h
Spec. Thickness	:	25.40 mm	Net Thickness	:	20.33 mm
Spec. Width	:	50.82 mm	Flow Stress σ_f	:	301.40 MPa
Modulus E	:	177.49 GPa	(Effective)		
Modulus E	:	168.90 GPa	(Nominal)		
Initial Crack	:	29.5594 mm	Initial a/w	:	0.5816 (Measured)
Final Crack	:	43.1563 mm	Final a/w	:	0.8492 (Measured)
Final Crack	:	42.1334 mm	Final a/w	:	0.8291 (Compliance)

LINEAR FIT $J = B+M(\Delta a)$

Intercept B	=	170.382 kJ/m^2	Slope M = 258.62
Fit Coeff R	=	0.9860	(13 Data Points)
J_{IC}	=	216.9 kJ/m^2	(1238.6 in·lb/in^2)
Δa (J_{IC})	=	0.180 mm	(0.0071 in)
T Average	=	505.3	(J_{IC} at 0.15)

POWER LAW FIT $J=C(\Delta a)^n$

Coeff C	=	439.34 kJ/m^2	Exponent N = 0.6208
Fit Coeff R	=	0.9924	(13 Data Points)
J_{IC} (0.20)	=	252.3 kJ/m^2	(1440.7 in·lb/in^2)
Δa (J_{IC})	=	0.409 mm	(0.0161 in)
T Average	=	504.4	(J_{IC} at 0.20)
J_{IC} (0.15)	=	222.7 kJ/m^2	(1271.6 in·lb/in^2)
Δa (J_{IC})	=	0.335 mm	(0.0132 in)
T Average	=	512.9	(J_{IC} at 0.15)
Kjc	=	350.2 MPa·m$^{0.5}$	

J_{IC} VALIDITY & DATA QUALIFICATION (E 813–85)

Jmax Allowed	:	427.20 kJ/m^2	(Jmax = $b_o\sigma_f/15$)
Data Limit	:	Jmax	Ignored
Δa (max) Allowed	:	2.073 mm	(at 1.5 exclusion line)
Data Limit	:	1.5 Exclusion line	
Data Points	:	Zone A = 3	Zone B = 4
Data Point Spacing	:	OK	
B_{net} and b_o Size	:	OK	
dJ/da at J_{IC}	:	OK	
Initial Crack Shape	:	OK	
Final Crack Shape	:	OK	
Crack Size Estimate	:	Inadequate	(by compliance)
E Effective	:	OK	
J_{IC} Estimate	:	INVALID	

J–R CURVE VALIDITY & DATA QUALIFICATION (E 1152–87)

Jmax Allowed	:	306.37 kJ/m^2	(Jmax = $B_{net}\sigma_f/20$)
Δa (max) Allowed	:	2.126 mm	($\Delta a = 0.1\ b_o$)
Δa (max) Allowed	:	5.613 mm	(Omega = 5)
Data Points	:	Zone A = 15	Zone B = 6
Data Point Spacing	:	Inadequate	
J–R Curve Data	:	INVALID	

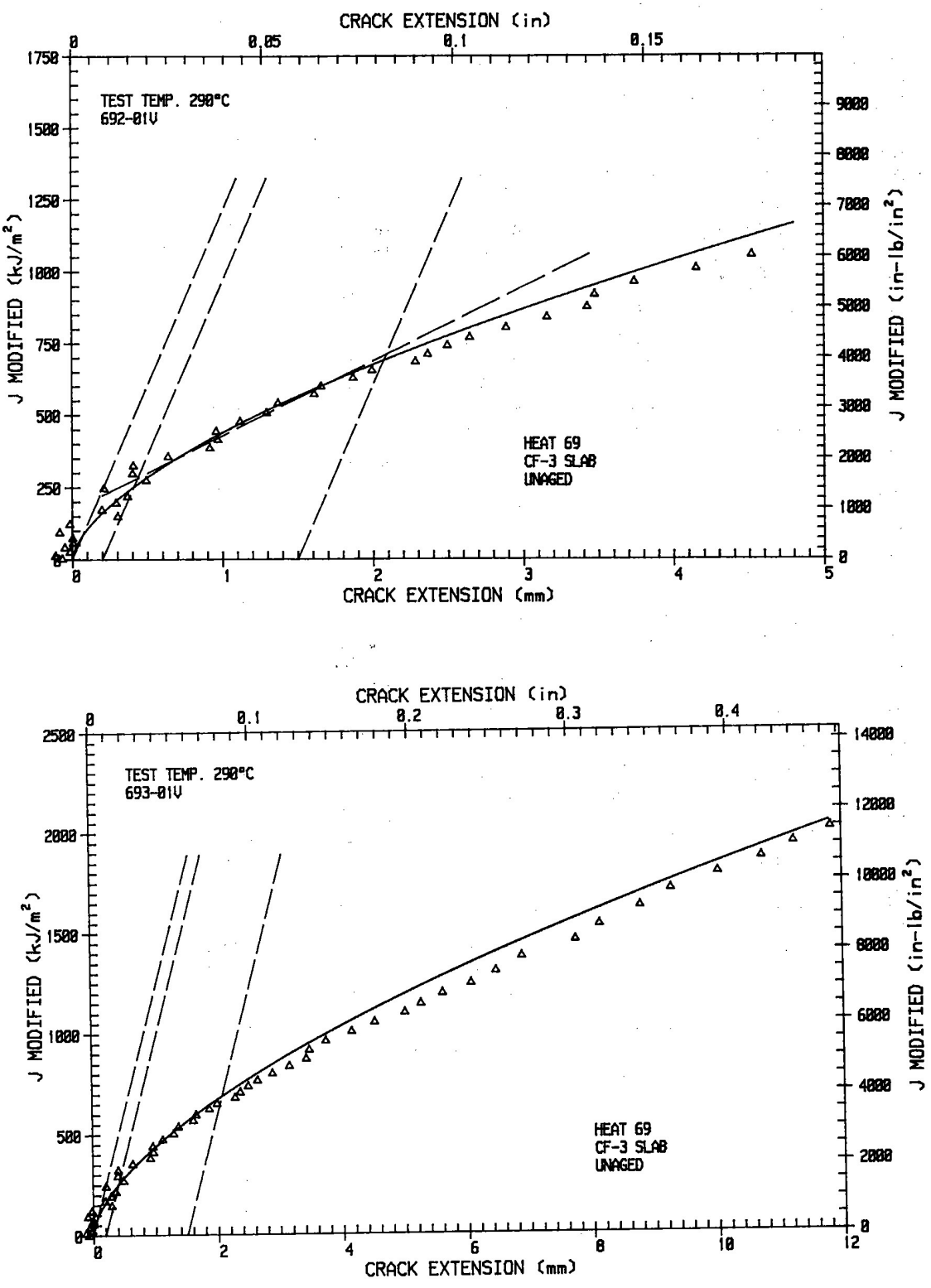


Figure D–6. Modified J_{IC} and J–R Curve for Unaged Heat 69 Tested at 290°C.

Table D–5. Test Data for Specimen KRB–01C

Test Number	:	0001	Test Temp	:	25°C
Material Type	:	CF–8 Pump Cover	Heat Number	:	KRB
Aging Temp	:	284°C	Aging Time	:	68,000 h
Spec. Thickness	:	25.40 mm	Net Thickness	:	20.33 mm
Spec. Width	:	50.84 mm	Flow Stress σ_f	:	428.35 MPa

Unload Number	J_d (kJ/m^2)	J_m (kJ/m^2)	Δa (mm)	Load (kN)	Deflection (mm)
1	3.98	3.98	0.0250	13.239	0.124
2	5.97	5.97	0.2258	15.607	0.152
3	8.22	8.21	0.0072	18.135	0.187
4	15.04	15.04	0.0286	22.038	0.255
5	22.80	22.78	–0.0110	25.084	0.325
6	29.64	29.71	0.1190	27.014	0.378
7	39.52	39.66	0.1743	29.145	0.454
8	57.92	57.84	0.0696	31.788	0.582
9	77.80	77.92	0.1328	33.724	0.704
10	104.31	104.67	0.1872	35.648	0.863
11	143.97	143.54	0.0673	37.615	1.087
12	188.29	188.19	0.1032	39.043	1.321
13	250.70	251.56	0.1801	40.418	1.646
14	291.45	292.25	0.1760	41.138	1.854
15	331.03	333.85	0.2930	41.584	2.055
16	369.63	376.32	0.4910	42.254	2.259
17	404.14	414.21	0.6472	42.534	2.443
18	448.30	451.51	0.3624	42.923	2.636
19	492.09	498.58	0.4852	43.260	2.840
20	547.08	552.91	0.4633	43.496	3.100
21	600.80	613.04	0.6554	43.407	3.370
22	662.48	683.73	0.8973	43.652	3.694
23	714.95	747.37	1.1716	43.471	3.985
24	778.26	813.91	1.2437	43.221	4.297
25	845.34	892.71	1.4824	43.203	4.647
26	899.71	963.31	1.7877	41.897	4.967
27	958.53	1030.04	1.9259	40.824	5.283
28	1009.67	1097.38	2.1918	40.818	5.592
29	1068.74	1167.30	2.3588	40.650	5.921
30	1119.81	1244.94	2.7436	40.820	6.268
31	1148.49	1296.33	3.0595	39.249	6.513
32	1196.47	1369.49	3.3913	39.014	6.854
33	1273.70	1445.23	3.3730	38.717	7.223
34	1352.49	1549.61	3.6662	38.000	7.690
35	1425.54	1660.20	4.0669	36.848	8.204
36	1456.09	1765.26	4.8186	33.776	8.704
37	1441.51	1826.52	5.5663	31.623	9.039
38	1470.02	1909.69	6.0822	30.563	9.493
39	1511.19	2006.39	6.5802	29.758	10.000

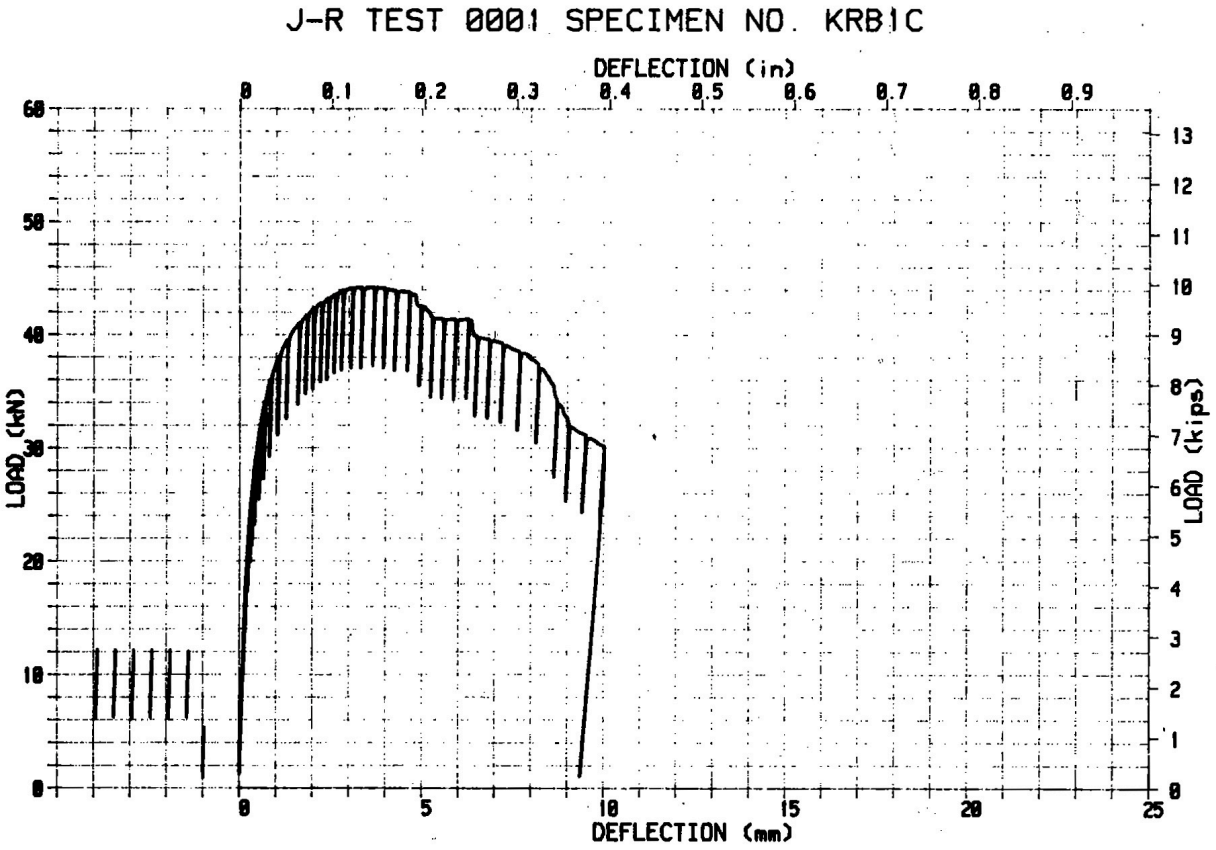


Figure D–7. Load vs Load Line Displacement Curve for Reactor–Aged KRB Pump Cover Plate Tested at Room Temperature.

Table D–6. Deformation J_{IC} and J–R Curve Results for Specimen KRB–01C

Test Number	:	0001	Test Temp	:	25°C
Material Type	:	CF–8 Pump Cover	Heat Number	:	KRB
Aging Temp	:	284°C	Aging Time	:	68,000 h
Spec. Thickness	:	25.40 mm	Net Thickness	:	20.33 mm
Spec. Width	:	50.84 mm	Flow Stress σ_f	:	428.35 MPa
Modulus E	:	199.86 GPa	(Effective)		
Modulus E	:	193.10 GPa	(Nominal)		
Initial Crack	:	28.0906 mm	Initial a/w	:	0.5525 (Measured)
Final Crack	:	34.5781 mm	Final a/w	:	0.6801 (Measured)
Final Crack	:	34.6708 mm	Final a/w	:	0.6820 (Compliance)

LINEAR FIT $J = B+M(\Delta a)$

Intercept B	=	305.506 kJ/m^2	Slope M = 350.67
Fit Coeff R	=	0.9566	(8 Data Points)
J_{IC}	=	384.1 kJ/m^2	(2193.4 in·lb/in^2)
Δa (J_{IC})	=	0.224 mm	(0.0088 in)
T Average	=	382.0	(J_{IC} at 0.15)

POWER LAW FIT $J=C(\Delta a)^n$

Coeff C	=	663.75 kJ/m^2	Exponent N = 0.6020
Fit Coeff R	=	0.9549	(8 Data Points)
J_{IC} (0.20)	=	401.9 kJ/m^2	(2294.9 in·lb/in^2)
Δa (J_{IC})	=	0.435 mm	(0.0171 in)
T Average	=	406.7	(J_{IC} at 0.20)
J_{IC} (0.15)	=	358.3 kJ/m^2	(2046.0 in·lb/in^2)
Δa (J_{IC})	=	0.359 mm	(0.0141 in)
T Average	=	413.8	(J_{IC} at 0.15)
Kjc	=	455.8 MPa·m$^{0.5}$	

J_{IC} VALIDITY & DATA QUALIFICATION (E 813–85)

Jmax Allowed	:	649.65 kJ/m^2	(Jmax = $b_o\sigma_f/15$)
Data Limit	:	Jmax	Ignored
Da (max) Allowed	:	2.107 mm	(at 1.5 exclusion line)
Data Limit	:	1.5 Exclusion line	
Data Points	:	Zone A = 2	Zone B = 2
Data Point Spacing	:	OK	
B_{net} or b_o Size	:	Inadequate	
dJ/da at J_{IC}	:	OK	
af Measurement	:	Near–surface	outside limit
Initial Crack Shape	:	OK	
Crack Size Estimate	:	OK	(by compliance)
E Effective	:	OK	
J_{IC} Estimate	:	INVALID	

J–R CURVE VALIDITY & DATA QUALIFICATION (E 1152–87)

Jmax Allowed	:	437.35 kJ/m^2	(Jmax = $B_{net}\sigma_f/20$)
Da (max) Allowed	:	2.275 mm	($\Delta a = 0.1\ b_o$)
Δa (max) Allowed	:	5.463 mm	(Omega = 5)
Data Points	:	Zone A = 17	Zone B = 10
Data Point Spacing	:	OK	
J–R Curve Data	:	INVALID	

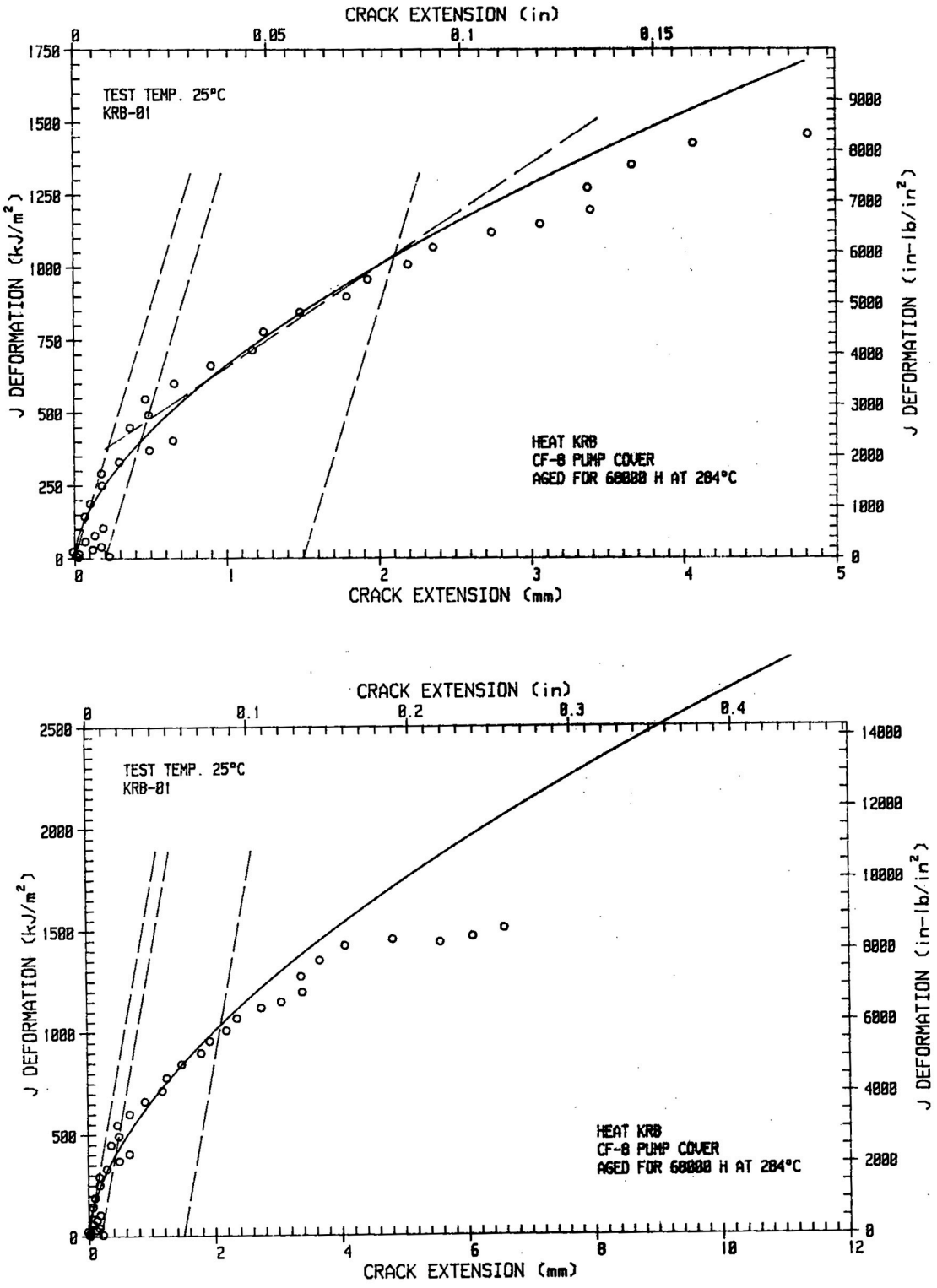


Figure D–8. Deformation J_{IC} and J–R Curve for Reactor–Aged KRB Pump Cover Plate Tested at Room Temperature.

Table D–7. Modified J_{IC} and J–R Curve Results for Specimen KRB–01C

Test Number	:	0001	Test Temp	:	25°C
Material Type	:	CF–8 Pump Cover	Heat Number	:	KRB
Aging Temp	:	284°C	Aging Time	:	68,000 h
Spec. Thickness	:	25.40 mm	Net Thickness	:	20.33 mm
Spec. Width	:	50.84 mm	Flow Stress σ_f	:	428.35 MPa
Modulus E	:	199.86 GPa	(Effective)		
Modulus E	:	193.10 GPa	(Nominal)		
Initial Crack	:	28.0906 mm	Initial a/w	:	0.5525 (Measured)
Final Crack	:	34.5781 mm	Final a/w	:	0.6801 (Measured)
Final Crack	:	34.6708 mm	Final a/w	:	0.6820 (Compliance)

LINEAR FIT $J = B+M(\Delta a)$

Intercept B	=	295.413 kJ/m^2	Slope M = 390.56
Fit Coeff R	=	0.9723	(9 Data Points)
J_{IC}	=	382.6 kJ/m^2	(2184.9 in·lb/in^2)
Da(J_{IC})	=	0.223 mm	(0.0088 in)
T Average	=	425.4	(J_{IC} at 0.15)

POWER LAW FIT $J=C(\Delta a)^n$

Coeff C	=	701.90 kJ/m^2	Exponent N = 0.5976
Fit Coeff R	=	0.9613	(9 Data Points)
J_{IC} (0.20)	=	439.2 kJ/m^2	(2507.9 in·lb/in^2)
Δa (J_{IC})	=	0.456 mm	(0.0180 in)
T Average	=	422.2	(J_{IC} at 0.20)
J_{IC} (0.15)	=	393.5 kJ/m^2	(2246.8 in·lb/in^2)
Δa (J_{IC})	=	0.380 mm	(0.0149 in)
T Average	=	429.5	(J_{IC} at 0.15)
Kjc	=	470.6 MPa·m$^{0.5}$	

J_{IC} VALIDITY & DATA QUALIFICATION (E 813–85)

Jmax Allowed	:	649.65 kJ/m^2	(Jmax = $b_o\sigma_f/15$)
Data Limit	:	Jmax	Ignored
Δa (max) Allowed	:	2.147 mm	(at 1.5 exclusion line)
Data Limit	:	1.5 Exclusion line	
Data Points	:	Zone A = 4	Zone B = 2
Data Point Spacing	:	OK	
B_{net} or b_o Size	:	Inadequate	
dJ/da at J_{IC}	:	OK	
af Measurement	:	Near–surface	outside limit
Initial Crack Shape	:	OK	
Crack Size Estimate	:	OK	(by compliance)
E Effective	:	OK	
J_{IC} Estimate	:	INVALID	

J–R CURVE VALIDITY & DATA QUALIFICATION (E 1152–87)

Jmax Allowed	:	437.35 kJ/m^2	(Jmax = $B_{net}\sigma_f/20$)
Δa (max) Allowed	:	2.275 mm	($\Delta a = 0.1\ b_o$)
Δa (max) Allowed	:	5.428 mm	(Omega = 5)
Data Points	:	Zone A = 18	Zone B = 9
Data Point Spacing	:	OK	
J–R Curve Data	:	INVALID	

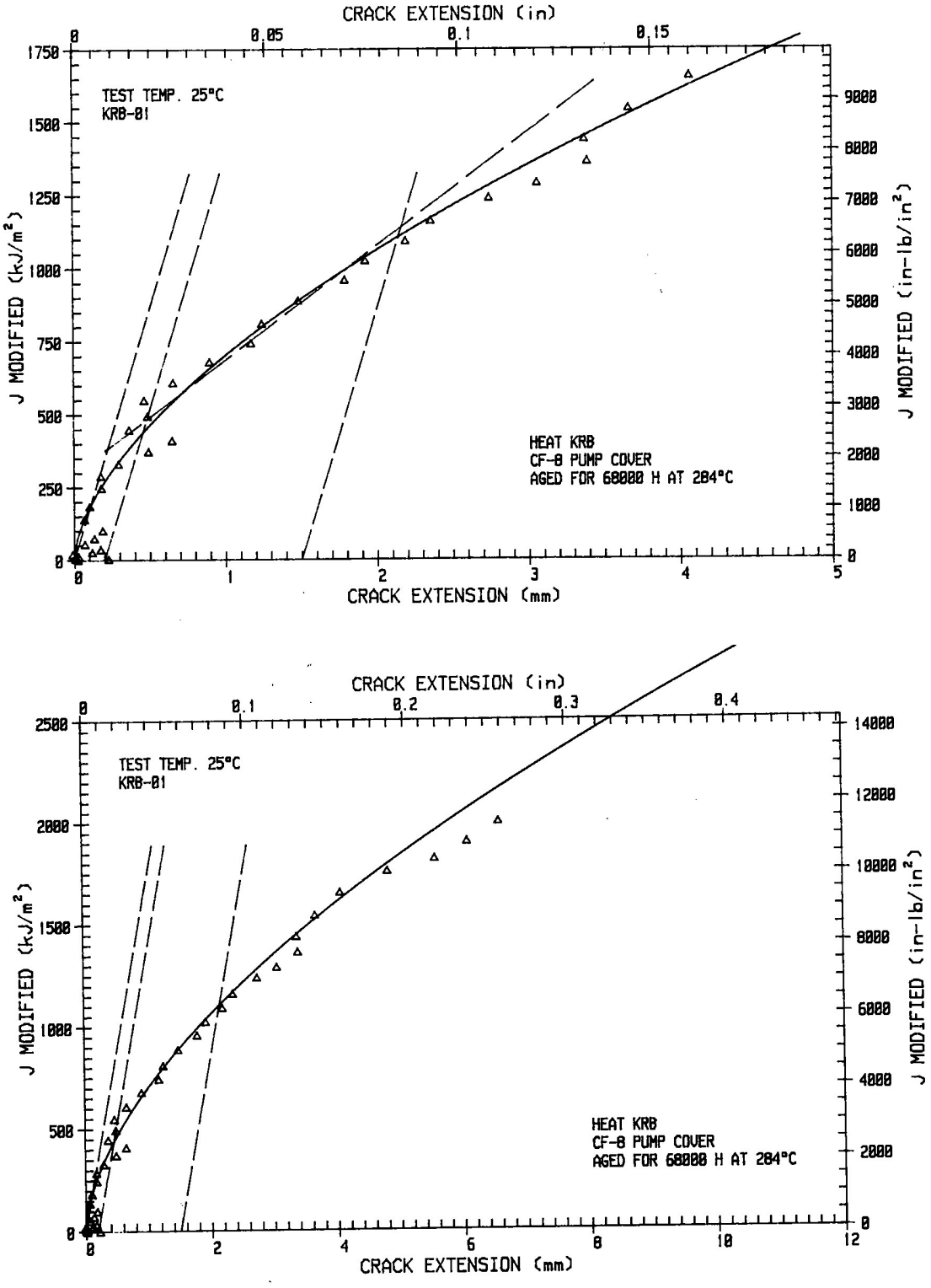


Figure D–9. Modified J_{IC} and J–R Curve for Reactor–Aged KRB Pump Cover Plate Tested at Room Temperature.

Table D–8. Test Data for Specimen KRB–04C

Test Number	:	0009	Test Temp	:	25°C
Material Type	:	CF–8 Pump Cover	Heat Number	:	KRB
Aging Temp	:	550°C	Aging Time	:	68,000 h
Spec. Thickness	:	25.41 mm	Net Thickness	:	20.33 mm
Spec. Width	:	50.82 mm	Flow Stress σ_f	:	416.30 MPa

Unload Number	J_d (kJ/m^2)	J_m (kJ/m^2)	Δa (mm)	Load (kN)	Deflection (mm)
1	5.59	5.59	0.1350	15.077	0.128
2	9.21	9.21	0.2326	18.006	0.174
3	15.05	15.05	0.2032	20.949	0.236
4	23.09	23.11	0.2518	23.495	0.307
5	35.07	34.99	0.1502	25.914	0.405
6	60.32	60.06	0.0828	28.651	0.583
7	87.94	88.53	0.2971	30.609	0.762
8	117.97	118.04	0.2044	32.099	0.955
9	152.47	152.54	0.2048	33.097	1.156
10	187.36	186.62	0.1216	34.165	1.354
11	222.34	220.86	0.0592	34.969	1.546
12	255.09	256.03	0.2344	35.583	1.732
13	291.17	289.38	0.0629	36.137	1.924
14	327.04	326.17	0.1139	36.646	2.112
15	363.61	361.58	0.0569	37.027	2.303
16	395.99	400.09	0.3305	37.384	2.493
17	431.73	434.88	0.2921	37.928	2.685
18	462.80	468.83	0.4012	37.926	2.852
19	487.83	496.34	0.4892	38.191	2.992
20	513.21	518.82	0.3911	38.390	3.112
21	540.64	546.12	0.3870	38.516	3.244
22	566.94	571.98	0.3736	38.742	3.373
23	593.45	597.93	0.3573	38.842	3.502
24	612.74	626.16	0.6067	39.001	3.633
25	635.85	650.75	0.6464	38.910	3.764
26	660.36	677.66	0.7081	39.150	3.894
27	686.40	704.00	0.7154	39.311	4.024
28	709.96	731.22	0.8023	39.344	4.153
29	734.55	758.23	0.8577	39.451	4.285
30	757.01	785.16	0.9563	39.528	4.412
31	780.69	812.61	1.0368	39.582	4.545
32	805.87	839.33	1.0684	39.587	4.674
33	834.40	866.29	1.0372	39.743	4.804
34	866.95	893.46	0.9341	39.827	4.934
35	890.51	923.08	1.0466	39.841	5.064
36	903.14	951.62	1.3356	40.020	5.194
37	940.90	973.80	1.0623	40.096	5.324
38	969.63	1005.11	1.1062	40.185	5.453
39	993.17	1033.29	1.1828	40.316	5.583
40	1016.91	1067.23	1.3463	40.184	5.738
41	1036.64	1096.16	1.4901	40.451	5.874
42	1074.73	1121.02	1.2896	40.402	6.003
43	1101.11	1152.60	1.3663	40.483	6.134
44	1119.87	1181.76	1.5162	40.473	6.265
45	1146.42	1208.54	1.5194	40.438	6.394
46	1172.48	1238.23	1.5692	40.493	6.526
47	1202.05	1268.76	1.5820	40.372	6.667
48	1243.69	1331.23	1.8500	40.268	6.944
49	1301.33	1395.76	1.9303	40.382	7.233
50	1368.86	1462.86	1.9232	40.217	7.542
51	1424.63	1534.92	2.1084	40.304	7.873
52	1486.56	1619.85	2.3521	40.100	8.243
53	1525.35	1664.71	2.4136	39.891	8.444

Table D–8. (Contd.)

Unload Number	J_d (kJ/m^2)	J_m (kJ/m^2)	Δa (mm)	Load (kN)	Deflection (mm)
54	1592.85	1763.50	2.7139	39.440	8.873
55	1676.91	1865.61	2.8820	38.899	9.342
56	1718.18	1921.91	3.0135	38.578	9.583
57	1781.49	2034.89	3.4285	37.711	10.083
58	1815.35	2088.84	3.5906	37.357	10.332
59	1839.61	2143.04	3.8266	37.047	10.572
60	1906.28	2204.39	3.7861	36.963	10.863
61	1992.93	2329.19	4.0632	36.639	11.406
62	2047.51	2402.96	4.1966	36.530	11.735
63	2089.56	2470.07	4.3653	34.804	12.031
64	2136.81	2559.71	4.6416	35.514	12.425
65	2262.39	2760.89	5.1152	34.048	13.345
66	2314.37	2870.36	5.4473	33.358	13.823
67	2402.87	2976.10	5.5426	32.884	14.322
68	2451.72	3089.72	5.8873	31.710	14.826
69	2507.52	3194.52	6.1387	30.805	15.326
70	2557.21	3299.71	6.4138	29.957	15.825
71	2602.85	3402.11	6.6858	28.892	16.320

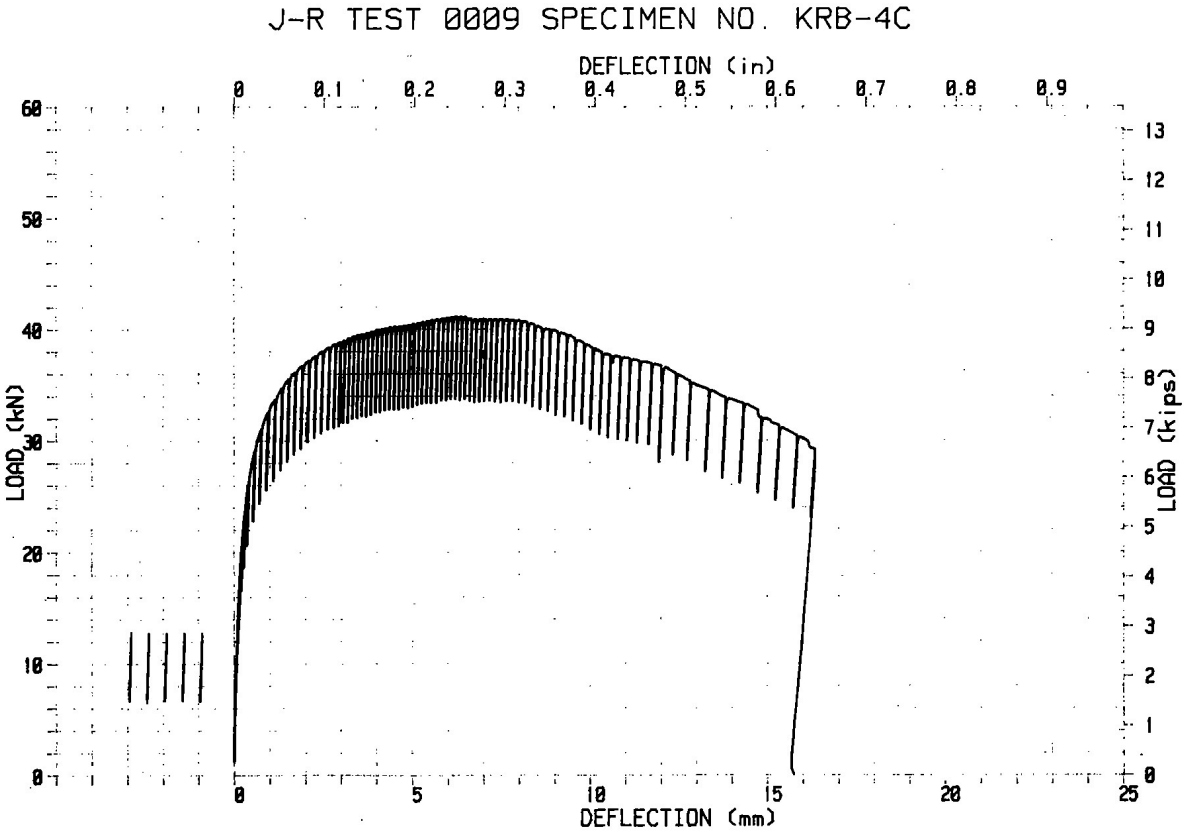


Figure D–10. Load vs Load Line Displacement Curve for Reannealed KRB Pump Cover Plate Tested at Room Temperature.

Table D–9. Deformation J_{IC} and J–R Curve Results for Specimen KRB–04C

Test Number	:	0009	Test Temp	:	25°C
Material Type	:	CF–8 Pump Cover	Heat Number	:	KRB
Aging Temp	:	550°C	Aging Time	:	68,000 h
Spec. Thickness	:	25.41 mm	Net Thickness	:	20.33 mm
Spec. Width	:	50.82 mm	Flow Stress σ_f	:	416.30 MPa
Modulus E	:	218.18 GPa	(Effective)		
Modulus E	:	193.10 GPa	(Nominal)		
Initial Crack	:	29.2938 mm	Initial a/w	:	0.5764 (Measured)
Final Crack	:	36.5844 mm	Final a/w	:	0.7199 (Measured)
Final Crack	:	35.9795 mm	Final a/w	:	0.7080 (Compliance)

LINEAR FIT J = B+M(Δa)

Intercept B	=	325.856 kJ/m^2	Slope M = 515.96
Fit Coeff R	=	0.9822	(36 Data Points)
J_{IC}	=	472.2 kJ/m^2	(2696.1 in·lb/in^2)
Δa (J_{IC})	=	0.284 mm	(0.0112 in)
T Average	=	649.6	(J_{IC} at 0.15)

POWER LAW FIT **J=C(Δa)^N**

Coeff C	=	843.71 kJ/m^2	Exponent N = 0.6864
Fit Coeff R	=	0.9831	(36 Data Points)
J_{IC} (0.20)	=	542.8 kJ/m^2	(3099.6 in·lb/in^2)
Δa (J_{IC})	=	0.526 mm	(0.0207 in)
T Average	=	657.4	(J_{IC} at 0.20)
J_{IC} (0.15)	=	478.0 kJ/m^2	(2729.6 in·lb/in^2)
Δa (J_{IC})	=	0.437 mm	(0.0172 in)
T Average	=	666.2	(J_{IC} at 0.15)
Kjc	=	582.1 MPa·m$^{0.5}$	

J_{IC} VALIDITY & DATA QUALIFICATION (E 813–85)

Jmax Allowed	:	597.43 kJ/m^2	(Jmax = $b_o\sigma_f$/15)
Data Limit	:	Jmax	Ignored
Δa (max) Allowed	:	2.433 mm	(at 1.5 exclusion line)
Data Limit	:	1.5 Exclusion line	
Data Points	:	Zone A = 8	Zone B = 10
Data Point Spacing	:	OK	
B_{net} or b_o Size	:	Inadequate	
dJ/da at J_{IC}	:	OK	
ao Measurement	:	9 outside limit	
ao Measurement	:	1 outside limit	
af Measurement	:	Near–surface	outside limit
Crack Size Estimate	:	Inadequate	(by compliance)
E Effective	:	Inadequate	
J_{IC} Estimate	:	INVALID	

J–R CURVE VALIDITY & DATA QUALIFICATION (E 1152–87)

Jmax Allowed	:	423.17 kJ/m^2	(Jmax = $B_{net}\sigma_f$/20)
Δa (max) Allowed	:	2.153 mm	(Δa = 0.1 b_o)
Δa (max) Allowed	:	6.135 mm	(Omega = 5)
Data Points	:	Zone A = 58	Zone B = 6
Data Point Spacing	:	Inadequate	
J–R Curve Data	:	INVALID	

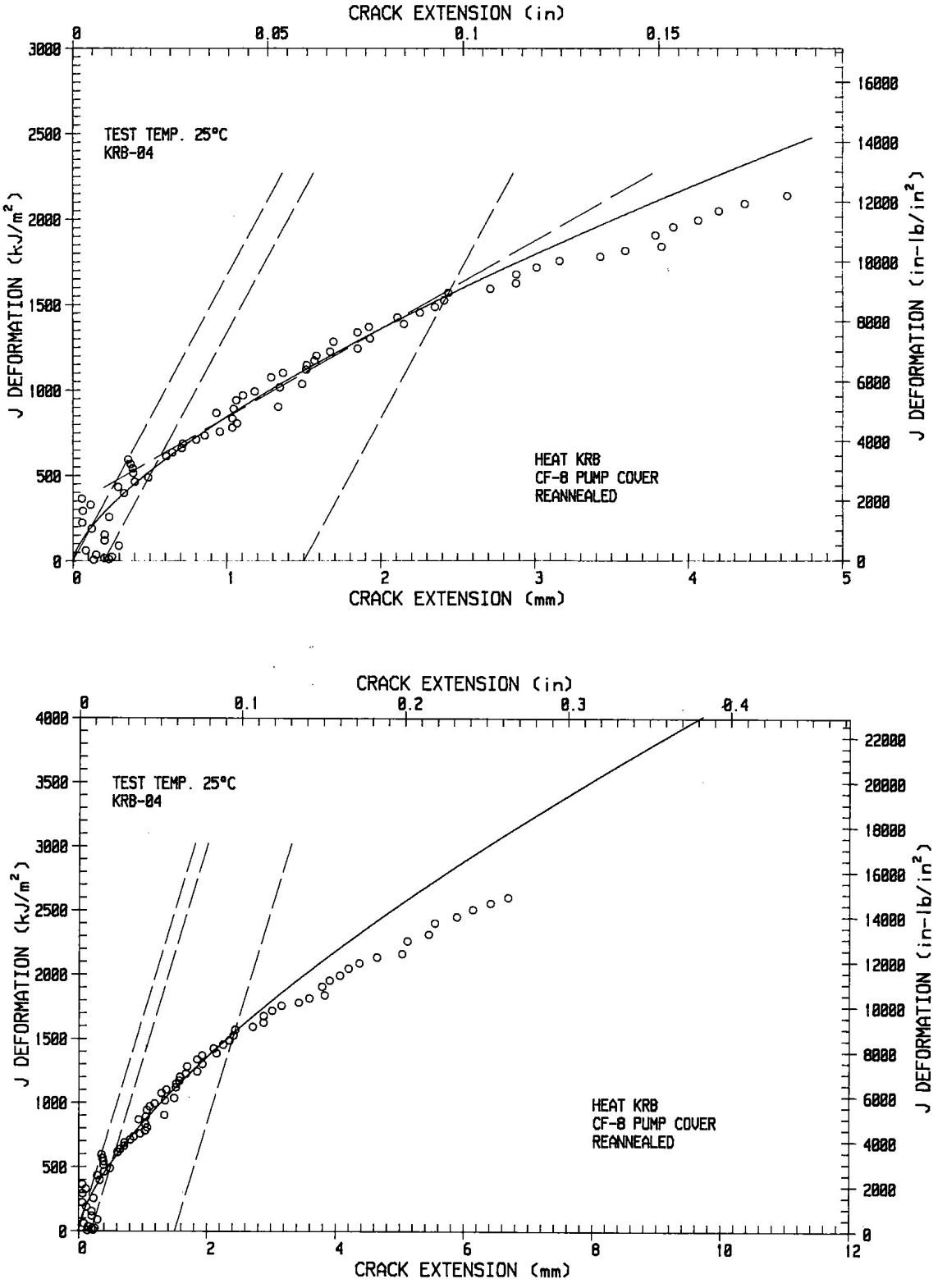


Figure D–11. Deformation J_{IC} and J–R Curve for Reannealed KRB Pump Cover Plate Tested at Room Temperature.

Table D–10. Modified J_{IC} and J–R Curve Results for Specimen KRB–04C

Test Number	:	0009	Test Temp	:	25°C
Material Type	:	CF–8 Pump Cover	Heat Number	:	KRB
Aging Temp	:	550°C	Aging Time	:	68,000 h
Spec. Thickness	:	25.41 mm	Net Thickness	:	20.33 mm
Spec. Width	:	50.82 mm	Flow Stress σ_f	:	416.30 MPa
Modulus E	:	218.18 GPa	(Effective)		
Modulus E	:	193.10 GPa	(Nominal)		
Initial Crack	:	29.2938 mm	Initial a/w	:	0.5764 (Measured)
Final Crack	:	36.5844 mm	Final a/w	:	0.7199 (Measured)
Final Crack	:	35.9795 mm	Final a/w	:	0.7080 (Compliance)

LINEAR FIT $J = B+M(\Delta a)$

Intercept B	=	286.152 kJ/m^2	Slope M = 586.33
Fit Coeff R	=	0.9870	(36 Data Points)
J_{IC}	=	441.7 kJ/m^2	(2522.0 in·lb/in^2)
Δa (J_{IC})	=	0.265 mm	(0.0104 in)
T Average	=	738.1	(J_{IC} at 0.15)

POWER LAW FIT $J=C(\Delta a)^n$

Coeff C	=	875.64 kJ/m^2	Exponent N = 0.7341
Fit Coeff R	=	0.9863	(36 Data Points)
J_{IC} (0.20)	=	549.3 kJ/m^2	(3136.9 in·lb/in^2)
Δa (J_{IC})	=	0.530 mm	(0.0209 in)
T Average	=	733.8	(J_{IC} at 0.20)
J_{IC} (0.15)	=	475.9 kJ/m^2	(2717.4 in·lb/in^2)
Δa (J_{IC})	=	0.436 mm	(0.0172 in)
T Average	=	742.3	(J_{IC} at 0.15)
Kjc	=	615.7 MPa·m$^{0.5}$	

J_{IC} VALIDITY & DATA QUALIFICATION (E 813–85)

Jmax Allowed	:	597.43 kJ/m^2	(Jmax = $b_o\sigma_f/15$)
Data Limit	:	Jmax	Ignored
Δa (max) Allowed	:	2.544 mm	(at 1.5 exclusion line)
Data Limit	:	1.5 Exclusion line	
Data Points	:	Zone A = 10	Zone B = 9
Data Point Spacing	:	OK	
B_{net} or b_o Size	:	Inadequate	
dJ/da at J_{IC}	:	OK	
ao Measurement	:	9 outside limit	
ao Measurement	:	1 outside limit	
af Measurement	:	Near–surface	outside limit
Crack Size Estimate	:	Inadequate	(by compliance)
E Effective	:	Inadequate	
J_{IC} Estimate	:	INVALID	

J–R CURVE VALIDITY & DATA QUALIFICATION (E 1152–87)

Jmax Allowed	:	423.17 kJ/m^2	(Jmax = $B_{net}\sigma_f/20$)
Δa (max) Allowed	:	2.153 mm	($\Delta a = 0.1\ b_o$)
Δa (max) Allowed	:	6.506 mm	(Omega = 5)
Data Points	:	Zone A = 66	Zone B = 6
Data Point Spacing	:	Inadequate	
J–R Curve Data	:	INVALID	

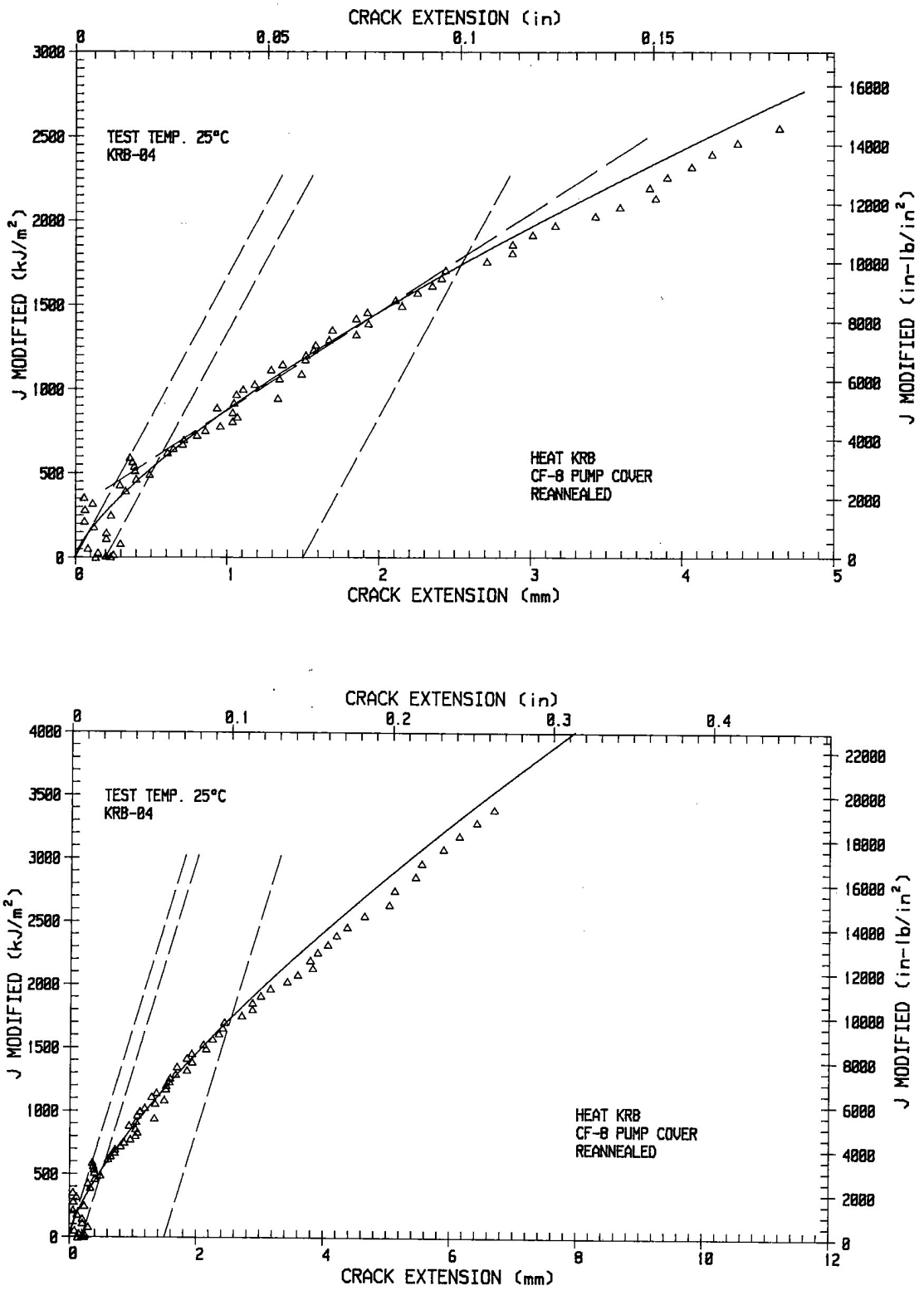


Figure D–12. Modified J_{IC} and J–R Curve for Reannealed KRB Pump Cover Plate Tested at Room Temperature.

Table D–11. Test Data for Specimen KRB–05R

Test Number	:	0004	Test Temp	:	290°C
Material Type	:	CF–8 Pump Cover	Heat Number	:	KRB
Aging Temp	:	284°C	Aging Time	:	68,000 h
Spec. Thickness	:	25.40 mm	Net Thickness	:	20.33 mm
Spec. Width	:	50.82 mm	Flow Stress σ_f	:	329.01 MPa

Unload Number	J_d (kJ/m^2)	J_m (kJ/m^2)	Δa (mm)	Load (kN)	Deflection (mm)
1	7.20	7.22	0.2359	11.963	0.204
2	11.50	11.45	−0.0193	13.548	0.275
3	19.62	19.50	−0.1194	15.035	0.375
4	31.60	32.17	0.3881	16.313	0.509
5	43.83	43.80	0.1033	17.305	0.655
6	61.65	61.68	0.1230	18.153	0.828
7	79.40	79.74	0.1931	18.869	1.002
8	97.63	97.08	0.0276	19.577	1.172
9	118.21	118.64	0.1748	20.098	1.359
10	137.56	136.50	−0.0134	20.538	1.530
11	156.74	159.04	0.3536	21.002	1.709
12	177.86	179.43	0.2842	21.298	1.898
13	199.63	201.68	0.3245	21.705	2.080
14	223.00	222.24	0.1143	21.957	2.257
15	248.76	244.27	−0.1367	22.337	2.437
16	275.24	266.91	−0.3698	22.675	2.619
17	293.58	291.52	−0.0170	23.076	2.798
18	318.07	313.60	−0.1421	23.304	2.990
19	339.45	339.07	0.0554	23.656	3.177
20	362.33	363.00	0.1024	23.903	3.366
21	388.40	388.47	0.0776	24.140	3.561
22	414.73	413.73	0.0355	24.377	3.750
23	436.95	440.13	0.1900	24.523	3.939
24	460.01	465.53	0.2717	24.765	4.129
25	492.34	489.49	−0.0026	24.716	4.318
26	509.02	518.98	0.3975	24.891	4.508
27	536.93	542.30	0.2614	24.921	4.699
28	557.36	570.60	0.4843	25.011	4.889
29	582.28	596.07	0.4995	25.108	5.080
30	612.13	621.83	0.3938	25.102	5.267
31	635.86	650.15	0.5073	25.089	5.459
32	686.49	703.43	0.5674	25.230	5.838
33	713.14	730.30	0.5724	25.477	6.028
34	727.32	760.43	0.9102	25.531	6.226
35	746.43	785.04	1.0232	25.409	6.407
36	782.49	810.75	0.8193	25.482	6.598
37	799.53	841.36	1.0781	25.270	6.788
38	812.02	873.84	1.4487	25.367	7.009
39	833.75	901.78	1.5600	25.218	7.213
40	859.15	930.41	1.6161	25.183	7.408
41	893.96	959.09	1.5136	25.128	7.609
42	908.27	991.36	1.8058	25.023	7.808
43	928.02	1019.29	1.9352	24.833	8.007
44	947.85	1048.96	2.0866	24.703	8.207
45	987.97	1076.45	1.8993	24.629	8.410
46	1006.64	1108.49	2.0922	24.398	8.607
47	1035.51	1136.52	2.0805	24.215	8.809
48	1051.12	1167.27	2.2876	24.024	9.008
49	1083.20	1194.17	2.2188	23.788	9.208
50	1096.98	1226.07	2.4541	23.477	9.413
51	1103.09	1254.29	2.7364	23.307	9.610
52	1131.09	1280.37	2.7125	23.184	9.808
53	1156.07	1310.31	2.7728	22.928	10.010

Table D–11. (Contd.)

Unload Number	J_d (kJ/m^2)	J_m (kJ/m^2)	Δa (mm)	Load (kN)	Deflection (mm)
54	1177.17	1338.92	2.8617	22.672	10.208
55	1187.68	1368.12	3.0792	22.408	10.409
56	1203.14	1395.59	3.2162	22.193	10.609
57	1198.09	1424.98	3.6041	21.946	10.809
58	1224.20	1449.85	3.5904	21.712	11.010
59	1239.78	1488.54	3.8386	21.348	11.268
60	1257.35	1521.22	3.9974	21.037	11.508
61	1253.00	1557.16	4.4135	20.609	11.757
62	1300.75	1631.88	4.6757	19.817	12.307
63	1343.14	1715.31	5.0596	19.025	12.928
64	1370.01	1806.81	5.6384	17.890	13.628
65	1393.05	1856.42	5.8652	17.348	14.009
66	1431.41	1960.99	6.4038	16.464	14.826
67	1473.47	2079.87	6.9872	15.588	15.765
68	1509.88	2131.61	7.0988	15.203	16.209
69	1533.84	2251.99	7.7733	14.294	17.193
70	1568.16	2313.14	7.9507	13.682	17.708
71	1557.16	2377.37	8.4345	12.921	18.248
72	1576.06	2437.22	8.6895	12.283	18.804
73	1572.04	2501.98	9.1052	11.559	19.387

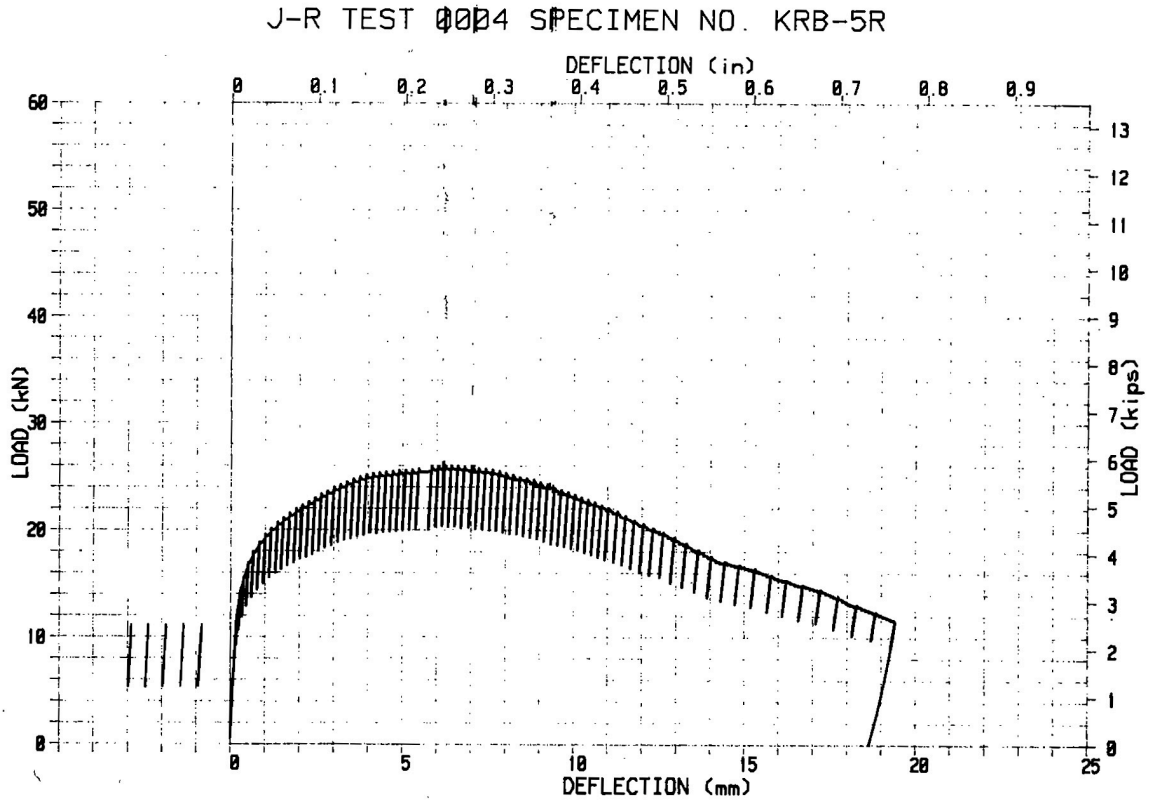


Figure D–13. Load vs Load Line Displacement Curve for Reactor–Aged KRB Pump Cover Plate Tested at 290°C.

Table D–12. Deformation J_{IC} and J–R Curve Results for Specimen KRB–05R

Test Number	:	0004	Test Temp	:	290°C
Material Type	:	CF–8 Pump Cover	Heat Number	:	KRB
Aging Temp	:	284°C	Aging Time	:	68,000 h
Spec. Thickness	:	25.40 mm	Net Thickness	:	20.33 mm
Spec. Width	:	50.82 mm	Flow Stress σ_f	:	329.01 MPa
Modulus E	:	173.77 GPa	(Effective)		
Modulus E	:	168.90 GPa	(Nominal)		
Initial Crack	:	31.0719 mm	Initial a/w	:	0.6114 (Measured)
Final Crack	:	41.5344 mm	Final a/w	:	0.8173 (Measured)
Final Crack	:	40.1770 mm	Final a/w	:	0.7906 (Compliance)

LINEAR FIT $J = B+M(\Delta a)$

Intercept B	=	540.262 kJ/m^2	Slope M = 218.35
Fit Coeff R	=	0.9411	(16 Data Points)
J_{IC}	=	647.7 kJ/m^2	(3698.7 in·lb/in^2)
Δa (J_{IC})	=	0.492 mm	(0.0194 in)
T Average	=	350.5	(J_{IC} at 0.15)

POWER LAW FIT $J=C(\Delta a)^n$

Coeff C	=	764.05 kJ/m^2	Exponent N = 0.3463
Fit Coeff R	=	0.9200	(16 Data Points)
J_{IC} (0.20)	=	681.1 kJ/m^2	(3889.0 in·lb/in^2)
Δa (J_{IC})	=	0.718 mm	(0.0282 in)
T Average	=	337.3	(J_{IC} at 0.20)
J_{IC} (0.15)	=	658.2 kJ/m^2	(3758.4 in·lb/in^2)
Δa (J_{IC})	=	0.650 mm	(0.0256 in)
T Average	=	344.0	(J_{IC} at 0.15)
Kjc	=	420.0 MPa·m$^{0.5}$	

J_{IC} VALIDITY & DATA QUALIFICATION (E 813–85)

Jmax Allowed	:	433.16 kJ/m^2	(Jmax = $b_o\sigma_f/15$)
Data Limit	:	Jmax	Ignored
Δa (max) Allowed	:	2.271 mm	(at 1.5 exclusion line)
Data Limit	:	1.5 Exclusion line	
Data Points	:	Zone A = 4	Zone B = 8
Data Point Spacing	:	OK	
B_{net} or b_o Size	:	Inadequate	
dJ/da at J_{IC}	:	OK	
ao Measurement	:	9 outside limit	
ao Measurement	:	1 outside limit	
af Measurement	:	Near–surface	outside limit
Crack Size Estimate	:	Inadequate	(by compliance)
E Effective	:	OK	
J_{IC} Estimate	:	INVALID	

J–R CURVE VALIDITY & DATA QUALIFICATION (E 1152–87)

Δa (max) Allowed	:	1.975 mm	($\Delta a = 0.1\ b_o$)
Δa (max) Allowed	:	3.292 mm	(Omega = 5)
Data Points	:	Zone A = 38	Zone B = 4
Data Point Spacing	:	Inadequate	
J–R Curve Data	:	INVALID	

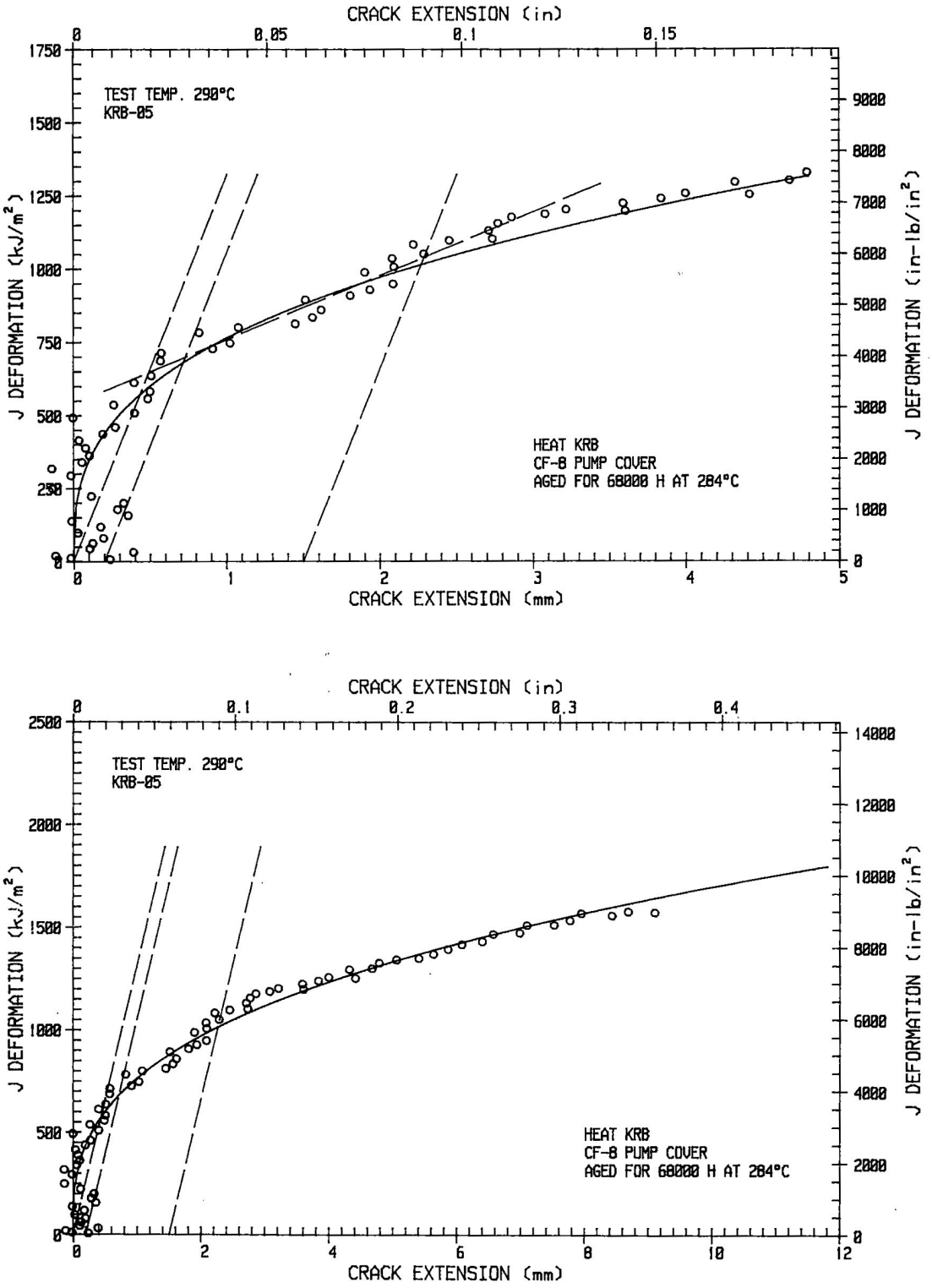


Figure D–14. Deformation J_{IC} and J–R Curve for Reactor–Aged KRB Pump Cover Plate Tested at 290°C.

Table D–13. Modified J_{IC} and J–R Curve Results for Specimen KRB–05R

Test Number	:	0004	Test Temp	:	290°C
Material Type	:	CF–8 Pump Cover	Heat Number	:	KRB
Aging Temp	:	284°C	Aging Time	:	68,000 h
Spec. Thickness:		25.40 mm	Net Thickness	:	20.33 mm
Spec. Width	:	50.82 mm	Flow Stress σ_f	:	329.01 MPa
Modulus E	:	173.77 GPa	(Effective)		
Modulus E	:	168.90 GPa	(Nominal)		
Initial Crack	:	31.0719 mm	Initial a/w	:	0.6114 (Measured)
Final Crack	:	41.5344 mm	Final a/w	:	0.8173 (Measured)
Final Crack	:	40.1770 mm	Final a/w	:	0.7906 (Compliance)

LINEAR FIT $J = B+M(\Delta a)$

Intercept B	=	517.854 kJ/m^2	Slope M = 277.52
Fit Coeff R	=	0.9606	(16 Data Points)
J_{IC}	=	656.2 kJ/m^2	(3747.2 in·lb/in^2)
Δa (J_{IC})	=	0.499 mm	(0.0196 in)
T Average	=	445.5	(J_{IC} at 0.15)

POWER LAW FIT $J=C(\Delta a)^n$

Coeff C	=	801.87 kJ/m^2	Exponent N = 0.4113
Fit Coeff R	=	0.9442	(16 Data Points)
J_{IC} (0.20)	=	707.5 kJ/m^2	(4040.0 in·lb/in^2)
Δa (J_{IC})	=	0.738 mm	(0.0290 in)
T Average	=	420.3	(J_{IC} at 0.20)
J_{IC} (0.15)	=	678.1 kJ/m^2	(3872.0 in·lb/in^2)
Δa (J_{IC})	=	0.665 mm	(0.0262 in)
T Average	=	428.0	(J_{IC} at 0.15)
Kjc	=	445.7 MPa·m$^{0.5}$	

J_{IC} VALIDITY & DATA QUALIFICATION (E 813–85)

Jmax Allowed	:	433.16 kJ/m^2	(Jmax = $b_o\sigma_f/15$)
Data Limit	:	Jmax	Ignored
Δa (max) Allowed	:	2.369 mm	(at 1.5 exclusion line)
Data Limit	:	1.5 Exclusion line	
Data Points	:	Zone A = 4	Zone B = 8
Data Point Spacing	:	OK	
B_{net} or b_o Size	:	Inadequate	
dJ/da at J_{IC}	:	OK	
ao Measurement	:	9 outside limit	
ao Measurement	:	1 outside limit	
af Measurement	:	Near–surface	outside limit
Crack Size Estimate	:	Inadequate	(by compliance)
E Effective	:	OK	
J_{IC} Estimate	:	INVALID	

J–R CURVE VALIDITY & DATA QUALIFICATION (E 1152–87)

Δa (max) Allowed	:	1.975 mm	($\Delta a = 0.1\ b_o$)
Δa (max) Allowed	:	3.863 mm	(Omega = 5)
Data Points	:	Zone A = 43	Zone B = 4
Data Point Spacing	:	Inadequate	
J–R Curve Data	:	INVALID	

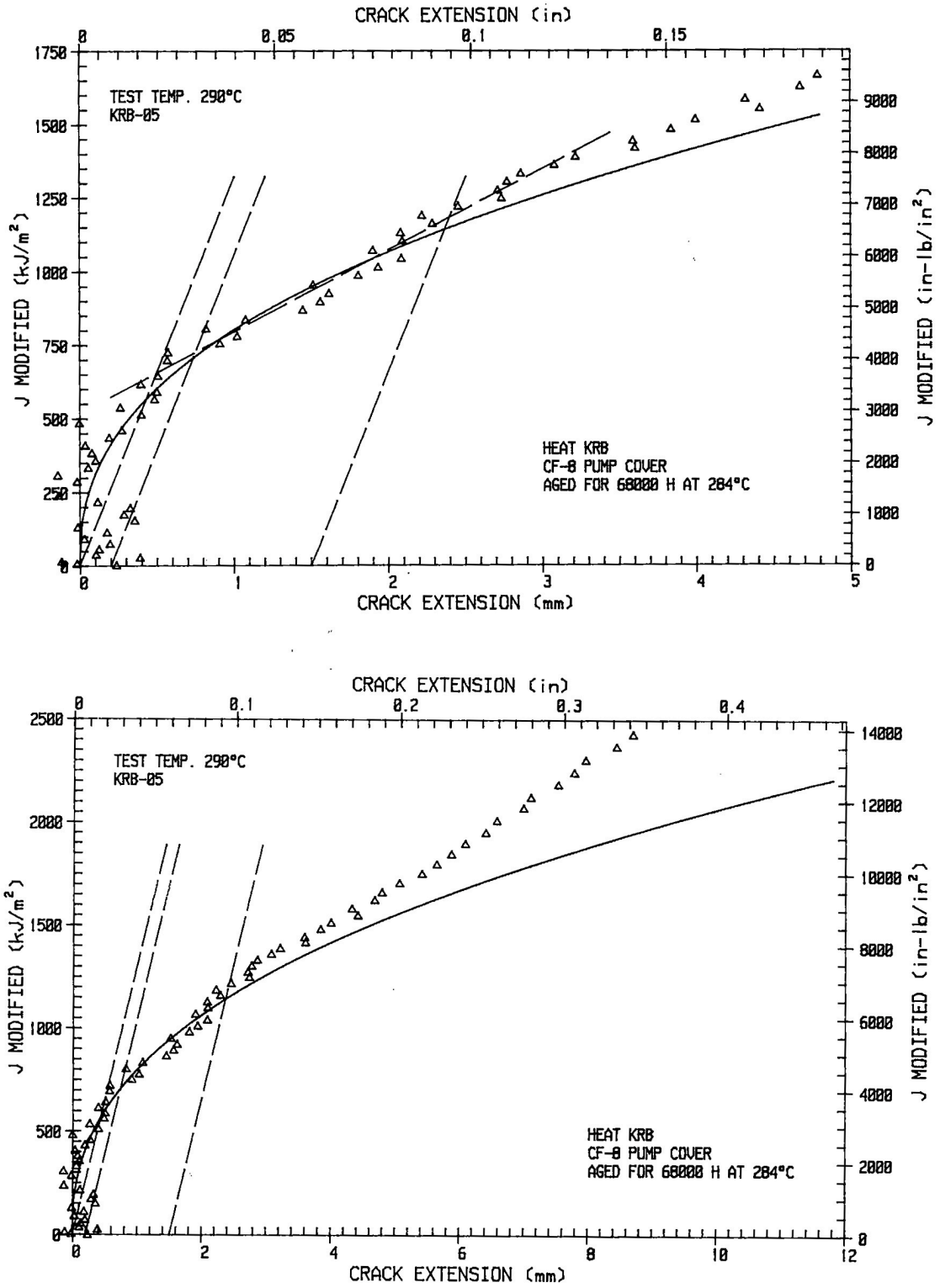


Figure D–15. Modified J_{IC} and J–R Curve for Reactor–Aged KRB Pump Cover Plate Tested at 290°C.

Table D–14. Test Data for Specimen 207–09C

Test Number	:	0002	Test Temp	:	290°C
Material Type	:	CF–8M Pipe	Heat Number	:	207
Aging Temp	:	25°C	Aging Time	:	0 h
Spec. Thickness	:	25.40 mm	Net Thickness	:	20.40 mm
Spec. Width	:	50.80 mm	Flow Stress σ_f	:	339.00 MPa

Unload Number	J_d (kJ/m^2)	J_m (kJ/m^2)	Δa (mm)	Load (kN)	Deflection (mm)
1	4.60	4.60	0.3812	12.087	0.149
2	6.66	6.65	0.0438	13.946	0.190
3	12.78	12.61	−0.3830	15.920	0.272
4	20.82	20.83	−0.1396	17.438	0.361
5	28.04	27.39	−0.7140	18.379	0.450
6	46.03	47.44	0.2687	19.916	0.633
7	61.25	60.46	−0.4786	20.853	0.801
8	75.98	76.91	−0.0273	21.292	0.931
9	94.07	92.24	−0.6018	22.153	1.098
10	109.21	110.45	−0.0665	22.306	1.238
11	123.35	128.02	0.4565	23.153	1.395
12	142.63	143.32	−0.0648	23.704	1.553
13	160.66	161.57	−0.0389	23.958	1.689
14	179.68	186.40	0.5481	24.599	1.880
15	207.61	208.52	0.0404	25.040	2.089
16	242.22	243.25	0.0490	25.807	2.345
17	278.32	276.63	−0.1261	26.449	2.607
18	312.66	312.27	−0.0521	26.992	2.868
19	349.23	349.31	−0.0282	27.636	3.143
20	375.64	380.42	0.1918	28.012	3.362
21	412.38	411.35	−0.0561	28.118	3.597
22	441.13	449.50	0.3147	28.622	3.846
23	485.94	476.86	−0.3187	29.006	4.071
24	514.03	513.10	−0.0415	29.448	4.292
25	538.23	547.12	0.2739	29.444	4.524
26	566.58	583.08	0.5046	29.952	4.768
27	613.04	624.01	0.3495	30.155	5.051
28	620.80	654.02	0.9554	30.416	5.226
29	648.63	675.87	0.7994	30.468	5.396
30	675.44	703.35	0.8161	30.427	5.563
31	704.23	730.72	0.7821	30.403	5.739
32	725.15	762.05	1.0226	30.580	5.929
33	757.54	796.35	1.0646	30.784	6.153
34	782.89	832.70	1.2976	30.675	6.373
35	811.53	866.67	1.4059	30.685	6.589
36	839.68	901.81	1.5425	30.826	6.806
37	856.76	936.02	1.8670	30.684	7.010
38	908.31	965.45	1.4677	30.757	7.222
39	929.43	1006.48	1.8144	30.561	7.443
40	972.72	1065.17	2.0681	30.227	7.808
41	1015.25	1108.29	2.0774	29.958	8.083
42	1050.50	1181.66	2.6453	29.543	8.512
43	1124.51	1253.52	2.6154	29.680	8.977
44	1167.72	1337.87	3.1544	29.078	9.466
45	1239.87	1422.92	3.3123	28.429	10.004
46	1262.91	1530.31	4.2865	27.544	10.647
47	1319.99	1609.17	4.5241	26.787	11.175
48	1369.85	1690.94	4.8543	25.929	11.677
49	1395.11	1770.68	5.3942	25.149	12.176
50	1461.95	1837.19	5.3911	24.625	12.634
51	1493.78	1913.20	5.7915	24.190	13.099
52	1523.67	1982.36	6.1343	23.384	13.554
53	1531.64	2049.34	6.6343	22.699	13.992

Table D–14. (Contd.)

Unload Number	J_d (kJ/m^2)	J_m (kJ/m^2)	Δa (mm)	Load (kN)	Deflection (mm)
54	1567.87	2132.73	7.0166	21.855	14.552
55	1578.41	2204.39	7.4961	20.846	15.034
56	1596.96	2276.25	7.8998	19.844	15.540
57	1628.20	2356.61	8.2566	18.853	16.111
58	1605.57	2477.64	9.2538	17.299	16.993
59	1630.63	2601.27	9.8986	15.840	17.977
60	1493.46	2590.38	10.7552	15.691	17.983

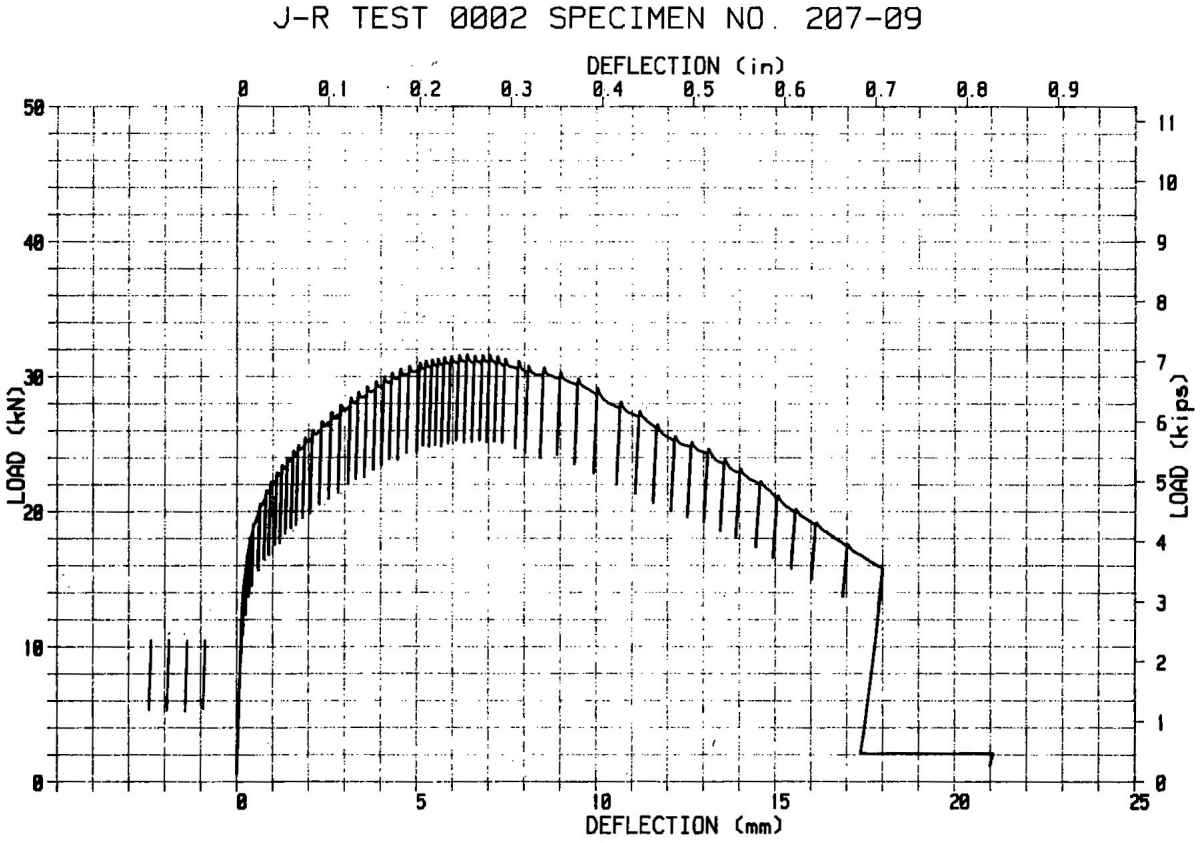


Figure D–16. Load vs Load Line Displacement Curve for Unaged Heat 207 Tested at 290°C.

Table D–15. Deformation J_{IC} and J–R Curve Results for Specimen 207–09C

Test Number	:	0002	Test Temp	:	290°C
Material Type	:	CF–8M Pipe	Heat Number	:	207
Aging Temp	:	25°C	Aging Time	:	0 h
Spec. Thickness	:	25.40 mm	Net Thickness	:	20.40 mm
Spec. Width	:	50.80 mm	Flow Stress σ_f	:	339.00 MPa
Modulus E	:	177.08 GPa	(Effective)		
Modulus E	:	168.90 GPa	(Nominal)		
Initial Crack	:	28.6094 mm	Initial a/w	:	0.5632 (Measured)
Final Crack	:	34.9213 mm	Final a/w	:	0.6874 (Measured)
Final Crack	:	39.3646 mm	Final a/w	:	0.7749 (Compliance)

LINEAR FIT $J = B+M(\Delta a)$

Intercept B	=	467.622 kJ/m^2	Slope M = 247.71
Fit Coeff R	=	0.9408	(14 Data Points)
J_{IC}	=	572.1 kJ/m^2	(3267.0 in·lb/in^2)
Δa (J_{IC})	=	0.422 mm	(0.0166 in)
T Average	=	381.7	(J_{IC} at 0.15)

POWER LAW FIT $J=C(\Delta a)^n$

Coeff C	=	719.04 kJ/m^2	Exponent N = 0.4047
Fit Coeff R	=	0.9326	(14 Data Points)
J_{IC} (0.20)	=	601.6 kJ/m^2	(3435.5 in·lb/in^2)
Δa (J_{IC})	=	0.644 mm	(0.0253 in)
T Average	=	372.7	(J_{IC} at 0.20)
J_{IC} (0.15)	=	574.1 kJ/m^2	(3278.4 in·lb/in^2)
Δa (J_{IC})	=	0.573 mm	(0.0226 in)
T Average	=	380.3	(J_{IC} at 0.15)
Kjc	=	419.9 MPa·m$^{0.5}$	

J_{IC} VALIDITY & DATA QUALIFICATION (E 813–85)

Jmax Allowed	:	501.51 kJ/m^2	(Jmax = $b_o\sigma_f/15$)
Data Limit	:	Jmax	Ignored
Δa (max) Allowed	:	2.234 mm	(at 1.5 exclusion line)
Data Limit	:	1.5 Exclusion line	
Data Points	:	Zone A = 5	Zone B = 4
Data Point Spacing	:	OK	
B_{net} or b_o Size	:	Inadequate	
dJ/da at J_{IC}	:	OK	
af Measurement	:	Near–surface	outside limit
Initial Crack Shape	:	OK	
Crack Size Estimate	:	Inadequate	(by compliance)
E Effective	:	OK	
J_{IC} Estimate	:	INVALID	

J–R CURVE VALIDITY & DATA QUALIFICATION (E 1152–87)

Jmax Allowed	:	345.78 kJ/m^2	(Jmax = $B_{net}\sigma_f/20$)
Δa (max) Allowed	:	2.219 mm	($\Delta a = 0.1\ b_o$)
Δa (max) Allowed	:	3.804 mm	(Omega = 5)
Data Points	:	Zone A = 21	Zone B = 5
Data Point Spacing	:	Inadequate	
J–R Curve Data	:	INVALID	

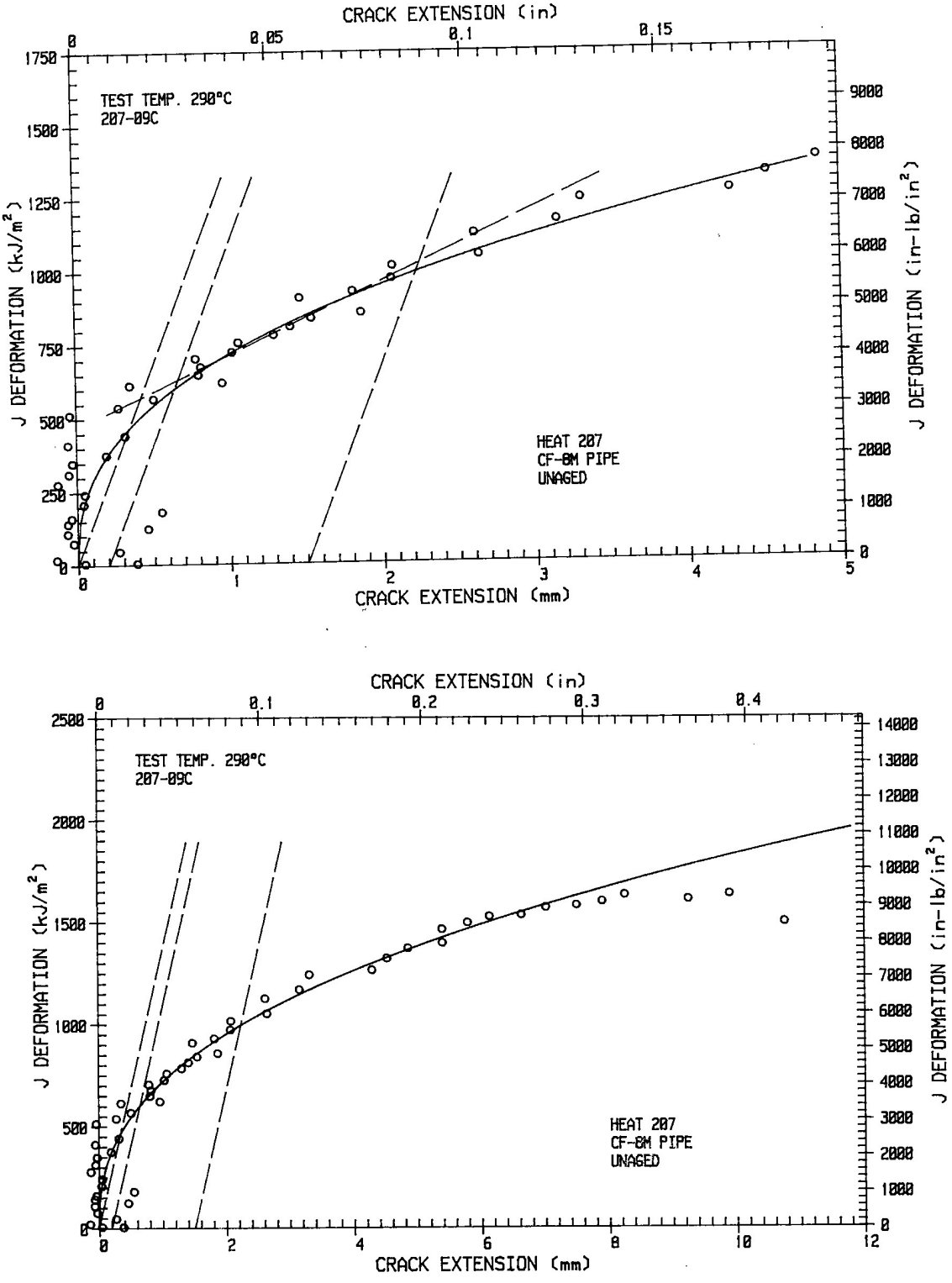


Figure D–17. Deformation J_{IC} and J–R Curve for Unaged Heat 207 Tested at 290°C.

Table D–16. Modified J_{IC} and J–R Curve Results for Specimen 207–09C

Test Number	:	0002	Test Temp	:	290°C
Material Type	:	CF–8M Pipe	Heat Number	:	207
Aging Temp	:	25°C	Aging Time	:	0 h
Spec. Thickness	:	25.40 mm	Net Thickness	:	20.40 mm
Spec. Width	:	50.80 mm	Flow Stress σ_f	:	339.00 MPa
Modulus E	:	177.08 GPa	(Effective)		
Modulus E	:	168.90 GPa	(Nominal)		
Initial Crack	:	28.6094 mm	Initial a/w	:	0.5632 (Measured)
Final Crack	:	34.9213 mm	Final a/w	:	0.6874 (Measured)
Final Crack	:	39.3646 mm	Final a/w	:	0.7749 (Compliance)

LINEAR FIT J = B+M(Δa)

Intercept B	=	452.706 kJ/m^2	Slope M	= 298.57
Fit Coeff R	=	0.9580	(14 Data Points)	
J_{IC}	=	580.5 kJ/m^2	(3314.9 in·lb/in^2)	
Δa (J_{IC})	=	0.428 mm	(0.0169 in)	
T Average	=	460.1	(J_{IC} at 0.15)	

POWER LAW FIT J=C(Δa)^n

Coeff C	=	755.80 kJ/m^2	Exponent N	= 0.4563
Fit Coeff R	=	0.9501	(14 Data Points)	
J_{IC} (0.20)	=	626.0 kJ/m^2	(3574.4 in·lb/in^2)	
Δa (J_{IC})	=	0.662 mm	(0.0260 in)	
T Average	=	440.3	(J_{IC} at 0.20)	
J_{IC} (0.15)	=	592.8 kJ/m^2	(3384.8 in·lb/in^2)	
Δa (J_{IC})	=	0.587 mm	(0.0231 in)	
T Average	=	448.5	(J_{IC} at 0.15)	
Kjc	=	443.2 MPa·m$^{0.5}$		

J_{IC} VALIDITY & DATA QUALIFICATION (E 813–85)

Jmax Allowed	:	501.51 kJ/m^2	(Jmax = $b_o\sigma_f$/15)
Data Limit	:	Jmax	Ignored
Δa (max) Allowed	:	2.318 mm	(at 1.5 exclusion line)
Data Limit	:	1.5 Exclusion line	
Data Points	:	Zone A = 6	Zone B = 4
Data Point Spacing	:	OK	
B_{net} or b_o Size	:	Inadequate	
dJ/da at J_{IC}	:	OK	
af Measurement	:	Near–surface	outside limit
Initial Crack Shape	:	OK	
Crack Size Estimate	:	Inadequate	(by compliance)
E Effective	:	OK	
J_{IC} Estimate	:	INVALID	

J–R CURVE VALIDITY & DATA QUALIFICATION (E 1152–87)

Jmax Allowed	:	345.78 kJ/m^2	(Jmax = $B_{net}\sigma_f$/20)
Δa (max) Allowed	:	2.219 mm	(Δa = 0.1 b_o)
Δa (max) Allowed	:	4.248 mm	(Omega = 5)
Data Points	:	Zone A = 22	Zone B = 5
Data Point Spacing	:	Inadequate	
J–R Curve Data	:	INVALID	

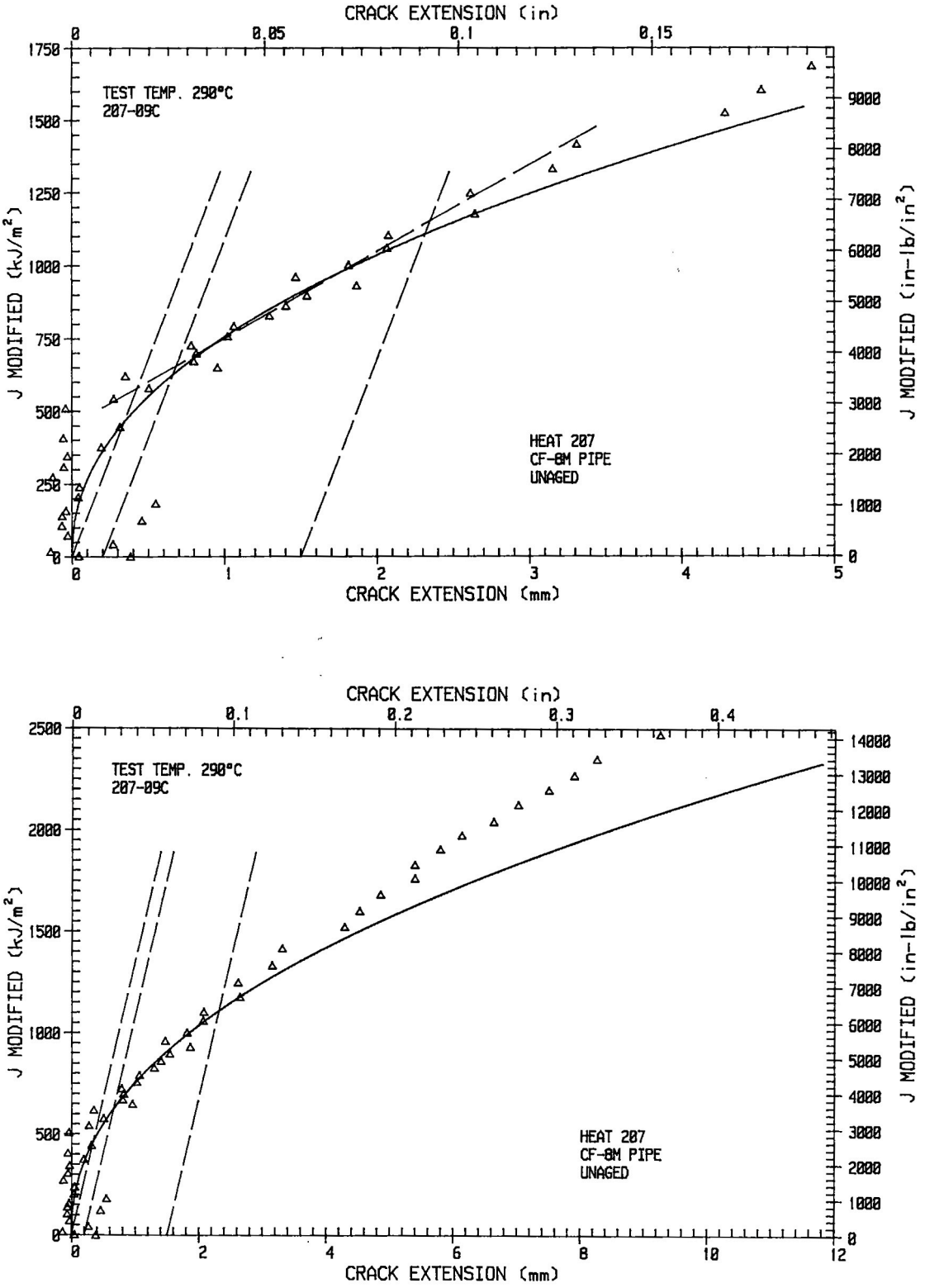


Figure D–18. Modified J_{IC} and J–R Curve for Unaged Heat 207 Tested at 290°C.

Table D–17. Test Data for Specimen 207–10C

Test Number	:	0011	Test Temp	:	290°C
Material Type	:	CF–8M Pipe	Heat Number	:	207
Aging Temp	:	25°C	Aging Time	:	0 h
Spec. Thickness	:	25.42 mm	Net Thickness	:	20.31 mm
Spec. Width	:	50.81 mm	Flow Stress σ_f	:	339.00 MPa

Unload Number	J_d (kJ/m^2)	J_m (kJ/m^2)	Δa (mm)	Load (kN)	Deflection (mm)
1	7.04	7.06	0.1096	13.057	0.189
2	14.24	14.32	0.2504	15.503	0.290
3	21.93	21.97	0.2159	16.960	0.386
4	33.69	33.95	0.3582	18.164	0.515
5	46.04	46.04	0.2418	19.189	0.647
6	56.83	56.37	0.0766	19.653	0.751
7	72.49	71.91	0.0429	20.479	0.898
8	86.87	87.54	0.3209	21.043	1.038
9	101.80	101.74	0.1849	21.558	1.178
10	117.96	117.70	0.1518	22.169	1.318
11	134.36	133.77	0.1080	22.567	1.458
12	149.10	151.44	0.4638	22.916	1.599
13	166.33	165.94	0.1672	23.347	1.739
14	184.17	184.32	0.2191	23.713	1.880
15	200.64	201.54	0.2862	24.137	2.019
16	219.63	218.34	0.1093	24.428	2.160
17	237.98	236.52	0.0964	24.866	2.298
18	256.65	255.64	0.1275	25.100	2.446
19	273.11	273.07	0.1894	25.560	2.580
20	291.90	290.84	0.1282	25.824	2.718
21	308.18	310.60	0.3247	26.052	2.860
22	326.81	328.54	0.2879	26.317	3.000
23	348.19	349.68	0.2764	26.576	3.153
24	362.74	367.81	0.4457	26.834	3.280
25	382.08	387.56	0.4642	27.067	3.426
26	409.09	413.90	0.4364	27.210	3.613
27	426.65	433.86	0.5322	27.647	3.749
28	447.55	453.84	0.4975	27.791	3.892
29	470.30	473.47	0.3839	28.016	4.029
30	492.99	496.88	0.4086	28.300	4.184
31	503.66	517.93	0.7560	28.496	4.319
32	523.23	536.75	0.7320	28.582	4.459
33	547.11	558.11	0.6544	28.788	4.602
34	567.75	580.03	0.6921	28.827	4.742
35	587.06	601.10	0.7424	28.929	4.881
36	606.49	622.45	0.7951	28.987	5.021
37	622.63	644.09	0.9416	28.902	5.160
38	648.01	664.11	0.8039	29.153	5.300
39	662.96	687.78	1.0215	29.145	5.441
40	682.03	708.33	1.0570	29.193	5.581
41	703.57	730.13	1.0631	29.328	5.723
42	724.63	751.65	1.0736	29.362	5.860
43	735.80	774.55	1.3332	29.080	5.998
44	753.99	795.58	1.3945	29.397	6.141
45	776.67	817.70	1.3827	29.295	6.284
46	790.44	840.42	1.5653	29.379	6.420
47	810.57	861.47	1.5837	29.333	6.560
48	826.37	885.19	1.7373	29.251	6.703
49	862.05	929.35	1.8942	29.168	6.981
50	884.65	950.92	1.8758	29.044	7.122
51	910.76	996.15	2.2097	28.853	7.401
52	946.62	1041.70	2.3683	28.563	7.682
53	997.25	1092.90	2.3791	28.450	8.010

Table D–17. (Contd.)

Unload Number	J_d (kJ/m^2)	J_m (kJ/m^2)	Δa (mm)	Load (kN)	Deflection (mm)
54	1008.82	1125.73	2.7023	28.283	8.200
55	1036.75	1157.61	2.7606	28.184	8.411
56	1066.20	1195.39	2.8793	28.203	8.640
57	1123.85	1279.73	3.2420	27.417	9.159
58	1176.59	1376.06	3.7939	26.335	9.761
59	1209.88	1428.24	4.0191	25.747	10.094
60	1230.31	1486.56	4.4553	25.483	10.459
61	1278.19	1546.73	4.5904	24.874	10.860
62	1309.31	1610.41	4.9340	24.304	11.261
63	1345.72	1671.12	5.1803	23.640	11.664
64	1395.66	1790.83	5.8536	22.390	12.462
65	1448.61	1906.21	6.4190	21.029	13.259
66	1470.08	2020.78	7.2108	19.883	14.058
67	1488.03	2078.04	7.5287	19.185	14.460
68	1510.59	2132.94	7.7824	18.674	14.857
69	1539.17	2312.22	8.8945	16.177	16.205
70	1554.23	2376.58	9.2370	15.686	16.706
71	1560.56	2440.53	9.6254	15.033	17.208

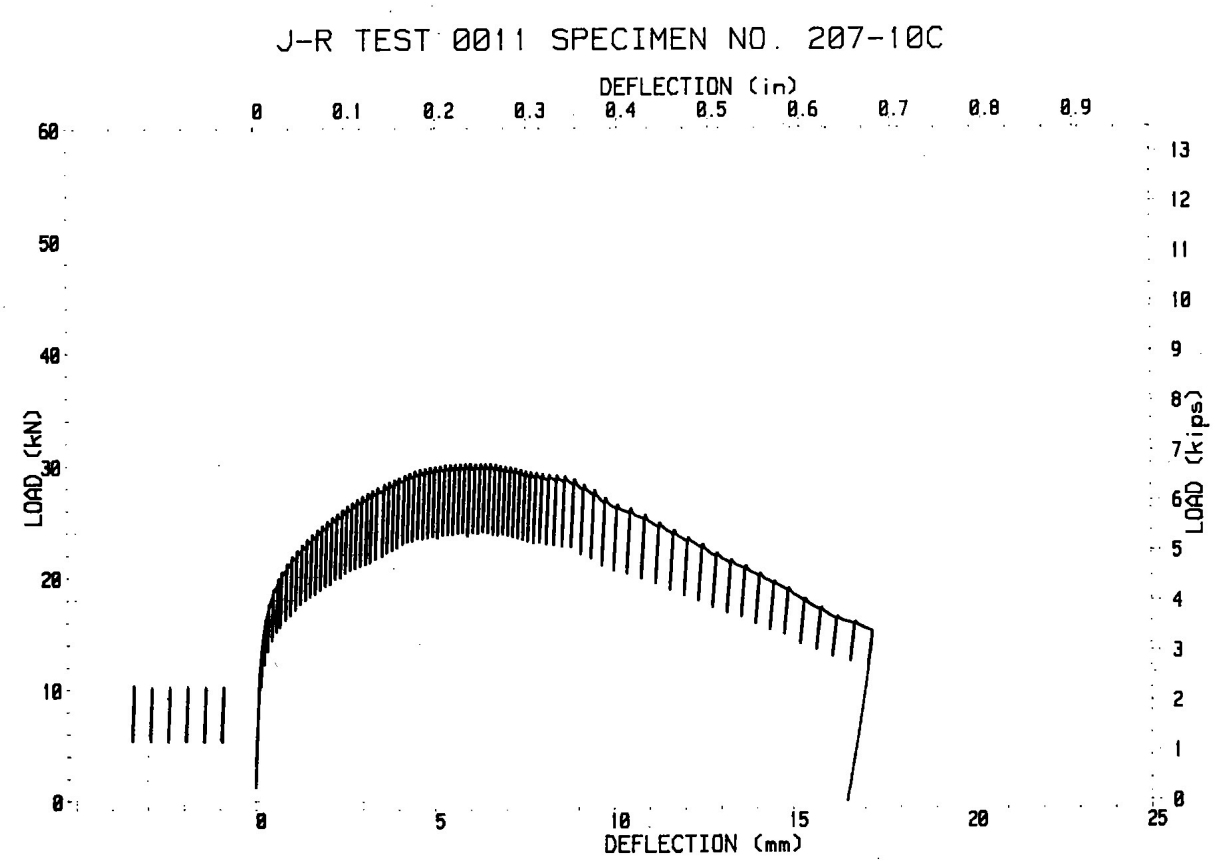


Figure D–19. Load vs Load Line Displacement Curve for Unaged Heat 207 Tested at 290°C.

Table D–18. Deformation J_{IC} and J–R Curve Results for Specimen 207–10C

Test Number	:	0011	Test Temp	:	290°C
Material Type	:	CF–8M Pipe	Heat Number	:	207
Aging Temp	:	25°C	Aging Time	:	0 h
Spec. Thickness	:	25.42 mm	Net Thickness	:	20.31 mm
Spec. Width	:	50.81 mm	Flow Stress σ_f	:	339.00 MPa
Modulus E	:	178.72 GPa	(Effective)		
Modulus E	:	168.90 GPa	(Nominal)		
Initial Crack	:	29.1100 mm	Initial a/w	:	0.5729 (Measured)
Final Crack	:	39.8900 mm	Final a/w	:	0.7851 (Measured)
Final Crack	:	38.7354 mm	Final a/w	:	0.7624 (Compliance)

LINEAR FIT $J = B+M(\Delta a)$

Intercept B	=	331.101 kJ/m^2	Slope M = 295.12
Fit Coeff R	=	0.9590	(27 Data Points)
J_{IC}	=	423.2 kJ/m^2	(2416.6 in·lb/in^2)
Δa (J_{IC})	=	0.312 mm	(0.0123 in)
T Average	=	459.0	(J_{IC} at 0.15)

POWER LAW FIT $J=C(\Delta a)^n$

Coeff C	=	638.72 kJ/m^2	Exponent N = 0.5317
Fit Coeff R	=	0.9708	(27 Data Points)
J_{IC} (0.20)	=	459.9 kJ/m^2	(2626.1 in·lb/in^2)
Δa (J_{IC})	=	0.539 mm	(0.0212 in)
T Average	=	467.5	(J_{IC} at 0.20)
J_{IC} (0.15)	=	423.9 kJ/m^2	(2420.8 in·lb/in^2)
Δa (J_{IC})	=	0.463 mm	(0.0182 in)
T Average	=	476.2	(J_{IC} at 0.15)
Kjc	=	417.6 MPa·m$^{0.5}$	

J_{IC} VALIDITY & DATA QUALIFICATION (E 813–85)

Jmax Allowed	:	490.42 kJ/m^2	(Jmax = $b_o\sigma_f/15$)
Data Limit	:	Jmax	Ignored
Δa (max) Allowed	:	2.220 mm	(at 1.5 exclusion line)
Data Limit	:	1.5 Exclusion line	
Data Points	:	Zone A = 12	Zone B = 6
Data Point Spacing	:	OK	
B_{net} or b_o Size	:	Inadequate	
dJ/da at J_{IC}	:	OK	
Initial Crack Shape	:	OK	
Final Crack Shape	:	OK	
Crack Size Estimate	:	Inadequate	(by compliance)
E Effective	:	OK	
J_{IC} Estimate	:	INVALID	

J–R CURVE VALIDITY & DATA QUALIFICATION (E 1152–87)

Jmax Allowed	:	344.25 kJ/m^2	(Jmax = $B_{net}\sigma_f/20$)
Δa (max) Allowed	:	2.170 mm	($\Delta a = 0.1\ b_o$)
Δa (max) Allowed	:	4.884 mm	(Omega = 5)
Data Points	:	Zone A = 44	Zone B = 8
Data Point Spacing	:	OK	
J–R Curve Data	:	INVALID	

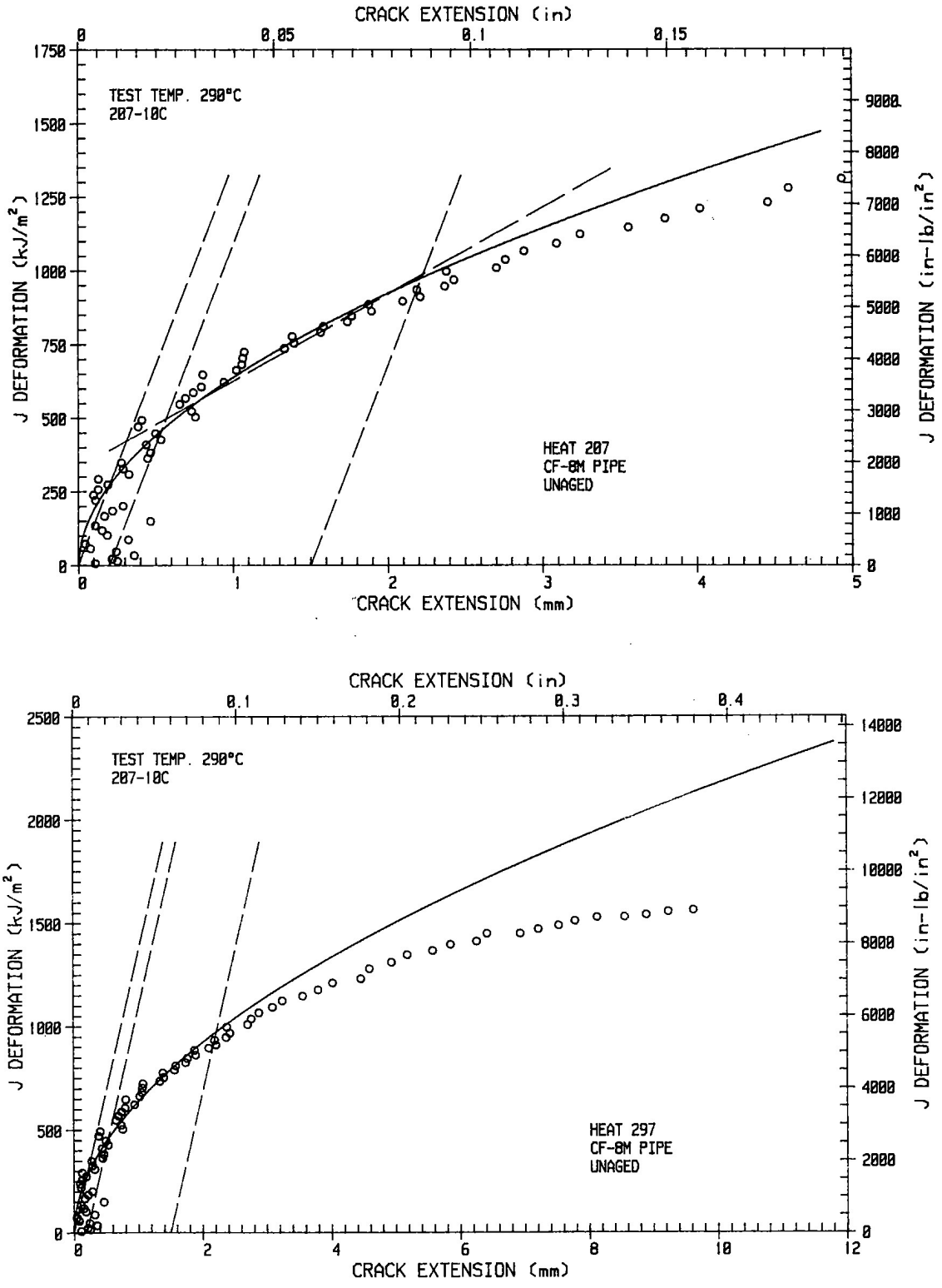


Figure D–20. Deformation J_{IC} and J–R Curve for Unaged Heat 207 Tested at 290°C.

Table D–19. Modified J_{IC} and J–R Curve Results for Specimen 207–10C

Test Number	:	0011	Test Temp	:	290°C
Material Type	:	CF–8M Pipe	Heat Number	:	207
Aging Temp	:	25°C	Aging Time	:	0 h
Spec. Thickness	:	25.42 mm	Net Thickness	:	20.31 mm
Spec. Width	:	50.81 mm	Flow Stress σ_f	:	339.00 MPa
Modulus E	:	178.72 GPa	(Effective)		
Modulus E	:	168.90 GPa	(Nominal)		
Initial Crack	:	29.1100 mm	Initial a/w	:	0.5729 (Measured)
Final Crack	:	39.8900 mm	Final a/w	:	0.7851 (Measured)
Final Crack	:	38.7354 mm	Final a/w	:	0.7624 (Compliance)

LINEAR FIT J = B+M(Δa)

Intercept B	=	319.363 kJ/m^2	Slope M = 331.97
Fit Coeff R	=	0.9713	(28 Data Points)
J_{IC}	=	422.9 kJ/m^2	(2414.8 in·lb/in^2)
Δa (J_{IC})	=	0.312 mm	(0.0123 in)
T Average	=	516.3	(J_{IC} at 0.15)

POWER LAW FIT J=C(Δa)^n

Coeff C	=	664.31 kJ/m^2	Exponent N = 0.5718
Fit Coeff R	=	0.9789	(28 Data Points)
J_{IC} (0.20)	=	470.5 kJ/m^2	(2686.6 in·lb/in^2)
Δa (J_{IC})	=	0.547 mm	(0.0215 in)
T Average	=	522.2	(J_{IC} at 0.20)
J_{IC} (0.15)	=	429.8 kJ/m^2	(2454.3 in·lb/in^2)
Δa (J_{IC})	=	0.467 mm	(0.0184 in)
T Average	=	531.2	(J_{IC} at 0.15)
Kjc	=	436.4 MPa·m$^{0.5}$	

J_{IC} VALIDITY & DATA QUALIFICATION (E 813–85)

Jmax Allowed	:	490.42 kJ/m^2	(Jmax = $b_o\sigma_f$/15)
Data Limit	:	Jmax	Ignored
Δa (max) Allowed	:	2.286 mm	(at 1.5 exclusion line)
Data Limit	:	1.5 Exclusion line	
Data Points	:	Zone A = 12	Zone B = 7
Data Point Spacing	:	OK	
B_{net} or b_o Size	:	Inadequate	
dJ/da at J_{IC}	:	OK	
Initial Crack Shape	:	OK	
Final Crack Shape	:	OK	
Crack Size Estimate	:	Inadequate	(by compliance)
E Effective	:	OK	
J_{IC} Estimate	:	INVALID	

J–R CURVE VALIDITY & DATA QUALIFICATION (E 1152–87)

Jmax Allowed	:	344.25 kJ/m^2	(Jmax = $B_{net}\sigma_f$/20)
Δa (max) Allowed	:	2.170 mm	(Δa = 0.1 b_o)
Δa (max) Allowed	:	5.214 mm	(Omega = 5)
Data Points	:	Zone A = 47	Zone B = 7
Data Point Spacing	:	Inadequate	
J–R Curve Data	:	INVALID	

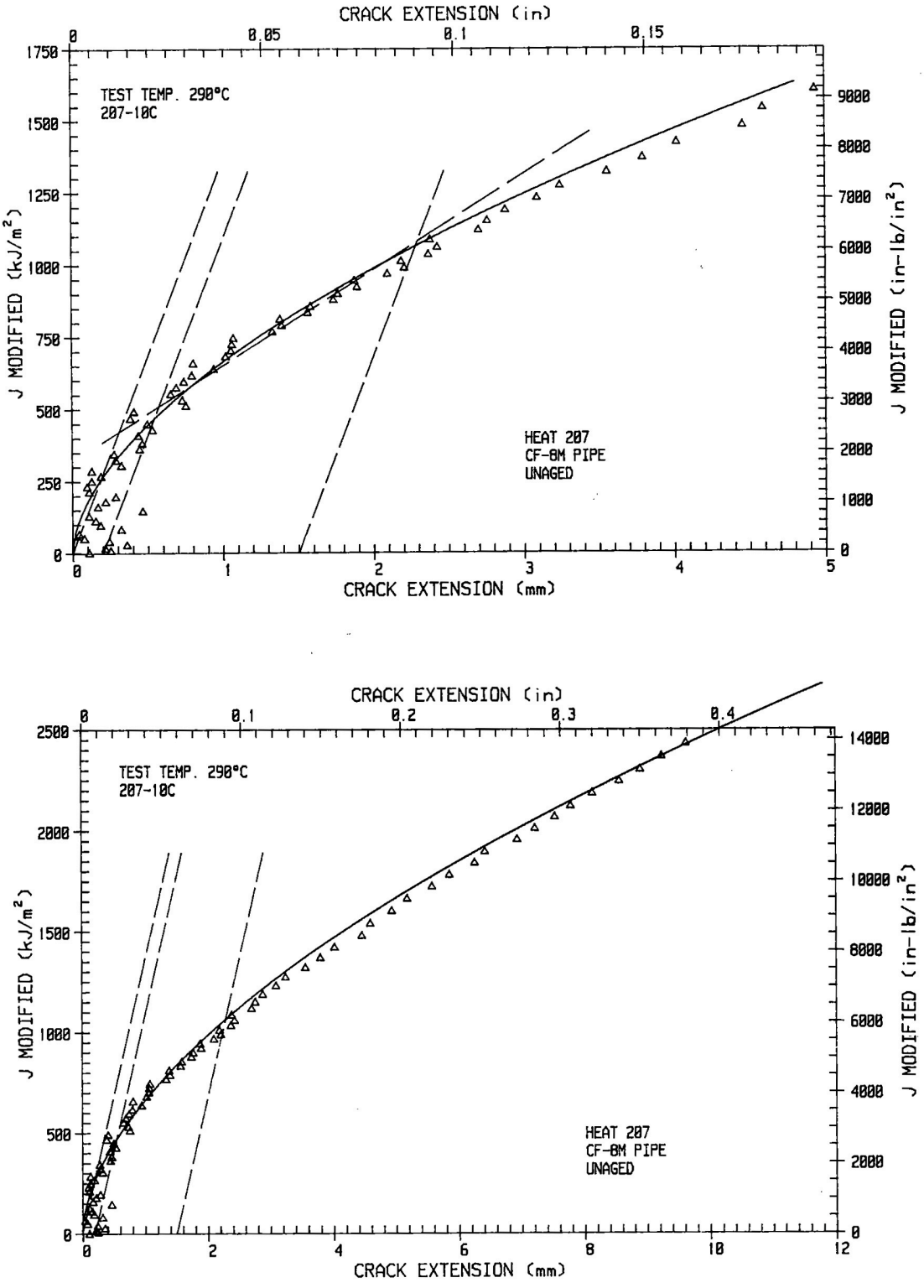


Figure D–21. Modified J_{IC} and J–R Curve for Unaged Heat 207 Tested at 290°C.

Table D–20. Test Data for Specimen 205–24C

Test Number	:	0006	Test Temp	:	290°C
Material Type	:	CF–8M Pipe	Heat Number	:	205
Aging Temp	:	400°C	Aging Time	:	18,000 h
Spec. Thickness	:	25.28 mm	Net Thickness	:	20.19 mm
Spec. Width	:	50.68 mm	Flow Stress σ_f	:	338.95 MPa

Unload Number	J_d (kJ/m^2)	J_m (kJ/m^2)	Δa (mm)	Load (kN)	Deflection (mm)
1	9.93	9.95	0.0999	13.974	0.223
2	15.66	15.70	0.1208	15.278	0.300
3	25.88	25.83	0.0403	16.817	0.423
4	38.77	38.76	0.0634	18.070	0.562
5	53.93	53.91	0.0629	19.169	0.718
6	70.53	70.28	–0.0034	20.165	0.879
7	85.77	87.40	0.4151	20.941	1.026
8	101.93	101.75	0.0816	21.651	1.174
9	121.79	122.20	0.1695	22.401	1.339
10	140.08	140.48	0.1694	22.868	1.495
11	159.55	160.17	0.1941	23.409	1.655
12	175.89	179.10	0.4556	23.845	1.801
13	195.88	195.79	0.1572	24.281	1.948
14	212.69	216.42	0.4707	24.599	2.089
15	229.33	233.39	0.4958	24.912	2.228
16	249.29	251.41	0.3613	25.135	2.368
17	263.53	272.84	0.8275	25.376	2.509
18	283.21	288.76	0.6007	25.574	2.649
19	300.44	310.45	0.8517	25.660	2.790
20	317.97	328.80	0.8953	25.809	2.929
21	336.99	348.44	0.9258	25.975	3.069
22	353.86	369.02	1.1003	25.943	3.210
23	373.23	387.75	1.0718	26.034	3.350
24	387.14	409.27	1.3940	25.943	3.490
25	406.66	427.27	1.3326	25.836	3.630
26	421.74	448.72	1.5772	25.894	3.768
27	441.01	469.56	1.6348	25.955	3.920
28	460.26	491.39	1.7245	25.889	4.069
29	476.56	514.10	1.9382	25.738	4.221
30	494.86	535.17	2.0269	25.573	4.371
31	508.90	557.37	2.2775	25.220	4.519
32	531.68	580.74	2.2944	24.985	4.690
33	539.65	607.56	2.8281	24.865	4.859
34	560.76	632.00	2.9180	24.555	5.049
35	580.29	660.35	3.1463	24.270	5.239
36	602.16	690.93	3.3608	23.714	5.452
37	617.94	724.60	3.7821	23.132	5.680
38	636.02	758.84	4.1451	22.347	5.930
39	657.68	795.39	4.4632	21.684	6.197
40	680.97	835.88	4.8120	21.154	6.491
41	711.27	877.03	5.0199	20.585	6.800
42	719.45	923.21	5.7154	19.532	7.129
43	746.85	965.23	5.9692	18.913	7.477
44	771.60	1018.77	6.4401	17.990	7.879
45	789.41	1075.53	7.0422	17.103	8.327
46	824.99	1135.36	7.3922	16.193	8.827
47	840.01	1197.55	8.0358	15.259	9.331
48	866.50	1253.62	8.4168	14.406	9.829
49	873.14	1311.35	9.0432	13.491	10.326
50	898.13	1364.53	9.3711	12.903	10.826
51	918.54	1419.97	9.7578	12.105	11.329
52	925.28	1473.39	10.2512	11.518	11.826

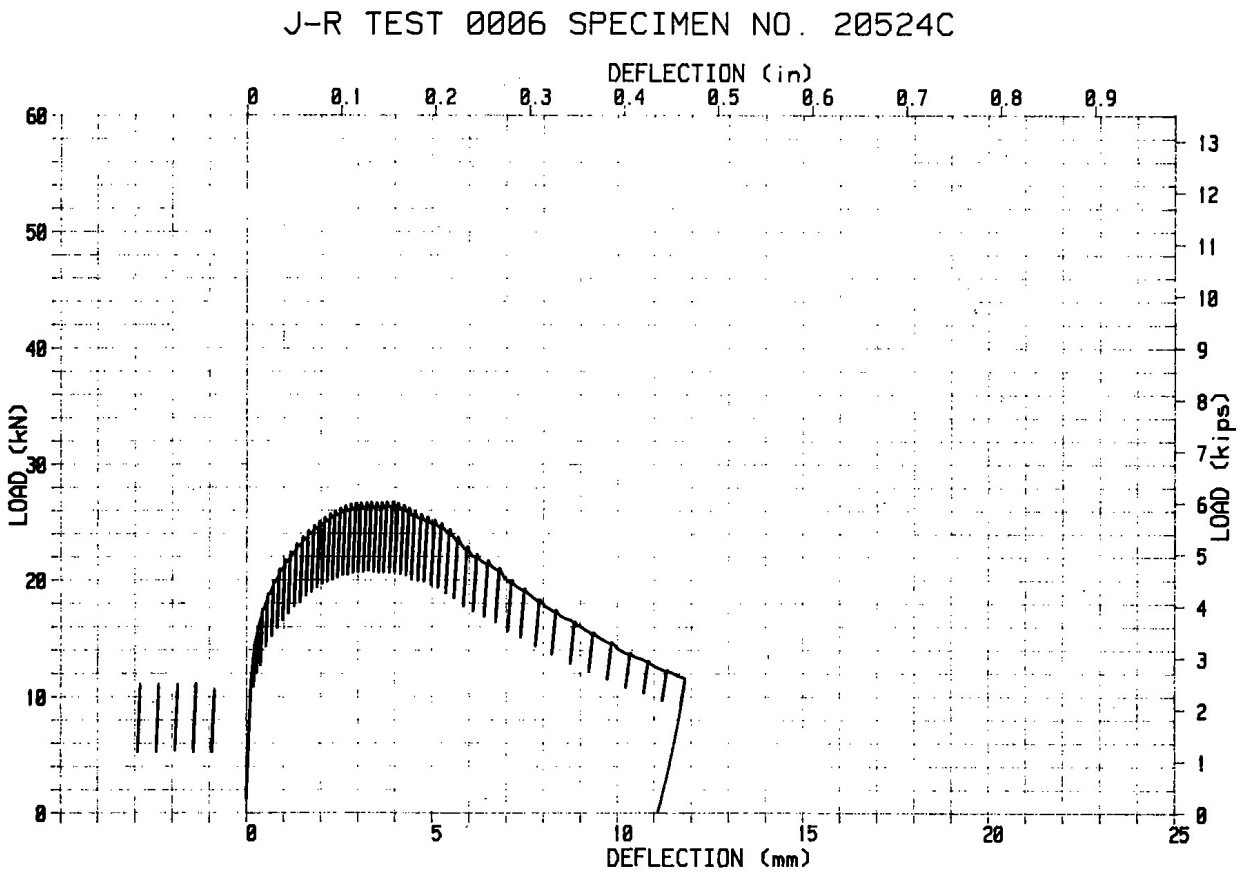


Figure D–22. Load vs Load Line Displacement Curve for Heat 205 Pipe Aged for 18,000 h at 400°C and Tested at 290°C.

Table D–21. Deformation J_{IC} and J–R Curve Results for Specimen 205–24C

Test Number	:	0006	Test Temp	:	290°C
Material Type	:	CF–8M Pipe	Heat Number	:	205
Aging Temp	:	400°C	Aging Time	:	18,000 h
Spec. Thickness	:	25.28 mm	Net Thickness	:	20.19 mm
Spec. Width	:	50.68 mm	Flow Stress σ_f	:	338.95 MPa
Modulus E	:	182.68 GPa	(Effective)		
Modulus E	:	168.90 GPa	(Nominal)		
Initial Crack	:	31.3344 mm	Initial a/w	:	0.6183 (Measured)
Final Crack	:	40.6031 mm	Final a/w	:	0.8012 (Measured)
Final Crack	:	41.5856 mm	Final a/w	:	0.8206 (Compliance)

LINEAR FIT J = B+M(Δa)

Intercept B	=	159.374 kJ/m^2	Slope M = 173.40
Fit Coeff R	=	0.9680	(15 Data Points)
J_{IC}	=	182.7 kJ/m^2	(1043.5 in·lb/in^2)
Δa (J_{IC})	=	0.135 mm	(0.0053 in)
T Average	=	275.7	(J_{IC} at 0.15)

POWER LAW FIT J=C(Δa)^n

Coeff C	=	340.03 kJ/m^2	Exponent N = 0.4754
Fit Coeff R	=	0.9450	(15 Data Points)
J_{IC} (0.20)	=	207.2 kJ/m^2	(1183.3 in·lb/in^2)
Δa (J_{IC})	=	0.353 mm	(0.0139 in)
T Average	=	255.9	(J_{IC} at 0.20)
J_{IC} (0.15)	=	188.5 kJ/m^2	(1076.2 in·lb/in^2)
Δa (J_{IC})	=	0.289 mm	(0.0114 in)
T Average	=	262.0	(J_{IC} at 0.15)
Kjc	=	287.9 MPa·m$^{0.5}$	

J_{IC} VALIDITY & DATA QUALIFICATION (E 813–85)

Jmax Allowed	:	437.15 kJ/m^2	(Jmax = $b_o\sigma_f$/15)
Data Limit	:	Jmax	Ignored
Δa (max) Allowed	:	1.835 mm	(at 1.5 exclusion line)
Data Limit	:	1.5 Exclusion line	
Data Points	:	Zone A = 4	Zone B = 5
Data Point Spacing	:	OK	
B_{net} and b_o Size	:	OK	
dJ/da at J_{IC}	:	OK	
ao Measurement	:	2 outside limit	
ao Measurement	:	7 outside limit	
ao Measurement	:	8 outside limit	
ao Measurement	:	9 outside limit	
ao Measurement	:	1 outside limit	
af Measurement	:	Near–surface	outside limit
Crack Size Estimate	:	Inadequate	(by compliance)
E Effective	:	OK	
J_{IC} Estimate	:	INVALID	

J–R CURVE VALIDITY & DATA QUALIFICATION (E 1152–87)

Δa (max) Allowed	:	1.935 mm	(Δa = 0.1 b_o)
Δa (max) Allowed	:	4.400 mm	(Omega = 5)
Data Points	:	Zone A = 11	Zone B = 16
Data Point Spacing	:	OK	
J–R Curve Data	:	INVALID	

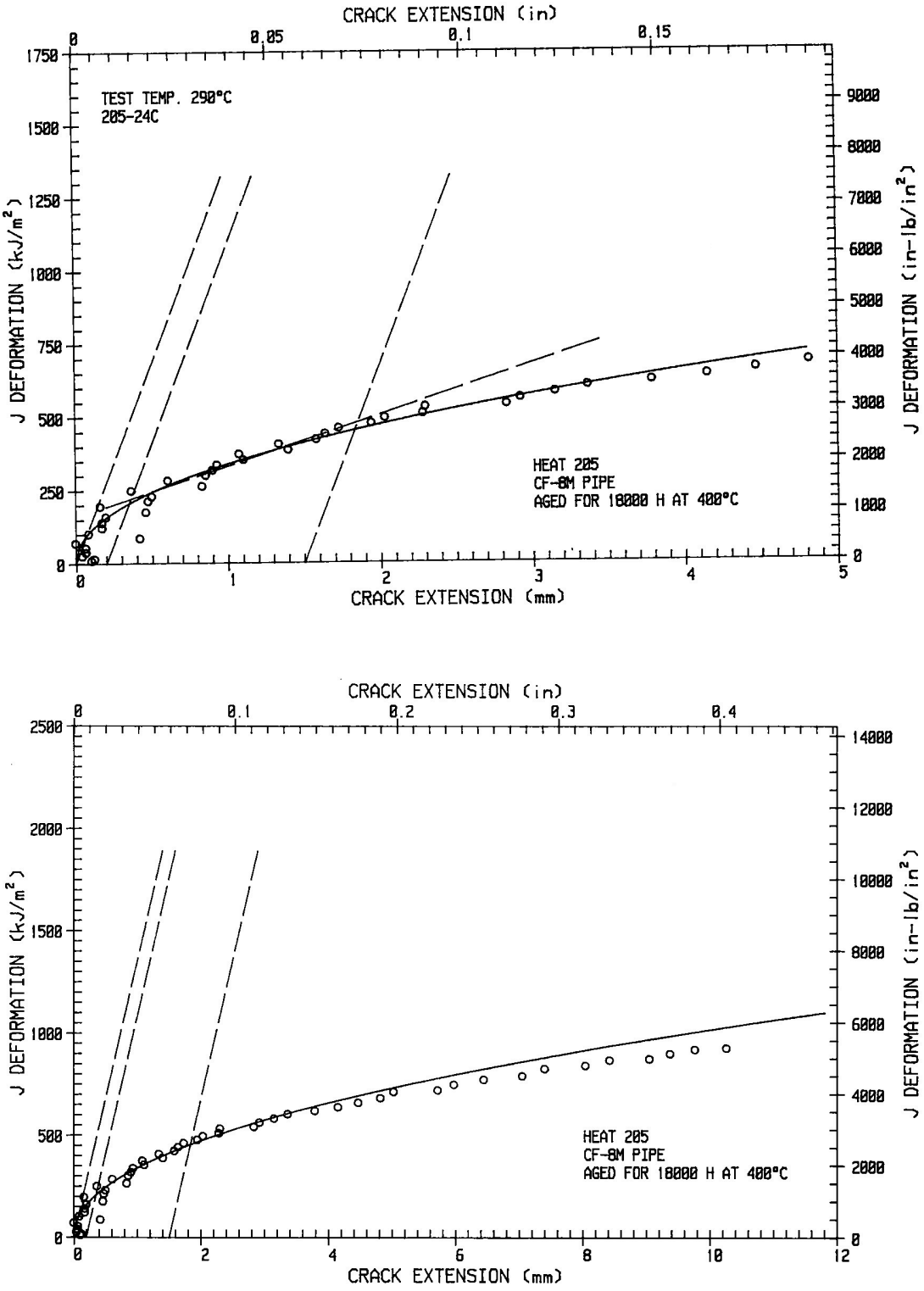


Figure D–23. Deformation J_{IC} and J–R Curve for Heat 205 Pipe Aged for 18,000 h at 400°C and Tested at 290°C.

Table D–22. Modified J_{IC} and J–R Curve Results for Specimen 205–24C

Test Number	:	0006	Test Temp	:	290°C
Material Type	:	CF–8M	Heat Number	:	205
Aging Temp	:	400°C	Aging Time	:	18,000 h
Spec. Thickness	:	25.28 mm	Net Thickness	:	20.19 mm
Spec. Width	:	50.68 mm	Flow Stress σ_f	:	338.95 MPa
Modulus E	:	182.68 GPa	(Effective)		
Modulus E	:	168.90 GPa	(Nominal)		
Initial Crack	:	31.3344 mm	Initial a/w	:	0.6183 (Measured)
Final Crack	:	40.6031 mm	Final a/w	:	0.8012 (Measured)
Final Crack	:	41.5856 mm	Final a/w	:	0.8206 (Compliance)

LINEAR FIT $J = B+M(\Delta a)$

Intercept B	=	152.014 kJ/m^2	Slope M = 194.79
Fit Coeff R	=	0.9744	(15 Data Points)
J_{IC}	=	177.5 kJ/m^2	(1013.7 in·lb/in^2)
Δa (J_{IC})	=	0.131 mm	(0.0052 in)
T Average	=	309.7	(J_{IC} at 0.15)

POWER LAW FIT $J=C(\Delta a)^n$

Coeff C	=	354.33 kJ/m^2	Exponent N = 0.5118
Fit Coeff R	=	0.9521	(15 Data Points)
J_{IC} (0.20)	=	208.1 kJ/m^2	(1188.3 in·lb/in^2)
Δa (J_{IC})	=	0.353 mm	(0.0139 in)
T Average	=	285.4	(J_{IC} at 0.20)
J_{IC} (0.15)	=	187.5 kJ/m^2	(1070.5 in·lb/in^2)
Δa (J_{IC})	=	0.288 mm	(0.0113 in)
T Average	=	291.8	(J_{IC} at 0.15)
Kjc	=	298.2 MPa·m$^{0.5}$	

J_{IC} VALIDITY & DATA QUALIFICATION (E 813–85)

Jmax Allowed	:	437.15 kJ/m^2	(Jmax = $b_o\sigma_f/15$)
Data Limit	:	Jmax	Ignored
Δa (max) Allowed	:	1.859 mm	(at 1.5 exclusion line)
Data Limit	:	1.5 Exclusion line	
Data Points	:	Zone A = 4	Zone B = 5
Data Point Spacing	:	OK	
B_{net} and b_o Size	:	OK	
dJ/da at J_{IC}	:	OK	
ao Measurement	:	2 outside limit	
ao Measurement	:	7 outside limit	
ao Measurement	:	8 outside limit	
ao Measurement	:	9 outside limit	
ao Measurement	:	1 outside limit	
af Measurement	:	Near–surface	outside limit
Crack Size Estimate	:	Inadequate	(by compliance)
E Effective	:	OK	
J_{IC} Estimate	:	INVALID	

J–R CURVE VALIDITY & DATA QUALIFICATION (E 1152–87)

Δa (max) Allowed	:	1.935 mm	($\Delta a = 0.1\ b_o$)
Δa (max) Allowed	:	4.706 mm	(Omega = 5)
Data Points	:	Zone A = 12	Zone B = 15
Data Point Spacing	:	OK	
J–R Curve Data	:	INVALID	

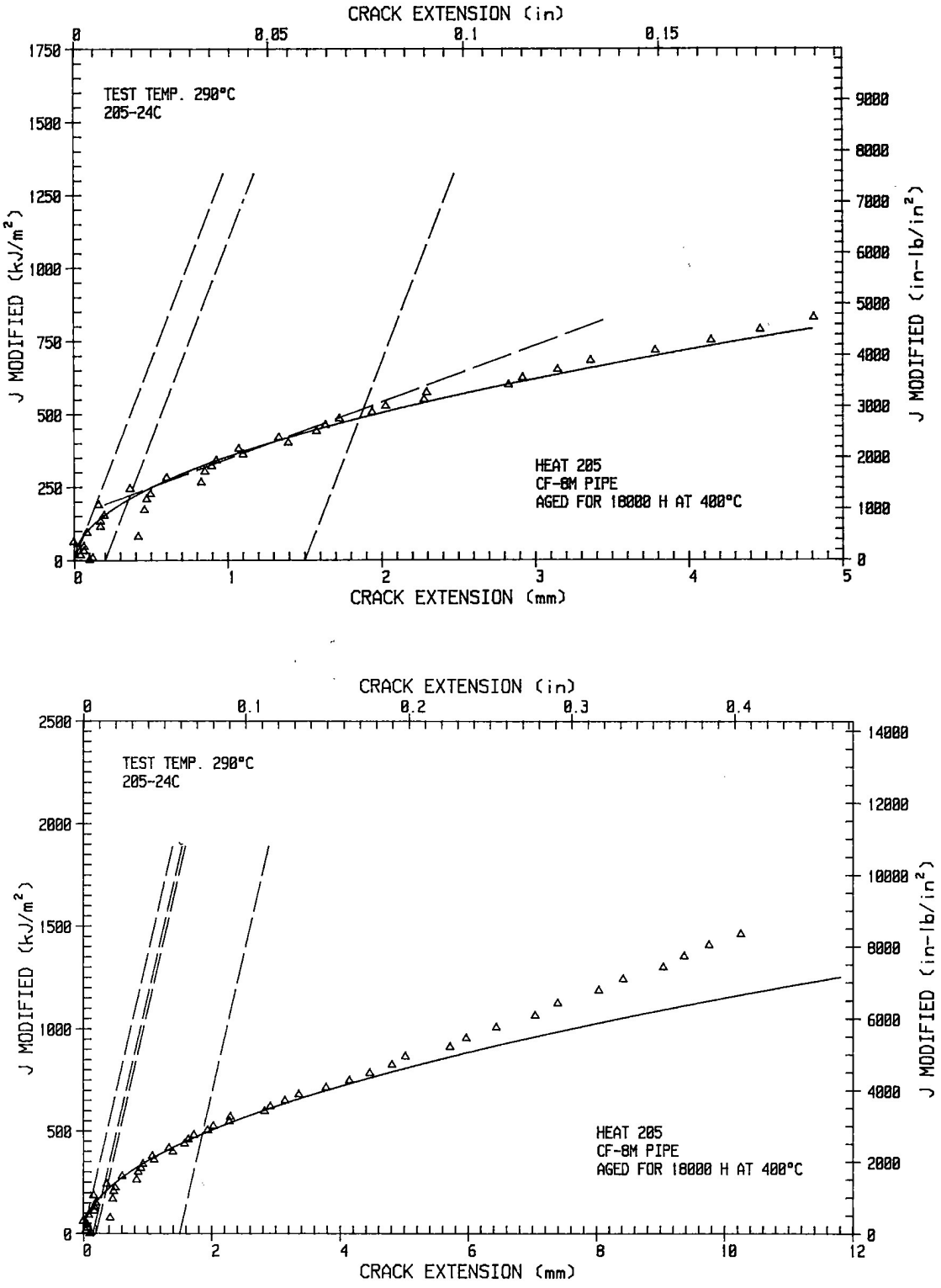


Figure D–24. Modified J_{IC} and J–R Curve for Heat 205 Pipe Aged for 18,000 h at 400°C and Tested at 290°C.

Table D–23. Test Data for Specimen 205–23C

Test Number	:	0012	Test Temp	:	290°C
Material Type	:	CF–8M Pipe Weld	Heat Number	:	205
Aging Temp	:	400°C	Aging Time	:	18,000 h
Spec. Thickness	:	25.44 mm	Net Thickness	:	20.34 mm
Spec. Width	:	50.78 mm	Flow Stress σ_f	:	418.20 MPa

Unload Number	J_d (kJ/m^2)	J_m (kJ/m^2)	Δa (mm)	Load (kN)	Deflection (mm)
1	4.25	4.25	0.0468	14.616	0.113
2	7.19	7.19	0.1084	18.609	0.154
3	8.45	8.44	−0.2614	20.586	0.174
4	11.99	12.00	−0.0425	23.066	0.202
5	14.96	14.99	0.1851	25.612	0.231
6	17.33	17.33	−0.1563	28.109	0.261
7	23.74	23.77	−0.0028	30.916	0.300
8	29.36	29.37	−0.0638	34.025	0.345
9	37.86	37.89	−0.0425	37.018	0.397
10	48.04	48.06	−0.0486	39.994	0.457
11	59.37	59.35	−0.0828	42.447	0.519
12	76.14	76.22	−0.0327	44.914	0.603
13	94.48	94.86	0.0737	46.909	0.693
14	112.46	112.14	−0.1147	48.324	0.783
15	141.26	141.64	0.0222	49.779	0.905
16	173.69	175.79	0.2772	51.022	1.053
17	203.29	207.26	0.5037	51.654	1.191
18	234.51	239.36	0.5925	52.110	1.333
19	277.56	281.04	0.4814	52.500	1.514
20	307.11	314.57	0.7661	52.661	1.637
21	330.13	343.35	1.1420	52.432	1.755
22	350.36	361.06	0.9892	52.498	1.852
23	376.18	395.20	1.4496	51.992	1.966
24	396.28	414.22	1.3937	51.350	2.070
25	417.02	445.85	1.9211	50.820	2.177
26	433.23	464.44	2.0306	50.275	2.278
27	456.06	485.61	1.9590	49.791	2.374
28	477.81	514.64	2.2547	48.931	2.479
29	494.70	542.17	2.6634	47.095	2.595
30	503.51	553.64	2.7629	46.111	2.664
31	519.09	581.75	3.2086	44.846	2.775
32	524.78	598.04	3.5765	43.862	2.859
33	537.21	611.50	3.6116	43.419	2.939
34	546.74	630.44	3.9194	42.638	3.013
35	556.18	649.74	4.2314	41.100	3.106
36	558.75	664.56	4.6122	40.287	3.178
37	568.37	676.27	4.6756	39.396	3.254
38	578.27	694.95	4.9339	38.620	3.334
39	595.53	734.63	5.5554	36.241	3.513
40	600.01	745.62	5.7324	35.408	3.601
41	607.05	761.12	5.9582	34.820	3.680
42	614.14	776.73	6.1799	33.850	3.763
43	621.41	790.83	6.3540	33.328	3.842
44	624.45	807.45	6.6939	32.589	3.923
45	632.45	818.21	6.7616	32.001	4.000
46	643.15	831.33	6.8198	31.529	4.071
47	649.79	848.82	7.0750	31.097	4.154
48	658.63	862.43	7.1845	30.467	4.240
49	664.49	876.54	7.3709	29.913	4.314
50	669.04	893.54	7.6460	28.940	4.406
51	679.69	918.73	7.9592	27.958	4.558
52	683.81	931.25	8.1361	27.362	4.636
53	691.31	956.58	8.5029	26.250	4.791

Table D–23. (Contd.)

Unload Number	J_d (kJ/m^2)	J_m (kJ/m^2)	Δa (mm)	Load (kN)	Deflection (mm)
54	695.79	972.31	8.7280	25.246	4.883
55	696.31	994.26	9.1500	24.132	5.033
56	701.83	1006.09	9.2713	23.667	5.111
57	710.06	1029.30	9.5553	22.813	5.273
58	710.94	1044.83	9.8252	22.315	5.355
59	717.62	1053.37	9.8592	22.086	5.432
60	723.28	1075.22	10.1460	21.228	5.555
61	728.03	1108.43	10.6370	19.960	5.792
62	731.23	1126.19	10.8813	19.321	5.921
63	743.11	1179.92	11.5569	17.292	6.328
64	755.69	1220.01	11.9761	16.322	6.631
65	765.00	1242.56	12.1702	15.860	6.808
66	780.75	1295.22	12.6891	14.603	7.227
67	788.73	1324.52	12.9745	13.912	7.466
68	799.34	1387.64	13.6413	12.429	8.008
69	810.17	1418.68	13.8861	11.853	8.308
70	818.62	1453.69	14.1960	11.140	8.628
71	816.01	1533.69	15.1067	9.403	9.428
72	819.81	1569.08	15.4355	8.734	9.827
73	827.11	1603.20	15.7050	8.313	10.210

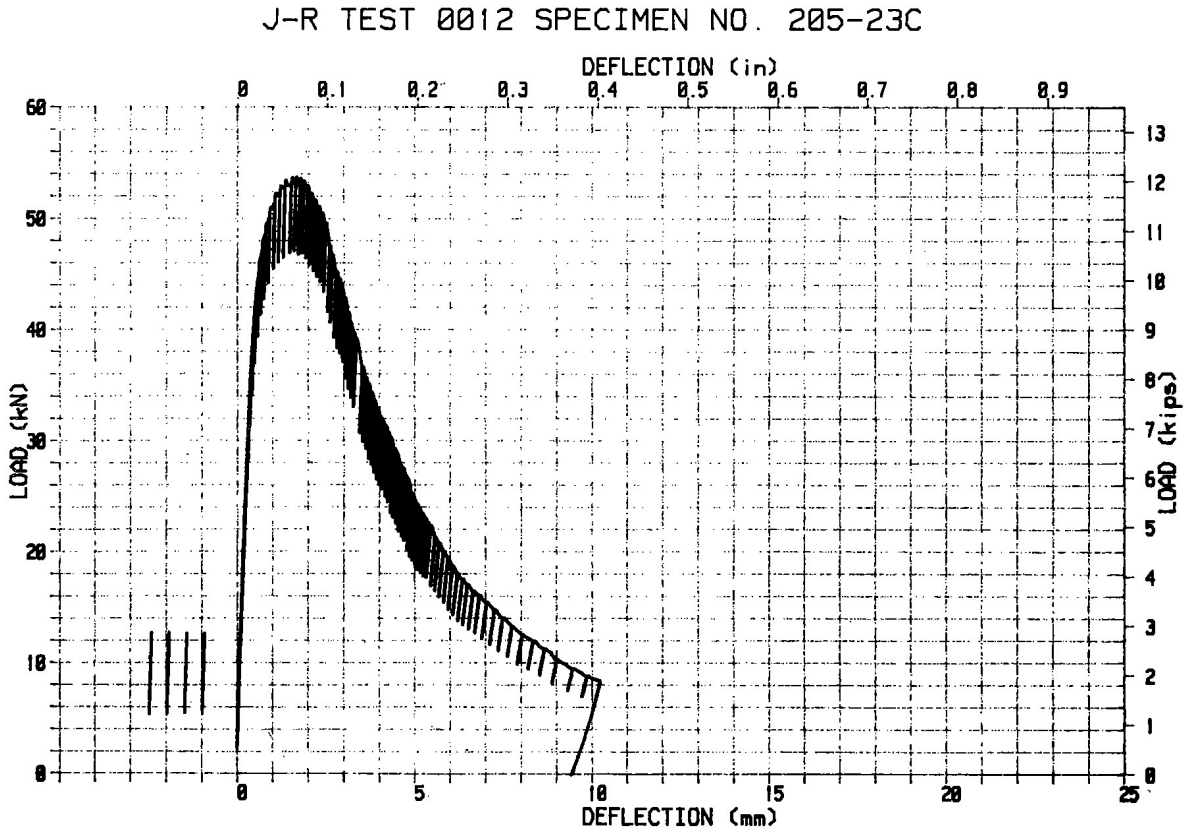


Figure D–25. Load vs Load Line Displacement Curve for Heat 205 Pipe Weld Aged for 18,000 h at 400°C and Tested at 290°C.

Table D–24. Deformation J_{IC} and J–R Curve Results for Specimen 205–23C

Test Number	:	0012	Test Temp	:	290°C
Material Type	:	CF–8M Pipe Weld	Heat Number	:	205
Aging Temp	:	400°C	Aging Time	:	18,000 h
Spec. Thickness	:	25.44 mm	Net Thickness	:	20.34 mm
Spec. Width	:	50.78 mm	Flow Stress σ_f	:	418.20 MPa
Modulus E	:	176.87 GPa	(Effective)		
Modulus E	:	200.00 GPa	(Nominal)		
Initial Crack	:	25.9469 mm	Initial a/w	:	0.5110 (Measured)
Final Crack	:	42.3031 mm	Final a/w	:	0.8331 (Measured)
Final Crack	:	41.6519 mm	Final a/w	:	0.8202 (Compliance)

LINEAR FIT $J = B+M(\Delta a)$

Intercept B	= 149.049 kJ/m^2	Slope M	= 172.16
Fit Coeff R	= 0.9317	(9 Data Points)	
J_{IC}	= 166.1 kJ/m^2	(948.7 in·lb/in^2)	
Δa (J_{IC})	= 0.099 mm	(0.0039 in)	
T Average	= 174.1	(J_{IC} at 0.15)	

POWER LAW FIT $J=C(\Delta a)^n$

Coeff C	= 328.05 kJ/m^2	Exponent N	= 0.4823
Fit Coeff R	= 0.9382	(9 Data Points)	
J_{IC} (0.20)	= 187.0 kJ/m^2	(1067.7 in·lb/in^2)	
Δa (J_{IC})	= 0.312 mm	(0.0123 in)	
T Average	= 164.5	(J_{IC} at 0.20)	
J_{IC} (0.15)	= 168.3 kJ/m^2	(960.9 in·lb/in^2)	
Δa (J_{IC})	= 0.251 mm	(0.0099 in)	
T Average	= 168.5	(J_{IC} at 0.15)	
Kjc	= 276.0 MPa·m$^{0.5}$		

J_{IC} VALIDITY & DATA QUALIFICATION (E 813–85)

Jmax Allowed	:	692.35 kJ/m^2	(Jmax = $b_o\sigma_f/15$)
Data Limit	:	Jmax	Ignored
Δa (max) Allowed	:	1.757 mm	(at 1.5 exclusion line)
Data Limit	:	1.5 Exclusion line	
Data Points	:	Zone A = 4	Zone B = 2
Data Point Spacing	:	OK	
B_{net} and b_o Size	:	OK	
dJ/da at J_{IC}	:	OK	
af Measurement	:	Near–surface	outside limit
Initial Crack Shape	:	OK	
Crack Size Estimate	:	Inadequate	(by compliance)
E Effective	:	Inadequate	
J_{IC} Estimate	:	INVALID	

J–R CURVE VALIDITY & DATA QUALIFICATION (E 1152–87)

Jmax Allowed	:	425.31 kJ/m^2	(Jmax = $B_{net}\sigma_f/20$)
Δa (max) Allowed	:	2.483 mm	($\Delta a = 0.1\ b_o$)
Δa (max) Allowed	:	4.468 mm	(Omega = 5)
Data Points	:	Zone A = 4	Zone B = 14
Data Point Spacing	:	OK	
J–R Curve Data	:	INVALID	

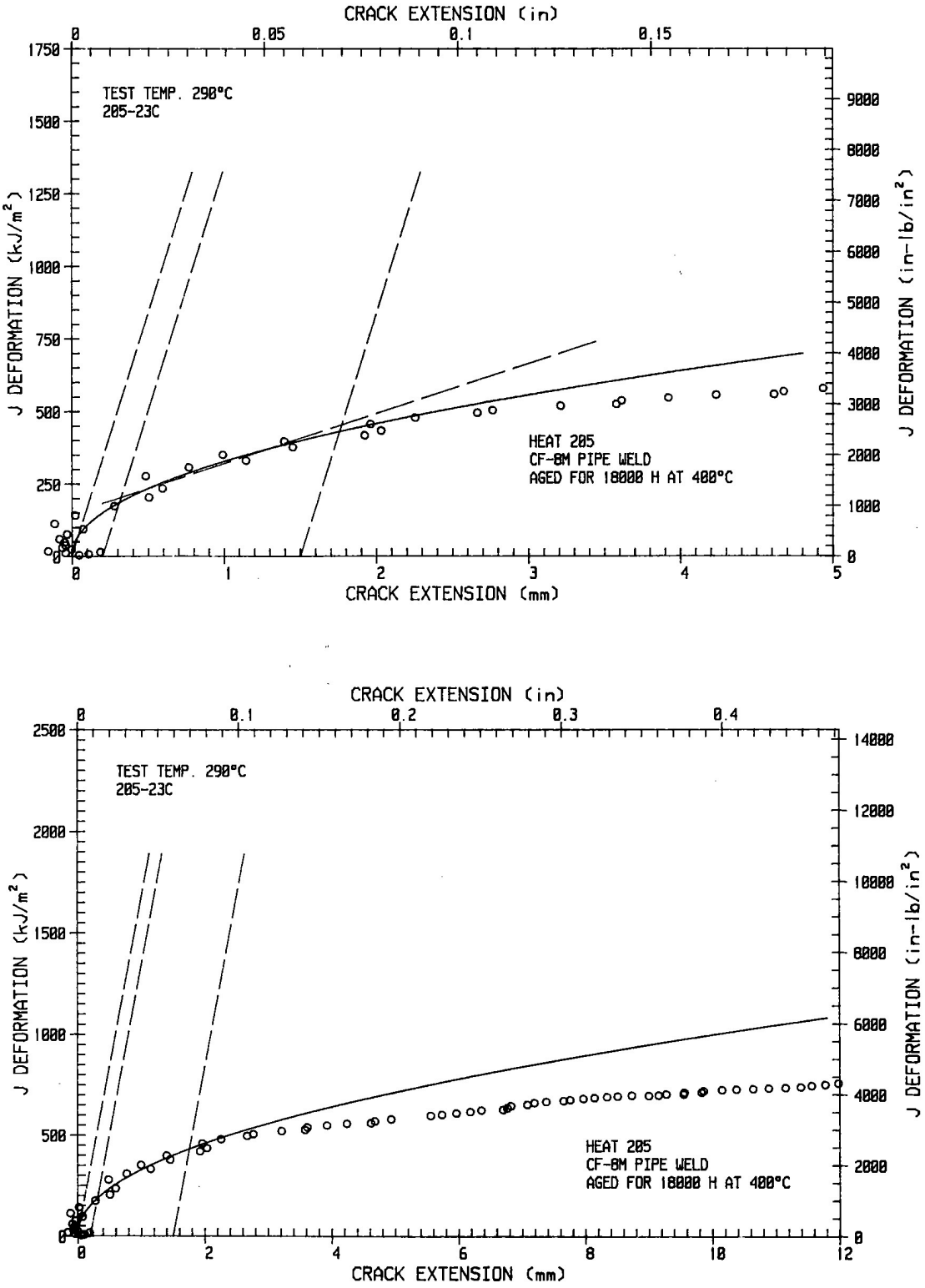


Figure D–26. Deformation J_{IC} and J–R Curve for Heat 205 Pipe Weld Aged for 18,000 h at 400°C and Tested at 290°C.

Table D–25. Modified J_{IC} and J–R Curve Results for Specimen 205–23CC

Test Number	:	0012	Test Temp	:	290°C
Material Type	:	CF–8M Pipe Weld	Heat Number	:	205
Aging Temp	:	400°C	Aging Time	:	18,000 h
Spec. Thickness	:	25.44 mm	Net Thickness	:	20.34 mm
Spec. Width	:	50.78 mm	Flow Stress σ_f	:	418.20 MPa
Modulus E	:	176.87 GPa	(Effective)		
Modulus E	:	200.00 GPa	(Nominal)		
Initial Crack	:	25.9469 mm	Initial a/w	:	0.5110 (Measured)
Final Crack	:	42.3031 mm	Final a/w	:	0.8331 (Measured)
Final Crack	:	41.6519 mm	Final a/w	:	0.8202 (Compliance)

LINEAR FIT $J = B+M(\Delta a)$

Intercept B	=	145.569 kJ/m^2	Slope M = 187.18
Fit Coeff R	=	0.9425	(9 Data Points)
J_{IC}	=	163.9 kJ/m^2	(936.0 in·lb/in^2)
Δa (J_{IC})	=	0.098 mm	(0.0039 in)
T Average	=	189.3	(J_{IC} at 0.15)

POWER LAW FIT $J=C(\Delta a)^n$

Coeff C	=	339.66 kJ/m^2	Exponent N = 0.5055
Fit Coeff R	=	0.9457	(9 Data Points)
J_{IC} (0.20)	=	188.8 kJ/m^2	(1077.9 in·lb/in^2)
Δa (J_{IC})	=	0.313 mm	(0.0123 in)
T Average	=	177.5	(J_{IC} at 0.20)
J_{IC} (0.15)	=	168.9 kJ/m^2	(964.2 in·lb/in^2)
Δa (J_{IC})	=	0.251 mm	(0.0099 in)
T Average	=	181.7	(J_{IC} at 0.15)
Kjc	=	283.2 MPa·m$^{0.5}$	

J_{IC} VALIDITY & DATA QUALIFICATION (E 813–85)

Jmax Allowed	:	692.35 kJ/m^2	(Jmax = $b_o\sigma_f/15$)
Data Limit	:	Jmax	Ignored
Δa (max) Allowed	:	1.771 mm	(at 1.5 exclusion line)
Data Limit	:	1.5 Exclusion line	
Data Points	:	Zone A = 4	Zone B = 2
Data Point Spacing	:	OK	
B_{net} and b_o Size	:	OK	
dJ/da at J_{IC}	:	OK	
af Measurement	:	Near–surface	outside limit
Initial Crack Shape	:	OK	
Crack Size Estimate	:	Inadequate	(by compliance)
E Effective	:	Inadequate	
J_{IC} Estimate	:	INVALID	

J–R CURVE VALIDITY & DATA QUALIFICATION (E 1152–87)

Jmax Allowed	:	425.31 kJ/m^2	(Jmax = $B_{net}\sigma_f/20$)
Δa (max) Allowed	:	2.483 mm	($\Delta a = 0.1\ b_o$)
Δa (max) Allowed	:	4.663 mm	(Omega = 5)
Data Points	:	Zone A = 4	Zone B = 14
Data Point Spacing	:	OK	
J–R Curve Data	:	INVALID	

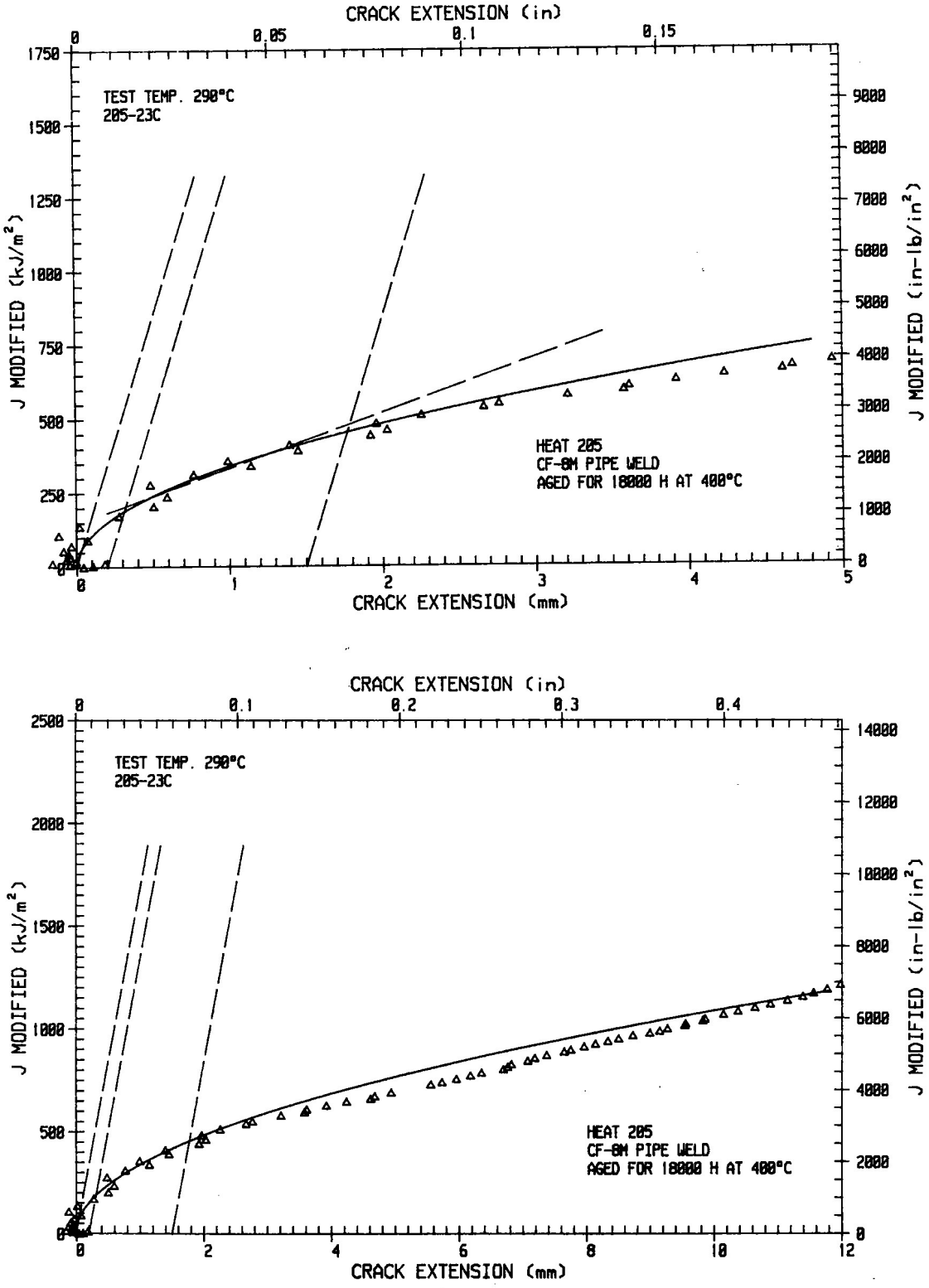


Figure D–27. Modified J_{IC} and J–R Curve for Heat 205 Pipe Weld Aged for 18,000 h at 400°C and Tested at 290°C.

Table D–26. Test Data for Specimen 752–08T

Test Number	:	0008	Test Temp	:	25°C
Material Type	:	CF–8M Slab	Heat Number	:	75
Aging Temp	:	25°C	Aging Time	:	0 h
Spec. Thickness	:	25.41 mm	Net Thickness	:	20.49 mm
Spec. Width	:	50.78 mm	Flow Stress σ_f	:	448.21 MPa

Unload Number	J_d (kJ/m^2)	J_m (kJ/m^2)	Δa (mm)	Load (kN)	Deflection (mm)
1	6.61	6.61	−0.1729	15.071	0.172
2	10.31	10.31	−0.1017	17.572	0.214
3	14.94	14.97	−0.0117	20.032	0.264
4	19.74	19.73	−0.1037	22.037	0.314
5	29.47	29.45	−0.1152	24.451	0.395
6	44.06	44.32	0.0766	26.854	0.504
7	60.27	60.05	−0.1279	28.756	0.627
8	79.63	79.88	0.0095	30.223	0.748
9	92.95	92.69	−0.1148	31.060	0.838
10	109.69	109.89	−0.0221	31.878	0.938
11	126.18	125.77	−0.1250	32.622	1.041
12	145.51	146.07	0.0129	33.326	1.152
13	165.72	166.30	0.0154	34.021	1.275
14	189.84	189.94	−0.0345	34.624	1.411
15	219.54	221.04	0.0867	35.271	1.577
16	250.51	252.34	0.1115	35.698	1.752
17	277.99	280.71	0.1714	36.226	1.904
18	301.23	304.90	0.2291	36.430	2.033
19	326.73	327.87	0.0877	36.781	2.161
20	350.48	355.56	0.2907	37.009	2.292
21	375.01	378.91	0.2340	37.365	2.425
22	400.98	404.46	0.2153	37.512	2.553
23	424.31	430.87	0.3433	37.726	2.683
24	447.91	456.00	0.4037	37.927	2.814
25	473.88	480.41	0.3459	37.987	2.943
26	496.82	508.30	0.5184	38.069	3.073
27	518.57	533.09	0.6193	38.008	3.202
28	541.06	559.25	0.7351	38.051	3.333
29	567.21	584.49	0.7079	37.930	3.465
30	593.41	611.46	0.7299	37.923	3.596
31	613.63	638.53	0.9174	37.722	3.724
32	634.67	663.41	1.0186	37.561	3.854
33	652.67	690.29	1.2438	37.485	3.983
34	676.20	714.24	1.2540	37.378	4.114
35	700.24	741.17	1.3219	37.192	4.244
36	723.25	768.01	1.4084	36.950	4.376
37	741.57	793.98	1.5756	36.923	4.502
38	767.75	818.29	1.5362	36.834	4.633
39	797.02	844.51	1.4742	36.722	4.763
40	816.24	873.45	1.6655	36.570	4.895
41	836.72	897.92	1.7416	36.225	5.024
42	850.88	924.81	1.9785	35.917	5.152
43	865.57	949.68	2.1631	35.654	5.282
44	889.29	980.46	2.2869	35.277	5.441
45	916.23	1012.83	2.3787	34.701	5.605
46	937.22	1052.02	2.6752	33.536	5.796
47	952.42	1092.16	3.0668	31.498	6.007
48	962.68	1136.16	3.5783	29.816	6.251
49	977.38	1174.66	3.9274	28.505	6.484
50	983.94	1208.78	4.3211	27.006	6.686
51	971.92	1248.12	5.0387	25.362	6.924
52	979.67	1279.22	5.3571	24.494	7.149
53	995.09	1315.28	5.6297	23.537	7.381

Table D–26. (Contd.)

54	1009.65	1353.94	5.9382	22.681	7.630
55	1024.07	1395.81	6.2778	21.839	7.903
56	1027.84	1435.84	6.7141	20.896	8.170
57	1028.20	1474.12	7.1587	19.929	8.439
58	1038.10	1510.73	7.4627	18.863	8.709
59	1046.51	1547.76	7.7791	17.948	8.979
60	1045.10	1588.20	8.2288	16.620	9.279
61	1036.53	1625.61	8.7116	15.783	9.580
62	1028.81	1661.72	9.1621	15.265	9.879
63	1039.59	1696.48	9.4015	14.621	10.178
64	1046.18	1734.34	9.7053	14.269	10.477
65	1063.78	1770.13	9.8767	13.868	10.778
66	1073.90	1808.15	10.1321	13.526	11.078
67	1084.49	1844.06	10.3575	12.990	11.377
68	1088.59	1880.67	10.6394	12.611	11.679
69	1103.40	1914.33	10.7983	12.155	11.978

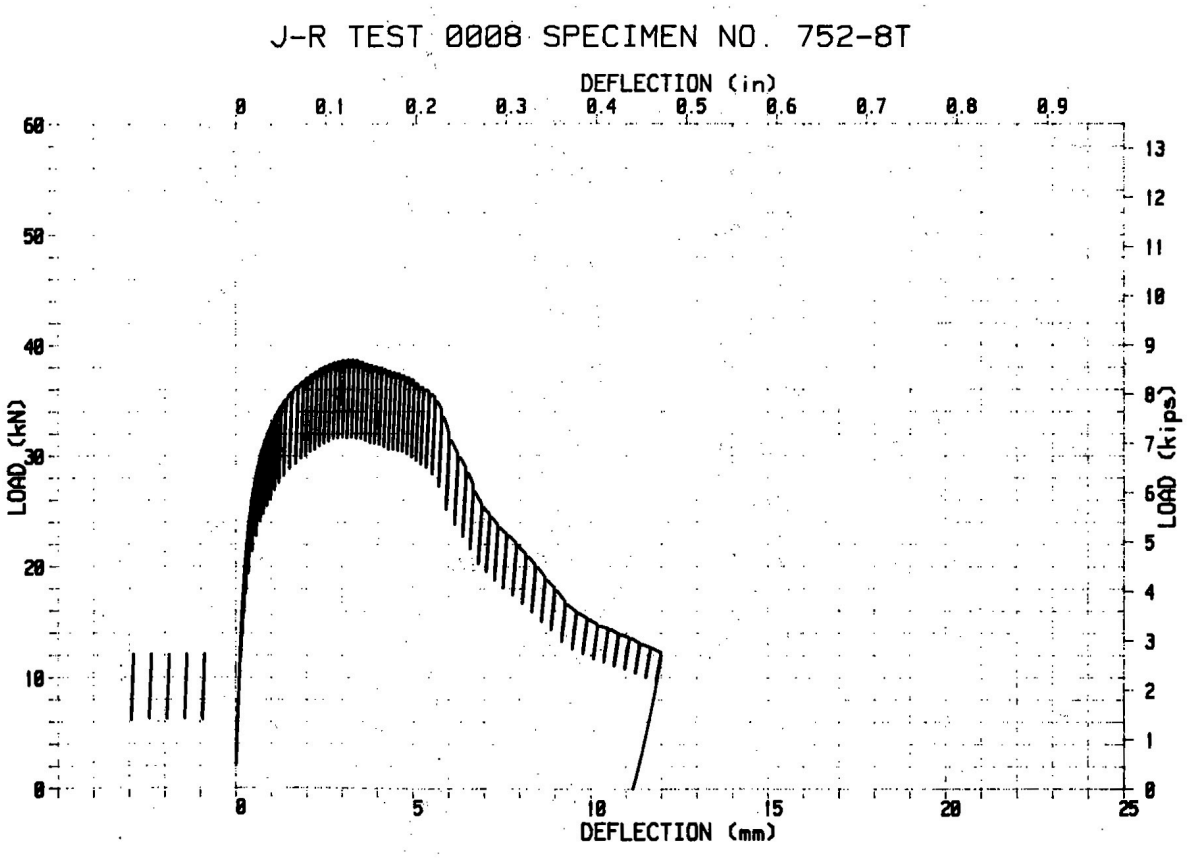


Figure D–28. Load vs Load Line Displacement Curve for Unaged Heat 75 Tested at Room Temperature.

Table D–27. Deformation J_{IC} and J–R Curve Results for Specimen 752–08T

Test Number	:	0008	Test Temp	:	25°C
Material Type	:	CF–8M	Heat Number	:	75
Aging Temp	:	25°C	Aging Time	:	0 h
Spec. Thickness	:	25.41 mm	Net Thickness	:	20.49 mm
Spec. Width	:	50.78 mm	Flow Stress σ_f	:	448.21 MPa
Modulus E	:	198.26 GPa	(Effective)		
Modulus E	:	193.10 GPa	(Nominal)		
Initial Crack	:	29.6406 mm	Initial a/w	:	0.5837 (Measured)
Final Crack	:	41.5594 mm	Final a/w	:	0.8184 (Measured)
Final Crack	:	40.4389 mm	Final a/w	:	0.7964 (Compliance)

LINEAR FIT $J = B+M(\Delta a)$

Intercept B	=	359.488 kJ/m^2	Slope M = 265.68
Fit Coeff R	=	0.9807	(17 Data Points)
J_{IC}	=	422.0 kJ/m^2	(2409.9 in·lb/in^2)
Δa (J_{IC})	=	0.235 mm	(0.0093 in)
T Average	=	262.2	(J_{IC} at 0.15)

POWER LAW FIT $J=C(\Delta a)^n$

Coeff C	=	639.27 kJ/m^2	Exponent N = 0.4047
Fit Coeff R	=	0.9804	(17 Data Points)
J_{IC} (0.20)	=	467.1 kJ/m^2	(2667.2 in·lb/in^2)
Δa (J_{IC})	=	0.461 mm	(0.0181 in)
T Average	=	237.1	(J_{IC} at 0.20)
J_{IC} (0.15)	=	438.9 kJ/m^2	(2506.0 in·lb/in^2)
Δa (J_{IC})	=	0.395 mm	(0.0155 in)
T Average	=	242.7	(J_{IC} at 0.15)
Kjc	=	408.3 MPa·m$^{0.5}$	

J_{IC} VALIDITY & DATA QUALIFICATION (E 813–85)

Jmax Allowed	:	631.66 kJ/m^2	(Jmax = $b_o\sigma_f/15$)
Data Limit	:	Jmax	Ignored
Δa (max) Allowed	:	1.969 mm	(at 1.5 exclusion line)
Data Limit	:	1.5 Exclusion line	
Data Points	:	Zone A = 6	Zone B = 6
Data Point Spacing	:	OK	
B_{net} or b_o Size	:	Inadequate	
dJ/da at J_{IC}	:	OK	
af Measurement	:	Near–surface	outside limit
Initial Crack Shape	:	OK	
Crack Size Estimate	:	Inadequate	(by compliance)
E Effective	:	OK	
J_{IC} Estimate	:	INVALID	

J–R CURVE VALIDITY & DATA QUALIFICATION (E 1152–87)

Jmax Allowed	:	459.19 kJ/m^2	(Jmax = $B_{net}\sigma_f/20$)
Δa (max) Allowed	:	2.114 mm	($\Delta a = 0.1\ b_o$)
Δa (max) Allowed	:	3.803 mm	(Omega = 5)
Data Points	:	Zone A = 21	Zone B = 11
Data Point Spacing	:	OK	
J–R Curve Data	:	INVALID	

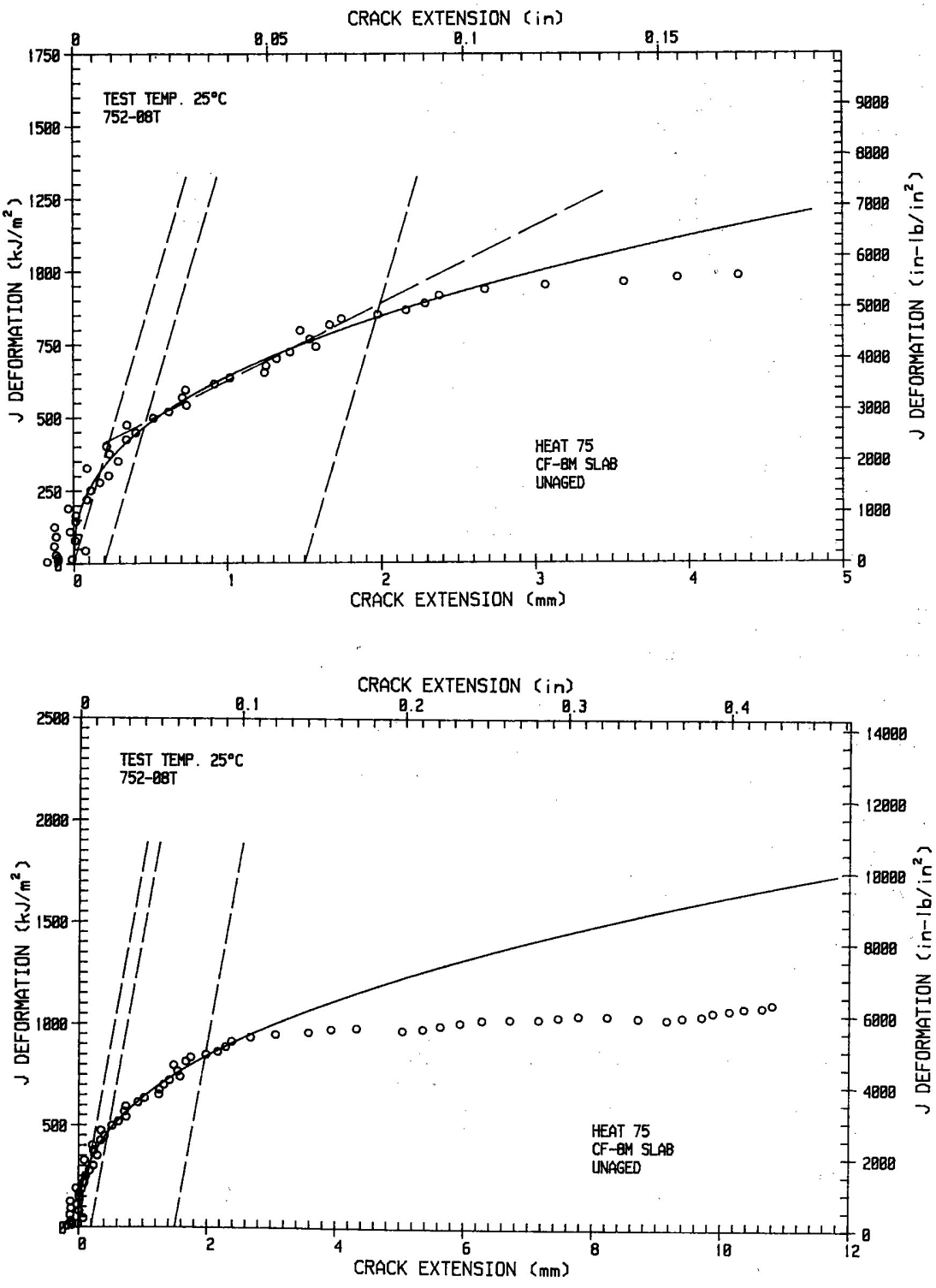


Figure D–29. Deformation J_{IC} and J–R Curve for Unaged Heat 75 Tested at Room Temperature.

Table D–28. Modified J_{IC} and J–R Curve Results for Specimen 752–08T

Test Number	:	0008	Test Temp	:	25°C
Material Type	:	CF–8M	Heat Number	:	75
Aging Temp	:	25°C	Aging Time	:	0 h
Spec. Thickness	:	25.41 mm	Net Thickness	:	20.49 mm
Spec. Width	:	50.78 mm	Flow Stress σ_f	:	448.21 MPa
Modulus E	:	198.26 GPa	(Effective)		
Modulus E	:	193.10 GPa	(Nominal)		
Initial Crack	:	29.6406 mm	Initial a/w	:	0.5837 (Measured)
Final Crack	:	41.5594 mm	Final a/w	:	0.8184 (Measured)
Final Crack	:	40.4389 mm	Final a/w	:	0.7964 (Compliance)

LINEAR FIT $J = B+M(\Delta a)$

Intercept B	=	362.045 kJ/m^2	Slope M	=	293.97
Fit Coeff R	=	0.9843	(17 Data Points)		
J_{IC}	=	433.1 kJ/m^2	(2472.8 in·lb/in^2)		
Δa (J_{IC})	=	0.242 mm	(0.0095 in)		
T Average	=	290.1	(J_{IC} at 0.15)		

POWER LAW FIT $J=C(\Delta a)^n$

Coeff C	=	668.89 kJ/m^2	Exponent N	=	0.4545
Fit Coeff R	=	0.9818	(17 Data Points)		
J_{IC} (0.20)	=	471.3 kJ/m^2	(2691.2 in·lb/in^2)		
Δa (J_{IC})	=	0.463 mm	(0.0182 in)		
T Average	=	277.3	(J_{IC} at 0.20)		
J_{IC} (0.15)	=	438.2 kJ/m^2	(2502.4 in·lb/in^2)		
Δa (J_{IC})	=	0.394 mm	(0.0155 in)		
T Average	=	283.5	(J_{IC} at 0.15)		
Kjc	=	426.9 MPa·m$^{0.5}$			

J_{IC} VALIDITY & DATA QUALIFICATION (E 813–85)

Jmax Allowed	:	631.66 kJ/m^2	(Jmax = $b_o\sigma_f/15$)
Data Limit	:	Jmax	Ignored
Δa (max) Allowed	:	2.013 mm	(at 1.5 exclusion line)
Data Limit	:	1.5 Exclusion line	
Data Points	:	Zone A = 5	Zone B = 6
Data Point Spacing	:	OK	
B_{net} or b_o Size	:	Inadequate	
dJ/da at J_{IC}	:	OK	
af Measurement	:	Near–surface	outside limit
Initial Crack Shape	:	OK	
Crack Size Estimate	:	Inadequate	(by compliance)
E Effective	:	OK	
J_{IC} Estimate	:	INVALID	

J–R CURVE VALIDITY & DATA QUALIFICATION (E 1152–87)

Jmax Allowed	:	459.19 kJ/m^2	(Jmax = $B_{net}\sigma_f/20$)
Δa (max) Allowed	:	2.114 mm	($\Delta a = 0.1\ b_o$)
Δa (max) Allowed	:	4.232 mm	(Omega = 5)
Data Points	:	Zone A = 21	Zone B = 11
Data Point Spacing	:	OK	
J–R Curve Data	:	INVALID	

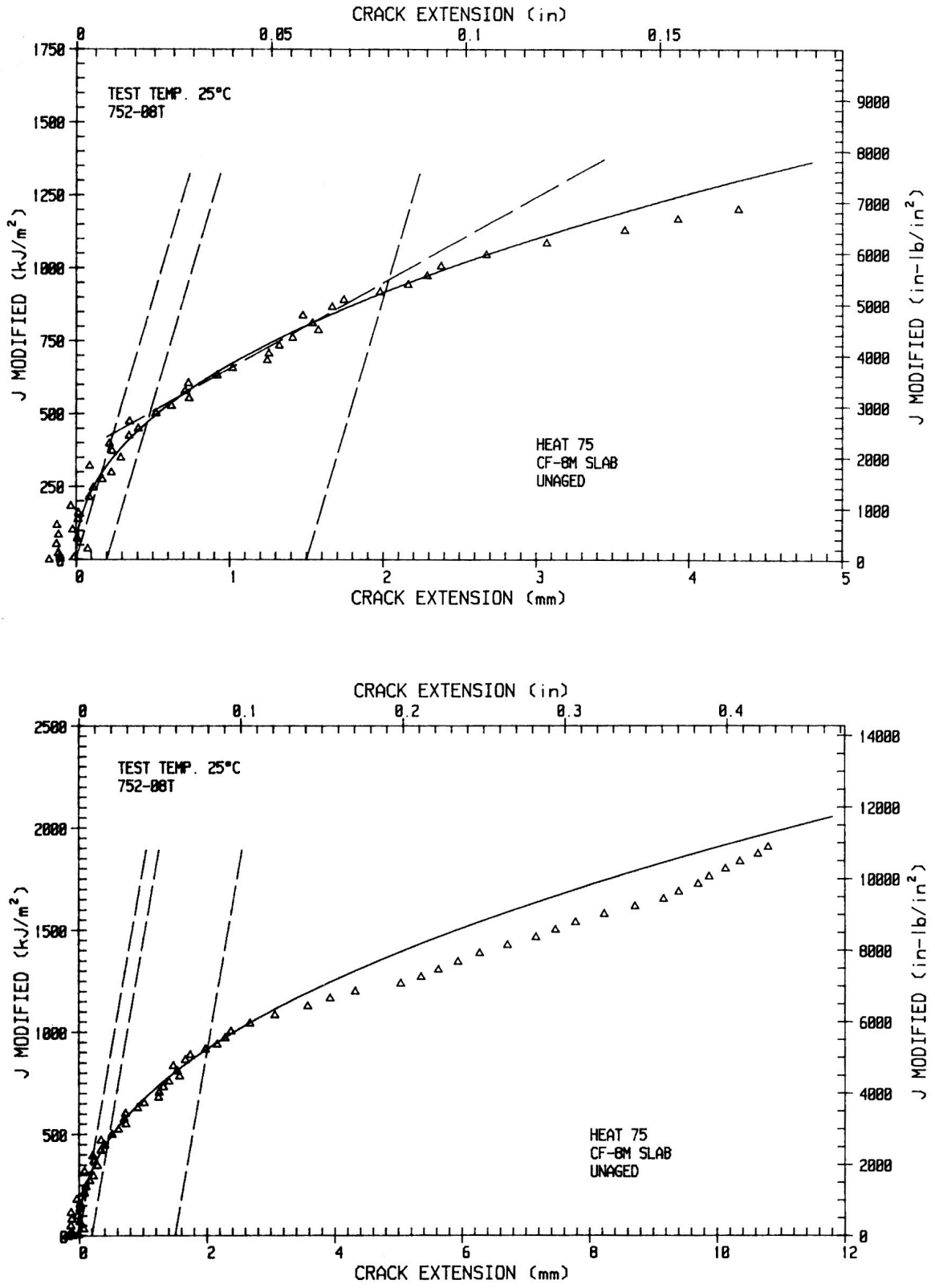


Figure D–30. Modified J_{IC} and J–R Curve for Unaged Heat 75 Tested at Room Temperature.

Table D–29. Test Data for Specimen 752–08B

Test Number	:	0007	Test Temp	:	290°C
Material Type	:	CF–8M	Heat Number	:	75
Aging Temp	:	25°C	Aging Time	:	0 h
Spec. Thickness	:	25.35 mm	Net Thickness	:	20.25 mm
Spec. Width	:	50.78 mm	Flow Stress σ_f	:	338.95 MPa

Unload Number	J_d (kJ/m^2)	J_m (kJ/m^2)	Δa (mm)	Load (kN)	Deflection (mm)
1	5.66	5.66	0.0719	13.065	0.158
2	9.79	9.74	−0.2680	15.583	0.221
3	17.73	17.66	−0.3084	17.879	0.309
4	25.79	26.17	0.2216	19.500	0.387
5	36.64	36.71	0.0044	20.886	0.506
6	54.35	54.36	−0.0187	22.436	0.658
7	73.47	73.60	0.0147	23.501	0.818
8	96.03	94.98	−0.2307	24.513	0.998
9	123.01	122.96	−0.0743	25.346	1.204
10	151.25	150.85	−0.1175	26.155	1.420
11	176.53	177.09	−0.0177	26.737	1.607
12	204.13	206.15	0.1128	27.431	1.814
13	230.50	233.93	0.2224	27.930	2.008
14	253.59	254.60	0.0516	28.280	2.158
15	275.35	277.52	0.1263	28.567	2.304
16	297.28	300.56	0.1919	28.789	2.459
17	320.10	322.82	0.1616	29.124	2.609
18	343.14	345.87	0.1623	29.384	2.758
19	367.28	372.96	0.3019	29.838	2.929
20	385.16	393.18	0.4064	30.051	3.061
21	407.34	412.33	0.2779	30.105	3.190
22	423.71	437.08	0.6152	30.182	3.331
23	442.74	455.57	0.5947	30.341	3.461
24	462.60	476.93	0.6492	30.411	3.590
25	481.50	497.87	0.7211	30.485	3.719
26	504.54	518.28	0.6329	30.732	3.850
27	520.79	543.48	0.9198	30.594	3.991
28	547.59	563.19	0.7029	30.750	4.132
29	566.28	589.03	0.9128	30.724	4.271
30	589.61	613.11	0.9339	30.717	4.426
31	610.17	641.60	1.1478	31.013	4.590
32	642.82	665.20	0.9153	30.838	4.750
33	659.25	696.12	1.2737	30.687	4.912
34	674.36	721.50	1.5197	30.721	5.072
35	705.20	749.64	1.4578	30.573	5.252
36	731.22	781.59	1.5880	30.478	5.433
37	754.19	813.34	1.7734	30.195	5.620
38	775.68	847.04	2.0212	29.800	5.821
39	802.38	881.19	2.1662	29.254	6.031
40	824.89	917.93	2.4326	29.097	6.248
41	850.30	955.96	2.6596	28.720	6.480
42	871.75	996.34	2.9870	28.182	6.722
43	906.43	1035.25	3.0569	27.943	6.971
44	930.11	1078.40	3.3668	27.580	7.221
45	950.30	1118.72	3.6761	26.946	7.470
46	981.76	1157.48	3.7839	26.671	7.719
47	1006.64	1207.99	4.1467	25.928	8.018
48	1037.39	1263.59	4.4828	25.258	8.370
49	1073.90	1318.04	4.7140	24.608	8.721
50	1105.42	1382.27	5.1155	23.897	9.120
51	1134.99	1443.39	5.4857	23.228	9.520
52	1173.62	1517.54	5.8799	22.252	10.004

Table D–29. (Contd.)

Unload Number	J_d (kJ/m^2)	J_m (kJ/m^2)	Δa (mm)	Load (kN)	Deflection (mm)
	1197.89	1593.90	6.4301	21.239	10.509
53					
54	1219.00	1665.38	6.9383	20.296	11.002
55	1245.10	1736.48	7.3710	19.108	11.508
56	1264.98	1806.86	7.8357	18.286	12.009

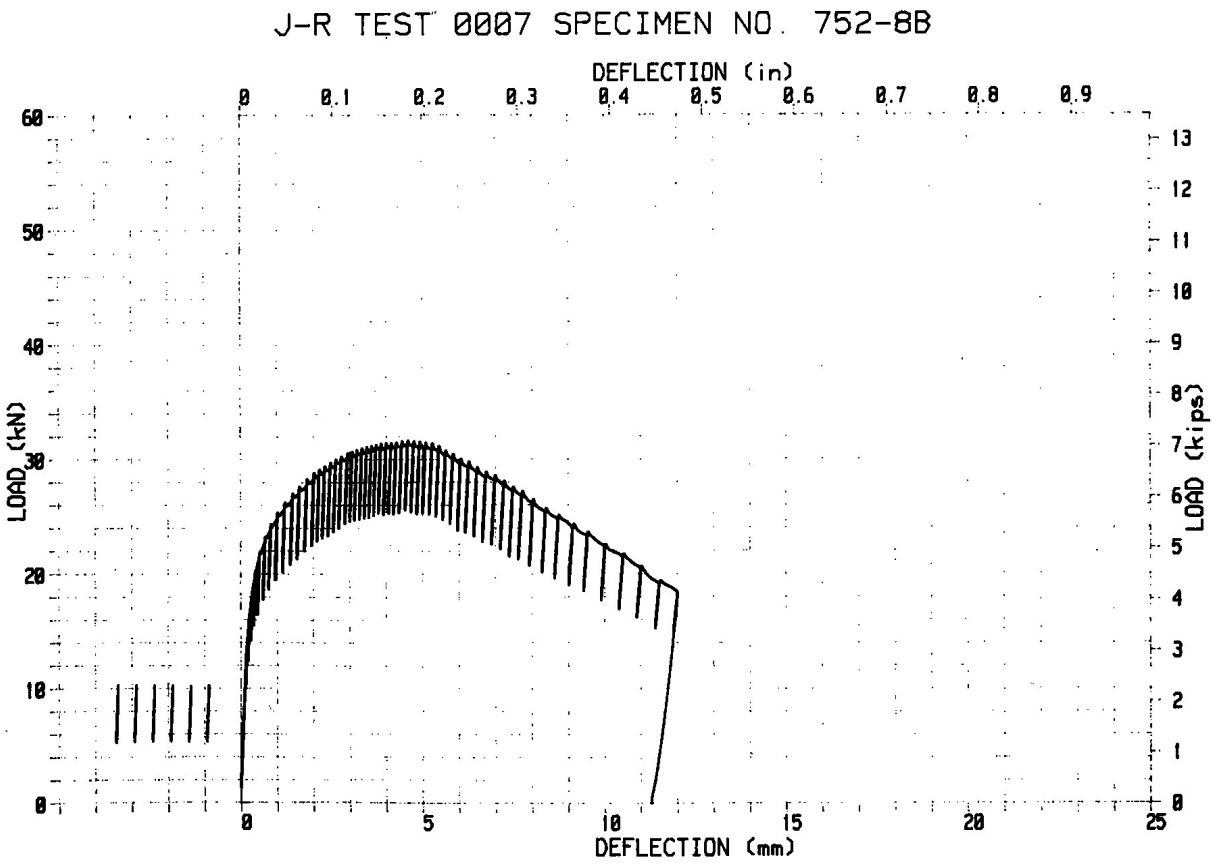


Figure D–31. Load vs Load Line Displacement Curve for Unaged Heat 75 Tested at 290°C.

Table D–30. Deformation J_{IC} and J–R Curve Results for Specimen 752–08B

Test Number	:	0007	Test Temp	:	290°C
Material Type	:	CF–8M	Heat Number	:	75
Aging Temp	:	25°C	Aging Time	:	0 h
Spec. Thickness	:	25.35 mm	Net Thickness	:	20.25 mm
Spec. Width	:	50.78 mm	Flow Stress σ_f	:	338.95 MPa
Modulus E	:	183.11 GPa	(Effective)		
Modulus E	:	168.90 GPa	(Nominal)		
Initial Crack	:	29.4281 mm	Initial a/w	:	0.5795 (Measured)
Final Crack	:	37.9031 mm	Final a/w	:	0.7464 (Measured)
Final Crack	:	37.2638 mm	Final a/w	:	0.7338 (Compliance)

LINEAR FIT $J = B+M(\Delta a)$

Intercept B	=	353.104 kJ/m^2	Slope M	= 226.24
Fit Coeff R	=	0.9458	(16 Data Points)	
J_{IC}	=	423.8 kJ/m^2	(2420.1 in·lb/in^2)	
Δa (J_{IC})	=	0.313 mm	(0.0123 in)	
T Average	=	360.6	(J_{IC} at 0.15)	

POWER LAW FIT $J=C(\Delta a)^n$

Coeff C	=	587.52 kJ/m^2	Exponent N	= 0.4304
Fit Coeff R	=	0.9501	(16 Data Points)	
J_{IC} (0.20)	=	446.9 kJ/m^2	(2552.0 in·lb/in^2)	
Δa (J_{IC})	=	0.530 mm	(0.0209 in)	
T Average	=	357.7	(J_{IC} at 0.20)	
J_{IC} (0.15)	=	420.7 kJ/m^2	(2402.5 in·lb/in^2)	
Δa (J_{IC})	=	0.460 mm	(0.0181 in)	
T Average	=	365.4	(J_{IC} at 0.15)	
Kjc	=	384.6 MPa·m$^{0.5}$		

J_{IC} VALIDITY & DATA QUALIFICATION (E 813–85)

Jmax Allowed	:	482.48 kJ/m^2	(Jmax = $b_o\sigma_f/15$)
Data Limit	:	Jmax	Ignored
Δa (max) Allowed	:	2.096 mm	(at 1.5 exclusion line)
Data Limit	:	1.5 Exclusion line	
Data Points	:	Zone A = 8	Zone B = 4
Data Point Spacing	:	OK	
B_{net} or b_o Size	:	Inadequate	
dJ/da at J_{IC}	:	OK	
af Measurement	:	Near–surface	outside limit
Initial Crack Shape	:	OK	
Crack Size Estimate	:	Inadequate	(by compliance)
E Effective	:	OK	
J_{IC} Estimate	:	INVALID	

J–R CURVE VALIDITY & DATA QUALIFICATION (E 1152–87)

Jmax Allowed	:	343.19 kJ/m^2	(Jmax = $B_{net}\sigma_f/20$)
Δa (max) Allowed	:	2.135 mm	($\Delta a = 0.1\ b_o$)
Δa (max) Allowed	:	4.024 mm	(Omega = 5)
Data Points	:	Zone A = 26	Zone B = 5
Data Point Spacing	:	Inadequate	
J–R Curve Data	:	INVALID	

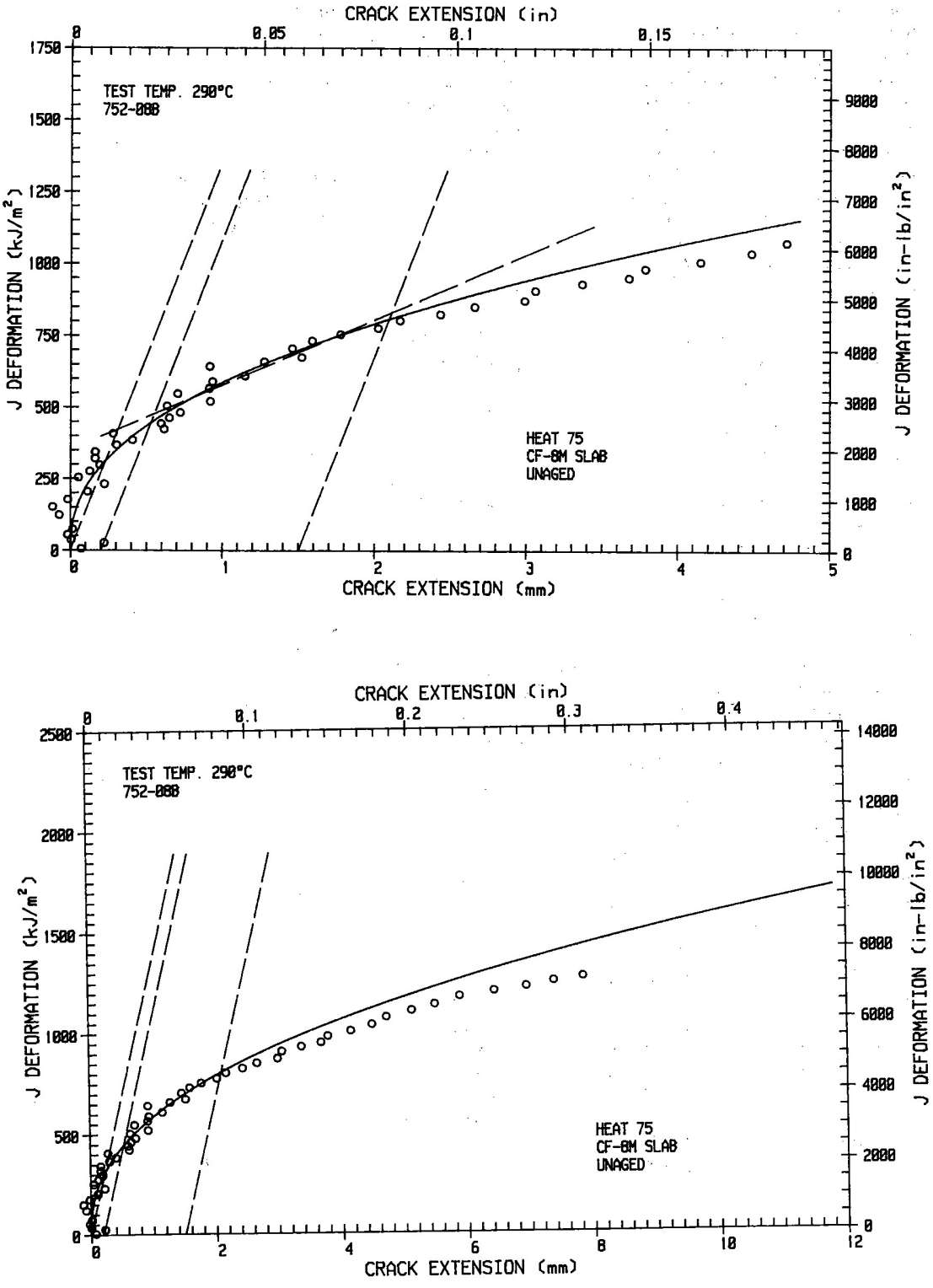


Figure D–32. Deformation J_{IC} and J–R Curve for Unaged Heat 75 Tested at 290°C.

Table D–31. Modified J_{IC} and J–R Curve Results for Specimen 752–08B

Test Number	:	0007	Test Temp	:	290°C
Material Type	:	CF–8M	Heat Number	:	75
Aging Temp	:	25°C	Aging Time	:	0 h
Spec. Thickness	:	25.35 mm	Net Thickness	:	20.25 mm
Spec. Width	:	50.78 mm	Flow Stress σ_f	:	338.95 MPa
Modulus E	:	183.11 GPa	(Effective)		
Modulus E	:	168.90 GPa	(Nominal)		
Initial Crack	:	29.4281 mm	Initial a/w	:	0.5795 (Measured)
Final Crack	:	37.9031 mm	Final a/w	:	0.7464 (Measured)
Final Crack	:	37.2638 mm	Final a/w	:	0.7338 (Compliance)

LINEAR FIT $J = B+M(\Delta a)$

Intercept B	=	325.439 kJ/m^2	Slope M = 276.30
Fit Coeff R	=	0.9594	(17 Data Points)
J_{IC}	=	408.7 kJ/m^2	(2334.0 in·lb/in^2)
Δa (J_{IC})	=	0.301 mm	(0.0119 in)
T Average	=	440.4	(J_{IC} at 0.15)

POWER LAW FIT $J=C(\Delta a)^n$

Coeff C	=	611.46 kJ/m^2	Exponent N = 0.4979
Fit Coeff R	=	0.9613	(17 Data Points)
J_{IC} (0.20)	=	445.0 kJ/m^2	(2540.9 in·lb/in^2)
Δa (J_{IC})	=	0.528 mm	(0.0208 in)
T Average	=	431.4	(J_{IC} at 0.20)
J_{IC} (0.15)	=	412.9 kJ/m^2	(2357.9 in·lb/in^2)
Δa (J_{IC})	=	0.455 mm	(0.0179 in)
T Average	=	439.9	(J_{IC} at 0.15)
Kjc	=	405.4 MPa·m$^{0.5}$	

J_{IC} VALIDITY & DATA QUALIFICATION (E 813–85)

Jmax Allowed	:	482.48 kJ/m^2	(Jmax = $b_o\sigma_f/15$)
Data Limit	:	Jmax	Ignored
Δa (max) Allowed	:	2.162 mm	(at 1.5 exclusion line)
Data Limit	:	1.5 Exclusion line	
Data Points	:	Zone A = 9	Zone B = 3
Data Point Spacing	:	OK	
B_{net} or b_o Size	:	Inadequate	
dJ/da at J_{IC}	:	OK	
af Measurement	:	Near–surface	outside limit
Initial Crack Shape	:	OK	
Crack Size Estimate	:	Inadequate	(by compliance)
E Effective	:	OK	
J_{IC} Estimate	:	INVALID	

J–R CURVE VALIDITY & DATA QUALIFICATION (E 1152–87)

Jmax Allowed	:	343.19 kJ/m^2	(Jmax = $B_{net}\sigma_f/20$)
Δa (max) Allowed	:	2.135 mm	($\Delta a = 0.1\ b_o$)
Δa (max) Allowed	:	4.599 mm	(Omega = 5)
Data Points	:	Zone A = 28	Zone B = 3
Data Point Spacing	:	Inadequate	
J–R Curve Data	:	INVALID	

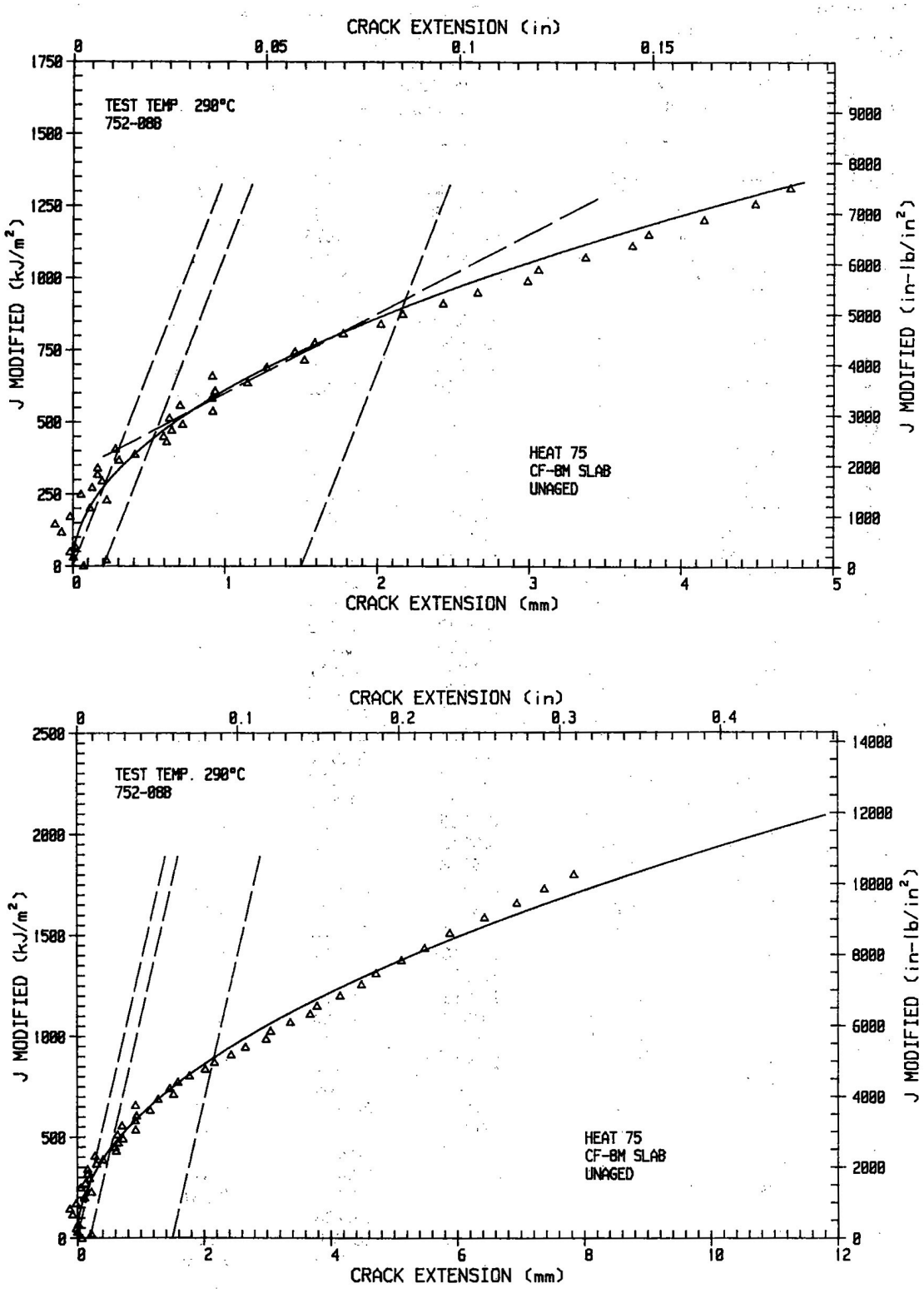


Figure D–33. Modified J_{IC} and J–R Curve for Unaged Heat 75 Tested at 290°C.

Table D–32. Test Data for Specimen 753–03V

Test Number	:	0010	Test Temp	:	290°C
Material Type	:	CF–8M Slab	Heat Number	:	75
Aging Temp	:	25°C	Aging Time	:	0 h
Spec. Thickness	:	25.35 mm	Net Thickness	:	20.26 mm
Spec. Width	:	50.80 mm	Flow Stress σ_f	:	333.46 MPa

Unload Number	J_d (kJ/m^2)	J_m (kJ/m^2)	Δa (mm)	Load (kN)	Deflection (mm)
1	5.61	5.60	−0.2338	13.088	0.160
2	11.38	11.39	−0.1467	16.071	0.236
3	18.91	19.02	0.0313	18.480	0.325
4	25.94	25.73	−0.3219	19.881	0.405
5	37.18	37.91	0.3295	21.285	0.503
6	48.54	47.92	−0.3228	22.539	0.625
7	66.57	66.38	−0.1804	23.530	0.765
8	83.11	83.64	−0.0019	24.427	0.909
9	99.83	99.71	−0.1319	25.200	1.047
10	117.23	119.69	0.3015	25.816	1.189
11	135.85	134.12	−0.2987	26.360	1.329
12	154.80	156.52	0.1263	26.849	1.468
13	173.48	172.55	−0.1630	27.270	1.607
14	192.18	194.62	0.1643	27.745	1.750
15	210.61	212.08	0.0798	28.047	1.887
16	228.33	234.13	0.4261	28.457	2.029
17	252.85	250.01	−0.2009	28.734	2.170
18	272.68	274.92	0.1372	29.143	2.310
19	293.42	293.23	−0.0128	29.463	2.450
20	311.72	315.84	0.2347	29.773	2.589
21	332.21	335.17	0.1725	30.183	2.728
22	353.76	357.05	0.1895	30.411	2.868
23	374.61	378.88	0.2357	30.572	3.009
24	394.75	401.11	0.3291	30.868	3.150
25	414.41	422.87	0.4183	31.040	3.289
26	438.13	440.14	0.1589	31.064	3.410
27	462.22	463.73	0.1398	31.112	3.549
28	473.25	488.23	0.6335	31.324	3.690
29	501.87	506.87	0.2865	31.478	3.838
30	507.93	533.23	0.9713	31.518	3.969
31	536.82	549.53	0.5666	31.592	4.113
32	556.09	576.06	0.7901	31.556	4.251
33	576.59	597.22	0.8095	31.721	4.389
34	601.59	627.93	0.9704	31.570	4.571
35	621.36	650.31	1.0413	31.382	4.711
36	640.23	674.16	1.1720	31.408	4.855
37	662.50	696.00	1.1611	31.329	4.993
38	672.63	724.37	1.6096	31.459	5.149
39	701.12	745.41	1.4336	31.265	5.303
40	717.81	773.15	1.6863	31.273	5.451
41	740.94	798.43	1.7339	31.186	5.612
42	761.00	825.62	1.8864	30.890	5.770
43	778.00	852.60	2.0934	30.628	5.931
44	804.12	881.23	2.1436	30.472	6.111
45	838.11	914.58	2.1312	30.454	6.312
46	858.26	953.36	2.4752	30.210	6.531
47	888.36	992.20	2.6298	29.734	6.773
48	913.46	1036.06	2.9480	28.748	7.033
49	924.30	1082.17	3.5265	28.289	7.312
50	971.17	1124.64	3.4580	27.552	7.608
51	984.64	1180.74	4.0968	26.974	7.931
52	1023.11	1234.38	4.3131	26.488	8.292

Table D–32. (Contd.)

Unload Number	J_d (kJ/m^2)	J_m (kJ/m^2)	Δa (mm)	Load (kN)	Deflection (mm)
53	1063.80	1298.59	4.6308	25.668	8.690
54	1106.58	1368.34	4.9749	24.984	9.134
55	1116.37	1430.32	5.6162	24.151	9.529
56	1162.59	1489.42	5.7668	23.517	9.943
57	1185.70	1550.64	6.1940	22.710	10.329
58	1209.54	1609.54	6.5718	21.856	10.729
59	1230.72	1667.75	6.9556	20.989	11.129
60	1248.39	1725.10	7.3520	19.903	11.531
61	1229.03	1785.08	8.1243	18.848	11.962
62	1255.80	1832.95	8.3225	18.141	12.360

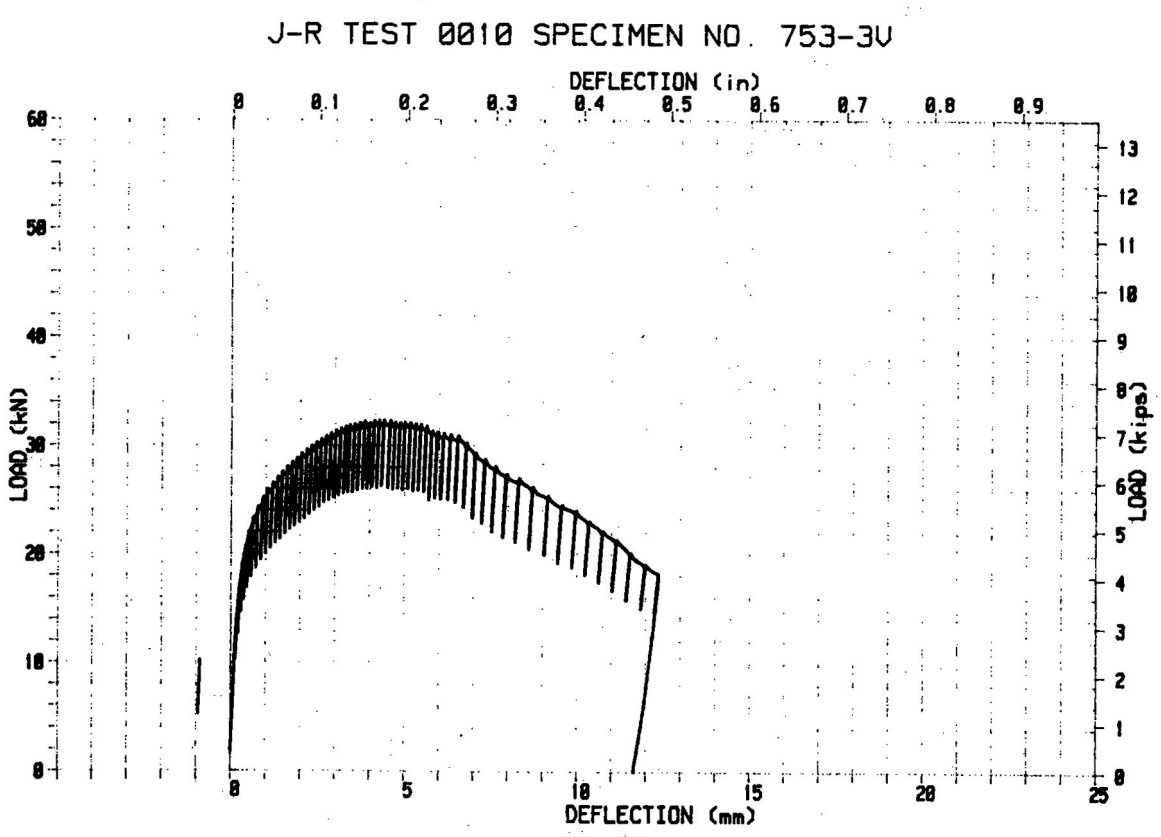


Figure D–34. Load vs Load Line Displacement Curve for Unaged Heat 75 Tested at 290°C.

Table D–33. Deformation J_{IC} and J–R Curve Results for Specimen 753–03V

Test Number	:	0010	Test Temp	:	290°C
Material Type	:	CF–8M Slab	Heat Number	:	75
Aging Temp	:	25°C	Aging Time	:	0 h
Spec. Thickness	:	25.35 mm	Net Thickness	:	20.26 mm
Spec. Width	:	50.80 mm	Flow Stress σ_f	:	333.46 MPa
Modulus E	:	178.22 GPa	(Effective)		
Modulus E	:	168.90 GPa	(Nominal)		
Initial Crack	:	28.7219 mm	Initial a/w	:	0.5654 (Measured)
Final Crack	:	37.9281 mm	Final a/w	:	0.7466 (Measured)
Final Crack	:	37.0443 mm	Final a/w	:	0.7292 (Compliance)

LINEAR FIT J = B+M(Δa)

Intercept B	=	400.322 kJ/m^2	Slope M	= 192.24
Fit Coeff R	=	0.9273	(14 Data Points)	
J_{IC}	=	467.7 kJ/m^2	(2670.9 in·lb/in^2)	
Δa (J_{IC})	=	0.351 mm	(0.0138 in)	
T Average	=	308.1	(J_{IC} at 0.15)	

POWER LAW FIT J=C(Δa)^n

Coeff C	=	599.82 kJ/m^2	Exponent N	= 0.3473
Fit Coeff R	=	0.9113	(14 Data Points)	
J_{IC} (0.20)	=	493.4 kJ/m^2	(2817.4 in·lb/in^2)	
Δa (J_{IC})	=	0.570 mm	(0.0224 in)	
T Average	=	289.0	(J_{IC} at 0.20)	
J_{IC} (0.15)	=	473.0 kJ/m^2	(2700.8 in·lb/in^2)	
Δa (J_{IC})	=	0.505 mm	(0.0199 in)	
T Average	=	295.6	(J_{IC} at 0.15)	
Kjc	=	371.3 MPa·m$^{0.5}$		

J_{IC} VALIDITY & DATA QUALIFICATION (E 813–85)

Jmax Allowed	:	490.81 kJ/m^2	(Jmax = $b_o\sigma_f$/15)
Data Limit	:	Jmax	Ignored
Δa (max) Allowed	:	2.080 mm	(at 1.5 exclusion line)
Data Limit	:	1.5 Exclusion line	
Data Points	:	Zone A = 4	Zone B = 4
Data Point Spacing	:	OK	
B_{net} or b_o Size	:	Inadequate	
dJ/da at J_{IC}	:	OK	
af Measurement	:	Near–surface	outside limit
Initial Crack Shape	:	OK	
Crack Size Estimate	:	Inadequate	(by compliance)
E Effective	:	OK	
J_{IC} Estimate	:	INVALID	

J–R CURVE VALIDITY & DATA QUALIFICATION (E 1152–87)

Jmax Allowed	:	337.79 kJ/m^2	(Jmax = $B_{net}\sigma_f$/20)
Δa (max) Allowed	:	2.208 mm	(Δa = 0.1 b_o)
Δa (max) Allowed	:	3.300 mm	(Omega = 5)
Data Points	:	Zone A = 25	Zone B = 9
Data Point Spacing	:	OK	
J–R Curve Data	:	INVALID	

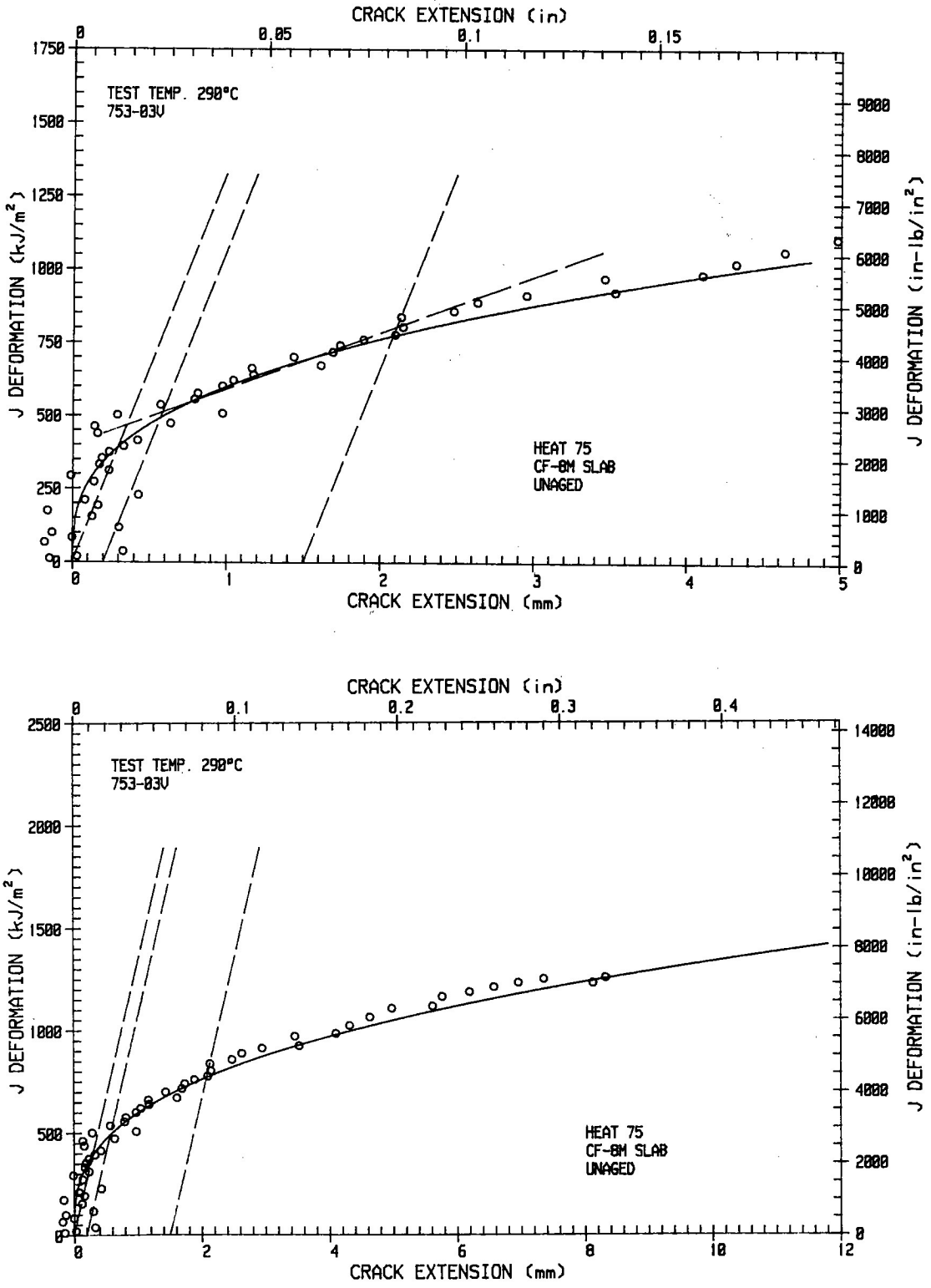


Figure D–35. Deformation J_{IC} and J–R Curve for Unaged Heat 75 Tested at 290°C.

Table D–34. Modified J_{IC} and J–R Curve Results for Specimen 753–03V

Test Number	:	0010	Test Temp	:	290°C
Material Type	:	CF–8M Slab	Heat Number	:	75
Aging Temp	:	25°C	Aging Time	:	0 h
Spec. Thickness	:	25.35 mm	Net Thickness	:	20.26 mm
Spec. Width	:	50.80 mm	Flow Stress σ_f	:	333.46 MPa
Modulus E	:	178.22 GPa	(Effective)		
Modulus E	:	168.90 GPa	(Nominal)		
Initial Crack	:	28.7219 mm	Initial a/w	:	0.5654 (Measured)
Final Crack	:	37.9281 mm	Final a/w	:	0.7466 (Measured)
Final Crack	:	37.0443 mm	Final a/w	:	0.7292 (Compliance)

LINEAR FIT J = B+M(Δa)

Intercept B	=	387.688 kJ/m^2	Slope M	= 232.87
Fit Coeff R	=	0.9696	(17 Data Points)	
J_{IC}	=	469.7 kJ/m^2	(2682.0 in·lb/in^2)	
Δa (J_{IC})	=	0.352 mm	(0.0139 in)	
T Average	=	373.2	(J_{IC} at 0.15)	

POWER LAW FIT J=C(Δa)^n

Coeff C	=	630.49 kJ/m^2	Exponent N	= 0.4178
Fit Coeff R	=	0.9557	(17 Data Points)	
J_{IC} (0.20)	=	500.4 kJ/m^2	(2857.4 in·lb/in^2)	
Δa (J_{IC})	=	0.575 mm	(0.0226 in)	
T Average	=	364.8	(J_{IC} at 0.20)	
J_{IC} (0.15)	=	474.1 kJ/m^2	(2707.2 in·lb/in^2)	
Δa (J_{IC})	=	0.505 mm	(0.0199 in)	
T Average	=	372.5	(J_{IC} at 0.15)	
Kjc	=	393.4 MPa·m$^{0.5}$		

J_{IC} VALIDITY & DATA QUALIFICATION (E 813–85)

Jmax Allowed	:	490.81 kJ/m^2	(Jmax = $b_o\sigma_f$/15)
Data Limit	:	Jmax	Ignored
Δa (max) Allowed	:	2.151 mm	(at 1.5 exclusion line)
Data Limit	:	1.5 Exclusion line	
Data Points	:	Zone A = 5	Zone B = 7
Data Point Spacing	:	OK	
B_{net} or b_o Size	:	Inadequate	
dJ/da at J_{IC}	:	OK	
af Measurement	:	Near–surface	outside limit
Initial Crack Shape	:	OK	
Crack Size Estimate	:	Inadequate	(by compliance)
E Effective	:	OK	
J_{IC} Estimate	:	INVALID	

J–R CURVE VALIDITY & DATA QUALIFICATION (E 1152–87)

Jmax Allowed	:	337.79 kJ/m^2	(Jmax = $B_{net}\sigma_f$/20)
Δa (max) Allowed	:	2.208 mm	(Δa = 0.1 b_o)
Δa (max) Allowed	:	3.918 mm	(Omega = 5)
Data Points	:	Zone A = 28	Zone B = 6
Data Point Spacing	:	Inadequate	
J–R Curve Data	:	INVALID	

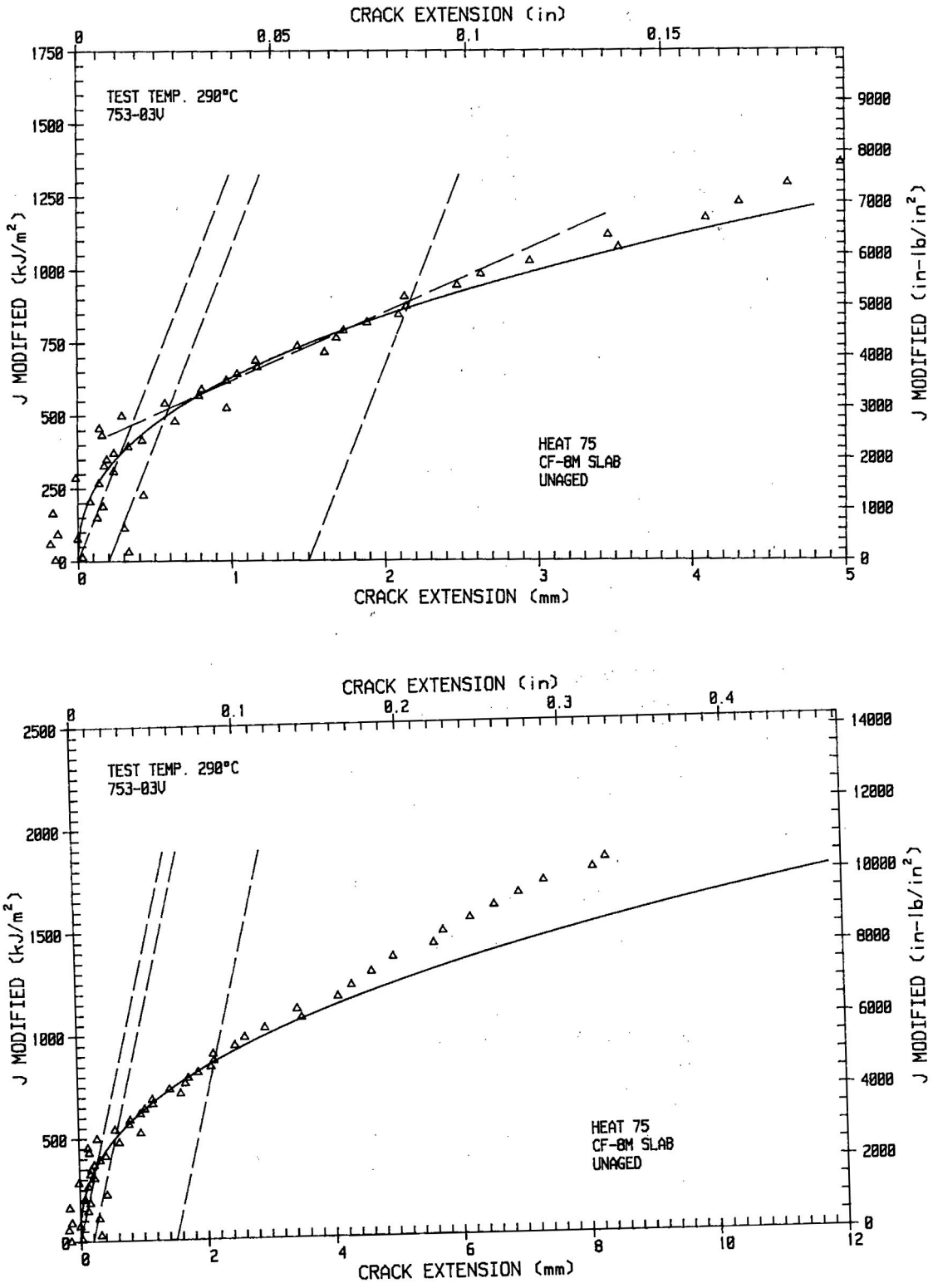


Figure D–36. Modified J_{IC} and J–R Curve for Unaged Heat 75 Tested at 290°C.

Table D–35. Test Data for Specimen 758–01C

Test Number	:	0005	Test Temp	:	290°C
Material Type	:	CF-8M	Heat Number	:	758
Aging Temp	:	400°C	Aging Time	:	18,000 h
Spec Thickness	:	25.37 mm	Net Thickness	:	20.31 mm
Spec Width	:	50.76 mm	Flow Stress	:	338.95 MPa

Unload Number	J_d (kJ/m^2)	J_m (kJ/m^2)	Δa (mm)	Load (kN)	Deflection (mm)
1	4.30	4.30	-0.0781	12.074	0.139
2	6.40	6.42	0.4191	13.542	0.166
3	7.71	7.71	0.0695	15.282	0.198
4	11.92	11.98	0.3473	17.019	0.241
5	16.51	16.52	0.2149	18.972	0.300
6	25.13	25.02	0.0586	21.151	0.385
7	36.07	35.96	0.0504	22.846	0.481
8	52.10	52.23	0.1690	25.024	0.614
9	66.80	66.77	0.1133	26.358	0.732
10	83.36	83.09	0.0486	27.584	0.852
11	107.59	108.02	0.1872	29.026	1.021
12	140.37	141.13	0.2354	30.519	1.244
13	170.84	172.26	0.3109	31.383	1.442
14	201.13	204.93	0.5395	32.218	1.639
15	232.48	237.26	0.6193	32.582	1.839
16	262.17	273.13	1.0538	32.823	2.039
17	283.45	296.31	1.1765	33.000	2.188
18	306.44	323.17	1.4036	32.880	2.340
19	331.91	350.69	1.5128	32.614	2.505
20	347.44	371.87	1.7965	32.416	2.621
21	364.64	393.28	1.9961	32.198	2.750
22	381.27	416.12	2.2738	31.944	2.880
23	398.25	437.72	2.4687	31.556	3.011
24	415.84	461.94	2.7342	31.232	3.148
25	434.32	481.24	2.7651	30.876	3.272
26	450.44	510.08	3.2227	30.292	3.420
27	470.19	531.97	3.2958	29.821	3.570
28	488.66	559.07	3.5752	29.415	3.719
29	503.58	584.74	3.9076	28.658	3.871
30	526.17	617.77	4.2116	28.153	4.071
31	545.40	651.02	4.5981	27.383	4.268
32	562.70	683.97	5.0079	26.697	4.470
33	586.88	723.90	5.3947	25.613	4.718
34	616.14	777.75	5.9518	24.219	5.048
35	632.29	811.17	6.3250	23.263	5.280
36	659.72	856.27	6.6826	22.198	5.581
37	681.69	902.38	7.1436	21.507	5.883
38	706.43	944.39	7.4555	20.663	6.180
39	739.58	995.37	7.7563	19.735	6.530
40	749.53	1047.27	8.4270	18.297	6.879
41	750.31	1084.50	8.9889	17.064	7.180
42	762.69	1120.61	9.3394	16.018	7.481
43	756.69	1159.95	9.9865	14.972	7.779
44	767.88	1191.02	10.2599	14.104	8.077
45	774.72	1228.23	10.6616	13.424	8.378
46	768.51	1263.21	11.1898	12.564	8.679
47	775.07	1292.82	11.4753	11.723	8.979
48	773.27	1326.23	11.8963	10.826	9.278

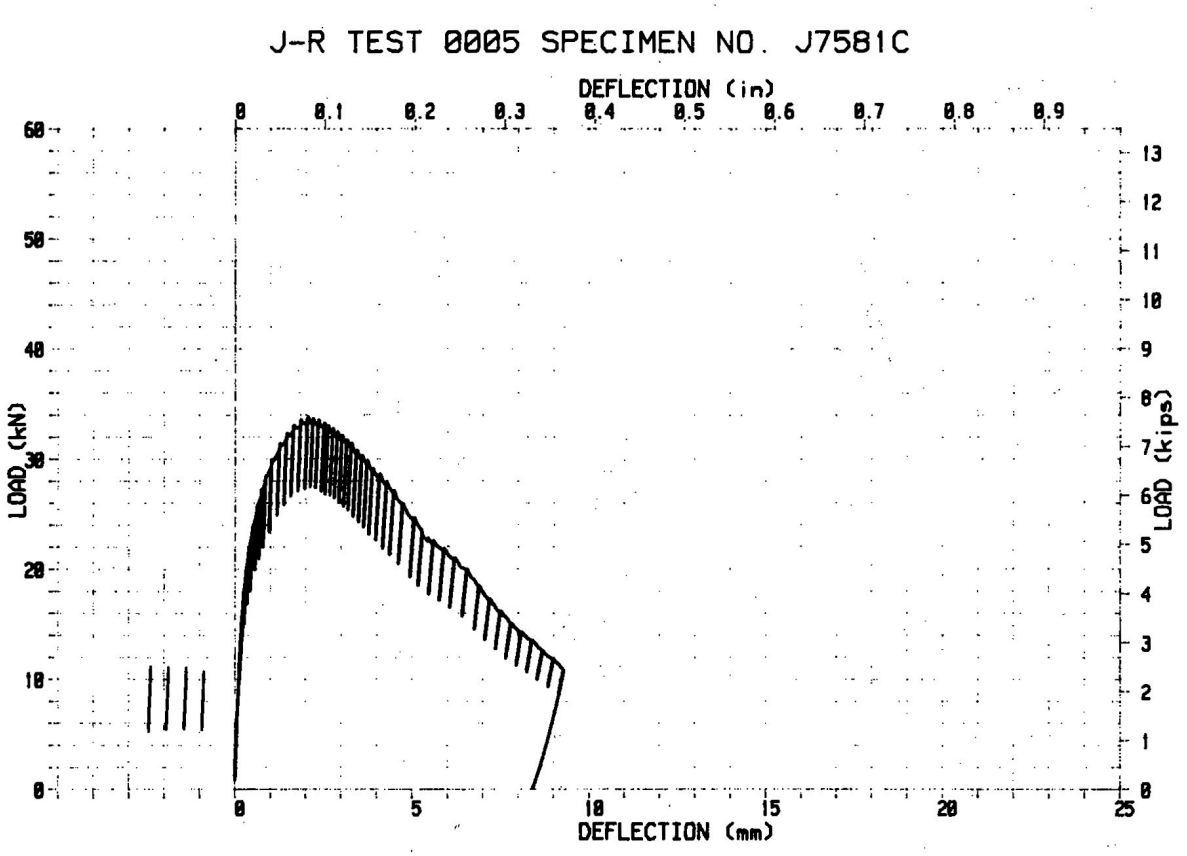


Figure D–37. Load vs Load Line Displacement Curve for Heat 758 Elbow Aged for 18,000 h at 400°C and Tested at 290°C.

Table D–36. Deformation J_{IC} and J–R Curve Results for Specimen 758–01C

Test Number	:	0005	Test Temp	:	290°C
Material Type	:	CF-8M Elbow	Heat Number	:	758
Aging Temp	:	400°C	Aging Time	:	18,000 h
Spec. Thickness	:	25.37 mm	Net Thickness	:	20.31 mm
Spec. Width	:	50.76 mm	Flow Stress	:	338.95 MPa
Modulus E	:	177.91 GPa	(Effective)		
Modulus E	:	168.90 GPa	(Nominal)		
Initial Crack	:	28.7625 mm	Initial a/w	:	0.5666 (Measured)
Final Crack	:	41.1313 mm	Final a/w	:	0.8103 (Measured)
Final Crack	:	40.6588 mm	Final a/w	:	0.8010 (Compliance)

LINEAR FIT $J = B+M(\Delta a)$

Intercept B	=	138.585 kJ/m^2	Slope M	=	123.68
Fit Coeff R	=	0.9881	(7 Data Points)		
J_{IC}	=	152.5 kJ/m^2	(870.8 in·lb/in^2)		
Δa (J_{IC})	=	0.112 mm	(0.0044 in)		
T Average	=	191.5	(J_{IC} at .15)		

POWER LAW FIT $J=C(\Delta a)^n$

Coeff C	=	268.83 kJ/m^2	Exponent N	=	0.4004
Fit Coeff R	=	0.9872	(7 Data Points)		
J_{IC} (0.20)	=	171.8 kJ/m^2	(980.8 in·lb/in^2)		
Δa (J_{IC})	=	0.327 mm	(0.0129 in)		
T Average	=	171.9	(J_{IC} at .20)		
J_{IC} (0.15)	=	158.4 kJ/m^2	(904.5 in·lb/in^2)		
Δa (J_{IC})	=	0.267 mm	(0.0105 in)		
T Average	=	176.7	(J_{IC} at .15)		
Kjc	=	244.6 MPa·m$^{0.5}$			

J_{IC} VALIDITY & DATA QUALIFICATION (E 813-85)

Jmax Allowed	:	497.07 kJ/m^2	(Jmax = $b_o\sigma_f/15$)
Data Limit	:	Jmax	Ignored
Δa (max) Allowed	:	1.748 mm	(at 1.5 exclusion line)
Data Limit	:	1.5 Exclusion line	
Data Points	:	Zone A = 3	Zone B = 2
Data Point Spacing	:	OK	
B_{net} or b_o Size	:	OK	
dJ/da at J_{IC}	:	OK	
af Measurement	:	Near-surface	outside limit
Initial Crack Shape	:	OK	
Crack Size Estimate	:	Inadequate	(by compliance)
E Effective	:	OK	
J_{IC} Estimate	:	INVALID	

J-R CURVE VALIDITY & DATA QUALIFICATION (E 1152-87)

Jmax Allowed	:	344.20 kJ/m^2	(Jmax = $B_{net}\sigma_f/20$)
Δa (max) Allowed	:	2.200 mm	($\Delta a = 0.1\ b_o$)
Δa (max) Allowed	:	3.763 mm	(Omega = 5)
Data Points	:	Zone A = 6	Zone B = 14
Data Point Spacing	:	OK	
J-R Curve Data	:	INVALID	

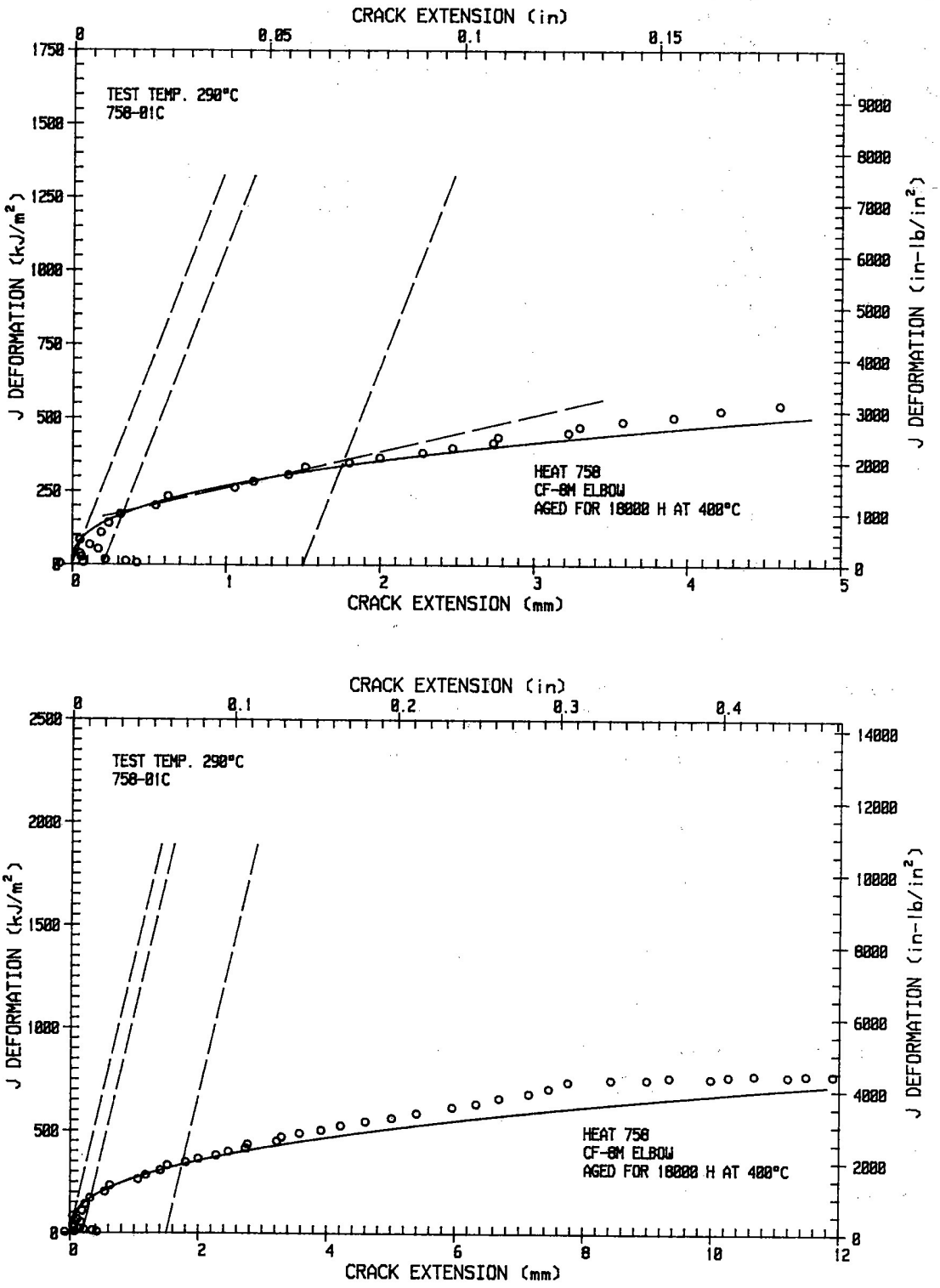


Figure D–38. Deformation J_{IC} and J–R Curve for Heat 758 Elbow Aged for 18,000 h at 400°C and Tested at 290°C.

Table D–37. Modified J_{IC} and J–R Curve Results for Specimen 758–01C

Test Number	:	0005	Test Temp	:	290°C
Material Type	:	CF-8M	Heat Number	:	758
Aging Temp	:	400°C	Aging Time	:	18,000 h
Spec. Thickness	:	25.37 mm	Net Thickness	:	20.31 mm
Spec. Width	:	50.76 mm	Flow Stress	:	338.95 MPa
Modulus E	:	177.91 GPa	(Effective)		
Modulus E	:	168.90 GPa	(Nominal)		
Initial Crack	:	28.7625 mm	Initial a/w	:	0.5666 (Measured)
Final Crack	:	41.1313 mm	Final a/w	:	0.8103 (Measured)
Final Crack	:	40.6588 mm	Final a/w	:	0.8010 (Compliance)

LINEAR FIT $J = B+M(\Delta a)$

Intercept B	=	134.734 kJ/m^2	Slope	M =	138.23
Fit Coeff R	=	0.9905	(7 Data Points)		
J_{IC}	=	150.0 kJ/m^2	(856.7 in·lb/in^2)		
Del a (J_{IC})	=	0.111 mm	(0.0044 in)		
T Average	=	214.1	(J1c at 0.15)		

POWER LAW FIT $J = C(\Delta a)^n$

Coeff C	=	279.85 kJ/m^2	Exponent N	=	0.4315
Fit Coeff R	=	0.9888	(7 Data Points)		
J_{IC} (0.20)	=	172.9 kJ/m^2	(987.2 in·lb/in^2)		
Δa (J_{IC})	=	0.328 mm	(0.0129 in)		
T Average	=	191.5	(J1c at 0.20)		
J_{IC} (0.15)	=	158.2 kJ/m^2	(903.5 in·lb/in^2)		
Δa (J_{IC})	=	0.267 mm	(0.0105 in)		
T Average	=	196.6	(J1c at 0.15)		
Kjc	=	252.2 MPa·m$^{0.5}$			

J_{IC} VALIDITY & DATA QUALIFICATION (E 813-85)

Jmax Allowed	:	497.07 kJ/m^2	(Jmax = $b_o\sigma_f$/15)
Data Limit	:	Jmax	Ignored
Δa (max) Allowed	:	1.764 mm	(at 1.5 exclusion line)
Data Limit	:	1.5 Exclusion line	
Data Points	:	Zone A = 3	Zone B = 2
Data Point Spacing	:	OK	
B_{net} or b_o Size	:	OK	
dJ/da at J_{IC}	:	OK	
af Measurement	:	Near-surface	outside limit
Initial Crack Shape	:	OK	
Crack Size Estimate	:	Inadequate	(by compliance)
E Effective	:	OK	
J_{IC} Estimate	:	INVALID	

J-R CURVE VALIDITY & DATA QUALIFICATION (E 1152-87)

Jmax Allowed	:	344.20 kJ/m^2	(Jmax = $B_{net}\sigma_f$/20)
Δa (max) Allowed	:	2.200 mm	(Δa = 0.1 b_o)
Δa (max) Allowed	:	4.033 mm	(Omega = 5)
Data Points	:	Zone A = 6	Zone B = 14
Data Point Spacing	:	OK	
J-R Curve Data	:	INVALID	

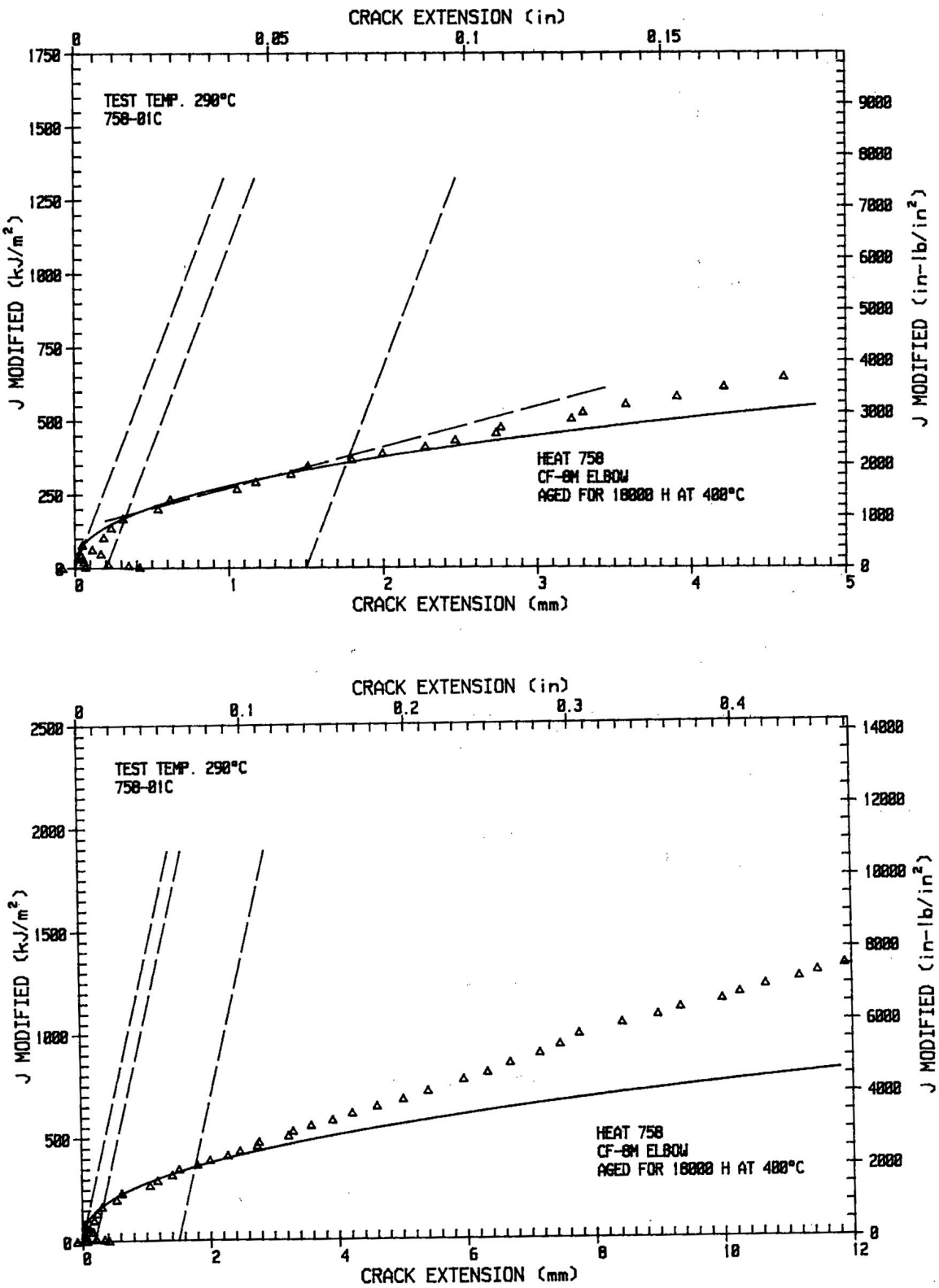


Figure D–39. Modified J_{IC} and J–R Curve for Heat 758 Elbow Aged for 18,000 h at 400°C and Tested at 290°C.