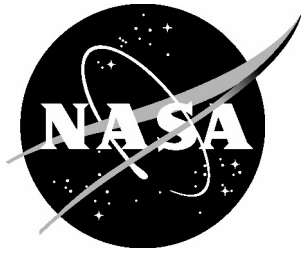


NASA/TM-2005-213907



7075-T6 and 2024-T351 Aluminum Alloy Fatigue Crack Growth Rate Data

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August 2005

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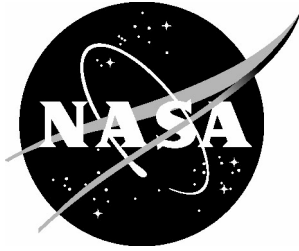
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Abstract

Experimental test procedures for the development of fatigue crack growth rate data has been standardized by the American Society for Testing and Materials. Over the past 30 years several gradual changes have been made to the standard without rigorous assessment of the affect these changes have on the precision or variability of the data generated. Therefore, the ASTM committee on fatigue crack growth has initiated an international round robin test program to assess the precision and variability of test results generated using the standard E647-00. Crack growth rate data presented in this report, in support of the ASTM round-robin, shows excellent precision and repeatability.

Introduction

The experimental test procedure for the development of fatigue crack growth rate data has been standardized by ASTM (American Society for Testing and Materials) in E647-00 "Standard Test Method for Measurement of Fatigue Crack Growth Rates." The laboratory procedure first evolved in the early to mid 1970's as a means to characterize the resistance of materials to cracking under cyclic loading conditions. Over the past 30 years several gradual changes have been made to the standard without rigorous assessment of the affect these changes have on the precision or variability of the data generated. Therefore, the ASTM committee on fatigue crack growth has initiated an international round robin test program to assess the precision and variability of test results generated using the standard E647-00. Test data in support of this ASTM round-robin presented in this report was generated at the National Aeronautics and Space Administration (NASA) Langley Research Center, Materials Characterization Laboratory in Hampton, Virginia USA.

Apparatus and Tests

The experiment section of this report is separated into two sections: laboratory equipment and specimen configuration. Testing was conducted in accordance with ASTM standard E647-00 "Standard Test Method for Measurement of Fatigue Crack Growth Rates."

Laboratory Equipment

All experiments were conducted sequentially in a single servo-hydraulic loading frame of 100kN capacity. The load cell was calibrated using NIST traceable standard to within 2.0% of any displayed reading. The tests were conducted in force control using a digital controller. The digital controller scales the internal load range to the smallest usable range to ensure accurate control. The specimens were installed in hydraulically actuated grips with a grip pressure of 350 bar. Wedge grips were used and equipped with alignment tabs for positive specimen location with serrated jaws for anti-slip control. Strain gauged test bars of similar geometry to the actual test specimens were used to ensure test stand alignment to a total maximum bending strain (front to back + side to side) amplitude of 2.5% at 5 kips and 1.2% at 10 kips.

Visual measurements of the specimen crack length were taken as a straight-line distance normal to the loading axis using a floating optical microscope. The translation stage used to measure crack length was calibrated to 0.03 mm.

Specimen Configuration

Two aluminum alloys were chosen to be included in the round robin: 7075-T6 and 2024-T351. The specimens were machined into middle tension specimens, denoted M(T), prior to delivery to NASA Langley. The standard

configuration for an M(T) specimen is presented in Figure 1. Actual specimen dimensions were measured prior to testing and are reported in Appendix A. The specimen surfaces were machined to a surface finish of 32 RMS or better and the area where crack growth was expected was hand polished to a surface finish better than 16 RMS. The hand-polishing was performed for easier detection of the crack using visual measurements.

Test Conditions

The fatigue crack growth testing was performed under constant amplitude force control. The applied force was introduced using a function generator producing a sine wave. The initial force level was chosen based on the desired crack growth rate range of the round robin (10^{-8} to 10^{-4} meters/cycle). The frequency of the applied loading was chosen to maintain the accuracy of controlling force to within 2%. The cyclic increment chosen to measure crack growth was determined through trial and error to achieve approximately 0.5 mm of growth on each side of the specimen between measurements. The average temperature and humidity during the testing program was 25 °C and 40 % respectively. Specific information on hold times, test frequency and test times can be found in Appendix A.

Results

The fatigue crack growth rate data generated for each aluminum alloy will be presented separately. The data collected during the test was crack length and cycle count. This data is collected and presented in tabular form in Appendix A. The stress intensity factor range, ΔK , is computed using the applied force, specimen dimensions and crack length defined by ASTM E647-00 as

$$\Delta K = \frac{\Delta P}{B} \sqrt{\frac{\pi \alpha}{2W} \sec \frac{\pi \alpha}{2}}$$

where the applied force range is $\Delta P = P_{max} - P_{min}$, B is the specimen thickness; W is the specimen

width; and $\alpha = 2a/W$ where a is the half crack length. The expression is valid for $2a/W < 0.95$ with the implicit assumption that the test material is linear-elastic, isotropic, and homogeneous. The computed stress intensity factor range and fatigue crack growth rate were reduced using the guidelines of ASTM E 647-00 and are presented with the measured crack length and cycle count data in Appendix A.

All crack growth data that does not meet ASTM E 647-00 standards are documented and italicized in Appendix A, but not presented in the main text. One form of data rejection applicable to this program is from inelastic material response where data is rejected if:

$$(W - 2a) \geq 1.25 P_{max} / (B \sigma_{YS})$$

where σ_{YS} is the 0.2% offset yield strength of material at the same temperature of the fatigue crack growth rate test. Two data points were rejected for the remaining ligament criterion. The other criterion for data rejection applicable to this program is crack symmetry where data is rejected if the crack length measurements referenced from the specimen center line differ more than 0.025W. None of the data generated was rejected for asymmetric crack growth.

7075-T6 Aluminum Data

The 7075-T6 material was provided by the Southwest Research Institute machined into specimens. No additional fabrication was performed by NASA Langley. Forty-four middle tension specimens were machined from a single 1.2 meter wide by 2.4 meter long by 3.175 millimeter thick sheet. The specimens were numbered AL-7-x where x = 1-44. The data presented in this report is for specimens AL-7-21, -22 and -23. Location of the specimens within the larger sheet was not provided. The supplied average material properties were σ_{TS} of 593 MPa, σ_{YS} of 524 MPa and elongation of 14%.

The maximum applied force was 19.02, 26.79 and 9.82 kilonewtons for specimens AL-7-21, -22 and -23 respectively. Figure 2 shows the

measured crack length versus cycle count for each test denoted in the legend by specimen number (AL7-x), front (F) or back (B) and left (L) or right (R) measurement. Figure 3 shows the computed fatigue crack growth rate versus stress intensity factor range for each test.

2024-T351 Aluminum Data

The 2024-T351 material was provided by the Southwest Research Institute machined into specimens. No additional fabrication was performed by NASA Langley. Thirty-two middle tension and sixty compact tension specimens were machined from a single 1.2 meter wide by 2.4 meter long by 9.525 millimeter thick sheet. The middle tension specimens were numbered AL-2-x where $x = 1-32$. The data presented in this report is for specimens AL-2-26, -27 and -28. Location of the specimens within the larger sheet was not provided. The supplied average material properties were σ_{TS} of 496 MPa, σ_{YS} of 386 MPa and elongation of 20%.

The maximum applied force was 57.05, 40.18 and 71.43 kilonewtons for specimens AL-2-26, -27 and -28 respectively. Figure 4 shows the measured crack length versus cycle count for each test denoted in the legend by specimen number (AL2-x), front (F) or back (B) and left (L) or right (R) measurement. Figure 5 shows the computed fatigue crack growth rate versus stress intensity factor range for each test.

Summary

Experimental fatigue crack growth rate data was generated according to the guidelines of ASTM standard E647-00 “Standard Test Method for Measurement of Fatigue Crack Growth Rates.” The testing was conducted in support of an ASTM round-robin on precision and variability. The crack growth rate data presented in this report for 7075-T6 and 2024-T351 aluminum alloys show excellent precision and repeatability.

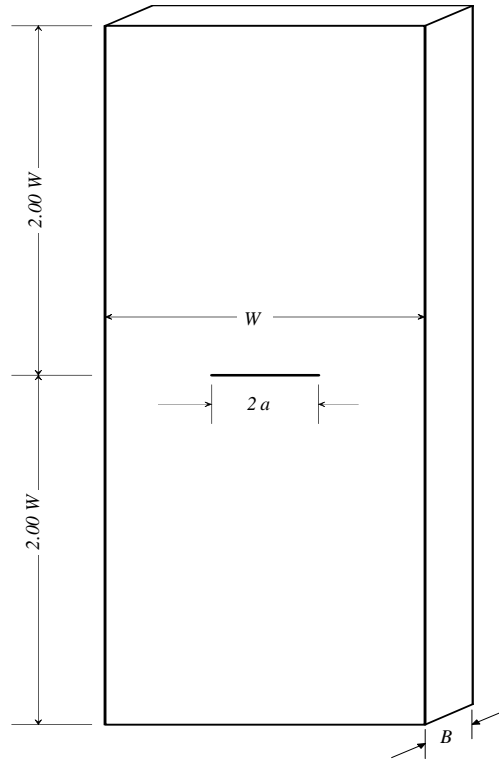


Figure 1. Schematic of a middle through crack specimen, M(T). ($W = 76.2$ mm, $B = 12.7$ mm, initial notch width ($2a$) of 12.7 mm)..

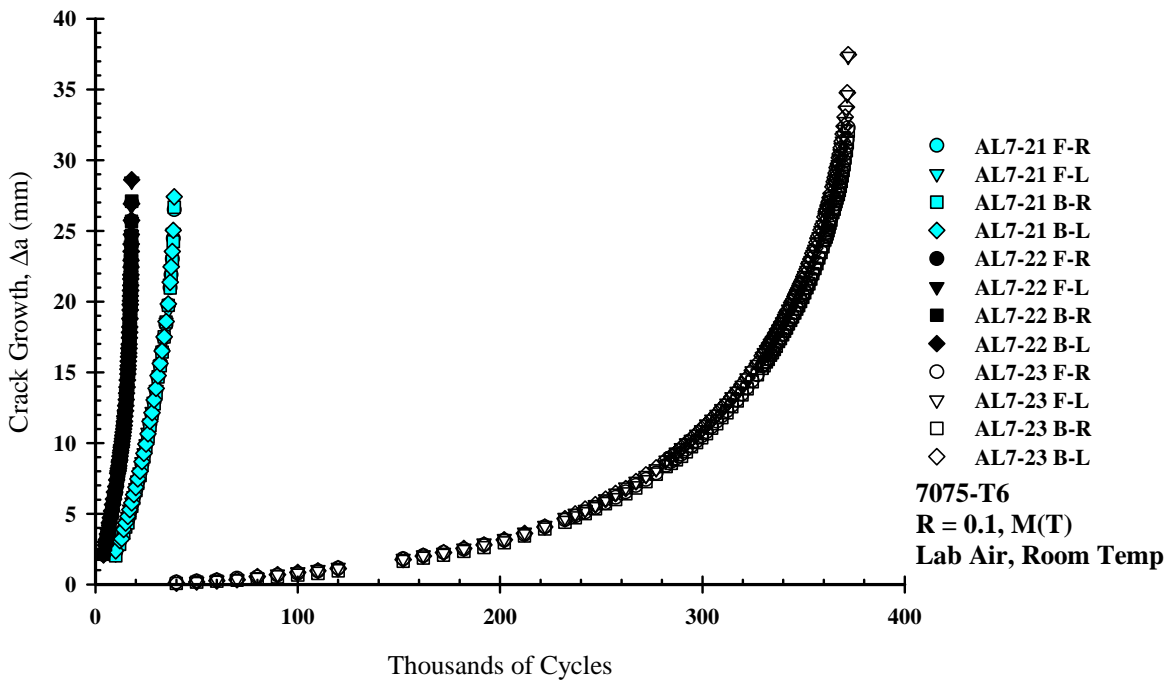


Figure 2. Crack growth versus cycles for 7075-T6 aluminum M(T) specimens (F-front; B-back; R-right; L-left).

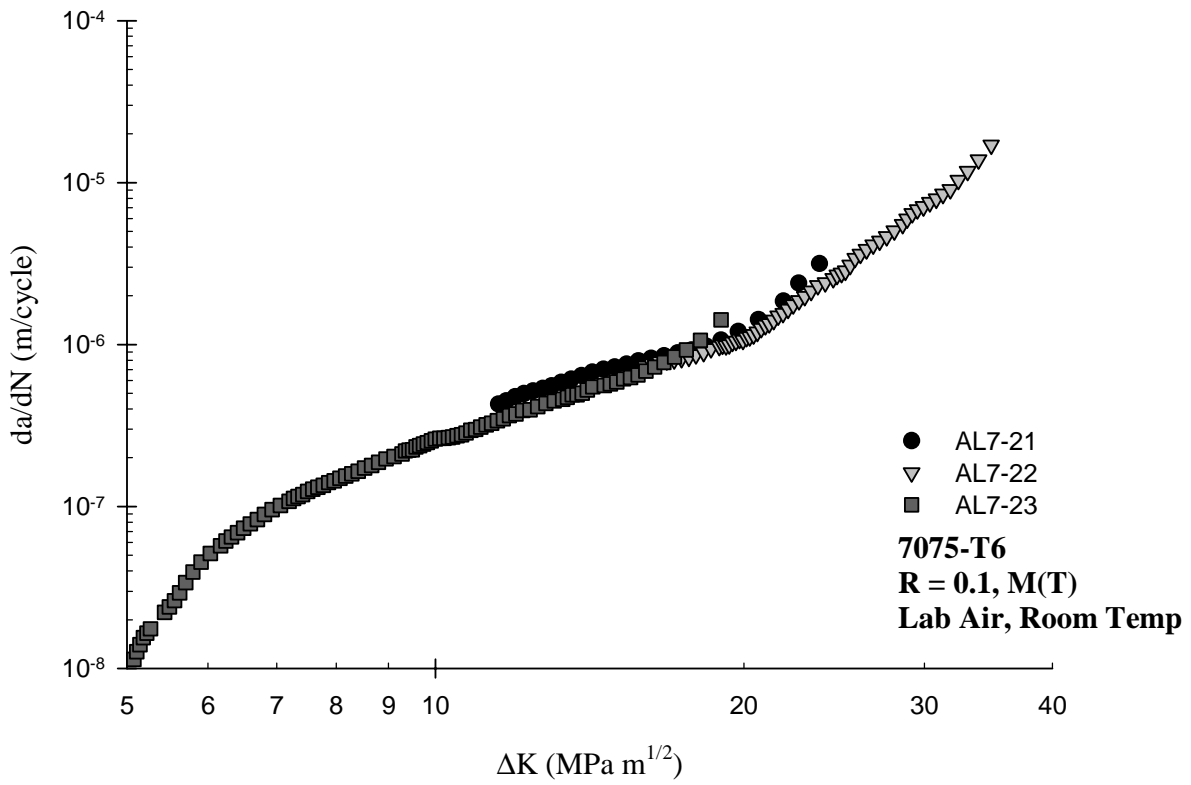


Figure 3. Fatigue crack growth rate versus stress intensity factor range for 7075-T6 aluminum M(T) specimens.

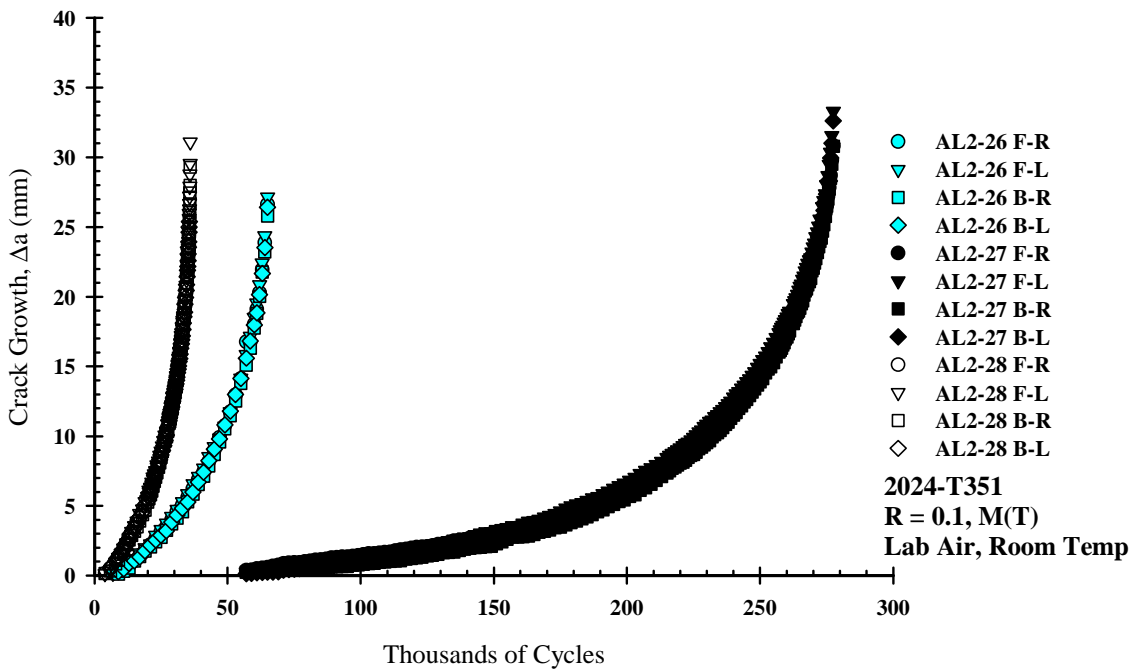


Figure 4: Crack growth versus cycles for 2024-T351 aluminum M(T) specimens (F-front; B-back; R-right; L-left).

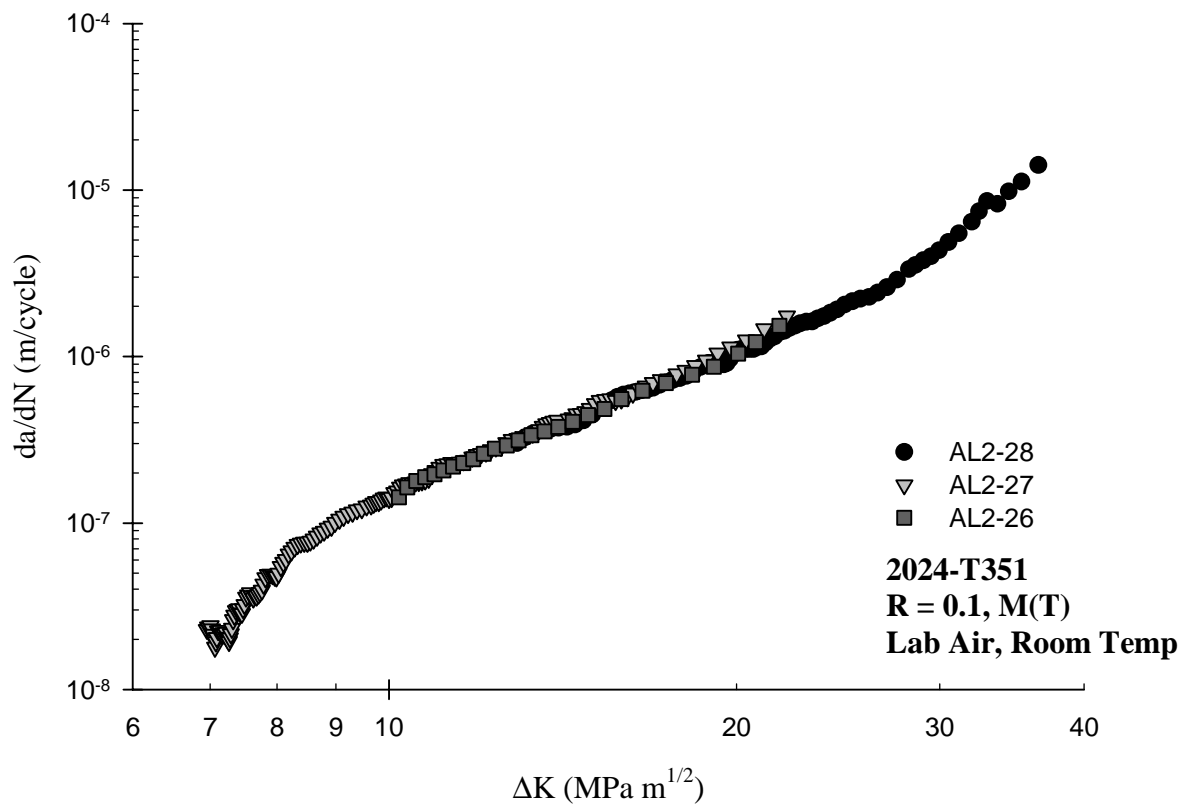


Figure 5: Fatigue crack growth rate versus stress intensity factor range for 2024-T351 aluminum M(T) specimens.

APPENDIX A

The measured test data and the computed fatigue crack growth rate and stress intensity factor range for 7075-T6 and 2024-T351 aluminum alloys are listed in Tables A1 through A3 and A4 through A6 of this appendix respectively in the order of the specimen number.

Table A1. Fatigue crack growth rate data for specimen AL-7-21 of 7075-T6 Al.

| Specimen: AL-7-21 | Frequency: 5 Hz | R = 0.1 | B = 3.18 mm | W = 102.03 mm | | |
|--------------------------------|----------------------------|-------------------------------------|-------------|---------------|------------|---------------------------------------|
| P _{max} = 19.02 N | P _{min} = 1.902 N | Initial notch length (2a): 20.28 mm | | | | |
| Time & Date | Δa front | | Δa back | | da/dN | ΔK |
| hours : minutes (date/note) | Total Cycles | left (mm) | right (mm) | left (mm) | right (mm) | (meter/cycle) (MPa m ^{1/2}) |
| 12:15 pm (1/7/2005) | 10,000 | 2.29 | 2.16 | 2.03 | 2.39 | |
| 1:00 | 12,000 | 3.05 | 3.00 | 2.84 | 3.10 | |
| 1:15 | 13,000 | 3.33 | 3.43 | 3.51 | 3.23 | |
| 1:21 | 14,000 | 3.86 | 3.76 | 3.63 | 3.89 | 4.29x10 ⁻⁷ |
| 1:27 | 15,000 | 4.27 | 4.32 | 4.06 | 4.34 | 4.49x10 ⁻⁷ |
| 1:35 | 16,000 | 4.60 | 4.80 | 4.34 | 4.80 | 4.75x10 ⁻⁷ |
| 1:42 | 17,000 | 5.13 | 5.31 | 5.05 | 5.28 | 4.97x10 ⁻⁷ |
| 1:50 | 18,000 | 5.64 | 5.82 | 5.54 | 5.77 | 5.17x10 ⁻⁷ |
| 1:57 | 19,000 | 6.20 | 6.27 | 6.07 | 6.35 | 5.37x10 ⁻⁷ |
| 2:05 | 20,000 | 6.71 | 6.83 | 6.63 | 6.86 | 5.56x10 ⁻⁷ |
| 2:10 | 21,000 | 7.26 | 7.37 | 7.16 | 7.47 | 5.83x10 ⁻⁷ |
| 2:17 | 22,000 | 7.87 | 7.95 | 7.70 | 8.00 | 6.11x10 ⁻⁷ |
| 2:24 | 23,000 | 8.48 | 8.66 | 8.41 | 8.69 | 6.43x10 ⁻⁷ |
| 2:30 | 24,000 | 9.22 | 9.30 | 9.02 | 9.27 | 6.77x10 ⁻⁷ |
| 2:37 | 25,000 | 9.91 | 9.93 | 9.75 | 9.93 | 7.05x10 ⁻⁷ |
| 2:45 | 26,000 | 10.59 | 10.74 | 10.44 | 10.64 | 7.29x10 ⁻⁷ |
| 2:52 | 27,000 | 11.35 | 11.40 | 11.23 | 11.53 | 7.57x10 ⁻⁷ |
| 3:00 | 28,000 | 12.01 | 12.22 | 12.07 | 12.14 | 7.94x10 ⁻⁷ |
| 3:07 | 29,000 | 12.90 | 12.95 | 12.78 | 13.06 | 8.23x10 ⁻⁷ |
| 3:15 | 30,000 | 13.77 | 13.79 | 13.54 | 13.87 | 8.51x10 ⁻⁷ |
| 3:21 | 31,000 | 14.68 | 14.61 | 14.68 | 14.76 | 8.86x10 ⁻⁷ |
| 3:28 | 32,000 | 15.54 | 15.52 | 15.47 | 15.62 | 9.26x10 ⁻⁷ |
| 3:35 | 33,000 | 16.48 | 16.36 | 16.43 | 16.51 | 9.78x10 ⁻⁷ |
| 3:44 | 34,000 | 17.45 | 17.27 | 17.50 | 17.50 | 1.06x10 ⁻⁶ |
| 3:50 | 35,000 | 18.36 | 18.54 | 18.57 | 18.59 | 1.20x10 ⁻⁶ |
| 3:57 (unclamped) | 36,000 | 19.76 | 19.41 | 19.74 | 19.84 | 1.43x10 ⁻⁶ |
| 9:05 am (1/10/2005) | 37,000 | 20.98 | 21.29 | 20.96 | 21.36 | 1.85x10 ⁻⁶ |
| 9:12 | 37,500 | 21.89 | 22.30 | 21.74 | 22.45 | 2.40x10 ⁻⁶ |
| 9:18 | 38,000 | 23.01 | 23.27 | 22.86 | 23.55 | 3.16x10 ⁻⁶ |
| 9:21 | 38,500 | 24.46 | 24.89 | 24.23 | 25.04 | |
| 9:27 | 39,000 | 26.49 | 27.18 | 26.67 | 27.41 | |
| 9:33 | 39,250 | 29.34 | 28.07 | 28.32 | 29.39 | |

Table A2. Fatigue crack growth rate data for specimen AL-7-22 of 7075-T6 Al.

| Specimen: AL-7-22 | | Frequency: 5 Hz | | R = 0.1 | | B = 3.18 mm | | W = 102.03 mm | |
|-----------------------------|--------|-----------------------------|------------|-------------------------------------|------------|-----------------------|--------------------------|---------------|--|
| $P_{max} = 26.79 \text{ N}$ | | $P_{min} = 2.679 \text{ N}$ | | Initial notch length (2a): 20.28 mm | | | | | |
| Time & Date | | Δa front | | Δa back | | da/dN | ΔK | | |
| hours : minutes | Total | | | | | | | | |
| (date/note) | Cycles | left (mm) | right (mm) | left (mm) | right (mm) | (meter/cycle) | ($\text{MPa m}^{1/2}$) | | |
| 10:19am (02/03/05) | 4,000 | 2.11 | 2.11 | 2.13 | 2.11 | | | | |
| 10:28 | 5,000 | 2.84 | 2.79 | 2.79 | 2.77 | | | | |
| 10:34 | 5,500 | 3.12 | 2.90 | 3.10 | 3.15 | | | | |
| 10:45 | 6,000 | 3.43 | 3.48 | 3.51 | 3.56 | 7.36×10^{-7} | 16.01 | | |
| 10:49 | 6,500 | 3.78 | 3.91 | 3.96 | 3.91 | 7.58×10^{-7} | 16.28 | | |
| 10:56 | 7,000 | 4.14 | 4.19 | 4.29 | 4.34 | 7.83×10^{-7} | 16.55 | | |
| 11:01 | 7,500 | 4.57 | 4.55 | 4.70 | 4.72 | 7.94×10^{-7} | 16.82 | | |
| 11:05 | 8,000 | 4.90 | 4.88 | 5.18 | 5.21 | 8.05×10^{-7} | 17.10 | | |
| 11:10 | 8,500 | 5.28 | 5.31 | 5.54 | 5.64 | 8.22×10^{-7} | 17.39 | | |
| 11:15 | 9,000 | 5.77 | 5.79 | 5.99 | 6.05 | 8.38×10^{-7} | 17.67 | | |
| 11:19 | 9,500 | 6.15 | 6.10 | 6.32 | 6.53 | 8.66×10^{-7} | 17.96 | | |
| 11:23 | 10,000 | 6.50 | 6.65 | 6.73 | 6.91 | 8.96×10^{-7} | 18.27 | | |
| 11:27 | 10,500 | 7.01 | 7.09 | 7.16 | 7.39 | 9.44×10^{-7} | 18.58 | | |
| 12:46 pm | 11,000 | 7.54 | 7.62 | 7.65 | 7.87 | 9.76×10^{-7} | 18.93 | | |
| 12:52 | 11,200 | 7.70 | 7.85 | 7.80 | 8.03 | 9.96×10^{-7} | 19.07 | | |
| 12:57 | 11,400 | 7.92 | 8.10 | 8.00 | 8.20 | 9.82×10^{-7} | 19.21 | | |
| 12:59 | 11,600 | 8.10 | 8.23 | 8.23 | 8.38 | 9.98×10^{-7} | 19.35 | | |
| 1:02 | 11,800 | 8.31 | 8.43 | 8.48 | 8.66 | 1.03×10^{-6} | 19.50 | | |
| 1:07 | 12,000 | 8.51 | 8.61 | 8.61 | 8.79 | 1.05×10^{-6} | 19.64 | | |
| 1:12 | 12,200 | 8.74 | 8.86 | 8.81 | 9.07 | 1.08×10^{-6} | 19.80 | | |
| 1:15 | 12,400 | 8.99 | 9.04 | 9.04 | 9.32 | 1.06×10^{-6} | 19.96 | | |
| 1:20 | 12,600 | 9.22 | 9.32 | 9.22 | 9.47 | 1.11×10^{-6} | 20.12 | | |
| 1:23 | 12,800 | 9.45 | 9.53 | 9.45 | 9.70 | 1.12×10^{-6} | 20.27 | | |
| 1:27 | 13,000 | 9.65 | 9.65 | 9.68 | 9.86 | 1.15×10^{-6} | 20.44 | | |
| 1:30 | 13,200 | 9.91 | 10.01 | 9.96 | 10.11 | 1.19×10^{-6} | 20.61 | | |
| 1:33 | 13,400 | 10.08 | 10.31 | 10.21 | 10.31 | 1.26×10^{-6} | 20.79 | | |
| 1:36 | 13,600 | 10.36 | 10.49 | 10.54 | 10.52 | 1.31×10^{-6} | 20.99 | | |
| 1:40 | 13,800 | 10.52 | 10.85 | 10.80 | 10.77 | 1.35×10^{-6} | 21.18 | | |
| 1:45 | 14,000 | 10.95 | 11.15 | 11.05 | 11.00 | 1.41×10^{-6} | 21.39 | | |
| 1:48 | 14,200 | 11.20 | 11.48 | 11.28 | 11.23 | 1.50×10^{-6} | 21.60 | | |
| 1:51 | 14,400 | 11.51 | 11.86 | 11.56 | 11.53 | 1.56×10^{-6} | 21.84 | | |
| 1:54 | 14,600 | 11.81 | 12.09 | 11.89 | 11.89 | 1.66×10^{-6} | 22.08 | | |
| 1:57 | 14,800 | 12.14 | 12.42 | 12.34 | 12.27 | 1.76×10^{-6} | 22.35 | | |
| 2:01 | 15,000 | 12.57 | 12.55 | 12.60 | 12.65 | 1.87×10^{-6} | 22.63 | | |
| 2:05 | 15,200 | 12.90 | 13.06 | 13.11 | 13.08 | 1.99×10^{-6} | 22.94 | | |
| 2:09 | 15,400 | 13.21 | 13.46 | 13.46 | 13.51 | 2.14×10^{-6} | 23.26 | | |
| 2:12 | 15,600 | 13.72 | 13.87 | 13.89 | 13.94 | 2.32×10^{-6} | 23.62 | | |
| 2:16 | 15,800 | 14.12 | 14.38 | 14.30 | 14.45 | 2.41×10^{-6} | 24.02 | | |
| 2:19 | 16,000 | 14.68 | 14.99 | 14.88 | 14.88 | 2.56×10^{-6} | 24.44 | | |
| 2:22 | 16,100 | 14.96 | 15.24 | 15.11 | 15.21 | 2.69×10^{-6} | 24.67 | | |
| 2:29 | 16,200 | 15.06 | 15.44 | 15.27 | 15.47 | 2.76×10^{-6} | 24.90 | | |
| 2:32 | 16,300 | 15.37 | 15.77 | 15.67 | 15.77 | 2.85×10^{-6} | 25.14 | | |
| 2:35 | 16,400 | 15.82 | 16.05 | 15.85 | 16.10 | 3.09×10^{-6} | 25.39 | | |
| 2:39 | 16,500 | 16.10 | 16.26 | 16.21 | 16.36 | 3.40×10^{-6} | 25.68 | | |

| | | | | | | | |
|--------------------|--------|-------|-------|-------|-------|-----------------------|-------|
| 2:42 | 16,600 | 16.43 | 16.61 | 16.54 | 16.69 | 3.62x10 ⁻⁶ | 25.99 |
| 2:47 | 16,700 | 16.79 | 17.20 | 16.94 | 16.99 | 3.86x10 ⁻⁶ | 26.35 |
| 2:50 | 16,800 | 17.20 | 17.55 | 17.37 | 17.45 | 4.12x10 ⁻⁶ | 26.74 |
| 2:53 | 16,900 | 17.65 | 17.98 | 17.81 | 17.83 | 4.36x10 ⁻⁶ | 27.14 |
| 2:56 | 17,000 | 18.06 | 18.42 | 18.24 | 18.21 | 4.64x10 ⁻⁶ | 27.56 |
| 2:59 | 17,100 | 18.44 | 18.85 | 18.67 | 18.80 | 5.04x10 ⁻⁶ | 28.04 |
| 3:03 | 17,200 | 18.97 | 19.38 | 19.10 | 19.41 | 5.53x10 ⁻⁶ | 28.57 |
| 3:07 | 17,250 | 19.30 | 19.66 | 19.38 | 19.79 | 5.96x10 ⁻⁶ | 28.87 |
| 3:10 | 17,300 | 19.58 | 19.94 | 19.66 | 20.07 | 6.43x10 ⁻⁶ | 29.20 |
| 3:13 | 17,350 | 19.81 | 20.32 | 19.89 | 20.40 | 6.80x10 ⁻⁶ | 29.55 |
| 3:16 (unclamped) | 17,400 | 20.24 | 20.70 | 20.27 | 20.78 | 7.12x10 ⁻⁶ | 29.95 |
| 8:02 am (02/03/05) | 17,450 | 20.60 | 21.03 | 20.75 | 21.16 | 7.54x10 ⁻⁶ | 30.37 |
| 8:05 | 17,500 | 20.98 | 21.46 | 21.03 | 21.59 | 7.91x10 ⁻⁶ | 30.82 |
| 8:09 | 17,550 | 21.36 | 21.84 | 21.36 | 21.89 | 8.48x10 ⁻⁶ | 31.28 |
| 8:11 | 17,600 | 21.72 | 22.28 | 21.87 | 22.43 | 9.06x10 ⁻⁶ | 31.80 |
| 8:15 | 17,650 | 22.15 | 22.76 | 22.23 | 22.91 | 1.03x10 ⁻⁵ | 32.38 |
| 8:19 | 17,700 | 22.61 | 23.29 | 22.86 | 23.55 | 1.18x10 ⁻⁵ | 33.07 |
| 8:24 | 17,750 | 23.22 | 23.98 | 23.29 | 24.08 | 1.38x10 ⁻⁵ | 33.87 |
| 8:27 | 17,800 | 23.95 | 24.74 | 24.00 | 24.74 | 1.70x10 ⁻⁵ | 34.86 |
| 8:31 | 17,850 | 24.69 | 25.65 | 24.69 | 25.76 | | |
| 8:35 | 17,900 | 25.70 | 26.77 | 25.68 | 26.92 | | |
| 8:39 | 17,950 | 27.00 | 28.52 | 27.10 | 28.63 | | |

Table A3. Fatigue crack growth rate data for specimen AL-7-23 of 7075-T6 Al.

| Specimen: AL-7-23 | | Frequency: 10 Hz | | R = 0.1 | | B = 3.18 mm | | W = 101.91 mm | |
|----------------------------|---------|-----------------------------|------------|-------------------------------------|------------|-----------------------|------------------------|---------------|--|
| $P_{max} = 9.82 \text{ N}$ | | $P_{min} = 0.982 \text{ N}$ | | Initial notch length (2a): 20.34 mm | | | | | |
| Time & Date | | Δa front | | Δa back | | da/dN | ΔK | | |
| hours : minutes | Total | | | | | | | | |
| (date/note) | Cycles | left (mm) | right (mm) | left (mm) | right (mm) | (meter/cycle) | $(\text{MPa m}^{1/2})$ | | |
| 8:15am (01/28/05) | 40,000 | 0.15 | | 0.08 | 0.10 | | | | |
| 8:38 | 50,000 | 0.23 | 0.20 | 0.15 | 0.18 | | | | |
| 9:00 | 60,000 | 0.30 | 0.30 | 0.23 | 0.25 | | | | |
| 9:24 | 70,000 | 0.43 | 0.38 | 0.30 | 0.33 | 1.14×10^{-8} | 5.08 | | |
| 9:44 | 80,000 | 0.51 | 0.51 | 0.41 | 0.56 | 1.27×10^{-8} | 5.11 | | |
| 10:04 | 90,000 | 0.66 | 0.71 | 0.53 | 0.69 | 1.41×10^{-8} | 5.15 | | |
| 10:25 | 100,000 | 0.79 | 0.89 | 0.66 | 0.84 | 1.55×10^{-8} | 5.19 | | |
| 10:57 | 110,000 | 0.94 | 1.04 | 0.79 | 0.97 | 1.65×10^{-8} | 5.23 | | |
| 11:21 | 120,000 | 1.14 | 1.19 | 0.97 | 1.12 | 1.76×10^{-8} | 5.27 | | |
| 1:16 pm | 152,138 | 1.80 | 1.83 | 1.63 | 1.75 | 2.22×10^{-8} | 5.44 | | |
| 1:52 | 162,138 | 2.03 | 2.08 | 1.85 | 2.01 | 2.40×10^{-8} | 5.50 | | |
| 2:31 | 172,138 | 2.26 | 2.26 | 2.06 | 2.26 | 2.62×10^{-8} | 5.56 | | |
| 3:06 | 182,138 | 2.49 | 2.57 | 2.34 | 2.54 | 2.94×10^{-8} | 5.63 | | |
| 3:45 | 192,138 | 2.79 | 2.92 | 2.62 | 2.79 | 3.39×10^{-8} | 5.71 | | |
| 4:21 | 202,138 | 3.12 | 3.23 | 2.95 | 3.15 | 3.94×10^{-8} | 5.80 | | |
| 8:17 am (01/31/05) | 212,138 | 3.53 | 3.68 | 3.43 | 3.61 | 4.53×10^{-8} | 5.91 | | |
| 8:54 | 222,138 | 4.06 | 4.17 | 3.91 | 4.06 | 5.13×10^{-8} | 6.03 | | |
| 9:33 | 232,138 | 4.57 | 4.72 | 4.39 | 4.65 | 5.72×10^{-8} | 6.17 | | |
| 9:52 | 237,138 | 4.83 | 5.03 | 4.70 | 4.98 | 6.12×10^{-8} | 6.24 | | |
| 10:13 | 242,138 | 5.11 | 5.28 | 5.00 | 5.33 | 6.49×10^{-8} | 6.32 | | |
| 10:32 | 247,138 | 5.44 | 5.64 | 5.36 | 5.64 | 6.89×10^{-8} | 6.41 | | |
| 11:05 | 252,138 | 5.77 | 6.05 | 5.72 | 6.02 | 7.36×10^{-8} | 6.50 | | |
| 11:31 | 257,138 | 6.15 | 6.45 | 5.99 | 6.43 | 7.83×10^{-8} | 6.60 | | |
| 11:50 | 262,138 | 6.53 | 6.88 | 6.40 | 6.78 | 8.31×10^{-8} | 6.70 | | |
| 2:46 pm | 267,138 | 6.99 | 7.29 | 6.83 | 7.26 | 8.94×10^{-8} | 6.81 | | |
| 3:09 | 272,138 | 7.42 | 7.70 | 7.26 | 7.75 | 9.57×10^{-8} | 6.93 | | |
| 3:28 | 277,138 | 7.87 | 8.18 | 7.80 | 8.23 | 1.02×10^{-7} | 7.06 | | |
| 3:47 | 282,138 | 8.41 | 8.79 | 8.33 | 8.81 | 1.08×10^{-7} | 7.20 | | |
| 3:57 | 284,638 | 8.69 | 9.02 | 8.56 | 9.07 | 1.12×10^{-7} | 7.27 | | |
| 4:10 | 287,138 | 8.92 | 9.35 | 8.81 | 9.32 | 1.15×10^{-7} | 7.35 | | |
| 4:20 | 289,638 | 9.22 | 9.65 | 9.07 | 9.65 | 1.19×10^{-7} | 7.42 | | |
| 8:18 am (02/01/05) | 292,138 | 9.55 | 10.01 | 9.37 | 9.98 | 1.24×10^{-7} | 7.50 | | |
| 8:32 | 294,638 | 9.80 | 10.26 | 9.73 | 10.29 | 1.28×10^{-7} | 7.59 | | |
| 8:46 | 297,138 | 10.13 | 10.62 | 10.03 | 10.62 | 1.32×10^{-7} | 7.68 | | |
| 8:57 | 299,638 | 10.49 | 10.92 | 10.36 | 11.00 | 1.35×10^{-7} | 7.77 | | |
| 9:09 | 302,138 | 10.80 | 11.33 | 10.67 | 11.30 | 1.41×10^{-7} | 7.87 | | |
| 9:21 | 304,638 | 11.15 | 11.68 | 11.05 | 11.66 | 1.44×10^{-7} | 7.97 | | |
| 9:34 | 307,138 | 11.53 | 12.01 | 11.38 | 12.07 | 1.49×10^{-7} | 8.07 | | |
| 9:48 | 309,638 | 11.91 | 12.42 | 11.79 | 12.45 | 1.54×10^{-7} | 8.18 | | |
| 10:04 | 312,138 | 12.27 | 12.80 | 12.14 | 12.83 | 1.59×10^{-7} | 8.29 | | |
| 10:16 | 314,638 | 12.65 | 13.26 | 12.57 | 13.26 | 1.65×10^{-7} | 8.41 | | |
| 10:31 | 317,138 | 13.03 | 13.64 | 12.98 | 13.69 | 1.73×10^{-7} | 8.53 | | |
| 10:44 | 319,638 | 13.46 | 14.07 | 13.41 | 14.15 | 1.80×10^{-7} | 8.66 | | |
| 11:03 | 322,138 | 13.92 | 14.61 | 13.82 | 14.61 | 1.88×10^{-7} | 8.80 | | |

| | | | | | | | |
|--------------------|---------|-------|-------|-------|-------|-----------------------|-------|
| 11:15 | 324,638 | 14.40 | 15.09 | 14.33 | 15.14 | 1.97x10 ⁻⁷ | 8.95 |
| 11:31 | 327,138 | 14.83 | 15.54 | 14.83 | 15.60 | 2.04x10 ⁻⁷ | 9.11 |
| 12:57 pm | 329,638 | 15.44 | 16.10 | 15.29 | 16.18 | 2.11x10 ⁻⁷ | 9.28 |
| 1:03 | 330,638 | 15.60 | 16.38 | 15.47 | 16.38 | 2.20x10 ⁻⁷ | 9.35 |
| 1:09 | 331,638 | 15.75 | 16.59 | 15.75 | 16.59 | 2.23x10 ⁻⁷ | 9.42 |
| 1:15 | 332,638 | 15.98 | 16.79 | 15.93 | 16.87 | 2.24x10 ⁻⁷ | 9.50 |
| 1:24 | 333,638 | 16.23 | 17.04 | 16.21 | 17.12 | 2.34x10 ⁻⁷ | 9.57 |
| 1:30 | 334,638 | 16.46 | 17.22 | 16.38 | 17.37 | 2.38x10 ⁻⁷ | 9.65 |
| 1:36 | 335,638 | 16.69 | 17.50 | 16.61 | 17.58 | 2.43x10 ⁻⁷ | 9.74 |
| 1:44 | 336,638 | 16.94 | 17.78 | 16.84 | 17.83 | 2.48x10 ⁻⁷ | 9.82 |
| 1:51 | 337,638 | 17.15 | 18.03 | 17.17 | 18.08 | 2.55x10 ⁻⁷ | 9.91 |
| 1:57 | 338,638 | 17.40 | 18.29 | 17.37 | 18.34 | 2.61x10 ⁻⁷ | 10.00 |
| 2:02 | 339,638 | 17.68 | 18.57 | 17.65 | 18.62 | 2.64x10 ⁻⁷ | 10.10 |
| 7:49 am (02/02/05) | 340,638 | 17.93 | 18.80 | 17.91 | 18.87 | 2.64x10 ⁻⁷ | 10.19 |
| 7:54 | 341,638 | 18.19 | 19.10 | 18.14 | 19.23 | 2.67x10 ⁻⁷ | 10.29 |
| 8:02 | 342,638 | 18.44 | 19.46 | 18.42 | 19.43 | 2.69x10 ⁻⁷ | 10.39 |
| 8:08 | 343,638 | 18.72 | 19.66 | 18.67 | 19.69 | 2.74x10 ⁻⁷ | 10.50 |
| 8:15 | 344,638 | 18.92 | 19.91 | 18.92 | 20.04 | 2.78x10 ⁻⁷ | 10.60 |
| 8:21 | 345,638 | 19.20 | 20.24 | 19.20 | 20.35 | 2.84x10 ⁻⁷ | 10.71 |
| 8:27 | 346,638 | 19.51 | 20.55 | 19.46 | 20.65 | 2.96x10 ⁻⁷ | 10.83 |
| 8:34 | 347,638 | 19.76 | 20.88 | 19.71 | 20.96 | 2.99x10 ⁻⁷ | 10.95 |
| 8:39 | 348,638 | 20.04 | 21.16 | 20.02 | 21.26 | 3.09x10 ⁻⁷ | 11.07 |
| 8:45 | 349,638 | 20.47 | 21.49 | 20.32 | 21.56 | 3.20x10 ⁻⁷ | 11.21 |
| 8:51 | 350,638 | 20.68 | 21.84 | 20.62 | 21.89 | 3.27x10 ⁻⁷ | 11.35 |
| 8:59 | 351,638 | 20.98 | 22.20 | 20.98 | 22.28 | 3.39x10 ⁻⁷ | 11.49 |
| 9:05 | 352,638 | 21.31 | 22.53 | 21.26 | 22.68 | 3.48x10 ⁻⁷ | 11.65 |
| 9:11 | 353,638 | 21.67 | 22.91 | 21.59 | 23.01 | 3.64x10 ⁻⁷ | 11.81 |
| 9:23 | 354,638 | 21.97 | 23.32 | 21.97 | 23.42 | 3.73x10 ⁻⁷ | 11.98 |
| 9:30 | 355,638 | 22.35 | 23.70 | 22.35 | 23.77 | 3.93x10 ⁻⁷ | 12.17 |
| 9:36 | 356,638 | 22.76 | 24.21 | 22.68 | 24.18 | 3.96x10 ⁻⁷ | 12.37 |
| 9:42 | 357,638 | 23.11 | 24.56 | 23.09 | 24.64 | 4.14x10 ⁻⁷ | 12.59 |
| 9:48 | 358,638 | 23.52 | 25.02 | 23.47 | 25.07 | 4.33x10 ⁻⁷ | 12.82 |
| 9:54 | 359,638 | 23.93 | 25.43 | 23.88 | 25.48 | 4.48x10 ⁻⁷ | 13.06 |
| 10:01 | 360,638 | 24.41 | 25.93 | 24.36 | 25.98 | 4.61x10 ⁻⁷ | 13.31 |
| 10:05 | 361,138 | 24.64 | 26.29 | 24.56 | 26.37 | 4.73x10 ⁻⁷ | 13.45 |
| 10:10 | 361,638 | 24.89 | 26.54 | 24.79 | 26.49 | 4.90x10 ⁻⁷ | 13.59 |
| 10:14 | 362,138 | 25.12 | 26.64 | 25.02 | 26.72 | 4.91x10 ⁻⁷ | 13.75 |
| 10:20 | 362,638 | 25.40 | 26.87 | 25.25 | 27.03 | 5.02x10 ⁻⁷ | 13.91 |
| 10:30 | 363,138 | 25.65 | 27.15 | 25.53 | 27.36 | 5.26x10 ⁻⁷ | 14.07 |
| 10:36 | 363,638 | 25.86 | 27.43 | 25.76 | 27.64 | 5.49x10 ⁻⁷ | 14.24 |
| 10:41 | 364,621 | 26.37 | 28.02 | 26.29 | 28.12 | 5.60x10 ⁻⁷ | 14.62 |
| 10:47 | 365,121 | 26.64 | 28.35 | 26.52 | 28.47 | 5.73x10 ⁻⁷ | 14.82 |
| 10:51 | 365,621 | 26.90 | 28.68 | 26.87 | 28.78 | 5.89x10 ⁻⁷ | 15.03 |
| 10:56 | 366,121 | 27.18 | 29.01 | 27.08 | 29.11 | 6.14x10 ⁻⁷ | 15.26 |
| 11:00 | 366,621 | 27.51 | 29.34 | 27.33 | 29.46 | 6.26x10 ⁻⁷ | 15.51 |
| 11:05 | 367,121 | 27.81 | 29.69 | 27.56 | 29.74 | 6.51x10 ⁻⁷ | 15.77 |
| 11:09 | 367,621 | 28.12 | 30.07 | 27.86 | 30.18 | 6.88x10 ⁻⁷ | 16.05 |
| 11:14 | 368,121 | 28.45 | 30.45 | 28.17 | 30.45 | 7.26x10 ⁻⁷ | 16.37 |
| 11:18 | 368,621 | 28.78 | 30.91 | 28.50 | 30.89 | 7.76x10 ⁻⁷ | 16.71 |
| 11:23 | 369,121 | 29.11 | 31.34 | 28.88 | 31.34 | 8.37x10 ⁻⁷ | 17.11 |

| | | | | | | | |
|----------|---------|-------|-------|-------|-------|-----------------------|-------|
| 11:27 | 369,621 | 29.49 | 31.72 | 29.26 | 31.85 | 9.28×10^{-7} | 17.57 |
| 11:33 | 370,121 | 29.92 | 32.18 | 29.67 | 32.41 | 1.06×10^{-6} | 18.14 |
| 11:37 | 370,621 | 30.43 | 32.72 | 30.15 | 33.05 | 1.42×10^{-6} | 19.00 |
| 11:42 | 371,121 | 30.86 | 33.53 | 30.68 | 33.76 | | |
| 12:56 pm | 371,621 | 31.45 | 34.62 | 31.27 | 34.77 | | |
| 1:07 | 372,121 | 32.28 | 37.34 | 32.05 | 37.47 | | |

Table A4. Fatigue crack growth rate data for specimen AL-2-26 of 2024-T351 Al.

| Specimen: AL-2-26 | | Frequency: 5 Hz | | R = 0.1 | | B = 9.53 mm | | W = 100.35 mm | |
|----------------------------|--------|----------------------------|------------|-------------------------------------|------------|-----------------------|-------------------------|---------------|--|
| P _{max} = 57.04 N | | P _{min} = 5.704 N | | Initial notch length (2a): 20.28 mm | | | | | |
| Time & Date | | Δa front | | Δa back | | da/dN | ΔK | | |
| hours : minutes | Total | left (mm) | right (mm) | left (mm) | right (mm) | (meter/cycle) | (MPa m ^{1/2}) | | |
| (date/note) | Cycles | | | | | | | | |
| 2:30 pm (01/13/05) | 7,000 | 0.15 | 0.15 | | | | | | |
| 3:20 | 9,000 | 0.25 | 0.41 | 0.10 | 0.28 | | | | |
| 3:40 | 11,000 | 0.46 | 0.61 | 0.30 | 0.48 | | | | |
| 3:50 | 13,000 | 0.74 | 0.94 | 0.53 | 0.86 | 1.43x10 ⁻⁷ | 10.20 | | |
| 8:20 am (01/14/05) | 15,000 | 1.05 | 1.18 | 1.03 | 1.05 | 1.63x10 ⁻⁷ | 10.37 | | |
| 8:30 | 17,000 | 1.44 | 1.63 | 1.36 | 1.33 | 1.79x10 ⁻⁷ | 10.56 | | |
| 8:45 | 19,000 | 1.79 | 1.98 | 1.75 | 1.78 | 1.89x10 ⁻⁷ | 10.75 | | |
| 9:00 | 21,000 | 2.21 | 2.26 | 2.06 | 2.18 | 1.96x10 ⁻⁷ | 10.95 | | |
| 9:10 | 23,000 | 2.64 | 2.87 | 2.41 | 2.54 | 2.07x10 ⁻⁷ | 11.15 | | |
| 9:20 | 25,000 | 3.12 | 3.30 | 2.74 | 2.90 | 2.18x10 ⁻⁷ | 11.36 | | |
| 9:35 | 27,000 | 3.48 | 3.76 | 3.25 | 3.20 | 2.30x10 ⁻⁷ | 11.60 | | |
| 9:45 | 29,000 | 4.01 | 4.24 | 3.71 | 3.84 | 2.42x10 ⁻⁷ | 11.83 | | |
| 10:00 | 31,000 | 4.57 | 4.75 | 4.11 | 4.34 | 2.61x10 ⁻⁷ | 12.08 | | |
| 10:10 | 33,000 | 5.05 | 5.28 | 4.57 | 4.83 | 2.79x10 ⁻⁷ | 12.36 | | |
| 10:20 | 35,000 | 5.61 | 5.87 | 5.28 | 5.28 | 2.92x10 ⁻⁷ | 12.65 | | |
| 10:30 | 37,000 | 6.22 | 6.58 | 5.84 | 5.99 | 3.13x10 ⁻⁷ | 12.95 | | |
| 10:40 | 39,000 | 6.88 | 7.11 | 6.53 | 6.71 | 3.36x10 ⁻⁷ | 13.29 | | |
| 10:50 | 41,000 | 7.44 | 7.70 | 7.14 | 7.42 | 3.55x10 ⁻⁷ | 13.64 | | |
| 11:10 | 43,000 | 8.18 | 8.53 | 7.87 | 8.23 | 3.78x10 ⁻⁷ | 14.02 | | |
| 11:15 | 45,000 | 8.99 | 9.25 | 8.69 | 9.07 | 4.06x10 ⁻⁷ | 14.43 | | |
| 12:00 | 47,000 | 9.91 | 9.86 | 9.58 | 9.80 | 4.44x10 ⁻⁷ | 14.87 | | |
| 1:00 | 49,000 | 10.74 | 10.72 | 10.52 | 10.82 | 4.84x10 ⁻⁷ | 15.36 | | |
| 1:10 | 51,000 | 11.73 | 11.73 | 11.46 | 11.79 | 5.56x10 ⁻⁷ | 15.90 | | |
| 1:15 | 53,000 | 12.95 | 12.83 | 12.52 | 13.00 | 6.22x10 ⁻⁷ | 16.58 | | |
| 1:28 | 55,000 | 14.12 | 14.15 | 13.79 | 14.15 | 6.94x10 ⁻⁷ | 17.38 | | |
| 1:35 | 57,000 | 16.76 | 15.85 | 15.09 | 15.60 | 7.75x10 ⁻⁷ | 18.31 | | |
| 1:45 | 58,500 | 16.76 | 17.15 | 16.31 | 16.81 | 8.69x10 ⁻⁷ | 19.12 | | |
| 1:55 | 60,000 | 18.03 | 18.52 | 17.75 | 17.98 | 1.04x10 ⁻⁶ | 20.07 | | |
| 2:05 | 61,000 | 19.10 | 19.53 | 18.82 | 18.85 | 1.22x10 ⁻⁶ | 20.79 | | |
| 2:10 | 62,000 | 20.29 | 20.85 | 20.02 | 20.14 | 1.52x10 ⁻⁶ | 21.79 | | |
| 2:18 | 63,000 | 21.95 | 22.40 | 21.77 | 21.67 | | | | |
| 2:25 | 64,000 | 23.88 | 24.36 | 23.22 | 23.52 | | | | |
| 2:30 | 65,000 | 26.62 | 27.15 | 25.78 | 26.42 | | | | |

Table A5. Fatigue crack growth rate data for specimen AL-2-27 of 2024-T351 Al.

| Specimen: AL-2-27 | Frequency: 5 Hz | R = 0.1 | B = 9.66 mm | W = 100.38 mm | | | |
|--------------------------------|---------------------|-------------------------------------|-------------|-----------------|------------|-----------------------|-------------------------|
| $P_{max} = 40.17$ N | $P_{min} = 4.017$ N | Initial notch length (2a): 20.29 mm | | | | | |
| Time & Date | | Δa front | | Δa back | | da/dN | ΔK |
| hours : minutes (date/note) | Total Cycles | left (mm) | right (mm) | left (mm) | right (mm) | (meter/cycle) | (MPa m ^{1/2}) |
| 3:10 pm (01/19/05) | 57,000 | 0.38 | 0.23 | 0.23 | 0.13 | | |
| 3:25 | 59,000 | 0.41 | 0.33 | 0.25 | 0.15 | | |
| 3:40 | 61,000 | 0.48 | 0.43 | 0.28 | 0.20 | | |
| 3:50 | 63,000 | 0.53 | 0.51 | 0.30 | 0.23 | 2.29×10^{-8} | 6.95 |
| 4:05 | 65,000 | 0.58 | 0.53 | 0.36 | 0.25 | 2.37×10^{-8} | 6.96 |
| 4:15 | 67,000 | 0.69 | 0.61 | 0.36 | 0.25 | 2.35×10^{-8} | 6.98 |
| 10:18 am (01/20/05) | 69,000 | 0.76 | 0.66 | 0.36 | 0.28 | 2.40×10^{-8} | 7.00 |
| 10:30 | 71,000 | 0.86 | 0.74 | 0.38 | 0.38 | 2.30×10^{-8} | 7.02 |
| 10:44 | 73,000 | 0.91 | 0.74 | 0.43 | 0.43 | 2.14×10^{-8} | 7.04 |
| 10:55 | 75,000 | 0.94 | 0.84 | 0.46 | 0.46 | 1.97×10^{-8} | 7.05 |
| 11:13 | 77,000 | 0.94 | 0.86 | 0.46 | 0.51 | 1.79×10^{-8} | 7.06 |
| 11:23 | 79,000 | 1.02 | 0.91 | 0.46 | 0.53 | 1.93×10^{-8} | 7.07 |
| 11:34 | 81,000 | 1.04 | 0.94 | 0.48 | 0.61 | 2.04×10^{-8} | 7.09 |
| 11:44 | 83,000 | 1.12 | 0.99 | 0.51 | 0.64 | 2.25×10^{-8} | 7.10 |
| 11:55 | 85,000 | 1.14 | 1.07 | 0.56 | 0.71 | 2.25×10^{-8} | 7.12 |
| 12:05 pm | 87,000 | 1.19 | 1.14 | 0.58 | 0.71 | 2.26×10^{-8} | 7.14 |
| 12:20 | 89,000 | 1.27 | 1.19 | 0.64 | 0.74 | 2.15×10^{-8} | 7.16 |
| 12:32 | 91,000 | 1.30 | 1.24 | 0.64 | 0.79 | 2.13×10^{-8} | 7.17 |
| 12:45 | 93,000 | 1.35 | 1.35 | 0.66 | 0.81 | 2.19×10^{-8} | 7.18 |
| 12:57 | 95,000 | 1.35 | 1.47 | 0.66 | 0.81 | 2.14×10^{-8} | 7.20 |
| 1:15 | 97,000 | 1.40 | 1.47 | 0.74 | 0.91 | 2.20×10^{-8} | 7.22 |
| 1:26 | 99,000 | 1.45 | 1.52 | 0.76 | 0.97 | 2.05×10^{-8} | 7.23 |
| 1:37 | 101,000 | 1.50 | 1.55 | 0.81 | 0.97 | 2.00×10^{-8} | 7.25 |
| 2:05 | 103,000 | 1.57 | 1.57 | 0.86 | 1.02 | 1.94×10^{-8} | 7.26 |
| 2:20 | 105,000 | 1.57 | 1.57 | 0.89 | 1.07 | 2.03×10^{-8} | 7.27 |
| 2:33 | 107,000 | 1.63 | 1.65 | 0.94 | 1.07 | 2.15×10^{-8} | 7.29 |
| 2:48 | 109,000 | 1.68 | 1.70 | 0.97 | 1.14 | 2.32×10^{-8} | 7.30 |
| 3:00 | 111,000 | 1.70 | 1.75 | 1.02 | 1.22 | 2.62×10^{-8} | 7.32 |
| 3:11 | 113,000 | 1.78 | 1.78 | 1.04 | 1.27 | 2.79×10^{-8} | 7.34 |
| 3:22 | 115,000 | 1.85 | 1.85 | 1.07 | 1.35 | 2.97×10^{-8} | 7.36 |
| 3:38 | 117,000 | 1.91 | 1.93 | 1.17 | 1.37 | 3.03×10^{-8} | 7.39 |
| 3:53 | 119,000 | 1.96 | 2.01 | 1.22 | 1.45 | 3.04×10^{-8} | 7.41 |
| 4:05 | 121,000 | 2.03 | 2.16 | 1.27 | 1.45 | 2.88×10^{-8} | 7.43 |
| 4:16 | 123,000 | 2.06 | 2.18 | 1.32 | 1.52 | 2.86×10^{-8} | 7.45 |
| 10:45 am (01/21/05) | 125,000 | 2.08 | 2.21 | 1.40 | 1.63 | 3.05×10^{-8} | 7.47 |
| 10:56 | 127,000 | 2.16 | 2.24 | 1.45 | 1.65 | 3.23×10^{-8} | 7.49 |
| 11:10 | 129,000 | 2.24 | 2.29 | 1.52 | 1.75 | 3.58×10^{-8} | 7.51 |
| 11:21 | 131,000 | 2.29 | 2.41 | 1.65 | 1.83 | 3.69×10^{-8} | 7.54 |
| 11:30 | 133,000 | 2.36 | 2.49 | 1.68 | 1.91 | 3.79×10^{-8} | 7.57 |
| 11:42 | 135,000 | 2.49 | 2.62 | 1.70 | 1.98 | 3.65×10^{-8} | 7.60 |
| 11:54 | 137,000 | 2.54 | 2.62 | 1.80 | 2.03 | 3.54×10^{-8} | 7.62 |
| 12:10 pm | 139,000 | 2.57 | 2.74 | 1.91 | 2.11 | 3.65×10^{-8} | 7.65 |
| 12:21 | 141,000 | 2.69 | 2.77 | 1.96 | 2.16 | 3.64×10^{-8} | 7.67 |
| 12:32 | 143,000 | 2.72 | 2.92 | 2.01 | 2.24 | 3.72×10^{-8} | 7.70 |

| | | | | | | | |
|--------------------|---------|-------|-------|------|-------|-----------------------|-------|
| 12:42 | 145,000 | 2.84 | 3.05 | 2.03 | 2.31 | 3.82x10 ⁻⁸ | 7.73 |
| 12:52 | 147,000 | 2.87 | 3.12 | 2.08 | 2.41 | 3.95x10 ⁻⁸ | 7.75 |
| 1:02 | 149,000 | 3.00 | 3.12 | 2.11 | 2.54 | 4.27x10 ⁻⁸ | 7.78 |
| 1:17 | 151,000 | 3.02 | 3.30 | 2.29 | 2.57 | 4.67x10 ⁻⁸ | 7.81 |
| 1:30 | 153,000 | 3.10 | 3.35 | 2.41 | 2.62 | 4.89x10 ⁻⁸ | 7.85 |
| 1:39 | 155,000 | 3.23 | 3.43 | 2.62 | 2.74 | 4.92x10 ⁻⁸ | 7.89 |
| 1:50 | 157,000 | 3.30 | 3.56 | 2.77 | 2.84 | 4.88x10 ⁻⁸ | 7.92 |
| 2:07 | 159,000 | 3.43 | 3.58 | 2.77 | 2.95 | 4.77x10 ⁻⁸ | 7.95 |
| 2:22 | 161,000 | 3.48 | 3.76 | 2.79 | 3.05 | 4.74x10 ⁻⁸ | 7.98 |
| 2:38 | 163,000 | 3.63 | 3.89 | 2.84 | 3.15 | 4.98x10 ⁻⁸ | 8.02 |
| 2:50 | 165,000 | 3.71 | 3.94 | 2.95 | 3.25 | 5.45x10 ⁻⁸ | 8.05 |
| 3:02 | 167,000 | 3.84 | 4.04 | 3.10 | 3.40 | 5.78x10 ⁻⁸ | 8.09 |
| 3:15 | 169,000 | 3.94 | 4.19 | 3.18 | 3.53 | 6.03x10 ⁻⁸ | 8.14 |
| 3:27 | 171,000 | 4.09 | 4.32 | 3.28 | 3.66 | 6.51x10 ⁻⁸ | 8.18 |
| 3:36 | 173,000 | 4.19 | 4.45 | 3.43 | 3.78 | 6.78x10 ⁻⁸ | 8.23 |
| 3:55 | 175,000 | 4.29 | 4.62 | 3.48 | 3.96 | 7.13x10 ⁻⁸ | 8.28 |
| 8:45 am (01/24/05) | 177,000 | 4.47 | 4.83 | 3.63 | 4.11 | 7.39x10 ⁻⁸ | 8.33 |
| 9:00 | 179,000 | 4.60 | 5.00 | 3.78 | 4.24 | 7.55x10 ⁻⁸ | 8.38 |
| 9:15 | 181,000 | 4.78 | 5.13 | 3.91 | 4.42 | 7.64x10 ⁻⁸ | 8.44 |
| 9:30 | 183,000 | 5.00 | 5.23 | 4.06 | 4.55 | 7.64x10 ⁻⁸ | 8.49 |
| 9:40 | 185,000 | 5.13 | 5.38 | 4.22 | 4.70 | 7.77x10 ⁻⁸ | 8.54 |
| 9:50 | 187,000 | 5.23 | 5.56 | 4.37 | 4.90 | 7.99x10 ⁻⁸ | 8.60 |
| 10:00 | 189,000 | 5.38 | 5.66 | 4.57 | 5.11 | 8.30x10 ⁻⁸ | 8.65 |
| 10:15 | 191,000 | 5.54 | 5.87 | 4.72 | 5.23 | 8.70x10 ⁻⁸ | 8.71 |
| 10:25 | 193,000 | 5.72 | 6.05 | 4.95 | 5.38 | 8.89x10 ⁻⁸ | 8.78 |
| 10:34 | 195,000 | 5.87 | 6.25 | 5.11 | 5.61 | 9.28x10 ⁻⁸ | 8.84 |
| 10:43 | 197,000 | 6.07 | 6.45 | 5.31 | 5.79 | 9.54x10 ⁻⁸ | 8.91 |
| 10:53 | 199,000 | 6.22 | 6.63 | 5.44 | 5.99 | 1.00x10 ⁻⁷ | 8.97 |
| 11:02 | 201,000 | 6.43 | 6.83 | 5.69 | 6.25 | 1.05x10 ⁻⁷ | 9.05 |
| 11:11 | 203,000 | 6.73 | 7.04 | 5.79 | 6.38 | 1.09x10 ⁻⁷ | 9.12 |
| 11:21 | 205,000 | 6.91 | 7.32 | 6.12 | 6.65 | 1.14x10 ⁻⁷ | 9.21 |
| 12:44 pm | 207,000 | 7.11 | 7.54 | 6.30 | 6.91 | 1.16x10 ⁻⁷ | 9.29 |
| 12:55 | 209,000 | 7.34 | 7.72 | 6.55 | 7.16 | 1.20x10 ⁻⁷ | 9.37 |
| 1:05 | 211,000 | 7.57 | 7.95 | 6.83 | 7.39 | 1.21x10 ⁻⁷ | 9.46 |
| 2:45 | 213,000 | 7.82 | 8.18 | 7.09 | 7.62 | 1.26x10 ⁻⁷ | 9.55 |
| 2:59 | 215,000 | 8.05 | 8.46 | 7.37 | 7.90 | 1.28x10 ⁻⁷ | 9.64 |
| 3:03 | 216,000 | 8.18 | 8.61 | 7.52 | 8.03 | 1.31x10 ⁻⁷ | 9.69 |
| 3:11 | 217,000 | 8.33 | 8.76 | 7.70 | 8.10 | 1.34x10 ⁻⁷ | 9.74 |
| 3:17 | 218,000 | 8.41 | 8.86 | 7.80 | 8.20 | 1.34x10 ⁻⁷ | 9.79 |
| 3:27 | 219,000 | 8.56 | 9.02 | 7.92 | 8.43 | 1.37x10 ⁻⁷ | 9.84 |
| 3:36 | 220,000 | 8.66 | 9.14 | 8.08 | 8.61 | 1.41x10 ⁻⁷ | 9.89 |
| 3:42 | 221,000 | 8.81 | 9.32 | 8.13 | 8.74 | 1.43x10 ⁻⁷ | 9.94 |
| 3:49 | 222,000 | 8.97 | 9.47 | 8.28 | 8.92 | 1.40x10 ⁻⁷ | 9.99 |
| 3:55 | 223,000 | 9.09 | 9.58 | 8.48 | 9.07 | 1.42x10 ⁻⁷ | 10.04 |
| 4:03 | 224,000 | 9.25 | 9.73 | 8.61 | 9.12 | 1.52x10 ⁻⁷ | 10.10 |
| 4:09 | 225,000 | 9.40 | 9.91 | 8.69 | 9.30 | 1.55x10 ⁻⁷ | 10.16 |
| 4:14 | 226,000 | 9.53 | 10.08 | 8.84 | 9.47 | 1.64x10 ⁻⁷ | 10.22 |
| 7:42 am (01/25/05) | 227,000 | 9.70 | 10.29 | 9.09 | 9.70 | 1.68x10 ⁻⁷ | 10.27 |
| 7:49 | 228,000 | 9.86 | 10.44 | 9.22 | 9.80 | 1.71x10 ⁻⁷ | 10.34 |
| 7:54 | 229,000 | 10.01 | 10.69 | 9.37 | 10.01 | 1.74x10 ⁻⁷ | 10.40 |

| | | | | | | | |
|---------|---------|-------|-------|-------|-------|-----------------------|-------|
| 8:03 | 230,100 | 10.19 | 10.85 | 9.53 | 10.11 | 1.73x10 ⁻⁷ | 10.47 |
| 8:09 | 231,118 | 10.39 | 11.05 | 9.68 | 10.31 | 1.76x10 ⁻⁷ | 10.54 |
| 8:16 | 232,000 | 10.57 | 11.15 | 9.96 | 10.54 | 1.77x10 ⁻⁷ | 10.60 |
| 8:23 | 233,000 | 10.72 | 11.40 | 10.11 | 10.64 | 1.78x10 ⁻⁷ | 10.67 |
| 8:30 | 234,000 | 10.95 | 11.53 | 10.26 | 10.77 | 1.81x10 ⁻⁷ | 10.74 |
| 8:38 | 235,000 | 11.13 | 11.73 | 10.41 | 11.05 | 1.86x10 ⁻⁷ | 10.81 |
| 8:44 | 236,000 | 11.25 | 11.89 | 10.62 | 11.20 | 1.97x10 ⁻⁷ | 10.89 |
| 8:50 | 237,000 | 11.48 | 12.12 | 10.85 | 11.43 | 2.06x10 ⁻⁷ | 10.97 |
| 8:57 | 238,000 | 11.66 | 12.32 | 11.00 | 11.68 | 2.16x10 ⁻⁷ | 11.05 |
| 9:02 | 239,000 | 11.94 | 12.50 | 11.28 | 11.89 | 2.24x10 ⁻⁷ | 11.13 |
| 9:08 | 240,000 | 12.12 | 12.80 | 11.51 | 12.04 | 2.27x10 ⁻⁷ | 11.22 |
| 9:20 | 241,000 | 12.34 | 13.03 | 11.68 | 12.40 | 2.30x10 ⁻⁷ | 11.31 |
| 9:28 | 242,000 | 12.60 | 13.18 | 11.99 | 12.57 | 2.29x10 ⁻⁷ | 11.41 |
| 9:34 | 243,000 | 12.80 | 13.44 | 12.17 | 12.85 | 2.31x10 ⁻⁷ | 11.50 |
| 9:41 | 244,000 | 13.03 | 13.64 | 12.45 | 13.06 | 2.35x10 ⁻⁷ | 11.60 |
| 9:47 | 245,000 | 13.26 | 13.89 | 12.62 | 13.28 | 2.37x10 ⁻⁷ | 11.69 |
| 9:54 | 246,000 | 13.54 | 14.10 | 12.90 | 13.54 | 2.48x10 ⁻⁷ | 11.80 |
| 10:06 | 247,000 | 13.82 | 14.35 | 13.16 | 13.82 | 2.57x10 ⁻⁷ | 11.90 |
| 10:30 | 248,000 | 14.02 | 14.61 | 13.39 | 13.97 | 2.60x10 ⁻⁷ | 12.01 |
| 10:36 | 249,000 | 14.33 | 14.94 | 13.67 | 14.35 | 2.66x10 ⁻⁷ | 12.12 |
| 10:42 | 250,000 | 14.58 | 15.21 | 13.89 | 14.63 | 2.75x10 ⁻⁷ | 12.24 |
| 10:50 | 251,000 | 14.76 | 15.49 | 14.12 | 14.86 | 2.85x10 ⁻⁷ | 12.36 |
| 10:56 | 252,000 | 15.09 | 15.75 | 14.53 | 15.14 | 2.88x10 ⁻⁷ | 12.49 |
| 11:02 | 253,000 | 15.37 | 16.05 | 14.81 | 15.52 | 3.03x10 ⁻⁷ | 12.62 |
| 11:09 | 254,000 | 15.72 | 16.41 | 14.96 | 15.82 | 3.17x10 ⁻⁷ | 12.76 |
| 11:16 | 255,000 | 16.05 | 16.71 | 15.27 | 16.08 | 3.21x10 ⁻⁷ | 12.91 |
| 11:26 | 256,000 | 16.31 | 17.07 | 15.70 | 16.51 | 3.29x10 ⁻⁷ | 13.06 |
| 1:15 pm | 257,056 | 16.69 | 17.40 | 16.03 | 16.87 | 3.41x10 ⁻⁷ | 13.23 |
| 1:23 | 257,556 | 16.76 | 17.63 | 16.15 | 17.04 | 3.46x10 ⁻⁷ | 13.31 |
| 1:35 | 258,056 | 16.97 | 17.81 | 16.31 | 17.25 | 3.51x10 ⁻⁷ | 13.40 |
| 1:55 | 258,556 | 17.17 | 17.93 | 16.54 | 17.48 | 3.62x10 ⁻⁷ | 13.48 |
| 1:59 | 259,056 | 17.30 | 18.16 | 16.69 | 17.58 | 3.81x10 ⁻⁷ | 13.58 |
| 2:05 | 259,556 | 17.50 | 18.36 | 16.97 | 17.75 | 3.94x10 ⁻⁷ | 13.67 |
| 2:11 | 260,056 | 17.65 | 18.54 | 17.12 | 17.96 | 4.01x10 ⁻⁷ | 13.77 |
| 2:16 | 260,556 | 17.86 | 18.80 | 17.35 | 18.24 | 4.09x10 ⁻⁷ | 13.87 |
| 2:21 | 261,056 | 18.14 | 18.95 | 17.55 | 18.44 | 4.12x10 ⁻⁷ | 13.98 |
| 2:32 | 262,500 | 18.72 | 19.51 | 18.06 | 19.05 | 4.20x10 ⁻⁷ | 14.30 |
| 2:38 | 263,000 | 18.92 | 19.71 | 18.34 | 19.30 | 4.28x10 ⁻⁷ | 14.41 |
| 2:42 | 263,500 | 19.15 | 19.91 | 18.59 | 19.46 | 4.51x10 ⁻⁷ | 14.52 |
| 2:47 | 264,000 | 19.33 | 20.17 | 18.85 | 19.74 | 4.54x10 ⁻⁷ | 14.65 |
| 2:51 | 264,500 | 19.46 | 20.47 | 18.97 | 20.02 | 4.64x10 ⁻⁷ | 14.78 |
| 3:02 | 265,000 | 19.71 | 20.75 | 19.18 | 20.24 | 4.87x10 ⁻⁷ | 14.92 |
| 3:07 | 265,500 | 19.94 | 20.90 | 19.51 | 20.45 | 5.20x10 ⁻⁷ | 15.06 |
| 3:12 | 266,000 | 20.24 | 21.23 | 19.71 | 20.70 | 5.42x10 ⁻⁷ | 15.21 |
| 3:16 | 266,500 | 20.47 | 21.46 | 20.12 | 20.98 | 5.51x10 ⁻⁷ | 15.37 |
| 3:22 | 267,000 | 20.80 | 21.84 | 20.42 | 21.31 | 5.56x10 ⁻⁷ | 15.54 |
| 3:27 | 267,500 | 21.06 | 22.10 | 20.55 | 21.59 | 5.42x10 ⁻⁷ | 15.70 |
| 3:33 | 268,000 | 21.23 | 22.38 | 20.85 | 21.87 | 5.54x10 ⁻⁷ | 15.88 |
| 3:36 | 268,500 | 21.56 | 22.63 | 21.08 | 22.17 | 5.72x10 ⁻⁷ | 16.07 |
| 3:43 | 269,000 | 21.89 | 22.78 | 21.31 | 22.43 | 6.01x10 ⁻⁷ | 16.26 |

| | | | | | | | |
|--------------------|---------|-------|-------|-------|-------|-----------------------|-------|
| 3:47 | 269,500 | 22.20 | 23.19 | 21.87 | 22.71 | 6.33x10 ⁻⁷ | 16.46 |
| 3:52 | 270,000 | 22.50 | 23.57 | 22.05 | 23.11 | 6.64x10 ⁻⁷ | 16.68 |
| 3:56 | 270,500 | 22.83 | 23.85 | 22.40 | 23.32 | 6.95x10 ⁻⁷ | 16.92 |
| 4:00 | 271,000 | 23.16 | 24.31 | 22.73 | 23.70 | 7.24x10 ⁻⁷ | 17.18 |
| 4:05 | 271,500 | 23.55 | 24.64 | 23.16 | 24.03 | 7.29x10 ⁻⁷ | 17.43 |
| 4:10 | 272,000 | 24.00 | 25.04 | 23.57 | 24.28 | 7.85x10 ⁻⁷ | 17.73 |
| 7:53 am (01/26/05) | 272,500 | 24.41 | 25.55 | 23.98 | 24.77 | 8.23x10 ⁻⁷ | 18.05 |
| 8:06 | 273,000 | 24.74 | 25.46 | 24.21 | 25.25 | 8.77x10 ⁻⁷ | 18.40 |
| 8:10 | 273,500 | 25.17 | 26.47 | 24.71 | 25.76 | 9.50x10 ⁻⁷ | 18.80 |
| 8:23 | 274,000 | 25.60 | 26.90 | 25.17 | 26.19 | 1.05x10 ⁻⁶ | 19.25 |
| 8:30 | 274,500 | 26.01 | 27.38 | 25.76 | 26.82 | 1.14x10 ⁻⁶ | 19.73 |
| 8:36 | 275,000 | 26.49 | 28.04 | 26.49 | 27.36 | 1.26x10 ⁻⁶ | 20.37 |
| 8:43 | 275,500 | 27.18 | 28.68 | 27.00 | 28.27 | 1.46x10 ⁻⁶ | 21.11 |
| 8:50 | 276,000 | 27.84 | 29.49 | 27.71 | 28.30 | 1.75x10 ⁻⁶ | 22.10 |
| 8:56 | 276,500 | 28.70 | 30.35 | 28.50 | 29.95 | 2.29x10 ⁻⁶ | |
| 9:04 | 277,000 | 29.79 | 31.55 | 29.49 | 31.01 | | |
| 9:15 | 277,500 | 30.81 | 33.30 | 30.78 | 32.61 | | |

Table A6. Fatigue crack growth rate data for specimen AL-2-28 of 2024-T351 Al.

| Specimen: AL-2-28 | | Frequency: 5 Hz | | R = 0.1 | | B = 9.65 mm | | W = 100.41 mm | |
|----------------------------|--------|----------------------------|------------|-------------------------------------|------------|-----------------------|-------------------------|---------------|--|
| P _{max} = 71.41 N | | P _{min} = 7.141 N | | Initial notch length (2a): 20.29 mm | | | | | |
| Time & Date | | Δa front | | Δa back | | da/dN | ΔK | | |
| hours : minutes | Total | left (mm) | right (mm) | left (mm) | right (mm) | (meter/cycle) | (MPa m ^{1/2}) | | |
| (date/note) | Cycles | | | | | | | | |
| 9:27 am (02/07/05) | 4,000 | 0.15 | 0.13 | 0.15 | | | | | |
| 9:37 | 6,000 | 0.53 | 0.43 | 0.33 | 0.56 | | | | |
| 9:46 | 8,000 | 1.04 | 0.97 | 0.84 | 1.07 | | | | |
| 9:52 | 9,000 | 1.35 | 1.30 | 1.12 | 1.30 | 3.01x10 ⁻⁷ | 12.91 | | |
| 9:59 | 10,000 | 1.57 | 1.57 | 1.52 | 1.57 | 3.26x10 ⁻⁷ | 13.12 | | |
| 10:05 | 11,000 | 2.03 | 1.96 | 1.80 | 1.88 | 3.45x10 ⁻⁷ | 13.33 | | |
| 10:11 | 12,000 | 2.34 | 2.34 | 2.21 | 2.26 | 3.59x10 ⁻⁷ | 13.57 | | |
| 10:17 | 13,000 | 2.79 | 2.69 | 2.57 | 2.57 | 3.66x10 ⁻⁷ | 13.80 | | |
| 10:24 | 14,000 | 3.12 | 3.15 | 2.87 | 2.97 | 3.72x10 ⁻⁷ | 14.03 | | |
| 10:31 | 15,000 | 3.43 | 3.56 | 3.18 | 3.40 | 3.78x10 ⁻⁷ | 14.26 | | |
| 10:38 | 16,000 | 3.89 | 3.89 | 3.51 | 3.71 | 3.90x10 ⁻⁷ | 14.50 | | |
| 10:44 | 17,000 | 4.14 | 4.45 | 3.91 | 4.19 | 4.11x10 ⁻⁷ | 14.74 | | |
| 10:52 | 18,000 | 4.52 | 4.78 | 4.37 | 4.57 | 4.46x10 ⁻⁷ | 15.00 | | |
| 10:58 | 19,000 | 4.98 | 5.28 | 4.70 | 5.08 | 4.89x10 ⁻⁷ | 15.29 | | |
| 11:04 | 20,000 | 5.46 | 5.66 | 5.26 | 5.69 | 5.45x10 ⁻⁷ | 15.60 | | |
| 11:09 | 20,500 | 5.72 | 6.12 | 5.51 | 5.94 | 5.71x10 ⁻⁷ | 15.78 | | |
| 11:13 | 21,000 | 6.05 | 6.32 | 5.79 | 6.25 | 5.89x10 ⁻⁷ | 15.97 | | |
| 11:18 | 21,500 | 6.32 | 6.71 | 6.07 | 6.53 | 6.00x10 ⁻⁷ | 16.16 | | |
| 12:30 pm | 22,000 | 6.65 | 7.06 | 6.40 | 6.78 | 6.11x10 ⁻⁷ | 16.35 | | |
| 12:34 | 22,500 | 6.88 | 7.29 | 6.76 | 7.16 | 6.23x10 ⁻⁷ | 16.55 | | |
| 12:37 | 23,000 | 7.24 | 7.52 | 7.06 | 7.42 | 6.31x10 ⁻⁷ | 16.75 | | |
| 12:41 | 23,500 | 7.62 | 7.92 | 7.39 | 7.72 | 6.49x10 ⁻⁷ | 16.95 | | |
| 12:45 | 24,000 | 7.90 | 8.20 | 7.77 | 8.03 | 6.75x10 ⁻⁷ | 17.16 | | |
| 12:49 | 24,500 | 8.20 | 8.61 | 8.10 | 8.31 | 6.98x10 ⁻⁷ | 17.38 | | |
| 12:53 | 25,000 | 8.64 | 8.92 | 8.48 | 8.66 | 7.21x10 ⁻⁷ | 17.61 | | |
| 12:56 | 25,500 | 9.04 | 9.30 | 8.89 | 8.97 | 7.38x10 ⁻⁷ | 17.86 | | |
| 1:00 | 26,000 | 9.37 | 9.68 | 9.27 | 9.32 | 7.64x10 ⁻⁷ | 18.10 | | |
| 1:05 | 26,500 | 9.91 | 10.06 | 9.63 | 9.70 | 8.06x10 ⁻⁷ | 18.35 | | |
| 1:09 | 27,000 | 10.31 | 10.29 | 9.96 | 10.08 | 8.61x10 ⁻⁷ | 18.62 | | |
| 1:13 | 27,500 | 10.64 | 10.87 | 10.36 | 10.62 | 9.14x10 ⁻⁷ | 18.92 | | |
| 1:17 | 28,000 | 11.15 | 11.35 | 10.92 | 11.13 | 9.39x10 ⁻⁷ | 19.24 | | |
| 1:20 | 28,200 | 11.46 | 11.46 | 11.07 | 11.35 | 9.03x10 ⁻⁷ | 19.38 | | |
| 1:23 | 28,400 | 11.56 | 11.61 | 11.23 | 11.53 | 8.95x10 ⁻⁷ | 19.51 | | |
| 1:26 | 28,600 | 11.73 | 11.71 | 11.46 | 11.68 | 9.11x10 ⁻⁷ | 19.62 | | |
| 1:29 | 28,800 | 11.86 | 11.86 | 11.71 | 11.91 | 9.65x10 ⁻⁷ | 19.74 | | |
| 1:32 | 29,000 | 11.96 | 12.09 | 11.94 | 12.09 | 1.03x10 ⁻⁶ | 19.89 | | |
| 1:34 | 29,200 | 12.24 | 12.29 | 12.14 | 12.37 | 1.09x10 ⁻⁶ | 20.04 | | |
| 1:37 | 29,400 | 12.50 | 12.57 | 12.37 | 12.52 | 1.11x10 ⁻⁶ | 20.21 | | |
| 1:41 | 29,600 | 12.67 | 12.78 | 12.57 | 12.75 | 1.11x10 ⁻⁶ | 20.37 | | |
| 1:44 | 29,800 | 12.83 | 13.13 | 12.78 | 13.08 | 1.11x10 ⁻⁶ | 20.53 | | |
| 1:50 | 30,000 | 13.00 | 13.34 | 13.03 | 13.18 | 1.10x10 ⁻⁶ | 20.69 | | |
| 1:55 | 30,200 | 13.21 | 13.59 | 13.23 | 13.36 | 1.14x10 ⁻⁶ | 20.85 | | |
| 1:58 | 30,400 | 13.59 | 13.79 | 13.46 | 13.59 | 1.15x10 ⁻⁶ | 21.02 | | |
| 2:02 | 30,600 | 13.84 | 14.07 | 13.59 | 13.74 | 1.21x10 ⁻⁶ | 21.19 | | |

| | | | | | | | |
|--------------------|--------|-------|-------|-------|-------|-----------------------|-------|
| 2:05 | 30,800 | 14.15 | 14.33 | 13.87 | 14.00 | 1.27x10 ⁻⁶ | 21.38 |
| 2:09 | 31,000 | 14.30 | 14.53 | 14.17 | 14.22 | 1.32x10 ⁻⁶ | 21.57 |
| 2:11 | 31,200 | 14.53 | 14.88 | 14.43 | 14.55 | 1.39x10 ⁻⁶ | 21.78 |
| 2:14 | 31,400 | 14.88 | 15.16 | 14.73 | 14.81 | 1.43x10 ⁻⁶ | 22.00 |
| 2:17 | 31,600 | 15.11 | 15.54 | 14.99 | 15.04 | 1.48x10 ⁻⁶ | 22.24 |
| 2:20 | 31,800 | 15.49 | 15.75 | 15.34 | 15.37 | 1.53x10 ⁻⁶ | 22.47 |
| 2:23 | 32,000 | 15.82 | 16.08 | 15.60 | 15.57 | 1.58x10 ⁻⁶ | 22.72 |
| 2:26 | 32,200 | 16.23 | 16.36 | 15.93 | 15.88 | 1.61x10 ⁻⁶ | 22.99 |
| 2:29 | 32,400 | 16.56 | 16.71 | 16.21 | 16.31 | 1.62x10 ⁻⁶ | 23.26 |
| 2:31 | 32,600 | 16.87 | 17.20 | 16.48 | 16.61 | 1.69x10 ⁻⁶ | 23.53 |
| 2:35 | 32,800 | 17.20 | 17.40 | 16.81 | 16.92 | 1.74x10 ⁻⁶ | 23.82 |
| 2:38 | 33,000 | 17.58 | 17.70 | 17.15 | 17.20 | 1.82x10 ⁻⁶ | 24.12 |
| 2:41 | 33,200 | 17.96 | 18.16 | 17.58 | 17.65 | 1.91x10 ⁻⁶ | 24.45 |
| 2:44 | 33,400 | 18.26 | 18.49 | 18.01 | 18.11 | 2.05x10 ⁻⁶ | 24.81 |
| 2:50 | 33,600 | 18.69 | 18.82 | 18.49 | 18.57 | 2.14x10 ⁻⁶ | 25.20 |
| 2:53 | 33,800 | 19.15 | 19.25 | 18.87 | 18.90 | 2.21x10 ⁻⁶ | 25.61 |
| 2:57 | 34,000 | 19.61 | 19.76 | 19.33 | 19.46 | 2.27x10 ⁻⁶ | 26.06 |
| 3:00 | 34,200 | 20.09 | 20.24 | 19.69 | 19.94 | 2.41x10 ⁻⁶ | 26.51 |
| 3:03 | 34,400 | 20.57 | 20.80 | 20.14 | 20.45 | 2.60x10 ⁻⁶ | 27.00 |
| 3:07 | 34,600 | 20.93 | 21.21 | 20.62 | 20.88 | 2.88x10 ⁻⁶ | 27.55 |
| 3:15 | 34,800 | 21.59 | 21.89 | 21.39 | 21.44 | 3.34x10 ⁻⁶ | 28.20 |
| 3:19 | 34,900 | 21.87 | 22.23 | 21.72 | 21.89 | 3.54x10 ⁻⁶ | 28.58 |
| 3:22 | 35,000 | 22.20 | 22.73 | 22.05 | 22.17 | 3.77x10 ⁻⁶ | 29.03 |
| 3:27 | 35,100 | 22.68 | 23.14 | 22.35 | 22.58 | 3.99x10 ⁻⁶ | 29.48 |
| 3:33 | 35,200 | 23.01 | 23.50 | 22.68 | 23.06 | 4.33x10 ⁻⁶ | 29.96 |
| 3:36 | 35,300 | 23.29 | 23.95 | 23.22 | 23.55 | 4.85x10 ⁻⁶ | 30.52 |
| 3:39 | 35,400 | 23.62 | 24.61 | 23.70 | 23.95 | 5.47x10 ⁻⁶ | 31.17 |
| 3:44 | 35,500 | 24.38 | 25.12 | 24.28 | 24.64 | 6.44x10 ⁻⁶ | 31.98 |
| 3:48 (unclamped) | 35,550 | | 25.60 | 24.56 | 24.99 | 7.44x10 ⁻⁶ | 32.44 |
| 8:12 am (02/08/05) | 35,600 | | 25.96 | 24.92 | 25.37 | 8.58x10 ⁻⁶ | 32.96 |
| 8:40 | 35,650 | | 26.29 | 25.35 | | 8.25x10 ⁻⁶ | 33.66 |
| 9:04 | 35,700 | | 26.70 | 25.68 | | 9.81x10 ⁻⁶ | 34.42 |
| 9:24 | 35,750 | | 27.20 | 26.04 | | 1.12x10 ⁻⁵ | 35.31 |
| 9:32 | 35,800 | | 27.91 | 26.67 | | 1.41x10 ⁻⁵ | 36.53 |
| 9:49 | 35,850 | | 28.78 | 27.43 | | | |
| 9:56 | 35,900 | | 29.57 | 27.99 | | | |
| 10:03 | 35,950 | | 31.09 | 29.29 | | | |

| REPORT DOCUMENTATION PAGE | | | | Form Approved OMB No. 0704-0188 | |
|---|-------------|----------------------|----------------------------|---|--|
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| 1. REPORT DATE (DD-MM-YYYY) | | 2. REPORT TYPE | | 3. DATES COVERED (From - To) | |
| 01-08-2005 | | Technical Memorandum | | | |
| 4. TITLE AND SUBTITLE 7075-T6 and 2024-T351 Aluminum Alloy Fatigue Crack Growth Rate Data | | | | 5a. CONTRACT NUMBER | |
| | | | | 5b. GRANT NUMBER | |
| | | | | 5c. PROGRAM ELEMENT NUMBER | |
| 6. AUTHOR(S) Forth, Scott C.; Wright, Christopher W.; and Johnston, William M., Jr. | | | | 5d. PROJECT NUMBER | |
| | | | | 5e. TASK NUMBER | |
| | | | | 5f. WORK UNIT NUMBER 23-064-30-24 | |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) NASA Langley Research Center Hampton, VA 23681-2199 | | | | 8. PERFORMING ORGANIZATION REPORT NUMBER L-19163 | |
| 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) National Aeronautics and Space Administration Washington, DC 20546-0001 | | | | 10. SPONSOR/MONITOR'S ACRONYM(S) NASA | |
| | | | | 11. SPONSOR/MONITOR'S REPORT NUMBER(S) NASA/TM-2005-213907 | |
| 12. DISTRIBUTION/AVAILABILITY STATEMENT Unclassified - Unlimited Subject Category 26 Availability: NASA CASI (301) 621-0390 | | | | | |
| 13. SUPPLEMENTARY NOTES Langley Research Center: Forth and Wright; Lockheed Martin Corporation: Johnston An electronic version can be found at http://ntrs.nasa.gov | | | | | |
| 14. ABSTRACT Experimental test procedures for the development of fatigue crack growth rate data has been standardized by the American Society for Testing and Materials. Over the past 30 years several gradual changes have been made to the standard without rigorous assessment of the affect these changes have on the precision or variability of the data generated. Therefore, the ASTM committee on fatigue crack growth has initiated an international round robin test program to assess the precision and variability of test results generated using the standard E647-00. Crack growth rate data presented in this report, in support of the ASTM roundrobin, shows excellent precision and repeatability. | | | | | |
| 15. SUBJECT TERMS 2024-T351; 7075-T6; Alloy; Aluminum; Crack; Fatigue; Growth; Data; Rate | | | | | |
| 16. SECURITY CLASSIFICATION OF: | | | 17. LIMITATION OF ABSTRACT | 18. NUMBER OF PAGES | 19a. NAME OF RESPONSIBLE PERSON |
| a. REPORT | b. ABSTRACT | c. THIS PAGE | | | STI Help Desk (email: help@sti.nasa.gov) |
| U | U | U | UU | 24 | 19b. TELEPHONE NUMBER (Include area code) (301) 621-0390 |