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Washington, D.C. 20591

# **Development of a Supplemental Inspection Document for the Fairchild SA226 and SA227 Aircraft, Part 2, Volume II**

October 1999

Technical Report

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**Federal Aviation Administration**

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# APPENDIX D NASGRO SCHEDULE FILE

## GSFC GODDARD PAYLOAD SPECTRUM

|        |          |         |          |         |          |         |          |      |
|--------|----------|---------|----------|---------|----------|---------|----------|------|
| 2,     | -100.00, | 100.00, | -100.00, | 100.00, | -100.00, | 100.00, | -100.00, | 100. |
| 4,     | -90.00,  | 90.00,  | -90.00,  | 90.00,  | -90.00,  | 90.00,  | -90.00,  | 90.  |
| 8,     | -80.00,  | 80.00,  | -80.00,  | 80.00,  | -80.00,  | 80.00,  | -80.00,  | 80.  |
| 15,    | -70.00,  | 70.00,  | -70.00,  | 70.00,  | -70.00,  | 70.00,  | -70.00,  | 70.  |
| 49,    | -60.00,  | 60.00,  | -60.00,  | 60.00,  | -60.00,  | 60.00,  | -60.00,  | 60.  |
| 81,    | -50.00,  | 50.00,  | -50.00,  | 50.00,  | -50.00,  | 50.00,  | -50.00,  | 50.  |
| 178,   | -40.00,  | 40.00,  | -40.00,  | 40.00,  | -40.00,  | 40.00,  | -40.00,  | 40.  |
| 641,   | -30.00,  | 30.00,  | -30.00,  | 30.00,  | -30.00,  | 30.00,  | -30.00,  | 30.  |
| 3120,  | -20.00,  | 20.00,  | -20.00,  | 20.00,  | -20.00,  | 20.00,  | -20.00,  | 20.  |
| 3405,  | -10.00,  | 10.00,  | -10.00,  | 10.00,  | -10.00,  | 10.00,  | -10.00,  | 10.  |
| 5019,  | -7.00,   | 7.00,   | -7.00,   | 7.00,   | -7.00,   | 7.00,   | -7.00,   | 7.   |
| 28853, | -5.00,   | 5.00,   | -5.00,   | 5.00,   | -5.00,   | 5.00,   | -5.00,   | 5.   |
| 91655, | -3.00,   | 3.00,   | -3.00,   | 3.00,   | -3.00,   | 3.00,   | -3.00,   | 3.   |

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## CONSL1 CONSTANT AMPLITUDE LOADING

|    |       |        |       |        |       |        |       |     |
|----|-------|--------|-------|--------|-------|--------|-------|-----|
| 1, | 1.00, | -1.00, | 1.00, | -1.00, | 1.00, | -1.00, | 1.00, | -1. |
|----|-------|--------|-------|--------|-------|--------|-------|-----|

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## TAXI Taxi Spectrum for Metro 226

|         |       |       |        |       |       |       |        |       |
|---------|-------|-------|--------|-------|-------|-------|--------|-------|
| 1.9000, | -.30, | 0.30, | -0.30, | 0.30, | -.30, | 0.30, | -0.30, | 0.30, |
| .0900,  | -.40, | 0.40, | -0.40, | 0.40, | -.40, | 0.40, | -0.40, | 0.40, |
| .0100,  | -.46, | 0.46, | -0.46, | 0.46, | -.46, | 0.46, | -0.46, | 0.46, |

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## GUST-L Gust & Maneuver Spectrum (2 HR) For Long Range Flight Metro 226

|           |        |       |        |       |        |       |        |       |
|-----------|--------|-------|--------|-------|--------|-------|--------|-------|
| 38.28571, | -0.30, | 0.30, | -0.30, | 0.30, | -0.30, | 0.30, | -0.30, | 0.30, |
| 4.57143,  | -0.50, | 0.50, | -0.50, | 0.50, | -0.50, | 0.50, | -0.50, | 0.50, |
| 2.28572,  | -0.60, | 0.60, | -0.60, | 0.60, | -0.60, | 0.60, | -0.60, | 0.60, |
| .45714,   | -0.80, | 0.80, | -0.80, | 0.80, | -0.80, | 0.80, | -0.80, | 0.80, |
| .08286,   | -1.00, | 1.00, | -1.00, | 1.00, | -1.00, | 1.00, | -1.00, | 1.00, |
| .02057,   | -1.20, | 1.20, | -1.20, | 1.20, | -1.20, | 1.20, | -1.20, | 1.20, |
| .00686,   | -1.40, | 1.40, | -1.40, | 1.40, | -1.40, | 1.40, | -1.40, | 1.40, |
| .00240,   | -1.60, | 1.60, | -1.60, | 1.60, | -1.60, | 1.60, | -1.60, | 1.60, |
| .00074,   | -1.80, | 1.80, | -1.80, | 1.80, | -1.80, | 1.80, | -1.80, | 1.80, |
| .00086,   | -2.00, | 2.00, | -2.00, | 2.00, | -2.00, | 2.00, | -2.00, | 2.00, |

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## GUST-M Gust & Maneuver Spectrum (1 Hour) For Medium Range Flight Metro 226

|           |        |       |        |       |        |       |        |       |
|-----------|--------|-------|--------|-------|--------|-------|--------|-------|
| 19.14286, | -0.30, | 0.30, | -0.30, | 0.30, | -0.30, | 0.30, | -0.30, | 0.30, |
| 2.28571,  | -0.50, | 0.50, | -0.50, | 0.50, | -0.50, | 0.50, | -0.50, | 0.50, |
| 1.14286,  | -0.60, | 0.60, | -0.60, | 0.60, | -0.60, | 0.60, | -0.60, | 0.60, |
| .22857,   | -0.80, | 0.80, | -0.80, | 0.80, | -0.80, | 0.80, | -0.80, | 0.80, |
| .04143,   | -1.00, | 1.00, | -1.00, | 1.00, | -1.00, | 1.00, | -1.00, | 1.00, |
| .01029,   | -1.20, | 1.20, | -1.20, | 1.20, | -1.20, | 1.20, | -1.20, | 1.20, |
| .00343,   | -1.40, | 1.40, | -1.40, | 1.40, | -1.40, | 1.40, | -1.40, | 1.40, |
| .00120,   | -1.60, | 1.60, | -1.60, | 1.60, | -1.60, | 1.60, | -1.60, | 1.60, |
| .00037,   | -1.80, | 1.80, | -1.80, | 1.80, | -1.80, | 1.80, | -1.80, | 1.80, |
| .00043,   | -2.00, | 2.00, | -2.00, | 2.00, | -2.00, | 2.00, | -2.00, | 2.00, |

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## GUST-S Gust & Maneuver Spectrum (30 MIN) For Short Range Flight Metro 226

|          |        |       |        |       |        |       |        |       |
|----------|--------|-------|--------|-------|--------|-------|--------|-------|
| 9.57143, | -0.30, | 0.30, | -0.30, | 0.30, | -0.30, | 0.30, | -0.30, | 0.30, |
| 1.14286, | -0.50, | 0.50, | -0.50, | 0.50, | -0.50, | 0.50, | -0.50, | 0.50, |
| .57143,  | -0.60, | 0.60, | -0.60, | 0.60, | -0.60, | 0.60, | -0.60, | 0.60, |
| .11429,  | -0.80, | 0.80, | -0.80, | 0.80, | -0.80, | 0.80, | -0.80, | 0.80, |
| .02071,  | -1.00, | 1.00, | -1.00, | 1.00, | -1.00, | 1.00, | -1.00, | 1.00, |
| .00514,  | -1.20, | 1.20, | -1.20, | 1.20, | -1.20, | 1.20, | -1.20, | 1.20, |
| .00171,  | -1.40, | 1.40, | -1.40, | 1.40, | -1.40, | 1.40, | -1.40, | 1.40, |
| .00060,  | -1.60, | 1.60, | -1.60, | 1.60, | -1.60, | 1.60, | -1.60, | 1.60, |
| .00019,  | -1.80, | 1.80, | -1.80, | 1.80, | -1.80, | 1.80, | -1.80, | 1.80, |
| .00021,  | -2.00, | 2.00, | -2.00, | 2.00, | -2.00, | 2.00, | -2.00, | 2.00, |

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## GUST-L7 Gust & Maneuver Spectrum (2 HR) For Long Range Flight SA227

|           |        |       |        |       |        |       |        |       |
|-----------|--------|-------|--------|-------|--------|-------|--------|-------|
| 00.00000, | -0.00, | 0.00, | -0.00, | 0.00, | -0.00, | 0.00, | -0.00, | 0.00, |
| 24.51503, | -0.22, | 0.22, | -0.22, | 0.22, | -0.22, | 0.22, | -0.22, | 0.22, |
| 2.72800,  | -0.43, | 0.43, | -0.43, | 0.43, | -0.43, | 0.43, | -0.43, | 0.43, |
| .46463,   | -0.65, | 0.65, | -0.65, | 0.65, | -0.65, | 0.65, | -0.65, | 0.65, |
| .10640,   | -0.87, | 0.87, | -0.87, | 0.87, | -0.87, | 0.87, | -0.87, | 0.87, |
| .02640,   | -1.08, | 1.08, | -1.08, | 1.08, | -1.08, | 1.08, | -1.08, | 1.08, |

|         |        |       |        |       |        |       |        |       |
|---------|--------|-------|--------|-------|--------|-------|--------|-------|
| .00960, | -1.30, | 1.30, | -1.30, | 1.30, | -1.30, | 1.30, | -1.30, | 1.30, |
| .00297, | -1.52, | 1.52, | -1.52, | 1.52, | -1.52, | 1.52, | -1.52, | 1.52, |
| .00114, | -1.73, | 1.73, | -1.73, | 1.73, | -1.73, | 1.73, | -1.73, | 1.73, |
| .00051, | -1.95, | 1.95, | -1.95, | 1.95, | -1.95, | 1.95, | -1.95, | 1.95, |

0/  
GUST-M7 Gust & Maneuver Spectrum (1 HR) For Medium Range Flight SA227

|           |        |       |        |       |        |       |        |       |
|-----------|--------|-------|--------|-------|--------|-------|--------|-------|
| 00.00000, | -0.00, | 0.00, | -0.00, | 0.00, | -0.00, | 0.00, | -0.00, | 0.00, |
| 31.10351, | -0.22, | 0.22, | -0.22, | 0.22, | -0.22, | 0.22, | -0.22, | 0.22, |
| 2.98177,  | -0.43, | 0.43, | -0.43, | 0.43, | -0.43, | 0.43, | -0.43, | 0.43, |
| .44934,   | -0.65, | 0.65, | -0.65, | 0.65, | -0.65, | 0.65, | -0.65, | 0.65, |
| .09423,   | -0.87, | 0.87, | -0.87, | 0.87, | -0.87, | 0.87, | -0.87, | 0.87, |
| .02326,   | -1.08, | 1.08, | -1.08, | 1.08, | -1.08, | 1.08, | -1.08, | 1.08, |
| .00757,   | -1.30, | 1.30, | -1.30, | 1.30, | -1.30, | 1.30, | -1.30, | 1.30, |
| .00231,   | -1.52, | 1.52, | -1.52, | 1.52, | -1.52, | 1.52, | -1.52, | 1.52, |
| .00080,   | -1.73, | 1.73, | -1.73, | 1.73, | -1.73, | 1.73, | -1.73, | 1.73, |
| .00034,   | -1.95, | 1.95, | -1.95, | 1.95, | -1.95, | 1.95, | -1.95, | 1.95, |

0/  
GUST-S7 Gust & Maneuver Spectrum (0.5 HR) For Short Range Flight SA227

|           |        |       |        |       |        |       |        |       |
|-----------|--------|-------|--------|-------|--------|-------|--------|-------|
| 00.00000, | -0.00, | 0.00, | -0.00, | 0.00, | -0.00, | 0.00, | -0.00, | 0.00, |
| 15.09007, | -0.22, | 0.22, | -0.22, | 0.22, | -0.22, | 0.22, | -0.22, | 0.22, |
| 1.52174,  | -0.43, | 0.43, | -0.43, | 0.43, | -0.43, | 0.43, | -0.43, | 0.43, |
| .23221,   | -0.65, | 0.65, | -0.65, | 0.65, | -0.65, | 0.65, | -0.65, | 0.65, |
| .04871,   | -0.87, | 0.87, | -0.87, | 0.87, | -0.87, | 0.87, | -0.87, | 0.87, |
| .01210,   | -1.08, | 1.08, | -1.08, | 1.08, | -1.08, | 1.08, | -1.08, | 1.08, |
| .00397,   | -1.30, | 1.30, | -1.30, | 1.30, | -1.30, | 1.30, | -1.30, | 1.30, |
| .00123,   | -1.52, | 1.52, | -1.52, | 1.52, | -1.52, | 1.52, | -1.52, | 1.52, |
| .00043,   | -1.73, | 1.73, | -1.73, | 1.73, | -1.73, | 1.73, | -1.73, | 1.73, |
| .00017,   | -1.95, | 1.95, | -1.95, | 1.95, | -1.95, | 1.95, | -1.95, | 1.95, |

0/  
LAND-21 Landing Spectrum - Metro 226 gage 21

|        |       |       |       |       |       |       |       |       |
|--------|-------|-------|-------|-------|-------|-------|-------|-------|
| .2750, | 1.00, | 1.01, | 1.00, | 1.01, | 1.00, | 1.01, | 1.00, | 1.01, |
| .4400, | 0.81, | 1.12, | 0.81, | 1.12, | 0.81, | 1.12, | 0.81, | 1.12, |
| .2200, | 0.61, | 1.23, | 0.61, | 1.23, | 0.61, | 1.23, | 0.61, | 1.23, |
| .0590, | 0.42, | 1.33, | 0.42, | 1.33, | 0.42, | 1.33, | 0.42, | 1.33, |
| .0048, | 0.22, | 2.44, | 0.22, | 2.44, | 0.22, | 2.44, | 0.22, | 2.44, |
| .0012, | 0.03, | 2.55, | 0.03, | 2.55, | 0.03, | 2.55, | 0.03, | 2.55, |

0/  
LAND-26 Landing Spectrum - Metro 226 gage 26

|        |        |       |        |       |        |       |        |       |
|--------|--------|-------|--------|-------|--------|-------|--------|-------|
| .2750, | 1.00,  | 1.01, | 1.00,  | 1.01, | 1.00,  | 1.01, | 1.00,  | 1.01, |
| .4400, | 0.00,  | 1.74, | 0.00,  | 1.74, | 0.00,  | 1.74, | 0.00,  | 1.74, |
| .2200, | -1.00, | 2.48, | -1.00, | 2.48, | -1.00, | 2.48, | -1.00, | 2.48, |
| .0590, | -2.00, | 3.22, | -2.00, | 3.22, | -2.00, | 3.22, | -2.00, | 3.22, |
| .0048, | -3.00, | 3.96, | -3.00, | 3.96, | -3.00, | 3.96, | -3.00, | 3.96, |
| .0012, | -4.00, | 4.70, | -4.00, | 4.70, | -4.00, | 4.70, | -4.00, | 4.70, |

0/  
LAND-25 Landing Spectrum - gage 25

|        |       |       |       |       |       |       |       |       |
|--------|-------|-------|-------|-------|-------|-------|-------|-------|
| .2750, | 1.00, | 1.01, | 1.00, | 1.01, | 1.00, | 1.01, | 1.00, | 1.01, |
| .4400, | 0.80, | 1.10, | 0.80, | 1.10, | 0.80, | 1.10, | 0.80, | 1.10, |
| .2200, | 0.60, | 1.20, | 0.60, | 1.20, | 0.60, | 1.20, | 0.60, | 1.20, |
| .0590, | 0.40, | 1.30, | 0.40, | 1.30, | 0.40, | 1.30, | 0.40, | 1.30, |
| .0048, | 0.20, | 1.40, | 0.20, | 1.40, | 0.20, | 1.40, | 0.20, | 1.40, |
| .0012, | 0.00, | 1.50, | 0.00, | 1.50, | 0.00, | 1.50, | 0.00, | 1.50, |

0/  
LAND-23 Landing Spectrum - Metro 226 Gage 23

|        |       |       |       |       |       |       |       |       |
|--------|-------|-------|-------|-------|-------|-------|-------|-------|
| .2750, | 1.00, | 1.01, | 1.00, | 1.01, | 1.00, | 1.01, | 1.00, | 1.01, |
| .4400, | 0.81, | 1.06, | 0.81, | 1.06, | 0.81, | 1.06, | 0.81, | 1.06, |
| .2200, | 0.62, | 1.12, | 0.62, | 1.12, | 0.62, | 1.12, | 0.62, | 1.12, |
| .0590, | 0.43, | 1.18, | 0.42, | 1.18, | 0.43, | 1.18, | 0.43, | 1.18, |
| .0048, | 0.23, | 1.24, | 0.23, | 1.24, | 0.23, | 1.24, | 0.23, | 1.24, |
| .0012, | 0.04, | 1.30, | 0.04, | 1.30, | 0.04, | 1.30, | 0.04, | 1.30, |

0/  
LAND-G Estimated peak G's based on drop test

|        |        |       |        |       |        |       |        |       |
|--------|--------|-------|--------|-------|--------|-------|--------|-------|
| .2750, | -0.55, | 0.55, | -0.55, | 0.55, | -0.55, | 0.55, | -0.55, | 0.55, |
| .4400, | -0.57, | 0.57, | -0.57, | 0.57, | -0.57, | 0.57, | -0.57, | 0.57, |
| .2200, | -0.62, | 0.62, | -0.62, | 0.62, | -0.62, | 0.62, | -0.62, | 0.62, |
| .0590, | -0.70, | 0.70, | -0.70, | 0.70, | -0.70, | 0.70, | -0.70, | 0.70, |
| .0048, | -0.82, | 0.82, | -0.82, | 0.82, | -0.82, | 0.82, | -0.82, | 0.82, |
| .0012, | -0.98, | 0.98, | -0.98, | 0.98, | -0.98, | 0.98, | -0.98, | 0.98, |

0/  
 LAND-22 Landing Spectrum - Metro 226 gage 21  
 .2750, 1.00, 1.01, 1.00, 1.01, 1.00, 1.01, 1.00, 1.01,  
 .4400, 0.75, 1.23, 0.75, 1.23, 0.75, 1.23, 0.75, 1.23,  
 .2200, 0.50, 1.46, 0.50, 1.46, 0.50, 1.46, 0.50, 1.46,  
 .0590, 0.26, 1.69, 0.26, 1.69, 0.26, 1.69, 0.26, 1.69,  
 .0048, 0.01, 1.92, 0.01, 1.92, 0.01, 1.92, 0.01, 1.92,  
 .0012, -0.24, 2.14, -0.24, 2.14, -0.24, 2.14, -0.24, 2.14,  
 0/  
 LAND-24 Landing Spectrum - Metro 226 gage 24  
 .2750, 1.00, 1.01, 1.00, 1.01, 1.00, 1.01, 1.00, 1.01,  
 .4400, 0.79, 1.07, 0.79, 1.07, 0.79, 1.07, 0.79, 1.07,  
 .2200, 0.59, 1.14, 0.59, 1.14, 0.59, 1.14, 0.59, 1.14,  
 .0590, 0.38, 1.21, 0.38, 1.21, 0.38, 1.21, 0.38, 1.21,  
 .0048, 0.17, 1.29, 0.17, 1.29, 0.17, 1.29, 0.17, 1.29,  
 .0012, -0.04, 1.36, -0.04, 1.36, -0.04, 1.36, -0.04, 1.36,  
 0/  
 LAND-28 Landing Spectrum - Metro 226 gage 28  
 .2750, 1.00, 1.01, 1.00, 1.01, 1.00, 1.01, 1.00, 1.01,  
 .4400, -1.84, 4.64, -1.84, 4.64, -1.84, 4.64, -1.84, 4.64,  
 .2200, -4.69, 8.28, -4.69, 8.28, -4.69, 8.28, -4.69, 8.28,  
 .0590, -7.53, 11.92, -7.53, 11.92, -7.53, 11.92, -7.53, 11.92,  
 .0048, -10.37, 15.56, -10.37, 15.56, -10.37, 15.56, -10.37, 15.56,  
 .0012, -13.22, 19.20, -13.22, 19.20, -13.22, 19.20, -13.22, 19.20,  
 0/  
 PRESS-7 Pressure Cycle 7 psi  
 1, 0.00, 1.00, 0.00, 1.00, 0.00, 1.00, 0.00, 1.00,  
 0/  
 GND Ground fuselage reading  
 1, 0.00, 0.01, 0.00, 0.01, 0.00, 0.01, 0.00, 0.00,  
 0/  
 PROP-14 Gage 14  
 624, -0.3, 1.00, -0.3, 1.00, -0.3, 1.00, -0.3, 1.00,  
 0/  
 PROP-15 Gage 15  
 624, -2.2, 1.00, -2.2, 1.00, -2.2, 1.00, -2.2, 1.00,  
 0/  
 THRUST  
 1, 0.0, 1.00, 0.0, 1.00, 0.0, 1.00, 0.0, 1.00,  
 0/

## APPENDIX E FORTRAN SOURCE CODE FOR MODIFIED CRACK CASES

```

SUBROUTINE SITC11(SAFE,MODE,SMIN4,SMAX4,C,NSQUAN,IHDSQ,MSOP,
  K      SR,DELTAK,CAYMAX,F0,F3,FDUM1,FDUM2,NJOB,
  K      NETMSG,SFLO1,SYLD1,IACMSG,ISESS,*,*)
CD0
CD0  IDENTIFICATION
CD0
CD0  SUBROUTINE SITCA3(MODE,SMIN4,SMAX4,C,NSQUAN,IHDSQ,MSOP,
CD0  K      SR,DELTAK,CAYMAX,F0,F3,FDUM1,FDUM2,NJOB,
CD0  K      NETMSG,SFLO1,SYLD1,IACMSG,*)
CD0
CD0  PROGRAMMER -
CD0  MODIFIED FOR BATCH - L.C. WILLIAMS 4/93
CD0  MODIFIED -- ADDITIONAL MATERIAL CONSIDERATION.. CHEN 7/97
CD0  MODIFIED -- CORRECTED ERRORS IN 7/97 MOD.. J VANCE 9/98
CD1
CD1  PURPOSE
CD1
CD1  CONTROL OF INPUT, OUTPUT, CALCULATION, AND PROOF-TEST
CD1  FOR THROUGH CRACK FROM HOLE IN PLATE.
CD2
CD2  CALLING ARGUMENT INPUT
CD2
CD2  C      - CRACK LENGTH, C
CD2  MODE   - 'IPUT','OPUT','CALC', OR 'PRUF'
CD2  NETMSG - FLAG TO CHECK NET STRESS > YIELD STRESS (0=CHECK)
CD2  NJOB   - NO. OF TIMES THROUGH ROUTINE
CD2  SMAX4  - (t1) STRESSES CORR. TO F0,F3,FDUM1,FDUM2
CD2  SMIN4  - (t2) STRESSES CORR. TO F0,F3,FDUM1,FDUM2
CD2  SYLD1  - YIELD STRESS
CD3
CD3  CALLING ARGUMENT OUTPUT
CD3
CD3  *      - RETURN1
CD3  CAYMAX - SIF<MAX>
CD3  DELTAK - SIF<MAX> - SIF<MIN>
CD3  F0     - NONDIMENSIONALIZED SIF FOR 1ST STRESS QUANTITY, S0
CD3  F3     - NONDIMENSIONALIZED SIF FOR 2ND STRESS QUANTITY, S3
CD3  FDUM1  - NONDIMENSIONALIZED SIF FOR UNUSED STRESS QUANTITY
CD3  FDUM2  - NONDIMENSIONALIZED SIF FOR UNUSED STRESS QUANTITY
CD3  IHDSQ  - (15,4) ARRAY OF 4 60-CHAR STRESS DESCRIPTIONS
CD3  NETMSG - FLAG TELLING IF NET STRESS > YIELD STRESS (1=TRUE)
CD3  NSQUAN - NO. OF STRESS QUANTITIES
CD3  SR     - 1 - DELTAK/CAYMAX
CD5
CD5  INTERNAL VARIABLES
CD5
CD5  ALPHA   - D/(D+2C)
CD5  AMBDA   - (PI/2) * (D+C) / (2B - C)
CD5  BOUND   - B - (D/2)
CD5  CONST   - SQRT(PI*C)
CD5  EPSI    - CORRECTION FOR CRACK TIP PLASTIC ZONE
CD5  PI      - 3.14159...
CD5  RNET1...3 - MEAN NET SECTION STRESS
CD5  OTHER VALUES DEFINED IN EQUATIONS
CD9
CD9  SPECIAL COMMENTS
CD9
CD9  SUBROUTINES CALLED: INTC03, OPTC03
C
  IMPLICIT DOUBLE PRECISION (A-H,O-Z)
  CHARACTER*80 MSOP(6)
  CHARACTER*1  SAFE,AREF,WFCHEK
  CHARACTER*4  MODE,IHDSQ(15,4)
  DIMENSION SMIN4(4),SMAX4(4)

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```

COMMON /GEO/ T,D,W,B,SBB,XFIL(15)
COMMON/NETOUT/SNETVT,SNETRT,SNETV(4),SNETR(4)
COMMON /IOUNTS/ IIN,IOU,IBF
C ADDED 7/21/97
COMMON /TC11/ AREATC11, AITC11, CENTTC11
COMMON /JUDGE/ AIJC

DATA PI/3.14159265358979D0/
DATA EPSI/0.13D0/

C      OPEN (UNIT=74,FILE='1111SDEL.TXT',STATUS='UNKNOWN')
C
C*****
C
C      Calc or 'Proof Test' Mode
C
C      IF (MODE.EQ.'CALC'.OR.MODE.EQ.'PRUF') THEN
C
C      Geometric checks
C
C      BOUND = B - 0.5D0*D
C      IF (C.LT.0D0.OR.C.GE.BOUND) THEN
C          IF (MODE.EQ.'CALC') WRITE (7,60001) C,BOUND
C          IF (MODE.EQ.'CALC') WRITE (IOU,60001) C,BOUND
C          IF (MODE.EQ.'PRUF') WRITE (7,60002) C,BOUND
C          IF (MODE.EQ.'PRUF') WRITE (IOU,60002) C,BOUND
C          RETURN 1
C      ENDIF

C=X=X=X=X=X=X=X=X
C      AREA3 IS ADDITIONAL AREA NOT PART OF THE PLATE WITH THE OFF-CENTER HOLE
C
C      AREA3 = AREATC11

C=X=X=X=X=X=X=X=X
C      SDEL = RECIPROCAL OF REDUCTION FACTOR FOR REMOTE STRESS. SDEL
C      IS GREATER THAN 1
C
C
C      SDEL = (W/(W-C))*((W-C)*T + AREA3)/(W*T + AREA3)

C
C      Check if Net stress > Yield stress
C
C      PF0 = DMAX1(DABS(SMAX4(1)/SDEL),DABS(SMIN4(1)/SDEL))*W*T
C      PF3 = DMAX1(DABS(SMAX4(2)/SDEL),DABS(SMIN4(2)/SDEL))*D*T
C      AL1 = W - B - D/2D0
C      AL2 = B - C - D/2D0
C      AREA1 = AL1*T
C      AREA2 = AL2*T
C      AREA = AREA1 + AREA2 + AREA3

C=X=X=X=X=X=X=X=X
C      S0A & S3A ARE P/A STRESSES
C
C
C      S0A = PF0/(AREA1 + AREA2)
C      S3A = PF3/(AREA1 + AREA2)
C      EX1 = AL1/2D0
C      EX2 = W - AL2/2D0

C=X=X=X=X=X=X=X=X
C      CENTTC11 IS CENTROID OF ADDITIONAL AREA WRT PART EDGE
C      EXC IS CENTROID OF W*T AND AREA3
C
C      EX3 = CENTTC11
C      EXB = (AREA1*EX1 + AREA2*EX2 + AREA3*EX3)/AREA
C      EXC = (W*T*W/2D0 + AREA3*EX3)/(W*T + AREA3)

```

```

      QOFF = DABS(EXC - EXB)
      AI1  = T*AL1**3/12D0 + AREA1*(EX1-EXB)**2
      AI2  = T*AL2**3/12D0 + AREA2*(EX2-EXB)**2
C=X=X=X=X=X=X=X=X
C      AITC11 IS MOMENT OF INERTIA OF ADDITIONAL AREA ABOUT CENTROID
C      OF THE CROSS SECTION
C
      AI3  = AITC11
      AI   = AI1 + AI2 + AI3
C=X=X=X=X=X=X=X=X
C      SOB, S3B IS MC/I FOR TWO PORTIONS OF CRACKED PLATE
C
      EXD  = (AREA1*EX1 + AREA2*EX2)/(AREA1+AREA2)
      SOB  = PF0*QOFF*((1D0-EPSI)*W - EXB)/AI
      S3B  = PF3*(W-B-EXD)*((1D0-EPSI)*W - EXB)/AI
C=X=X=X=X=X=X=X=X
C      TOTAL STRESS ON CRACKED PLATE MC/I + P/A
      SNETVT = S0A+S0B+S3A+S3B
      SNETRT = SNETVT/SYLD1
C ... CHECK FOR YIELD ONE TIME OR FLOW ALWAYS
      IF (NETMSG.EQ.0.AND.SNETVT.GE.SYLD1) THEN
        NETMSG=1
        WRITE(*,*) ' THE SNETVT ', SNETVT
      END IF
C
      IF (SNETVT.GE.SFLO1) THEN
        NETMSG=5
      ENDIF
C
C                                     Compute SIFs
C
      ALPHA = D/(D+2D0*C)
      AMBDA = (PI/2D0)*(D+C)/(2D0*B-C)
      G0    = 0.7071D0+ALPHA*(0.7548D0+ALPHA*(0.3415D0+
K          ALPHA*(0.642D0+ALPHA*0.9196D0)))
      G1    = ALPHA*(0.078D0+ALPHA*(0.7588D0+ALPHA*((-0.4293D0)+
K          ALPHA*(0.0644D0+ALPHA*0.651D0)))
      GW    = DSQRT(SBB/DCOS(AMBDA))
      F0    = G0*GW
      F3    = (0.5D0*G0*D/W + G1)*GW
      FDUM1 = 0.0D0
      FDUM2 = 0.0D0
      CONST = DSQRT(PI*C)
      IF (MODE.EQ.'CALC') THEN
C
C      CAYMAX = CONST*DMAX1( (SMAX4(1)*F0+DABS(SMAX4(2))*F3),
C      K      +              (SMIN4(1)*F0+DABS(SMIN4(2))*F3) )
C=X=X=X=X=X=X=X=X
C      SDEL REDUCES SMAX AND SMIN TO ACCOUNT FOR LOAD TRANSFER
C      TO ADDITIONAL AREA
      CAYMAX=CONST*DMAX1((SMAX4(1)/SDEL*F0+DABS(SMAX4(2)/SDEL)*F3),
K      +              (SMIN4(1)/SDEL *F0+DABS(SMIN4(2)/SDEL)*F3) )
C
      DELTAK=CONST*F0*DABS( SMAX4(1) - SMIN4(1) )
      DELTAK=CONST*F0*DABS( SMAX4(1)/ SDEL - SMIN4(1)/ SDEL)
C
C      CALCULATE DELTAK DUE TO PIN LOAD ALONE
C      DELTK2 = DABS( SMAX4(2)-SMIN4(2) ) *F3*CONST
      DELTK2 = DABS( SMAX4(2)/ SDEL-SMIN4(2)/ SDEL ) *F3*CONST

```

```

C... ADD THE DELTAK VALUES
      DELTAK = DELTAK+DELTK2

      ELSE IF (MODE.EQ.'PRUF') THEN
C      CAYMAX = CONST*(SMAX4(1)*F0+DABS(SMAX4(2))*F3)
      CAYMAX = ( CONST*(SMAX4(1)/SDEL*F0+DABS(SMAX4(2)/SDEL)*F3 )
      ENDIF

      IF (CAYMAX.NE.0D0) THEN
C      SR = 1D0 - DELTAK/CAYMAX
      WRITE(74,*) ' DELTAK/CAYMAX = ',DELTAK/CAYMAX

      ENDIF

C
C
C      Input Mode

      ELSE IF (MODE(1:1).EQ.'I') THEN
      CALL INTC11(NJOB,NSQUAN,MODE,IHDSQ,ISESS,*100)

C
C
C      Output Mode

      ELSE IF (MODE.EQ.'OPUT') THEN
      CALL OPTC11(MSOP)

C
C
C      Extraordinary ending

      ELSE
      WRITE (7,60009) MODE
      WRITE (IOU,60009) MODE
      RETURN 1
      ENDIF

C      WRITE(*,*) ' RUNNING THROUGH CRACK .. TC 11'

      RETURN

C
C - Return to previous prompt.
100 RETURN 2
C-----
C
60001 FORMAT(/ ' ',10X,'FINAL RESULTS: '/
      K      11X,'Crack outside geometric bounds: '/
      K      11X,'c = ',G12.4,' B - (D/2) = ',G12.4)
60002 FORMAT(/ ' ',10X,'Crack outside bounds: c = ',
      K      G12.4,' B - (D/2) = ',G12.4)
60009 FORMAT(/ ' ',10X,
      K      'Program coding error in Sbrtn SITC03: MODE = ',A4)
      END

SUBROUTINE SITC12(SAFE,MODE,SMIN4,SMAX4,C,NSQUAN,IHDSQ,MSOP,
      K      SR,DELTAK,CAYMAX,F0,F1,F2,FDUM1,NJOB,
      K      NETMSG,SFLO1,SYLD1,IACMSG,ISESS,*,*)

C97
C97      8/97 MODIFIED BY JUDGE CHEN ... ADDITIONAL AREA ADDED
C97      THIS SUBROUTINE IS SIMILAR TO SITC02
C97
C98      10/98 MODIFIED BY J VANCE... REV EQUATION FOR AND USE
C98      OF 'SDEL'
CD0
CD0      IDENTIFICATION
CD0
CD0      SUBROUTINE SITC02(MODE,SMIN4,SMAX4,C,NSQUAN,IHDSQ,MSOP,
CD0      K      SR,DELTAK,CAYMAX,F0,F1,F2,FDUM1,NJOB,
CD0      K      NETMSG,SFLO1,SYLD1,IACMSG,*)

```

```

CD0
CD0      PROGRAMMER - S. PIOTROWSKI, LOCKHEED-EMSCO
CD0      MODIFIED FOR BATCH - L.C. WILLIAMS 4/93
CD1
CD1 PURPOSE
CD1
CD1      CONTROL OF INPUT, OUTPUT, CALCULATION AND PROOF-TEST
CD1      FOR SINGLE EDGE THROUGH CRACK.
CD2
CD2 CALLING ARGUMENT INPUT
CD2
CD2      C      - CRACK LENGTH, C
CD2      MODE   - 'IPUT','OPUT','CALC', OR 'PRUF'
CD2      NETMSG - FLAG TO CHECK NET STRESS > YIELD STRESS (0=CHECK)
CD2      NJOB   - NO. OF TIMES THROUGH ROUTINE
CD2      SMAX4  - (t1) STRESSES CORR. TO F0,F1,F2,FDUM1
CD2      SMIN4  - (t2) STRESSES CORR. TO F0,F1,F2,FDUM1
CD2      SYLD1  - YIELD STRESS
CD3
CD3 CALLING ARGUMENT OUTPUT
CD3
CD3      *      - RETURN1
CD3      CAYMAX - SIF<MAX>
CD3      DELTAK - SIF<MAX> - SIF<MIN>
CD3      F0     - NONDIMENSIONALIZED SIF FOR 1ST STRESS QUANTITY
CD3      F1     - NONDIMENSIONALIZED SIF FOR 2ND STRESS QUANTITY
CD3      F2     - NONDIMENSIONALIZED SIF FOR 3RD STRESS QUANTITY
CD3      IHDSQ  - (15,4) ARRAY OF 4 60-CHAR STRESS DESCRIPTIONS
CD3      NETMSG - FLAG TELLING IF NET STRESS > YIELD STRESS (1=TRUE)
CD3      NSQUAN - NO. OF STRESS QUANTITIES
CD3      SR     - 1 - DELTAK/CAYMAX
CD5
CD5 INTERNAL VARIABLES
CD5
CD5      BETA   - (PI*C)/(WD*2)
CD5      CONST  - SQRT(PI*C)
CD5      EPSI   - CORRECTION FOR CRACK TIP PLASTIC ZONE
CD5      FSINB  - 1 - SIN(BETA)
CD5      PI     - 3.14159...
CD5      RNET   - MEAN NET SECTION STRESS
CD5      Y      - SEC(BETA)*SQRT( TAN(BETA)/BETA )
CD9
CD9 SPECIAL COMMENTS
CD9
CD9      SUBROUTINES CALLED: INTC02, OPTC02
C
C      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
C      CHARACTER*80 MSOP(6)
C      CHARACTER*1 SAFE,AREF,WFCHEK
C      CHARACTER*4 MODE,IHDSQ(15,4)
C      DIMENSION SMIN4(4),SMAX4(4)
C      COMMON /GEO/ TH,WD,XFIL(18)
C      COMMON/NETOUT/SNETVT,SNETRT,SNETV(4),SNETR(4)
C      COMMON /IOUNTS/ IIN,IOU,IBF
C      COMMON /TC12JC/ AREA3,F3,G3,RIX,RIY,RM,IBARCNT
C      COMMON /JUDGE/ AIJC
C      DATA PI/3.14159265358979D0/
C      DATA EPSI/0.13D0/
C
C *****
C
C
C      CALC OR 'PROOF TEST' MODE
C
C      IF(MODE.EQ.'CALC'.OR.MODE.EQ.'PRUF') THEN
C
C
C      GEOMETRY CHECK
C
C      IF (C.LT.0D0.OR.C.GE.WD) THEN
C      IF (MODE.EQ.'CALC') WRITE (IOU,20000) C,WD

```



```

c Now find the bending stress about the entire section center of gravity
c about the strong axis but in the end of the crack. Set the first xbar
c into xbar1, the same was as the ybar, to save it for use now.
c (Jack Simmons)

C Note that given the initial S2 value which is on the full uncracked face
c in order to find what that moment does to the net section, the moment
c from S@ is needed, then apply that moment to the net section thus
c M2 = S2 * T * W**2/6

ccc sample format   DMAX1( DABS(SMAX4(1)/SDEL), DABS(SMIN4(1)/SDEL) )
    S1 = RM * (YBAR - TH/2) / RIXCG
    S2MOD=S1+
k      DMAX1( DABS(SMAX4(1)/SDEL), DABS(SMIN4(1)/SDEL) ) *
k      TH*WD*EY*YBAR/RIXCG
    S2PRIME=((YBAR-T)/YBAR) * S2MOD
    S2AVE = (S2PRIME + S2MOD) /2.
    SOPRIME = DMAX1( DABS(SMAX4(1)/SDEL), DABS(SMIN4(1)/SDEL)) +S2AVE
    SBX = S2MOD -S2SAVE
    S2P = ( DMAX1( DABS(SMAX4(3)/SDEL), DABS(SMIN4(3)/SDEL) ) *
k      TH*WD**2)/6 +
k      DMAX1( DABS(SMAX4(1)/SDEL), DABS(SMIN4(1)/SDEL) ) *TH*WD*EX
k      * ((WD-C) -XBAR) /RIYCG

    SNETVT=SOPRIME+SBX+S2P

C      WRITE(7,*) '      th','      wd','      c'
C      WRITE(7,999)Th,Wd,C
C      WRITE(7,*) '      XBAR1','      YBAR1'
C      WRITE(7,999)XBAR1,YBAR1
C      WRITE(7,*) '      SOPRIME','      SBX','      S2P'
C      WRITE(7,997)SOPRIME,SBX,S2P
C      WRITE(7,*) 'SNETVT = ',SNETVT
C      SNETRT=SNETVT/SYLD1
C      WRITE(7,*) 'SNETVT = ',SNETVT
C      WRITE(7,*) 'SYLD1 = ',SYLD1

C97      SNETVT = RNET
C97      SNETRT = SNETVT/SYLD1

C ... CHECK FOR YIELD ONE TIME OR FLOW ALWAYS
    IF (NETMSG.EQ.0.AND.SNETVT.GE.SYLD1) THEN
        NETMSG=1
    END IF

C
    IF (SNETVT.GE.SFLO1) THEN
        NETMSG=5
    ENDIF

C
C      CALCULATION OF STRESS INTENSITY FACTORS

    BETA = 0.5D0*PI*C/WD
    IF (BETA.LT.1D-12) THEN
        Y = 1D0
    ELSE
        Y = DSQRT(DTAN(BETA)/BETA) / DCOS(BETA)
    ENDIF

    FSINB = 1.D0 - DSIN(BETA)
    F0 = Y * (0.752 + 2.02*(C/WD) + 0.37*FSINB**3)
    F1 = F0/2.
    F2 = Y * (0.923 + 0.199*FSINB**4)
    FDUM1 = 0.0D0
    CONST = DSQRT(PI*C)
    IF (MODE.EQ.'CALC') THEN

        CAYMAX = CONST*DMAX1( (F0*SMAX4(1)/SDEL
k      +F1*DABS(SMAX4(2))/SDEL +F2*SMAX4(3)/SDEL),
k      (F0*SMIN4(1)/SDEL + F1*DABS(SMIN4(2)/SDEL)

```



## **APPENDIX F**

### **Testing and Analysis for DTA of Fairchild SA226 Main Wing Spar Lower Cap at WS99**

**FINAL REPORT**  
SwRI Project No. 06-8520

***prepared by***

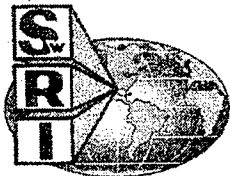
Joseph W. Cardinal  
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***prepared for***

Fairchild Aircraft, Inc.  
San Antonio, Texas

January 1999

APPROVED:



  
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Structural Engineering Department

**APPENDIX F TESTING AND ANALYSIS FOR DTA OF  
FAIRCHILD SA226 MAIN WING SPAR LOWER CAP AT WS99**

**Final Report**

SwRI Project No. 06-8520

## **ACKNOWLEDGEMENTS**

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A number of other Southwest Research Institute staff members also contributed to this effort. These individuals include Jon Cutshall, finite element analyses of the complex coupon; Dick Page, fracture surface analyses; Tom Masden, Dale Haines and Darryl Wagar, coupon testing; Isaac Rodriguez, photography; and Terry Sloan, document preparation.

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## EXECUTIVE SUMMARY

Southwest Research Institute (SwRI) performed testing and analyses to support a damage tolerance analysis (DTA) effort undertaken by Fairchild Aircraft to extend the useful life of the SA226/SA227 series of aircraft. Fairchild identified the most fatigue critical principal structural element (PSE) on this aircraft as the main wing spar lower cap at wing station 99.0. The lower spar at wing station 99.0 consists of a three-element spar cap comprised of the lower cap, the spar angles and the titanium straps. The lower cap and the spar angles are manufactured from 2014-T6511 aluminum extrusions. The fatigue critical location (FCL) is located in the horizontal legs of the spar angle at the last outboard fastener hole just prior to where the titanium straps end.

Material characterization tests were performed to obtain the basic properties of the 2014-T6511 aluminum extrusion. These included tensile, fracture toughness and fatigue crack growth rate tests. Coupon spectrum tests were performed to generate empirical data to determine whether or not crack growth at this FCL was influenced by load interaction effects (retardation) and to assess the validity of the NASGRO crack growth analysis model used for the DTA of this location. Two specimen geometries were investigated. A simple coupon design using an offset (open) hole in a plate was tested first. This was followed by a more complex coupon geometry designed to represent the load transfer and built-up nature of the actual joint. Load spectra for the coupon tests were derived from the stress spectra developed by Fairchild for this location.

Crack growth analyses were performed using NASGRO for each coupon geometry and demonstrated that very good predictions of the measured data were possible without the use of a retardation model. These results provide confidence in using the NASGRO software and these material properties in the DTA of the 2014-T6511 wing spar components on the SA226/SA227 aircraft. Recommendations were also provided for the final DTA of this location, including the assumption of an initial corner crack in the analysis and the use of a continuing damage analysis to determine the amount of additional life which exists in the part beyond failure of the short ligament.

## **F1.0 INTRODUCTION**

This report summarizes the results of testing and analyses performed by Southwest Research Institute (SwRI) in support of a damage tolerance analysis (DTA) effort undertaken by Fairchild Aircraft to extend the useful life of the SA226/SA227 series of aircraft and to assure the continued airworthiness of these airframes. This class of aircraft have been in production since 1970 and were not designed using damage tolerance techniques. In September 1995, Fairchild Aircraft was funded by the Federal Aviation Administration (FAA) to develop a Supplemental Inspection Document (SID) for the SA226/SA227 aircraft using a damage tolerance approach (FAA Contract No. DTFA03-95-C-00044). The testing and analysis described herein were performed to develop key information for use in the DTA of the most fatigue critical principal structure element (PSE) on the aircraft.

Fairchild identified the most fatigue critical PSE on the aircraft as the main wing spar lower cap at wing station 99.0. This fatigue critical location (FCL) was designed by Fairchild as FCL W1 in their interim SID development report [F1]. A selection and prioritization of FCLs for analysis was performed by Fairchild using a formal ranking procedure developed for use in USAF Structural Integrity Programs [F2]. The results of this ranking process are summarized in Reference [F1].

The geometry and materials of FCL W1 are described in Section F2.0 of this report. Since FCL W1 was the most critical location, SwRI was tasked by Fairchild to generate material property data that would support the DTA of this location. These data consisted of tensile and fracture properties as well as fatigue crack growth rate data and were obtained from specimens excised from representative spar material samples provided to SwRI by Fairchild. A description of these tests and their results are presented in Section F3.0.

In order to validate the predictability of the crack growth models used to represent FCL W1 in the DTA, SwRI performed two sets of coupon spectrum tests on hardware representative of the main spar lower cap at wing station 99.0. Prior to beginning these tests, the spectrum developed by Fairchild for use in the DTA had to be converted to a form suitable for use in the laboratory test machines. Section F4.0 summarizes this process. Details of the two coupon designs (simple and complex) and the spectrum test procedure are presented in Section F5.0 along with results from the tests. Raw data from all the testing performed in this program are contained in the appendices along with additional analyses used to interpret the crack growth measurements.

The results of the coupon tests are compared to analytical predictions made using the NASGRO crack growth analysis software [F3] in Section F6.0 of the report. Finally, a number of recommendations for DTA based on the findings of this program are provided in Section F7.0.

## F2.0 MAIN WING SPAR LOWER CAP GEOMETRY AT WS 99 (FCL W1)

A schematic of the geometry of SA226/SA227 main wing spar lower cap at wing station 99.0 (FCL W1) is provided in Figure F2.1. This is a three-element spar cap comprised of the lower cap, the spar angles and the titanium straps and is the primary load carrying member in the wing at this wing station. The lower cap and the spar angles are manufactured from 2014-T6511 aluminum extrusions. The FCL is located in the spar angle at the last outboard fastener hole just prior to where the titanium straps end. This is the highest stressed location in the main wing spar.

Figure F2.2 shows a dimensioned cross section of the lower spar cap at wing station 99.0 indicating the location of the presumed crack for the damage tolerance analysis. A through-thickness crack at the fastener hole is presumed to exist for the DTA. In addition to the high stress levels at this location, this area would be very difficult to inspect as well; hence, FCL W1 was chosen as the FCL on which to perform the coupon spectrum testing in support of the DTA.

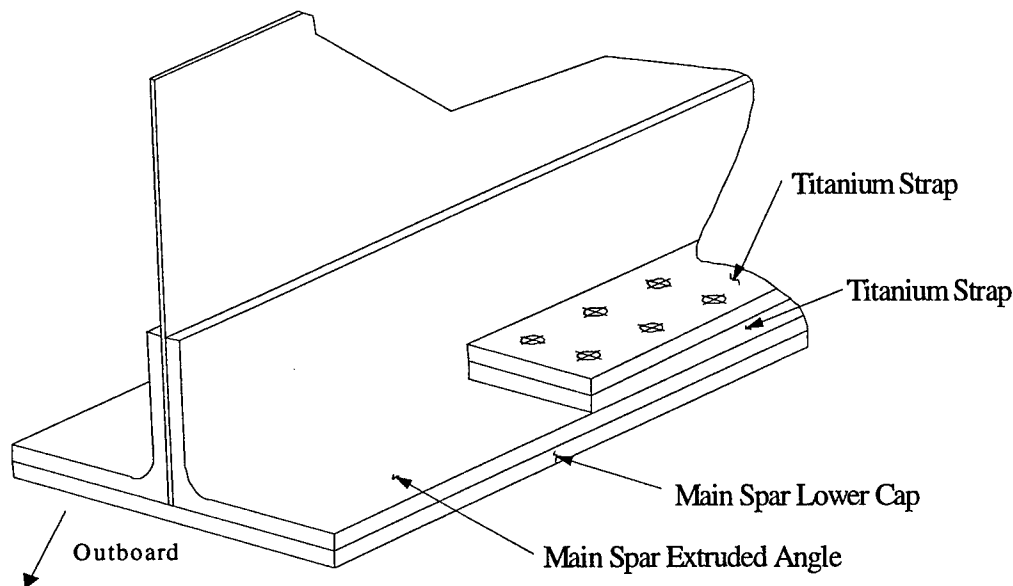
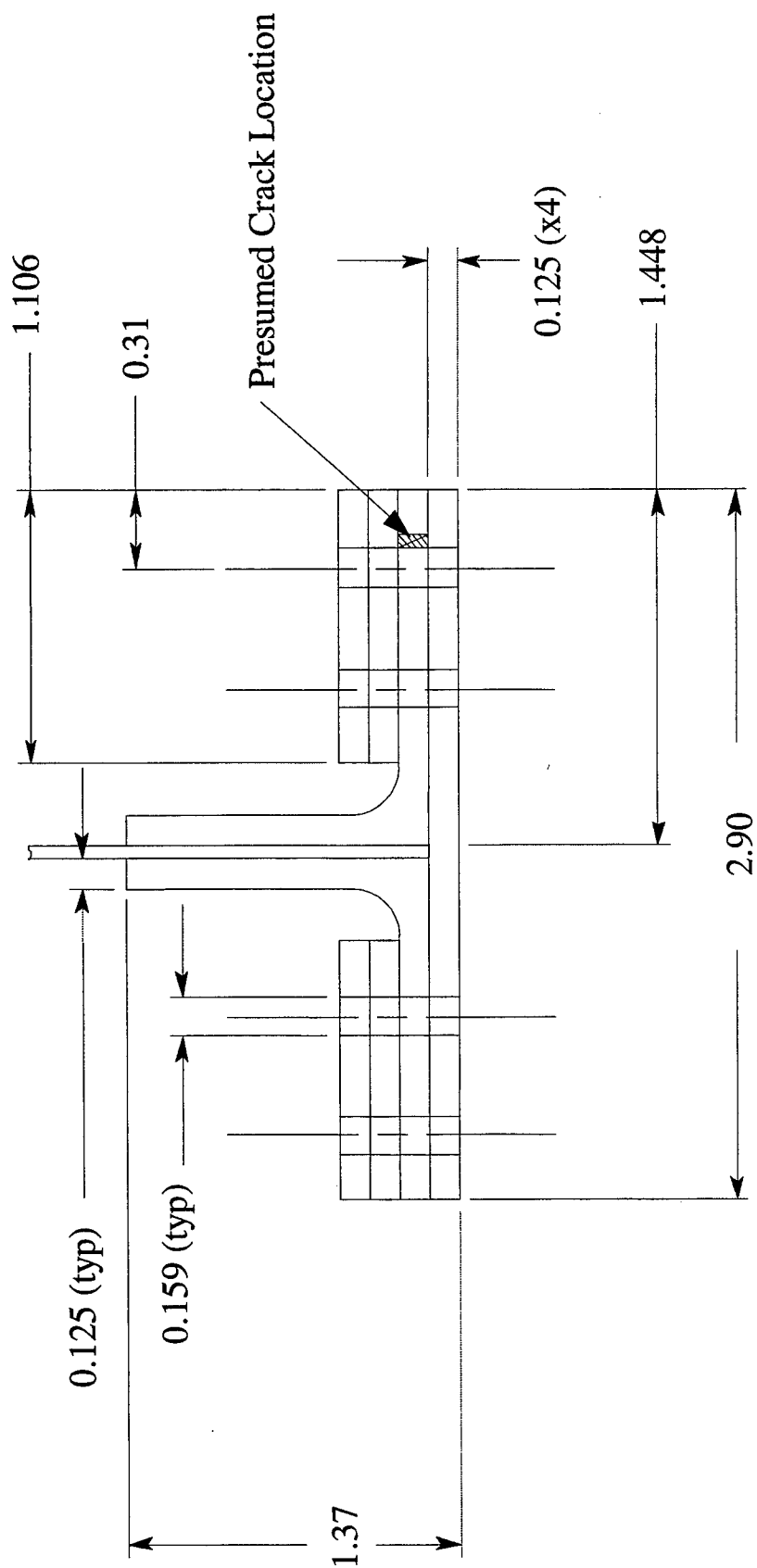


**Figure F2.1 FCL W1 — Main Wing Spar Lower Cap at Wing Station 99.0**



Note: Dimensions are inches

Figure F2.2 Cross Section of Main Wing Spar Lower Cap at Wing Station 99.0 Showing Location of Presumed Crack for DTA

## **F3.0 MATERIAL PROPERTIES TESTING**

This section describes the material characterization tests performed to obtain basic properties of the 2014-T6511 aluminum extrusion for use in the damage tolerance analysis of the main wing spar lower cap.

### **F3.1 MECHANICAL CHARACTERIZATION TESTING**

Mechanical characterization testing consisted of tensile, fracture toughness, and fatigue crack growth evaluations of the 2014-T6511 aluminum extrusion. The scope of the evaluations is summarized in Table F3.1. Fracture and fatigue testing was performed in the Solid and Fracture Mechanics laboratory at SwRI using a workstation similar to that shown in Figure F3.1. Tensile testing was subcontracted to the Charles C. Kawin Co. (Broadview, Illinois).

Fatigue crack growth testing was performed at different load ratios (denoted as R-ratio and defined as the ratio of minimum to maximum load applied during the fatigue cycle) to determine the influence of mean load level. The nominal R-ratios considered were -0.2, 0.2, 0.5 and 0.8.

#### **F3.1.1 Specimen Geometries**

The basic geometries and methods generally conformed to the relevant ASTM test specification [F4]:

- tensile testing: ASTM E8-96a (Standard Test Methods for Tension Testing of Metallic Materials).
- fracture testing: ASTM E399-90 (Standard Test Methods for Plane Strain Fracture Toughness of Metallic Materials).
- FCG rate testing: ASTM E647-95a (Standard Test Methods for Measurement of Fatigue Crack Growth Rates).

Tensile testing specimen blanks were machined into standard specimens with gage lengths of 0.500 inch, as illustrated in Figure F3.2. The tensile properties were determined in the longitudinal orientation for two different types of aluminum extrusion 2014-T6511, that is, a wide plate (specimen ID prefix TE) and angle extrusion (specimen ID prefix TA).

Fracture testing was performed on a sub-thickness (0.125 inch) 1-T plan geometry, compact-tension specimen as illustrated in Figure F3.3. All fracture toughness evaluations were performed on specimens in the L-T orientation and in the thickest geometry possible with the supplied material. This nomenclature implies that the applied loading axis is in the longitudinal direction and the direction of crack advance is in the transverse direction. This orientation is consistent with the crack plane used for the FCL coupons.

Fatigue crack growth rate testing was performed on middle crack tension, M(T), specimens, compact tension, C(T), specimens as well as eccentrically loaded single edge crack tension, ESE(T), specimens with a 1-1/2 T plan geometry. Schematics of the M(T) and ESE(T) specimen geometries are shown in Figure F3.4 and F3.5, respectively. A listing of the test conditions employed is

provided in Table F3.1. The ESE(T) specimen was selected for positive R-ratio fatigue crack growth testing because of non-coplanar crack growth observed in the C(T) specimens during FCG testing. It is not uncommon for 2xxx alloys to exhibit deflected crack growth due to the interaction of texture effects and stress state in the specimen. The ESE(T) specimen design results in a significant decrease in the T-stress (stress parallel to the crack surface) which will tend to increase self-similar cracking and reduce crack deflection [F5].

### **F3.2 TENSILE TEST RESULTS**

A summary of the tensile data obtained for the 2014-T6511 aluminum extrusion is shown in Table F3.2. The tensile test result summary is extracted from the actual data tabulated in Appendix G1 – Material Characterization Properties. Additional details regarding the specifics of all the tensile tests are included in this appendix. All tensile data exceeded the minimums provided for this material as presented in MIL Handbook 5G [F6].

### **F3.3 FRACTURE TOUGHNESS TEST RESULTS**

A summary of the fracture toughness data obtained for the 2014-T6511 aluminum extrusion is shown in Table F3.3. Additional details regarding the specifics of all the fracture tests are included in Appendix G1.

It is important to describe the terminology used to discuss the fracture toughness results. When a fracture test is described as obtaining an invalid plane-strain fracture toughness value (denoted  $K_{Ic}$ ), it does not imply that the test failed or was performed incorrectly. Rather, it implies that during fracture the specimen was not under true plane-strain conditions. The fracture toughness value is then termed  $K_{Ic}$  as opposed to  $K_{Ic}$ , see Table F3.3.

The most notable observation from Table F3.3 is the invalid plane-strain fracture toughness results for this material. The invalidity occurred due to non-plane-strain conditions as evidenced by insufficient thickness and nonlinearity in the load displacement trace. Nevertheless, the toughness levels observed can be considered relevant since the specimen thickness matched the extrusion thickness. Since the actual FCL location thickness used for this material is the same as the fracture test thickness, the toughness values listed in Table F3.3 are more representative of the actual fracture toughness in the less constrained, more plane-stress FCL specimen.

### **F3.4 FATIGUE CRACK GROWTH RATE TESTING AND RESULTS**

#### **F3.4.1 Crack Length Measurement and Crack Growth Test Control Methodology**

A special load control method, termed K-control by ASTM, was employed during fatigue crack growth testing to insure that a complete crack growth curve was generated from a single specimen. With this method, the quantity  $(1/K)(dK/da)$  is kept constant by changing loads as the test progresses [F7]. This effectively results in a greater  $\Delta K$  range and minimizes the number of specimens required to construct the crack growth curve from near-threshold to stage III failure. The obvious benefit of K-control methods is that test time is minimized and the number of required specimens is typically reduced. The K-rate (or, more appropriately, the quantity  $(1/K)(dK/da)$ ) during these crack growth tests was typically between 3.5 and -3.5  $\text{in}^{-1}$ .

Both visual (optical traveling microscope) and nonvisual (KRAK gages) crack length measurements were utilized during this crack growth rate characterization testing. The nonvisual crack length measurement technique used was the indirect potential drop method. The potential drop (PD) technique has been used quite successfully for many years to remotely measure crack length [F8]. The PD method utilized in this work is called indirect since the potential output from a KRAK gage bonded to the face of the specimen (illustrated in Figure F3.6) is used to determine crack length. A schematic of the electrical connections to the foil KRAK gage is shown in Figure F3.7.

In practice it is important to calibrate the indirect crack length measurements with the physically measured (e.g., visually measured) crack lengths to achieve the highest level of accuracy. This post-test correction uses a linear scheme based on a minimum of two crack length measurements: at the start and near the end of the test [F9]. Although more complicated, multiple degree-of-freedom correction techniques are available, the corrected crack length measurements typically do not usually differ significantly from the simple linear method [F8].

Fatigue crack growth rate curves for each of the four R-ratios tested in this program are provided in Appendix G1. Additional details regarding the specifics of all the fatigue tests are included in this appendix. For all tests, the repeatability of the replicate testing was quite reasonable. All fatigue testing was performed in laboratory-air conditions.

#### **F3.4.2 Modeling of Fatigue Crack Growth Rate Data**

Fatigue crack growth data obtained in this program are compared in Figure F3.8 with the fatigue crack growth curves obtained using the NASGRO crack growth equation and parameters obtained from the NASGRO material database [F3]. As shown in Figure F3.8, the NASGRO curves do not match the test data obtained in the current work. Note, however, that the NASGRO material constants were obtained from testing performed on 2014-T6 plate and sheet and not 2014-T6511 extrusion.

Preliminary crack growth analyses for FCL W1 were performed by Fairchild using the 2014-T6 plate and sheet parameters in the NASGRO material database. Clearly, use of these parameters will overestimate the crack growth rate in spectrum crack growth predictions. Therefore, an iterative process was performed with the parameters so as to produce a best fit to the 2014-T6511 extrusion experimental data obtained in this program. The results of this process are shown in Figure F3.9 along with the revised NASGRO parameters.

Given the original and modified values for the NASGRO parameters, it is worthwhile to compare the experimental crack growth data to predictions made using the NASGRO model. A life ratio can then be determined for each test as defined by the ratio between experimental and predicted crack growth results  $N_{\text{expt}}/N_{\text{pred}}$ . Based upon past experience, a life ratio between 0.5 and 2.0 implies an excellent prediction of the total life results.

The life ratios for the four different load ratios are shown on Figure F3.10 and Table F3.4. Results obtained using the original NASGRO parameters did not match the recorded data particularly well for any of the load ratios considered. The modified NASGRO constants proved relatively effective in predicting the experimental data.

**Table F3.1 Material Characterization Tests Performed on  
Aluminum Alloy 2014-T6511 Extrusion**

| Property Test        | Specimen ID  | Specimen Type | Orientation | Load Ratios (R-ratios) Examined |     |     |     |
|----------------------|--------------|---------------|-------------|---------------------------------|-----|-----|-----|
|                      |              |               |             | -0.2                            | 0.2 | 0.5 | 0.8 |
| Tensile              | TE-1 to TE-4 | rectangular   | L           |                                 |     |     |     |
|                      | TA-1 to TA-3 | rectangular   | L           |                                 |     |     |     |
| Fracture Toughness   | FC-1 to FC-4 | C(T)          | L-T         |                                 |     |     |     |
| Fatigue Crack Growth | CM-1 to CM-3 | M(T)          | L-T         | ✓                               |     |     |     |
|                      | CC-1         | C(T)          | L-T         |                                 | ✓   |     |     |
|                      | CE-3 to CE-4 | ESE(T)        | L-T         |                                 | ✓   |     |     |
|                      | CE-1 to CE-2 | ESE(T)        | L-T         |                                 |     | ✓   |     |
|                      | CE-5 to CE-6 | ESE(T)        | L-T         |                                 |     |     | ✓   |
|                      | CC-2         | C(T)          | L-T         |                                 |     |     | ✓   |
|                      |              |               |             |                                 |     |     |     |

**Table F3.2 Monotonic Tensile Test Data Obtained for the 2014-T6511 Material**

| Material                | Orientation  | Spec. ID | $\sigma_{YS}$ , ksi | $\sigma_{TS}$ , ksi | $\epsilon$ , % | RA, % | E, 10 <sup>3</sup> ksi |
|-------------------------|--------------|----------|---------------------|---------------------|----------------|-------|------------------------|
| 2014-T6511<br>extrusion | Longitudinal | TE-1     | 60.7                | 66.4                | 10.0           | 24.2  | 10.45                  |
|                         |              | TE-2     | 62.2                | 66.8                | 10.5           | 27.0  | 10.75                  |
|                         |              | TE-3     | 61.2                | 65.9                | 11.0           | 23.1  | 10.73                  |
|                         |              | TE-4     | 55.8                | 66.3                | 11.5           | 29.2  | 10.93                  |
|                         |              | TA-1     | 61.7                | 65.6                | 10.0           | 20.6  | 11.74                  |
|                         |              | TA-2     | 61.3                | 65.4                | 10.5           | 25.5  | 11.25                  |
|                         |              | TA-3     | 62.1                | 64.9                | 11.0           | 33.4  | 11.03                  |
| average →               |              |          | 60.7                | 65.9                | 10.6           | 26.1  | 10.98                  |
| MIL HNDBK 5G min. →     |              |          | 55.0                | 65.0                | 8.0            |       | 10.50                  |
| NASGRO (2014-T6) →      |              |          | 65.0                | 74.0                |                |       |                        |

**Table F3.3 Fracture Toughness Data Obtained for the 2014-T6511 Material**

| Material                              | Form      | Thickness (in) | Orientation | Specimen ID | Kq (ksi√in) | Valid?                   |
|---------------------------------------|-----------|----------------|-------------|-------------|-------------|--------------------------|
| 2014-T6511                            | extrusion | 0.121          | L-T         | FC1         | 35.3        | no <sup>1</sup>          |
|                                       |           | 0.123          | L-T         | FC2         | 39.7        | no <sup>1</sup>          |
|                                       |           | 0.121          | L-T         | FC3         | 43.7        | no <sup>1</sup>          |
|                                       |           | 0.121          | L-T         | FC4         | 40.5        | no <sup>1</sup>          |
| average →                             |           |                |             |             | 39.8        |                          |
| MIL HNDBK 5G min. (2014-T651 plate) → |           |                |             |             | 19.0        | (valid K <sub>Ic</sub> ) |
| NASGRO (2014-T6) →                    |           |                |             |             | 27.0        | (K <sub>Ic</sub> )       |

<sup>1</sup> invalid due to insufficient thickness, and  $P_{\max}/P_Q > 1.10$

**Table F3.4 Comparison Between the Experimental and NASGRO Predicted Crack Growth for All FCG Tests**

| NASGRO Parameters |     |     |      |                 |                |                                  |     | R-ratio | Life Ratio Range (N <sub>expt</sub> /N <sub>pred</sub> ) | Comments                   |
|-------------------|-----|-----|------|-----------------|----------------|----------------------------------|-----|---------|----------------------------------------------------------|----------------------------|
| C                 | n   | p   | q    | ΔK <sub>0</sub> | K <sub>c</sub> | S <sub>max</sub> /σ <sub>0</sub> | α   |         |                                                          |                            |
| 3.5E-8            | 2.8 | 0.5 | 1.00 | 2.70            | 51.8           | 0.3                              | 1.5 | -0.2    | 1.10 – 3.42                                              | original NASGRO parameters |
|                   |     |     |      |                 |                |                                  |     | 0.2     | 11.23 – 21.77                                            |                            |
|                   |     |     |      |                 |                |                                  |     | 0.5     | 5.23 – 7.90                                              |                            |
|                   |     |     |      |                 |                |                                  |     | 0.8     | 2.11 – 5.65                                              |                            |
| 2.0E-9            | 3.7 | 0.5 | 1.00 | 2.70            | 51.8           | 0.3                              | 2.0 | -0.2    | 0.23 – 1.00                                              | modified NASGRO parameters |
|                   |     |     |      |                 |                |                                  |     | 0.2     | 2.97 – 5.21                                              |                            |
|                   |     |     |      |                 |                |                                  |     | 0.5     | 0.91 – 1.54                                              |                            |
|                   |     |     |      |                 |                |                                  |     | 0.8     | 0.20 – 0.78                                              |                            |

**Note:** In NASGRO, K<sub>c</sub> is computed using input values of yield strength, σ<sub>YS</sub>, plane strain fracture toughness, K<sub>Ic</sub>, and thickness, t. The NASGRO values of σ<sub>YS</sub> (65.0 ksi) and K<sub>Ic</sub> (27 ksi √in) were used in the analyses to fit the data and compute a K<sub>c</sub> of 51.8 ksi √in as shown above.

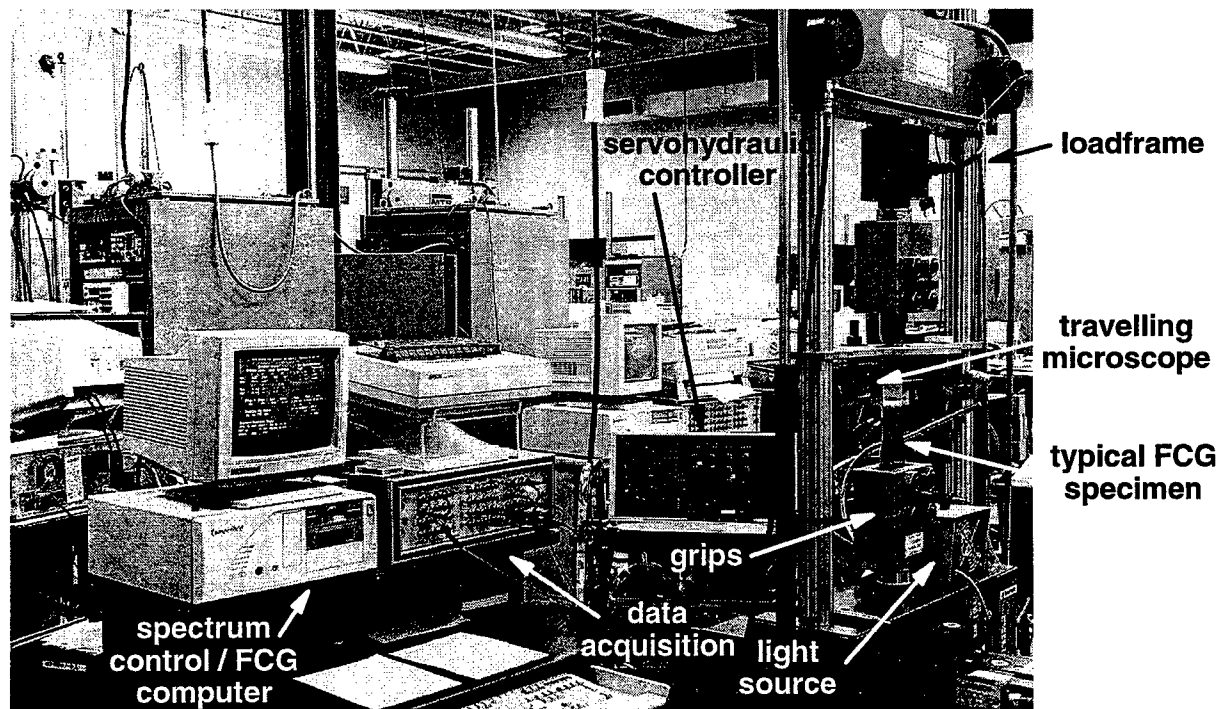


Figure F3.1 Typical Fatigue and Fracture Test Station in the SwRI Solid and Fracture Mechanics Laboratory

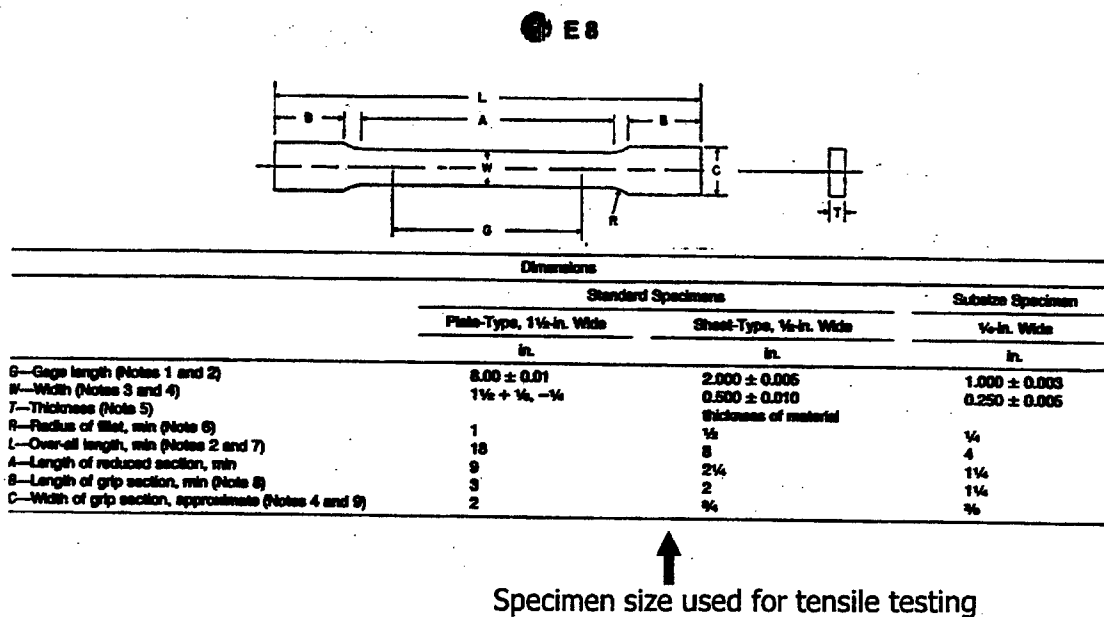


Figure F3.2 Tensile Specimen Geometry Utilized for Assessing the Tensile Strength of the Aluminum Extrusion (Extracted from ASTM Standard E8 [F1])

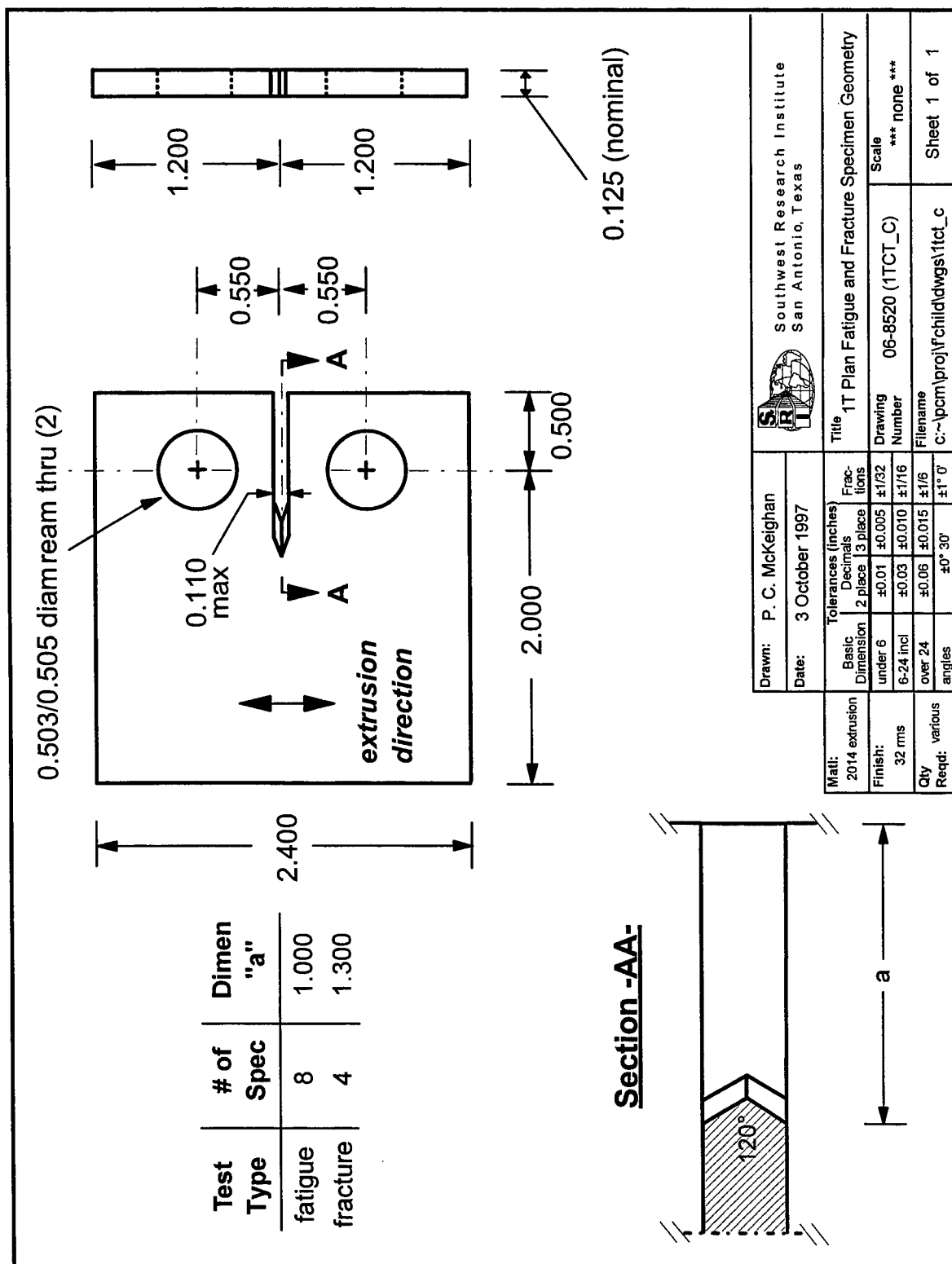


Figure F3.3 Design for the 1-T Plan Geometry Compact Tension Fracture and Fatigue Crack Growth Specimens

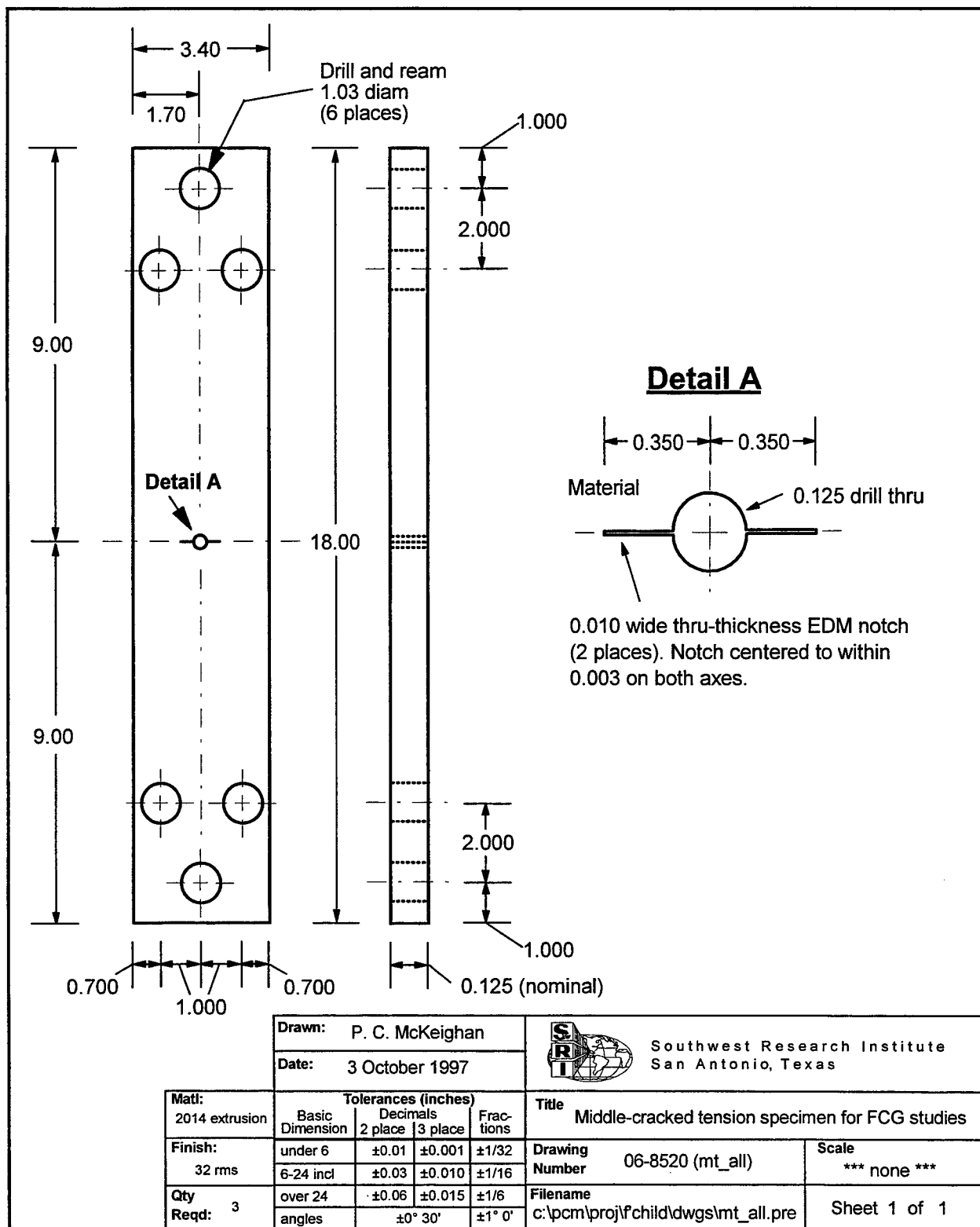
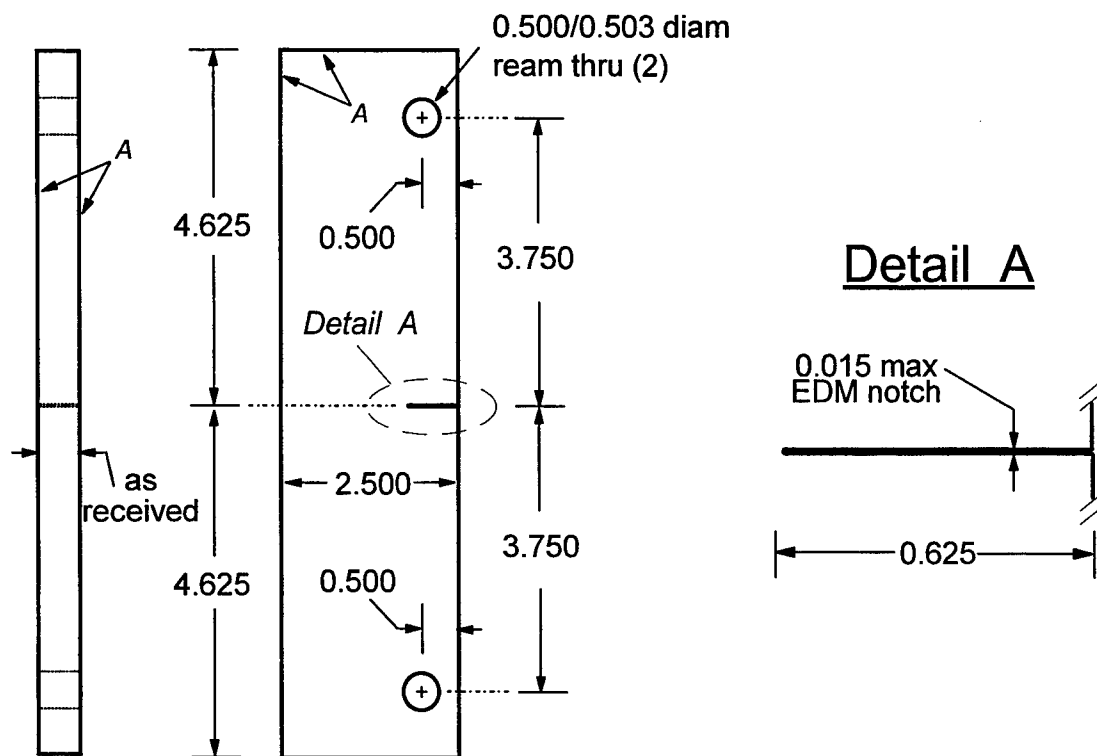


**Figure F3.4 Design for the Middle Crack Tension Specimen for Fatigue Crack Growth Studies**



**Note 1** A-surfaces perpendicular and parallel (as applicable) to within 0.006, TIR.

**Note 2** All surface finishes 32 RMS except loading hole bore (16 RMS).

**Note 3** The intersection of the tips of the machined notch with the specimen faces shall be equidistant from the top and bottom edges of the specimen to within 0.015.

| Material             | Number of Specs | Specimen ID's |
|----------------------|-----------------|---------------|
| 2014-T6511 extrusion | 6               | CE1 to CE8    |

Drawn: F. J. McMaster

Date: 12 December 1997



Southwest Research Institute  
San Antonio, Texas

| Matl:<br>2014-T6511 | Tolerances (inches) |                     |         |                | Title<br>Extended compact tension, EC(T), specimen for fatigue crack growth testing |
|---------------------|---------------------|---------------------|---------|----------------|-------------------------------------------------------------------------------------|
|                     | Basic Dimension     | Decimals<br>2 place | 3 place | Frac-<br>tions |                                                                                     |
| Finish:<br>32 rms   | under 6             | ±0.01               | ±0.005  | ±1/32          | Drawing<br>Number 06-8520 (15TECT_C)                                                |
|                     | 6-24 incl           | ±0.03               | ±0.010  | ±1/16          |                                                                                     |
| Qty<br>Reqd: 8      | over 24             | ±0.06               | ±0.015  | ±1/6           | Filename<br>c:\fraser\swri\projects\fairchd\15tect_c                                |
|                     | angles              | ±0° 30'             |         | ±1° 0'         |                                                                                     |
|                     |                     |                     |         |                | Scale<br>*** none ***                                                               |
|                     |                     |                     |         |                | Sheet 1 of 1                                                                        |

**Figure F3.5 Design for the 1-T Plan Geometry Eccentrically Loaded Single-Edge Crack Tension Specimen for Fatigue Crack Growth Studies**

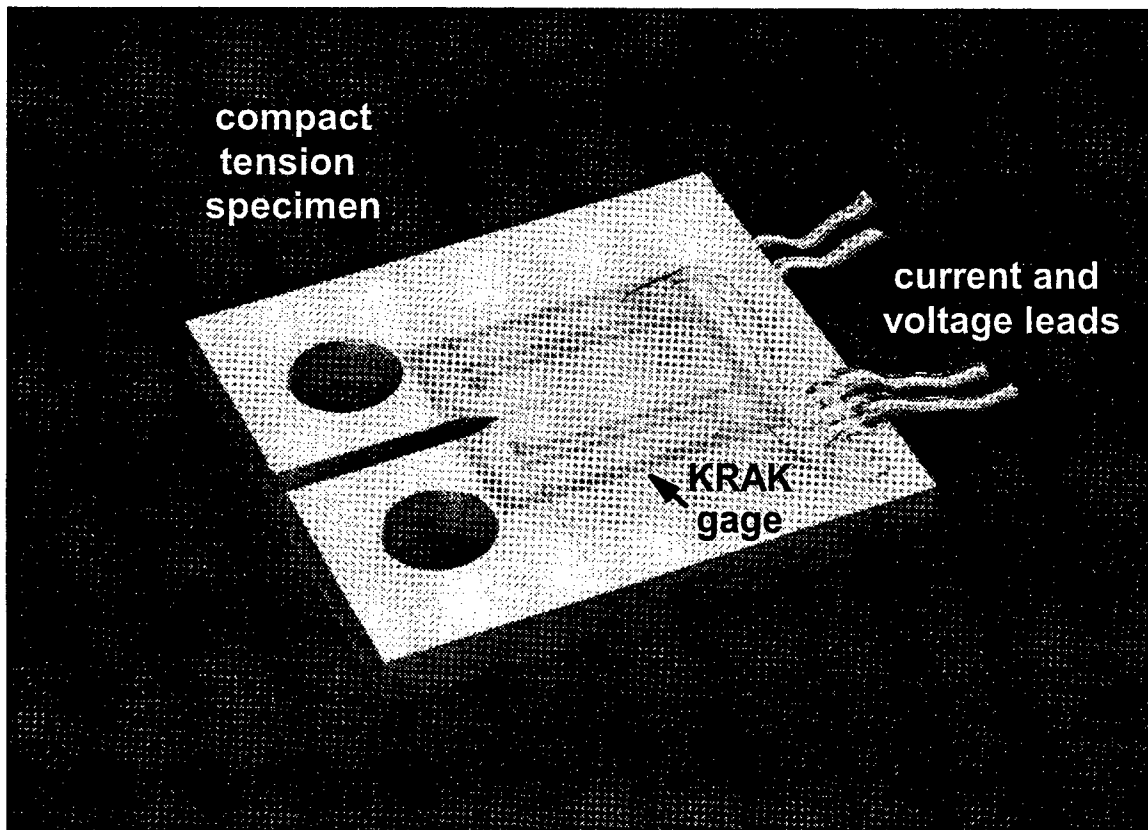


Figure F3.6 Typical Krak Gage Setup with Gage Bonded to Face of C(T) Specimen

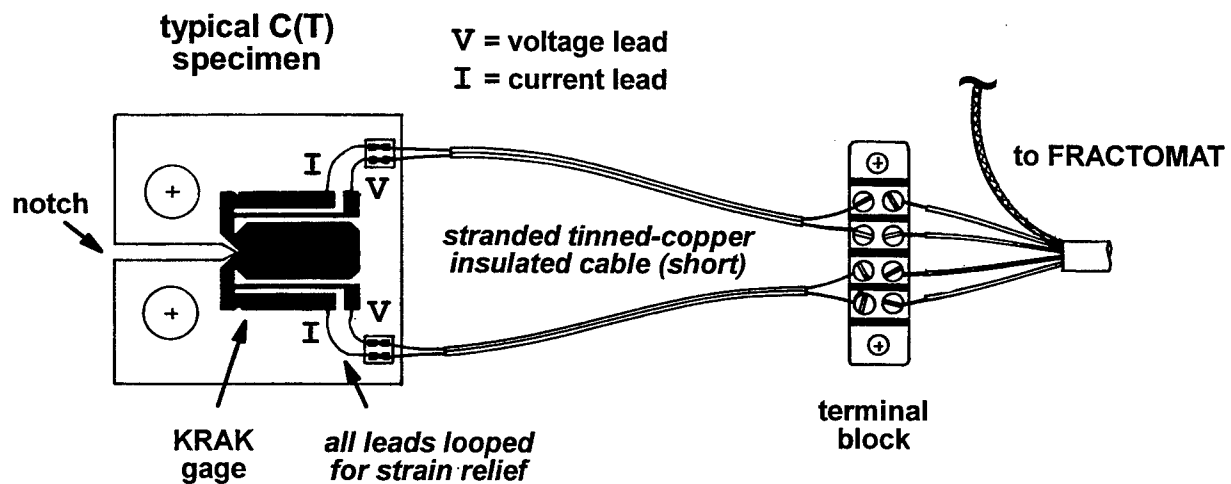


Figure F3.7 Schematic of Connections Required on a KRAK Gage on a C(T) Specimen

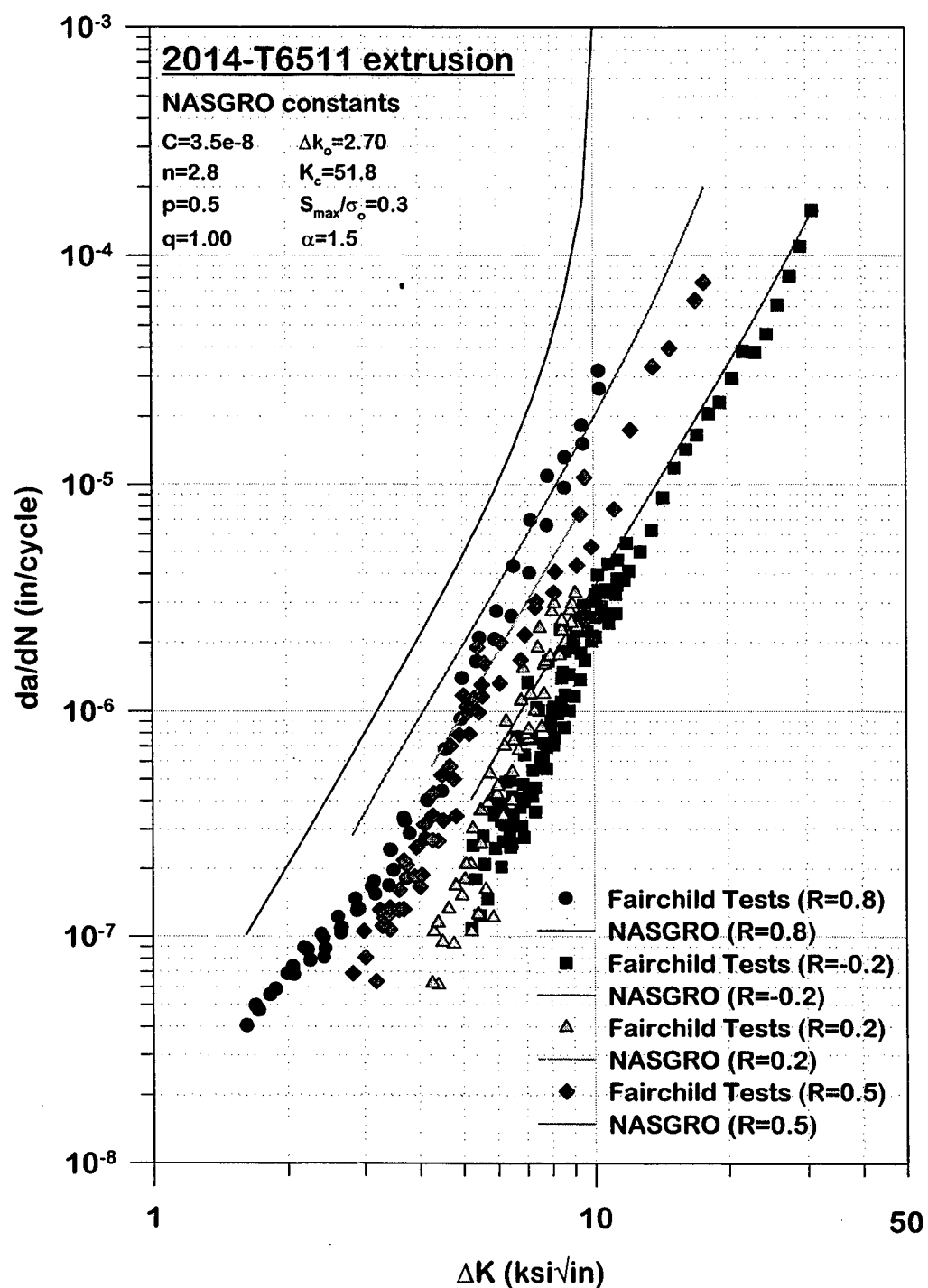


**Figure F3.8 FCG Data for the 2014-T6511 Extrusion Compared with the NASGRO Output (Using NASGRO Material Constants)**

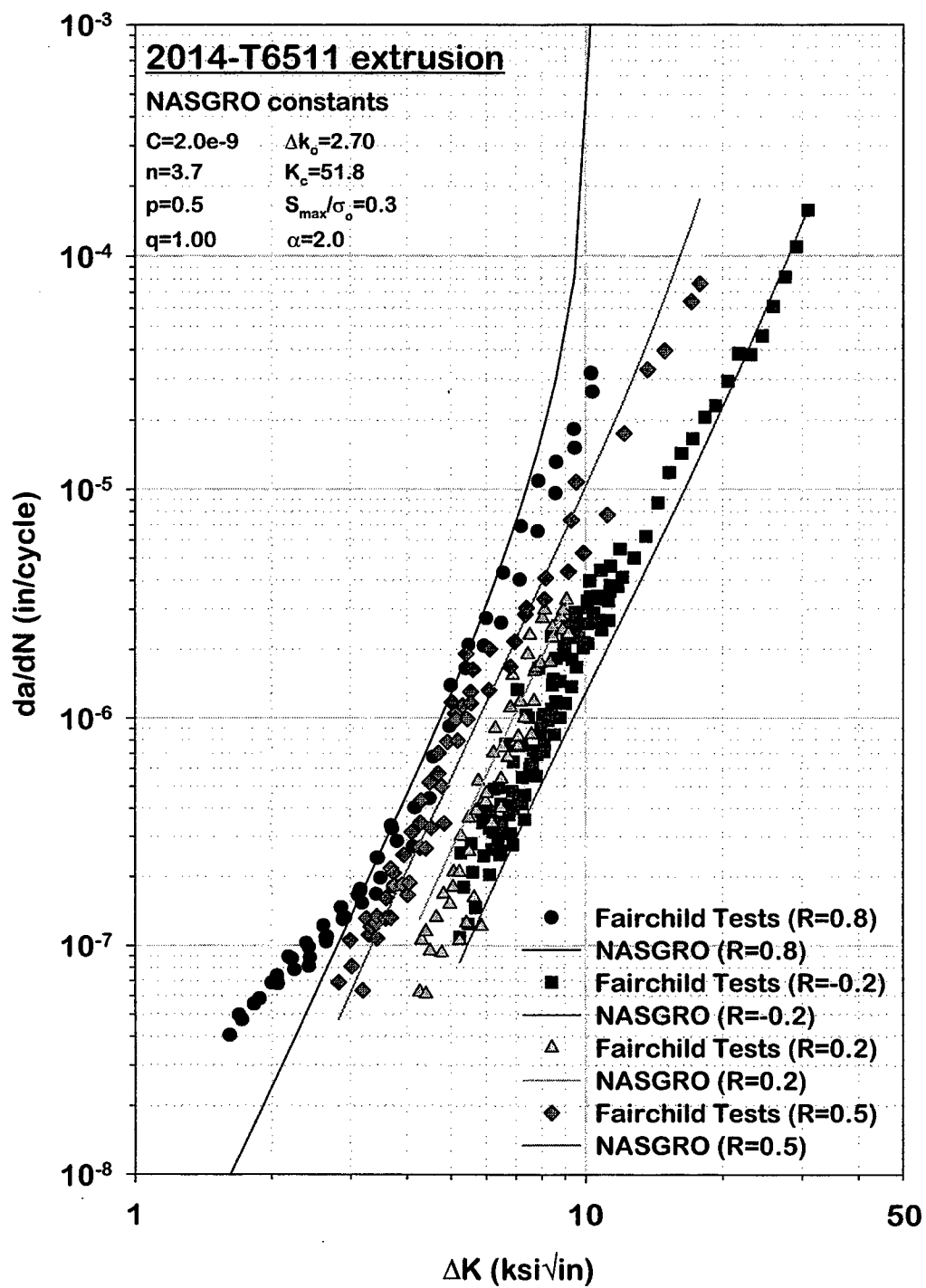


**Figure F3.9 FCG Data for the 2014-T6511 Extrusion Compared with the NASGRO Output (Using Modified NASGRO Material Constants)**

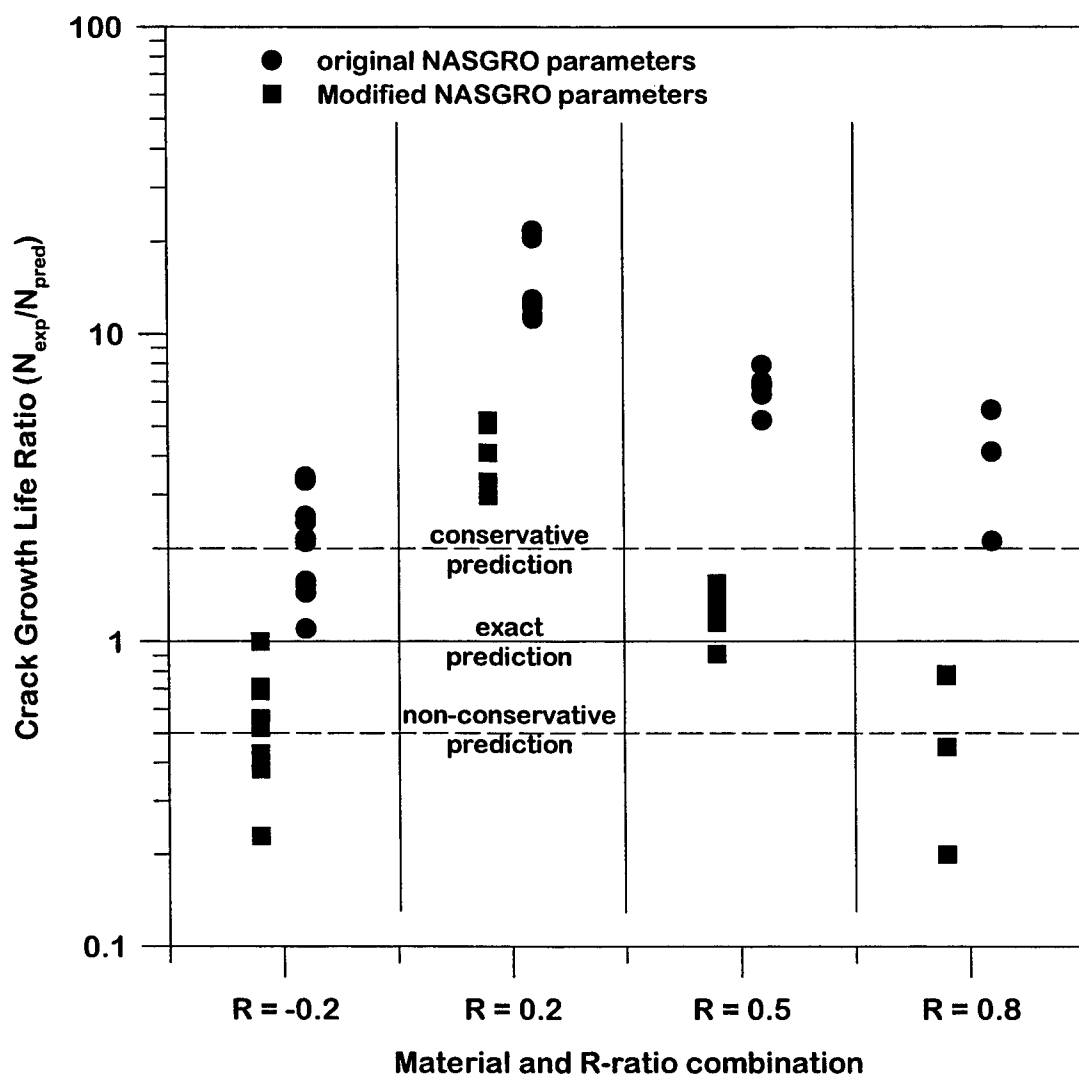


**Figure F3.10 Ratio of Experimental to Predicted Lives of FCG Test Specimens Using the NASGRO Model Parameters**

## F4.0 DEVELOPMENT OF SPECTRUM FOR FCL W1 COUPON TESTS

Fairchild developed load spectra for the SA226/SA227 aircraft as described in Reference [F1]. These loads were then, in turn, used by Fairchild to develop stress spectra at fatigue critical locations using the results of in-flight strain surveys and earlier full-scale fatigue tests. This section of the FCL W1 testing and analysis report describes how SwRI converted the stress spectra used by Fairchild for their DTA of FCL W1 to a spectra suitable for use in the coupon testing machines.

The original analysis spectrum provided to SwRI by Fairchild for FCL W1 was a 5.5 hour spectrum consisting of one short flight (0.5 hour), three medium length flights (1.0 hour each), and one long flight (2.0 hours). Each flight was comprised of three loading blocks: taxi, gust, and landing. The taxi and landing blocks were identical for all flights. Differences in the number of cycles contained in the gust blocks distinguished the three flight types from each other. Each spectrum block contained a set of load steps with a (noninteger) number of occurrences,  $N$ , and minimum and maximum loads ( $F_{\min}$ ,  $F_{\max}$ ) corresponding to specific g-levels. In addition, a constant load value,  $F_{\text{mean}}$ , was supplied such that it was added to each load step to increase the mean load level.

The damage tolerance analysis (DTA) of this FCL uses NASGRO model TC03, a through-crack emanating from a hole in a plate subject to both a remote tension load and a pin load [F3]. Fairchild provided scale factors converting the spectrum file loads data to tension stresses and bearing stresses. Thus, in the course of executing NASGRO, the stresses are computed as follows:

$$S_{0, \min} = (F_{\min} + F_{\text{mean}}) SF_t \quad \text{and} \quad S_{0, \max} = (F_{\max} + F_{\text{mean}}) SF_t \quad (1)$$

$$S_{3, \min} = (F_{\min} + F_{\text{mean}}) SF_b \quad \text{and} \quad S_{3, \max} = (F_{\max} + F_{\text{mean}}) SF_b \quad (2)$$

where  $S_0$  and  $S_3$  are the tension and bearing stresses, respectively (in the NASGRO notation), and  $SF_t$  and  $SF_b$  are the scale factors converting the spectrum file loads data to tension and bearing stresses, respectively.

The coupon test program was conducted in two phases, using a simple coupon and a complex coupon. The simple coupon was a single plate of aluminum with an offset open hole. The complex coupon was designed to represent the actual spar sandwich structure with two aluminum plates and two titanium plates, fastened together. In order to develop a spectrum for testing in the laboratory it was necessary to convert the analysis spectrum described above to a test spectrum that (1) was comprised of integer cycle numbers and (2) was represented in terms of uniaxial tension loads.

To convert the spectrum such that it contained only integer cycles, the number of cycles were multiplied by a factor of 100 and rounded off. This resulted in a 550 hour spectrum; however, the rounding off to integer cycle numbers resulted in the loss of a number of fractional cycles. These cycles were recovered by creating a select few make-up cycles and manually inserting them into the spectrum file. A total of seven make-up cycles were added, four gust and three landing. The magnitude of these cycles was determined using a weighted average technique based on the

fractional cycle amount lost during the round-off process and the corresponding magnitudes of those fractional cycles.

It was then necessary to convert the tension and bearing loads to remote tension loads to develop an equivalent tension test spectrum. This computation was made using the overall force balance on the coupon:

$$F_{eq} = S_0(Wt) + S_3(Dt) \quad (3)$$

where  $W$  is the coupon width,  $D$  is the hole diameter,  $t$  is the thickness, and  $S_0$  and  $S_3$  are computed as equations 1 and 2.

An analysis of the open-hole simple coupon was performed using the original spectrum (with tension and bearing loads) and compared to results obtained using the remote equivalent tension load spectrum. As expected, the life was somewhat less for the equivalent tension load spectrum case. Thus, the tension only spectrum was scaled up by a factor of 1.06 to approximate the life predicted by the pin load plus tension load analysis.

For the complex coupon tests, the same equivalent tension load spectrum was used; however, it was scaled up by a factor of 1.16 based on the results of a strain survey in order to achieve the desired peak spectrum stress of approximately 11 ksi at the test section of the coupon. This target value of 11 ksi was chosen based on the 2-g stresses for this location listed in Table D-11 of Reference [F1]. The analysis of the complex coupon uses the spectrum comprised of the tension and bearing loads since the hole is loaded by the fastener in the complex coupon test.

Comparisons between coupon test results and corresponding analytical predictions of crack growth must obviously use the same (test) spectrum. However, it is important to emphasize that the spectra developed for the simple and complex coupons were only developed for use in the coupon tests and should not be used for the final DTA. The original analysis spectrum should be used in the DTA.

## F5.0 COUPON SPECTRUM TESTING

The objectives of the coupon spectrum testing were to generate empirical data that could be used to (1) determine whether or not FCL W1 exhibited any effects of load interaction (retardation) on crack growth behavior and (2) to assess the validity of the NASGRO crack growth analysis model used for the DTA of this location. The test coupon geometries used to simulate FCL W1 as well as the test procedures used to perform the spectrum crack growth testing are described in this section.

The FCL W1 geometry is a sandwich structure comprised of the titanium straps and the aluminum spar angles and lower cap as shown in Figure F2.1. Based on stress analyses performed by Fairchild, the most critical areas of this joint are the last fastener holes at the outboard end of the titanium straps. Refer to Figures F2.1 and F2.2. The short ligament length in the horizontal leg of the spar cap is the worst case location at which a through-thickness crack is presumed to exist for the purposes of a damage tolerance analysis. In the coupon tests, a through-thickness crack was inserted at this location using an EDM procedure as described below.

The coupon designs used in this program were jointly developed by SwRI and Fairchild engineers. Fairchild Aircraft provided the aluminum and titanium material for manufacture of the coupons. Fairchild also drilled the fastener holes and assembled the complex specimens. SwRI was responsible for installation of the crack growth measurement gages and the strain gages.

The design of the coupons was based on three factors: (1) the availability of material stock at Fairchild; (2) the constraints of the test equipment (grips, fixtures, etc.); and (3) the geometry of the actual FCL W1 at WS 99. Generally, when performing coupon spectrum tests, it is desired to design a coupon that as closely as possible represents the actual geometry; however, as a practical matter, it is rare that the coupon geometry will exactly match the actual FCL geometry. Therefore, taking the three factors listed above into account, coupon design for spectrum testing must focus on developing a geometry that represents as best as practical the salient features of the actual FCL. Therefore, differences exist between the coupon design and the actual structure; however, the coupons do represent the general features of the FCL at WS 99.

Due to the complexity of this joint, it was deemed prudent by SwRI and Fairchild to implement a two-phase approach to the coupon spectrum testing for FCL W1. A simple coupon design using an offset (open) hole in a plate was tested first. This was followed by a more complex coupon geometry designed to represent the load transfer and built-up nature of the actual joint. Note that in the complex geometry the crack is not visible from the exterior of the coupon and that a fastener fills the hole. Therefore, as will be described, the simple coupon tests served as preliminary studies to investigate the general spectrum crack growth behavior in this material and to establish the viability of the crack growth measurement technique planned for use in the complex geometry where the crack growth was not directly visible.

In this section of the report, a general overview of the test procedures is first presented followed by specific details of each coupon design and test setup along with the results obtained. Comparisons to analytical predictions are presented in Section F6.0.

## **F5.1 GENERAL TEST PROCEDURES**

The test procedures used to perform the spectrum crack growth (SCG) testing were developed from many years of experience performing similar testing at SwRI. Although there is no specific industrywide standard related to SCG testing, the methods used are derived from the ASTM E647 standard for fatigue crack growth testing [F4]. Spectrum loads were applied in the frequency range of 5-20 Hz. The actual loading frequency used depended upon the response and controllability of the specific servo-hydraulic frame employed.

The spectrum crack growth test matrix for FCL W1 is shown in Table F5.1. This tabular representation of the matrix is organized in terms of the two different coupon geometries: simple and complex.

### **F5.1.1 Spectrum Test Methods and Control**

The coupon spectrum tests utilized closed-loop, servohydraulic testing systems specially designed to apply variable amplitude waveforms. The stress spectra were electronically stored in a format compatible with SwRI's computer software/hardware systems. The closed-looped control systems used in the test systems insure that the peak load levels are applied to the specimen during cycling. One of the key features of the systems used in the SwRI laboratory is a command/feedback certification procedure utilizing modification of the command signal based on the historical feedback performance during the last spectrum pass. This assures the most accurate and consistent loading of the specimen during testing.

### **F5.1.2 Spectrum Markerband Procedure**

In addition to nonvisual measurements of crack length obtained using KRAK gages, a spectrum marking procedure was used to provide markerbands on the fracture surface to verify and posttest correct the nonvisually measured crack lengths. The marking procedure was tested using the simple geometry SCG specimens to insure that the technique did in fact mark the fracture surface consistently and hence could be used effectively on the complex coupon geometry. With the marking procedure, a number of markerbands, each about 0.003-0.005 inch wide, are placed on the fracture surface with an average of 15-20 markerbands placed on the fracture surface over a ligament length of 0.295 inch. The marking procedure involved applying constant amplitude loading at a high R-ratio so as to induce a different fracture surface appearance. The markerbands were typically applied at a peak load of 80 percent of peak spectrum load and an R-ratio of 0.6.

Due to the premature failure of the KRAK gages in the second test performed on the simple geometry, it was deemed vital to use the markerband procedure on the complex coupon geometries. Since the plate containing the crack was not visible from the exterior of the complex specimen, this insured that crack length measurements could still be made (from the fracture surface) in the event that the KRAK gages failed during the test.

## **F5.2 SIMPLE COUPON GEOMETRY**

### **F5.2.1 Coupon Design**

The simple coupon geometry is shown in Figure F5.1. The FCL in the simple coupon geometry is defined as a through crack at a 0.19-inch-diameter offset hole having a 0.35-inch edge distance. The thickness of the coupon was 0.125 inch. EDM flaws were introduced into the coupons to facilitate the pre-cracking process prior to spectrum loading. All EDM flaws were through-thickness with a nominal width of 0.006 inch and a surface length of 0.025 inch.

### **F5.2.2 Test Setup and Coupon Pre-cracking**

Pre-cracking was performed in order to precondition and sharpen the EDM flaw into a fatigue crack prior to spectrum testing. In the strictest sense, the EDM flaw is initially machined into the specimen. Although crack-like in nature, it would not act enough like a real fatigue crack to insure good initial data. Therefore, prior to spectrum testing, blocks of constant amplitude loading were applied to initiate and grow a fatigue crack from the EDM flaw. Experience has shown that a minimum of approximately 0.010-0.015 inch of constant-amplitude fatigue crack growth is required.

The goal during the simple coupon geometry pre-cracking was to grow a fatigue crack from the tip of the EDM flaw to a total length of 0.050 inch measured from the edge of the hole. Pre-crack load levels were kept as low as practical, typically less than 75-80 percent of the peak spectrum load. Constant-amplitude cycles at an R-ratio of 0.1 were employed during pre-cracking.

A photograph of the simple geometry coupon gripped in the servohydraulic load frame is shown in Figure F5.2. A fixed constraint, or antibuckling guide, was attached to the main clevis to provide support for a variety of teflon-coated movable, or free, constraints (these antibuckling fixtures are not shown in Figure F5.2). The movable constraints located between the fixed constraint and test section were free to move in a vertical direction only. Horizontal constraint was achieved through set screws that were located in the fixed constraint.

Visual and nonvisual crack length measurements were recorded. Two different sized gages were used during the simple coupon geometry testing: KG-BH5616-X08 (short ligament) and KG-BH5616-X15 (long ligament). Due to the length of the short ligament in the simple coupon geometry (0.256 inch), part of the -X08 KRAK gage overhung the edge of the coupon and therefore needed to be supported by an extension plate. This type of arrangement was also used for the complex geometry tests and, hence, a more in-depth explanation of this arrangement is provided in Section F5.3.

### **F5.2.3 Results**

Two tests were performed using the simple coupon geometry as indicated in Table F5.1. In general, given a specific crack length envelope, if the cycles, or spectrum flight hours (SFHs) corresponding to the growth, are within  $\pm 15$  percent, the test is considered repeatable. This level of accuracy is based upon extensive SwRI spectrum testing experience. The test-to-test repeatability is dependent upon the coupon geometry (complexity), inherent material variability, crack shape and errors in crack length measurement.

Results obtained for the simple geometry coupons tested under flight spectrum conditions are shown in Figure F5.3. The data plotted in Figure F5.3 were obtained from visual measurements obtained using a microscope. Due to the failure of a KRAK gage on one of the coupons (SS-2), only nonvisual crack length measurements were obtained for one of the two tested coupons. Crack length measurements for each of the simple coupon geometry tests are provided in Appendix G2 – Spectrum Crack Growth Tests. The fracture surfaces for these coupons are shown, with test parameters, in Figure F5.4.

The results shown in Figures F5.3 and F5.4 for the simple coupon geometry tests can be summarized as follows:

- Total coupon life varied from 92 to 133 kSFH. Hence the tests exhibit poor repeatability.
- The crack growth curves observed (Figure F5.3) were concave up in accordance with typical behavior.
- The pre-cracked ligament failed prior to the initiation of a crack on the opposite side of the hole. Spectrum flight hours to failure of the short ligament ranged from 58 to 101 kSFH.
- Initiation of a crack on the non pre-cracked side of the hole took approximately 16 to 24 kSFH following failure of the short ligament.
- The time spent cracking the longer (uncracked) ligament was approximately 10 to 16 kSFH.
- For coupon ID (SS-2), both KRAK gages failed at the extension tab-coupon interface at approximately 37 kSFH.
- The marking procedure used on the simple geometry tests appeared to work well.

As illustrated in the micrographs in Figure F5.4, vastly different fracture surfaces were observed for the two simple geometry coupon tests. This necessitated further investigation as this may be the reason for the large differences in spectrum flight hours for the two coupons. Test coupon SS-2 had a rough fracture surface with areas of large cleavage facets and prominent striations. Conversely, the fracture surface of test coupon SS-3 was relatively flat with only the applied markerbands visible on the fracture surface. Photographs of the macroscopic grain structure of both specimens are shown in Figure F5.5. Crack propagation in both coupons was found to be transgranular; however, a dramatic difference in grain size for the two coupons was noted.

The contrast in the SCG lives of the two simple geometry tests can be explained in terms of the differences in their grain structure. Whereas dislocations easily shear the small grains in SS-3, the larger grains in SS-2 form obstacles to dislocation motion with the result that the dislocations loop around the grains and bypass them. Thus, the principal cause of the apparent differences in the spectrum crack growth response of the two microstructures is expected to be crack deflection and the attendant roughness-induced closure.

## **F5.3 COMPLEX COUPON GEOMETRY**

### **F5.3.1 Coupon Design**

The complex coupon design is shown in Figure F5.6. The complex geometry is a multiple-layered joint that represents the actual FCL with fastener loading, multiple load paths, and tension-bending. Testing of this joint required a high level of instrumentation, with strain gages (Figure F5.6) applied to various components of the joint to assess the overall loading and load paths in the structure. The test section of the coupon that contained the crack is labeled "E" in Figure F5.6. The FCL in the complex specimen is defined as a through crack at a 0.16-inch-diameter hole having a 0.375-inch edge distance. Again, the thickness of the test section was 0.125 inch.

### **F5.3.2 Test Setup and Coupon Pre-cracking**

During the pre-cracking phase of testing it was found to be extremely difficult to initiate a crack from the EDM notch (due to the complex nature of the joint and the low constant-amplitude loads applied). Therefore, a multitude of different peak constant amplitude loads and R-ratios were used to successfully initiate a crack and propagate the crack to the required 0.050-inch pre-crack length. The details of the pre-cracking loads and R-ratios used in the complex geometry pre-cracking process are summarized in Table F5.2.

A single sized gage was used during this testing phase: KG-BH5616-X08 (short ligament and middle ligament). Due to the length of the short ligament in the complex geometry (0.295 inch), part of the -X08 KRAK gage overhung the edge of the coupon and therefore needed to be supported by an extension tab. A photograph of the KRAK gages applied to the test section of the joint is shown in Figure F5.7. A photograph of the complex geometry coupon mounted in the servohydraulic load frame is shown in Figure F5.8. Hydraulic grips were used during this testing phase to insure the best load transfer. However, due to the large size (and mass) of the grips, test frequency was limited to a maximum of 10 Hz.

### **F5.3.3 Strain Survey**

An initial strain survey was performed on all complex geometry coupons to measure the relative strain levels reached during loading of the complex joint. Eight strain gages were attached to the coupons and the strain measurements were obtained at 85 percent of the peak spectrum load. A summary of the strain survey results is given in Figure F5.9 as a function of the relative positions of the strain gages. The repeatability of the strain gage measurements for the three complex coupons is quite excellent.

Strain gage numbers 7 and 8 were positioned on the complex coupon such that they matched the location of Fairchild flight test gages 3 and 2, respectively. (Refer to Table D-11 of Reference [F1].) Therefore, the average of gages 7 and 8 was used to scale the spectrum such that a target stress value of 11 ksi was achieved on the lower cap portion of the complex coupon. As discussed in Section F4.0, the scale factor obtained in this fashion was 1.16.

The complex geometry tests were also periodically interrupted to take strain data for a loading and unloading ramp to 85 percent of the peak spectrum load. Representative strain traces

for all three tests and compliance data are provided in Appendix G2. Compliance measurements taken during all three tests showed little difference between loading and unloading and remained constant for the majority of the test duration.

The compliance results can be used to determine both load transfer and bending using the following equations:

$$\text{Load Transfer (\%)} = 100 \left( 1 - \frac{C_5 + C_6}{C_3 + C_4} \right) \quad (4)$$

$$\text{Bending (\%)} = 100 \left( \frac{C_1 - C_2}{C_1 + C_2} \right) \quad (5)$$

where  $C_i$  is the calculated compliance value at gage  $i$ . The results are shown in Figure F5.10 plotting percent load transfer and percent secondary bending as a function of spectrum flight hour (loading cycle).

The mean load transfer observed for all tests was between 40-42 percent indicating that the titanium straps take approximately 40 percent of the load. The similarity of the responses is remarkable and presumably indicative of uniform joint behavior and fixed clamping. Relative to a pure tensile test, levels of bending were quite high, as expected, and typically averaged 17-20 percent. Bending in the actual wing spar would be expected to be less than that observed in the complex coupon geometry due to the presence of the vertical legs of the spar angles in the actual structure.

#### F5.3.4 Results

The test results obtained for the complex geometry coupons (CS-1, CS-2, and CS-3) tested under flight spectrum conditions are shown in Figure F5.11. Visual and nonvisual crack length measurements for each of the complex coupon geometry tests are provided in Appendix G2. Premature failure of the KRAK gages did not occur during any of the three complex geometry tests. The fracture surfaces for these coupons are shown in Figure F5.12, with the markerbands clearly visible for all three tests.

The results shown in Figures F5.11 and F5.12 can be summarized as follows:

- Complex geometry tests were terminated after the short ligament failed (or appeared to be completely fractured).
- Short ligament life was measured to be 121, 142, and 201 kSFH.
- Curved crack fronts were observed for all tests. This is indicative of the tension-bending loading obtained during testing of the built-up joint.
- Posttest visual crack length measurements (Figure F5.11) for all tests were shown to be approximately 0.010-0.020 inch greater than those measured using the KRAK gages. This difference is investigated and discussed further in Appendix G2.

**Table F5.1 Spectrum Crack Growth Tests and Specimen IDs**

| <b>FCL Designation</b> | <b>Geometry</b> | <b>Specimen ID</b> | <b>Thickness (inch)</b> | <b>EDM Length (inch)</b> |
|------------------------|-----------------|--------------------|-------------------------|--------------------------|
| W1                     | simple          | SS-2               | 0.1231                  | 0.024                    |
|                        |                 | SS-3               | 0.1232                  | 0.025                    |
|                        | complex         | CS-1               | 0.1243                  | 0.017                    |
|                        |                 | CS-2               | 0.1244                  | 0.023                    |
|                        |                 | CS-3               | 0.1242                  | 0.022                    |

**Table F5.2 Pre-Cracking Details for the Complex Geometry Tests**

| <b>Specimen ID</b> | <b>Number of Cycles</b> | <b>Maximum Precracking Load<br/>(% of peak spectrum load = 4520 lbs)</b> | <b>R-ratio</b> |
|--------------------|-------------------------|--------------------------------------------------------------------------|----------------|
| CS-1               | 51,000                  | 55                                                                       | 0.1            |
|                    | 83,000                  | 65                                                                       | 0.1            |
|                    | 100,000                 | 75                                                                       | 0.1            |
|                    | 100,000                 | 95                                                                       | 0.1            |
|                    | 250,000                 | 100                                                                      | 0.1            |
|                    | 65,000                  | 100                                                                      | -1.0           |
|                    | 3,978                   | 100                                                                      | 0.1            |
|                    | 107,400                 | 80                                                                       | 0.1            |
| CS-2               | 100,000                 | 100                                                                      | 0.0            |
|                    | 49,320                  | 100                                                                      | -1.0           |
|                    | 78,102                  | 80                                                                       | 0.0            |
| CS-3               | 29,070                  | 100                                                                      | -1.0           |
|                    | 3,000                   | 80                                                                       | 0.0            |



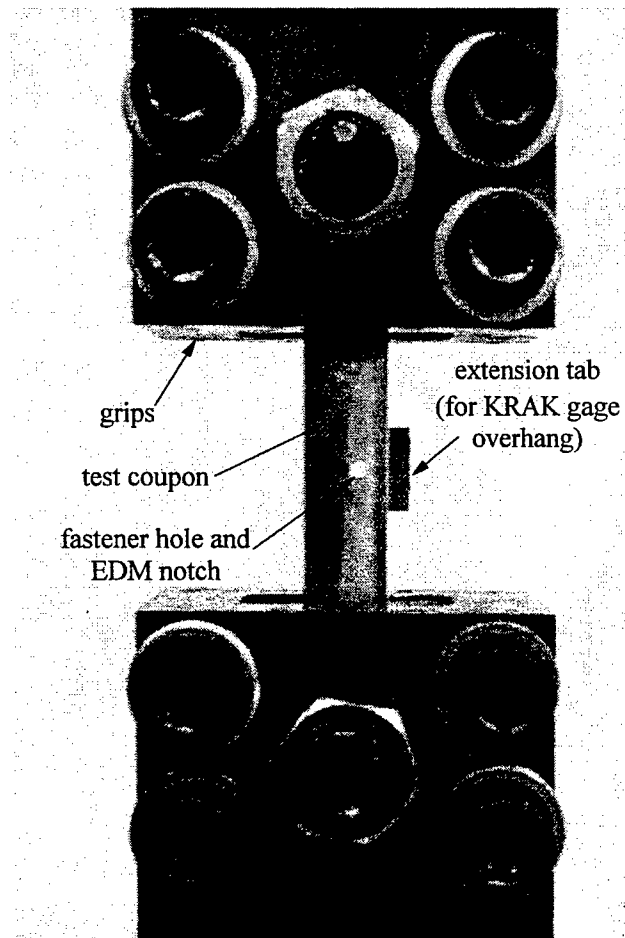


**Figure F5.2 Representative Test Setup for the Simple Geometry Coupon**

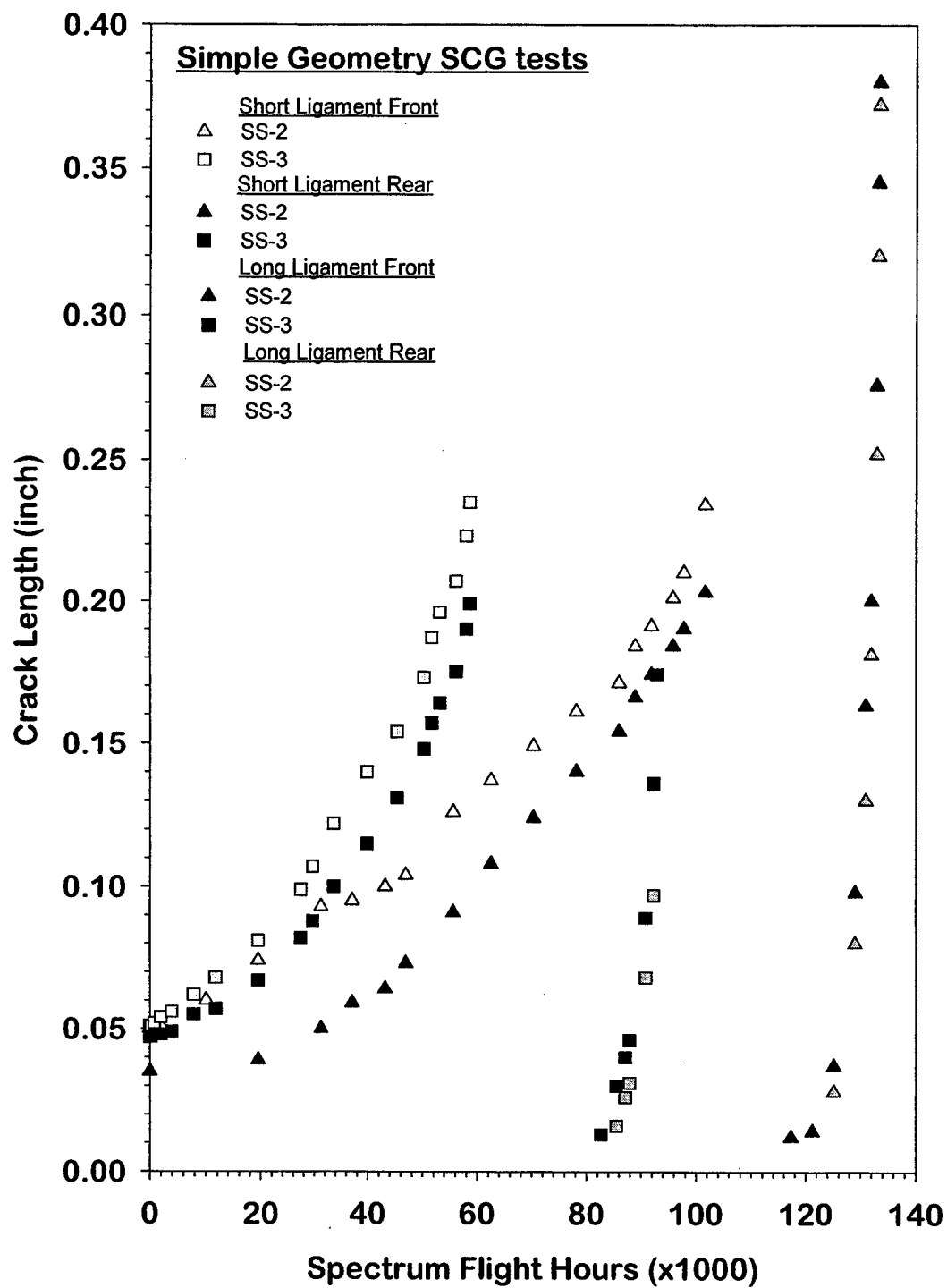


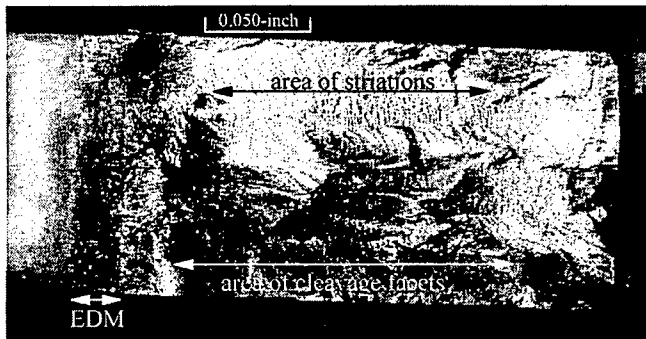
Figure F5.3 Summary of All SCG Tests Performed on the Simple Coupon Geometry

## SUMMARY OF SPECTRUM PARAMETERS

| Cycles per<br>550 SFH | Load levels (lbs) |         | Comments    |
|-----------------------|-------------------|---------|-------------|
|                       | Minimum           | Maximum |             |
| 14076                 | -1406             | 1451    | offset hole |

### FRACTURE SURFACES

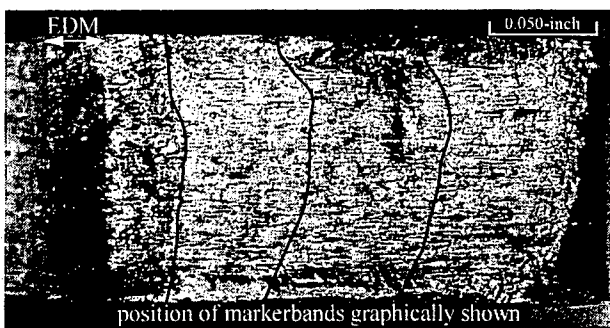
### MILESTONES



**Total Life = 133.5 kSFH**

ligament failed at 101.6 kSFH  
reinitiation at 117.3 kSFH

**Test = SS-2**

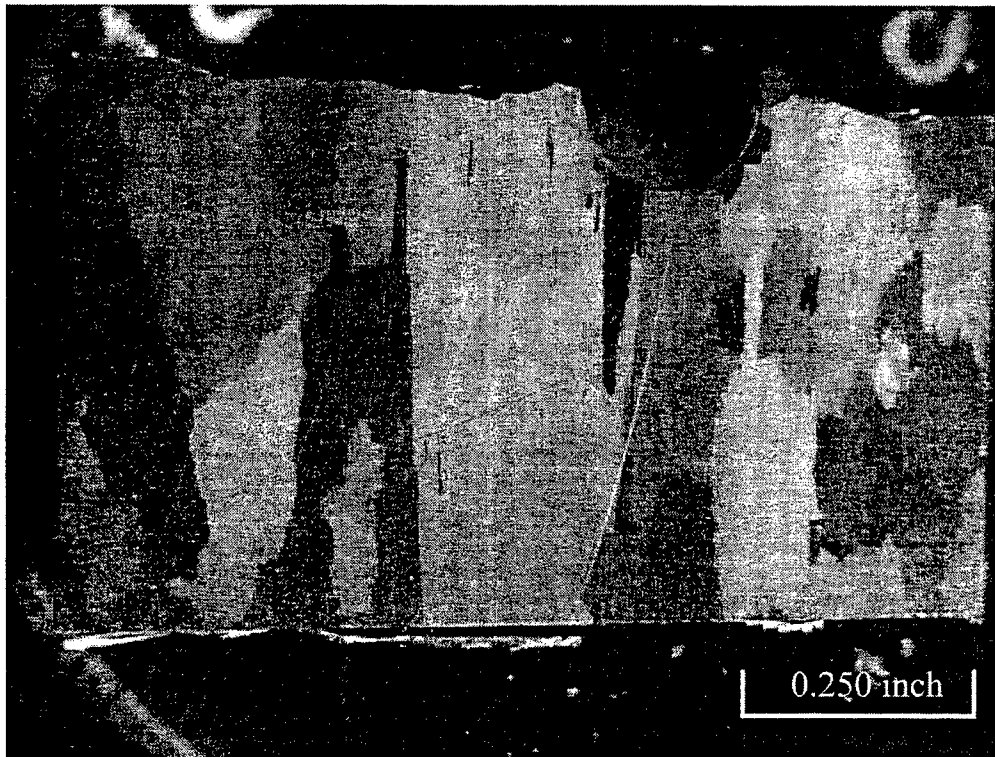


**Total Life = 92.9 kSFH**

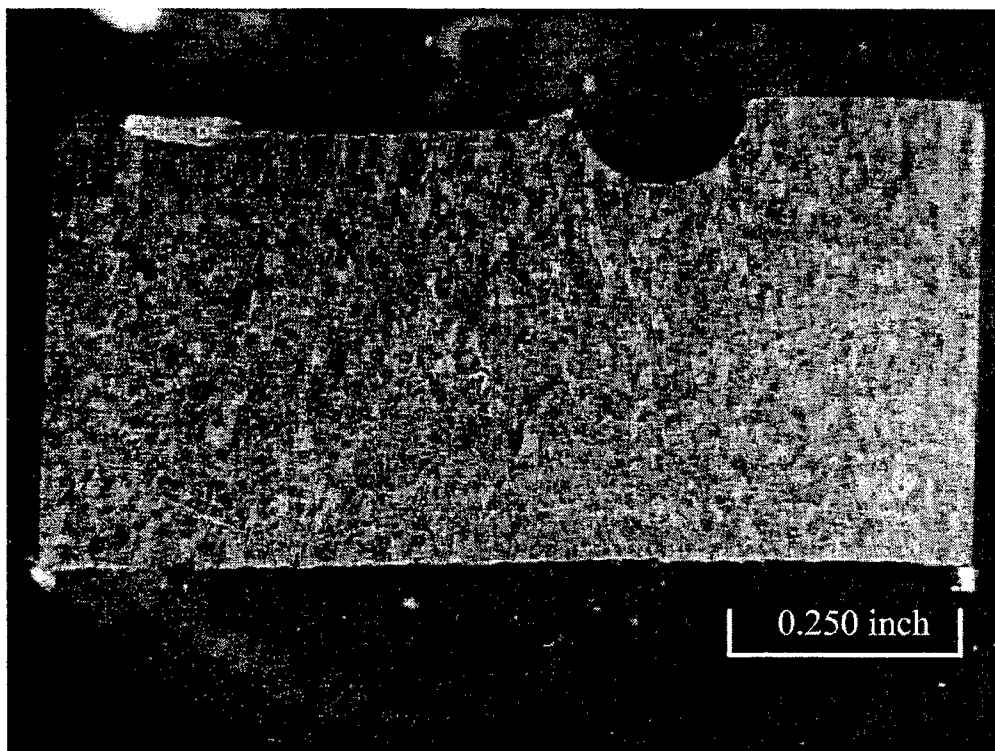
ligament failed at 58.6 kSFH  
reinitiation at 82.6 kSFH

**Test = SS-3**

**Figure F5.4 Summary of Spectrum Crack Growth Testing for the Simple Geometry Coupon**

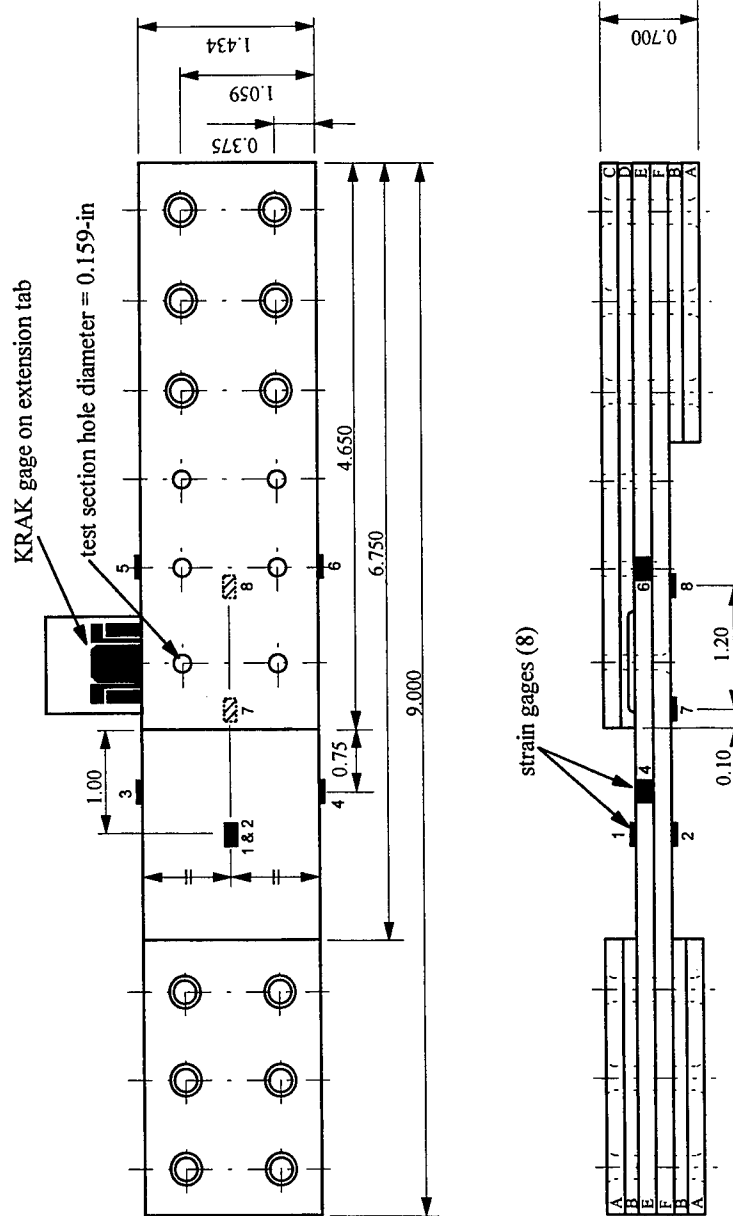


(a)



(b)

**Figure F5.5 Micrographs of the Simple Geometry Coupons Highlighting the Different Grain Structures (a) Test SS-2 and (b) Test SS-3**



Specimen sub-parts (number required per assembly)

- A. loading tabs (0.125-in thick) 3 off
- B. loading tabs (0.100-in thick) 3 off
- C. titanium strap (0.125-in thick) 1 off
- D. titanium strap (0.100-in thick) 1 off
- E. test section - spar angle (0.125-in thick) 1 off
- F. spar lower cap (0.125-in thick) 1 off

|                       |                          |                                                    |                                                        |
|-----------------------|--------------------------|----------------------------------------------------|--------------------------------------------------------|
| Drawn: F. J. McMaster |                          | Southwest Research Institute<br>San Antonio, Texas |                                                        |
| Date: 2 February 1998 |                          | Title: SCG Coupon Geometry - Layout                |                                                        |
| Mater: various        | Basic Dimension: 2 place | Tolerances (inches): Decimals: 3 place             | Fractions: 1/2                                         |
| Finish: 32 rms        | under 6                  | ±0.003                                             | ±1/2                                                   |
| Qty: 4 assys          | 6-24 incl                | ±0.010                                             | ±1/16                                                  |
| Reqt: 4 assys         | over 24 angles           | ±0.025                                             | ±1/6                                                   |
|                       |                          | ±0° 30'                                            | ±1° 0'                                                 |
|                       |                          |                                                    | Scale: *** none ***                                    |
|                       |                          |                                                    | File name: c:\fraser\swr\projects\fairchld\SCGspec.prz |
|                       |                          |                                                    | Sheet 1 of 1                                           |

Figure F5.6 Design for the Complex Geometry Coupon for Spectrum Crack Growth Studies

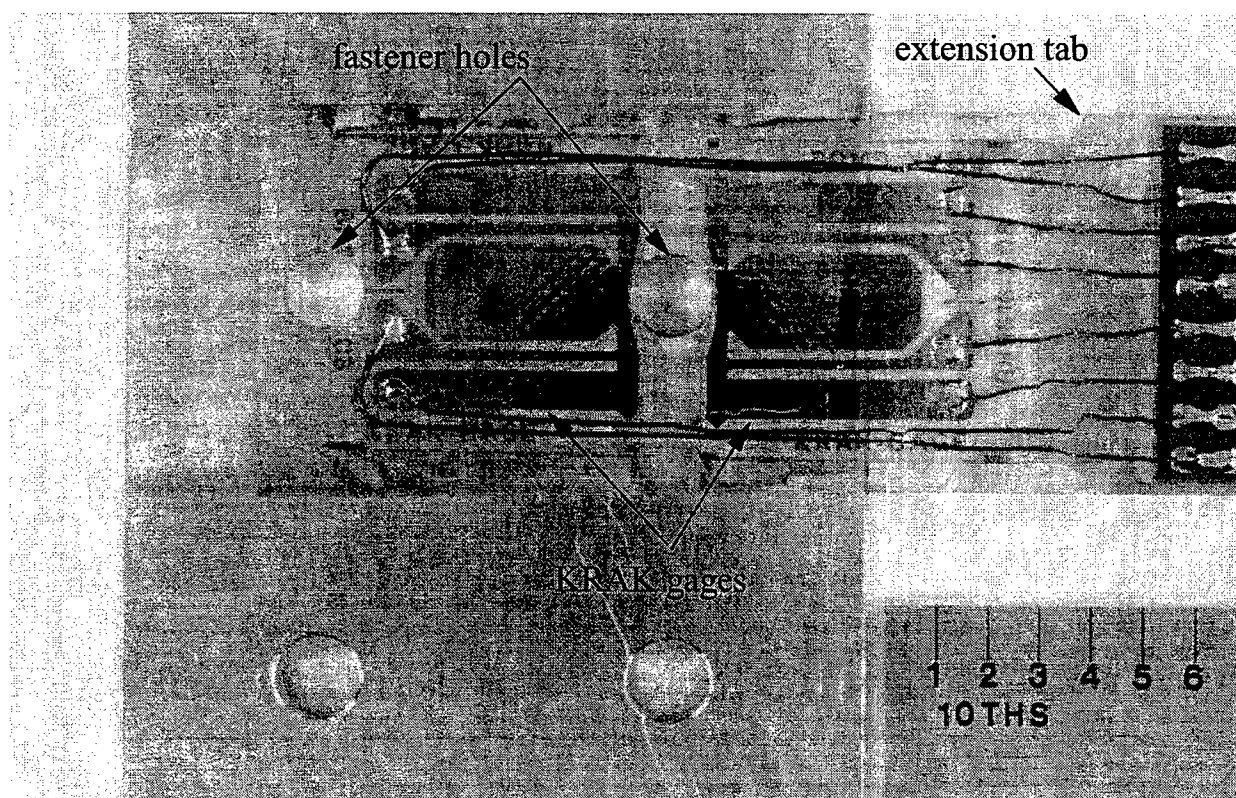
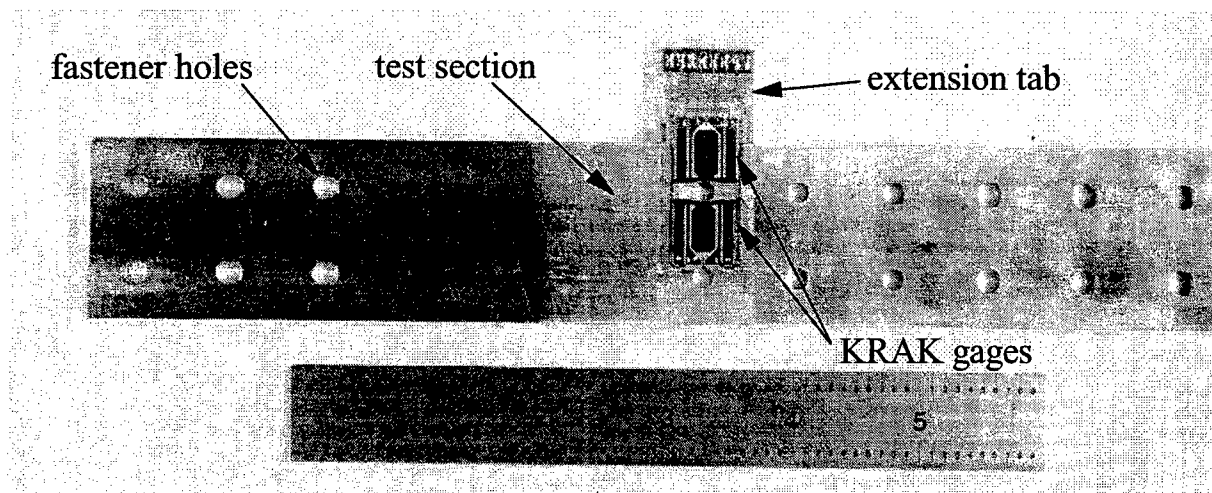


**Figure F5.7 KRAK Gage Details for the Complex Geometry Coupons**

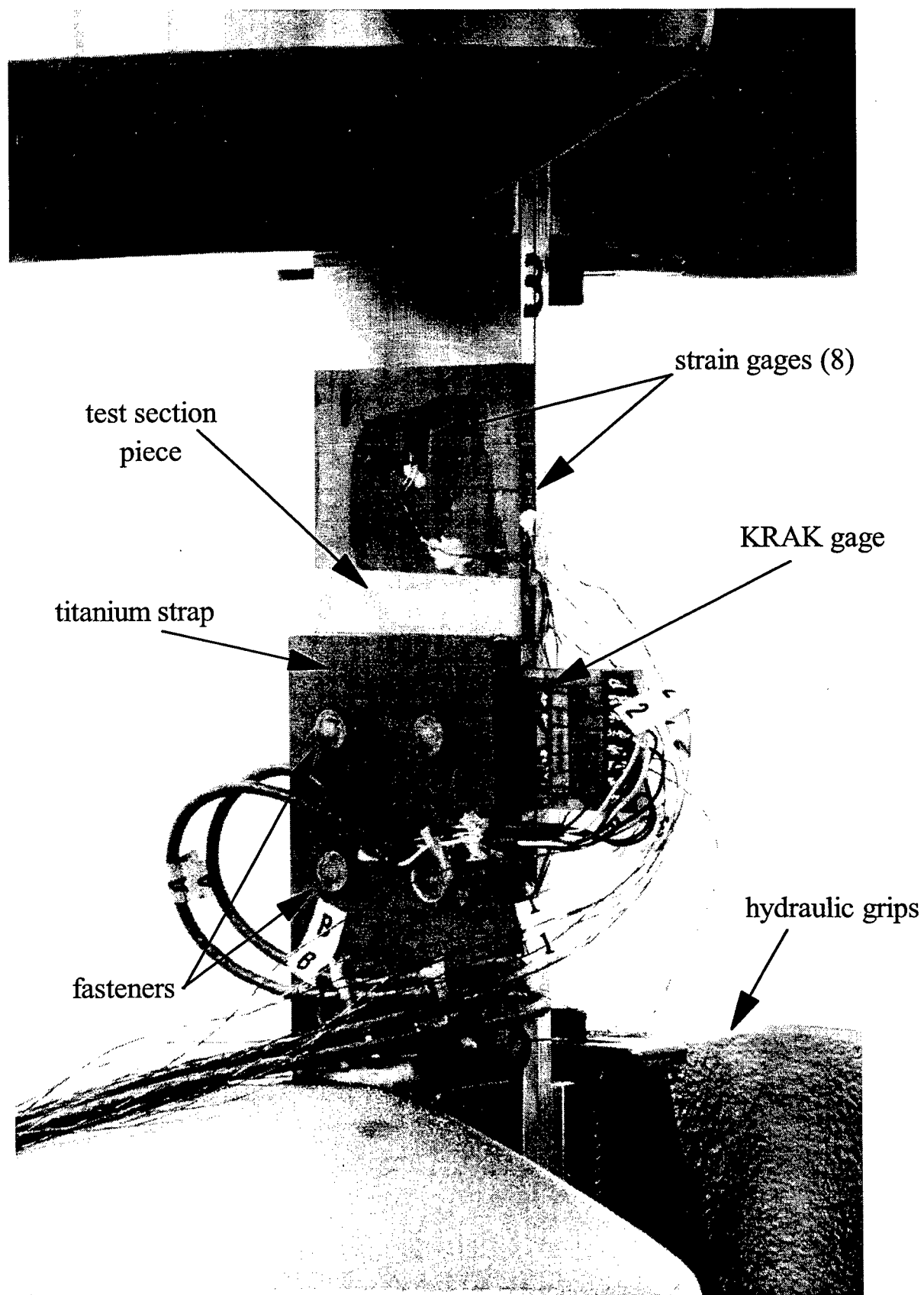


**Figure F5.8 Representative Test Setup for the Complex Geometry Coupon**

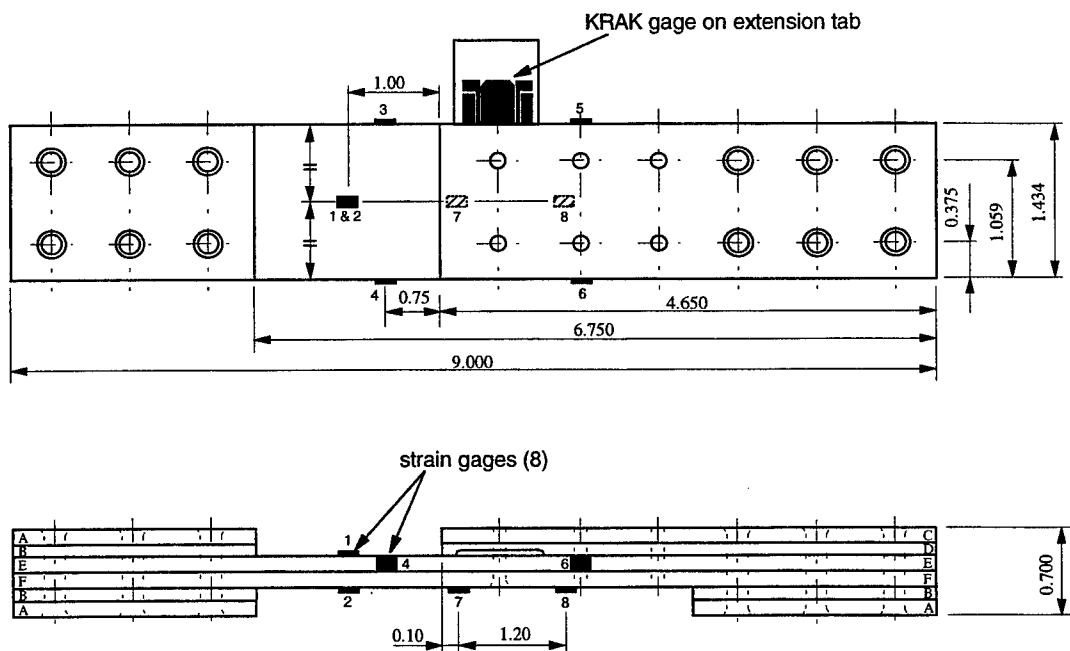
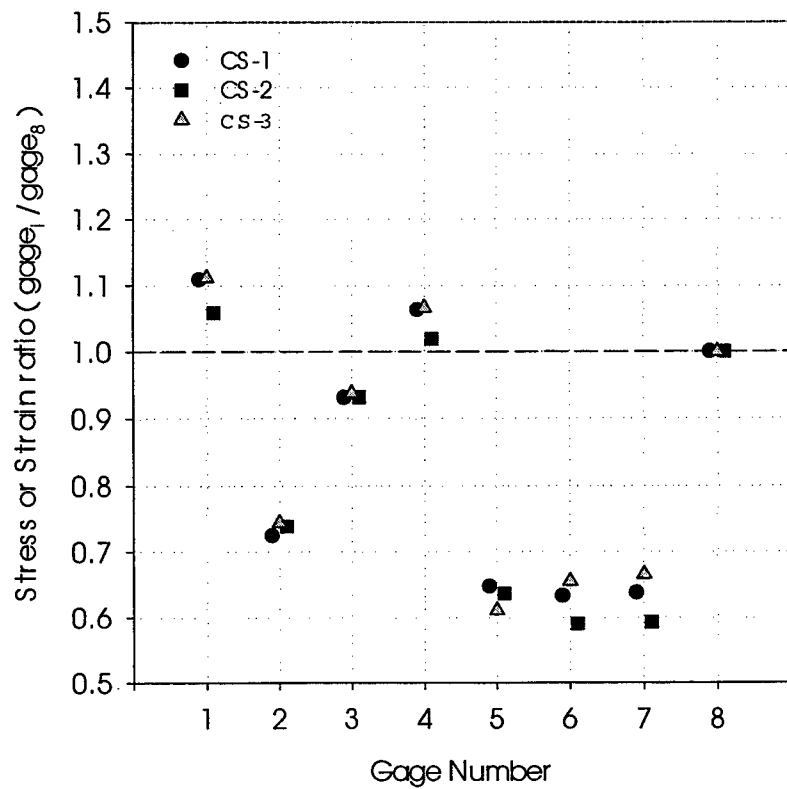


**Figure F5.9 Comparison of Initial Strain Gage Readings, Normalized with Respect to Strain Gage 8**

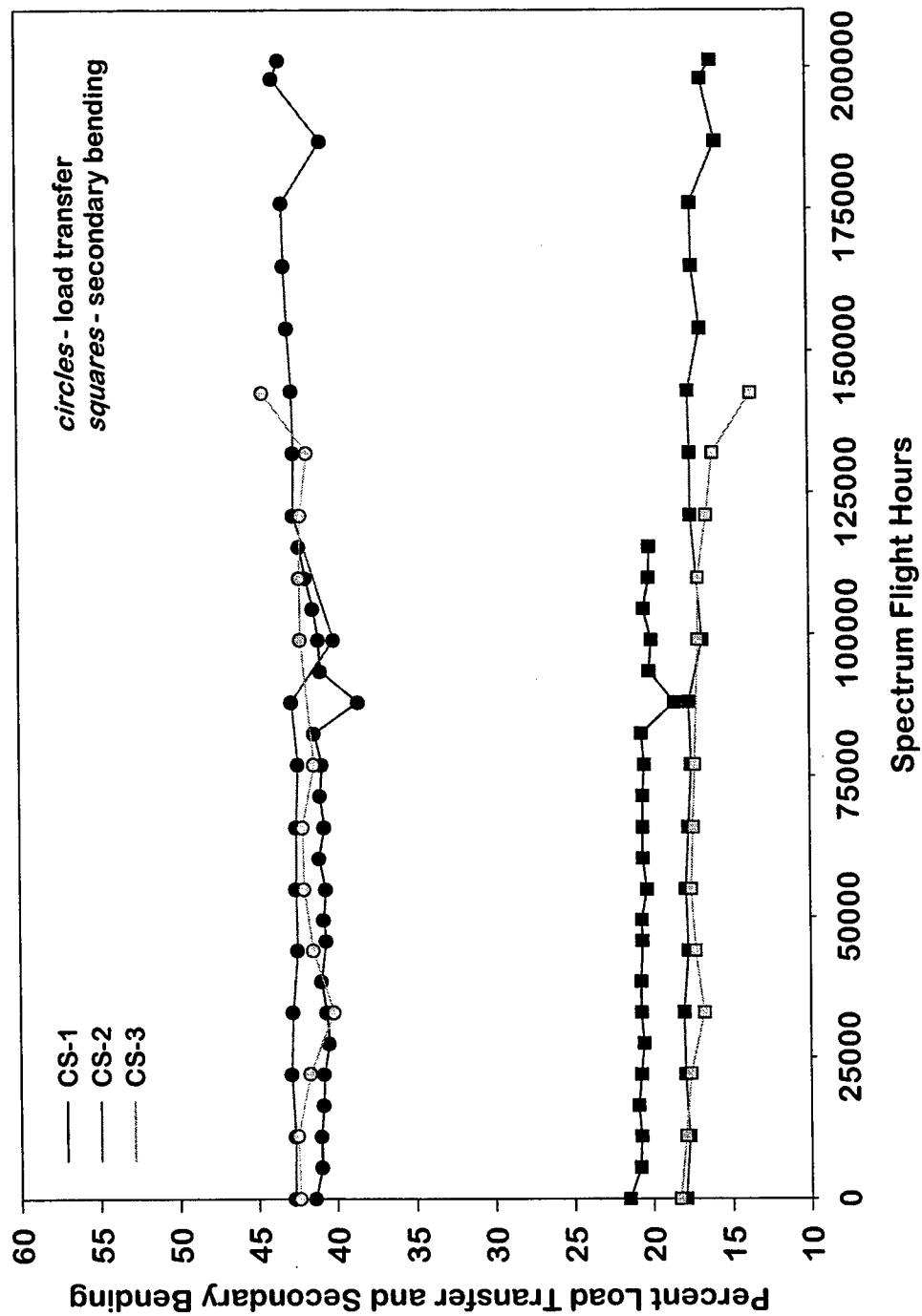


Figure F5.10 Percent Load Transfer and Secondary Bending for All Three Complex Geometry Tests

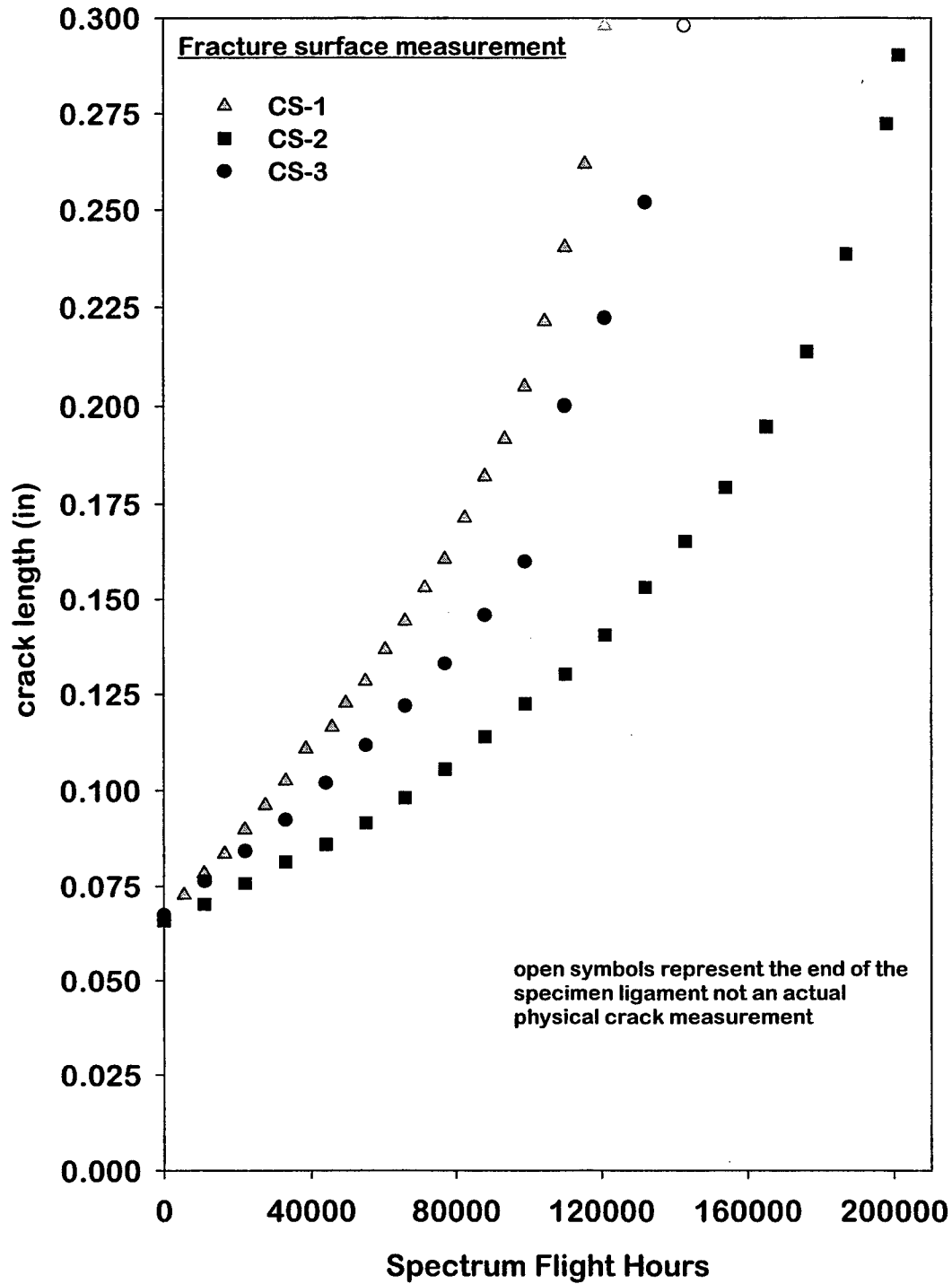


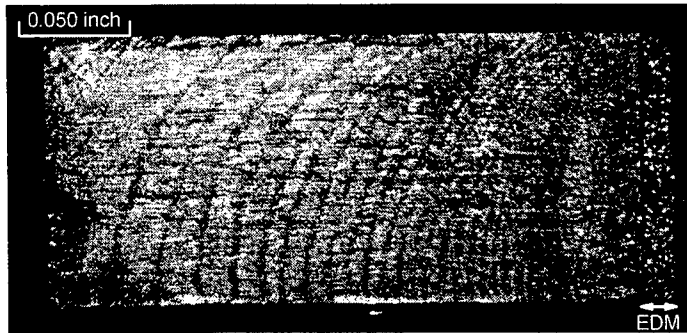
Figure F5.11 Summary of All SCG Tests Performed on the Complex Coupon Geometry

### SUMMARY OF SPECTRUM PARAMETERS

| Cycles per<br>550 SFH | Load levels (lbs) |         | Comments                     |
|-----------------------|-------------------|---------|------------------------------|
|                       | Minimum           | Maximum |                              |
| 14076                 | -4380             | 4520    | offset hole (built-up joint) |

### FRACTURE SURFACES

**Test = CS-3**  
**MILESTONES**



**Test = CS-1**

**Test terminated = 121.0 kSFH**



**Test = CS-2**

**Test terminated = 201.2 kSFH**



**Test terminated = 142.7 kSFH**

**Figure F5.12 Summary of Spectrum Crack Growth Testing for the Simple Geometry Coupon**

## F6.0 ANALYSIS OF COUPON TESTS

Crack growth analyses of the simple and complex coupon spectrum tests were performed using NASGRO to determine if FCL W1 exhibited any effects of load interaction (retardation) and to assess the general validity of the NASGRO crack growth analysis model (Figure 6-1) used for the DTA of this location. This section presents the results of these analyses and compares them to the data obtained in the coupon tests. For reference, Appendix G3 provides listings of the batch data files and the spectrum files used in the NASGRO analyses.

### F6.1 CRACK GROWTH RELATIONSHIP

The crack growth equation used in the NASGRO software [F3] is:

$$\frac{da}{dN} = \frac{C (1-f)^n \Delta K^n \left(1 - \frac{\Delta K_{th}}{\Delta K}\right)^p}{(1-R)^n \left(1 - \frac{\Delta K}{(1-K_c)}\right)^q} \quad (6)$$

where  $N$  is the number of applied fatigue cycles,  $a$  is the crack length,  $R$  is the stress ratio,  $\Delta K$  is the stress intensity factor range, and  $C$ ,  $n$ ,  $p$ , and  $q$  are parameters obtained from the curve fit to the empirical data, see Figure F3.9. The threshold intensity factor range,  $\Delta K_{th}$  is approximated in NASGRO as a function of the threshold intensity factor range at  $R = 0$ , defined as  $\Delta K_0$ .  $K_c$  is the thickness dependent fracture toughness of the material. The function  $f$  allows for the use of a crack closure model. Using this NASGRO crack growth equation, analytical comparisons were made to the coupon spectrum crack growth data and demonstrated that very good predictions were possible without the use of a retardation or closure model.

Based on the fatigue crack growth data generated in this program (Section F3.4) and the data contained in the NASGRO material properties database, the following parameters were used in the crack growth analyses of the 2014-T6511 aluminum extrusion coupon material:

$$C = 2.0E-09$$

$$n = 3.70$$

$$p = 0.50$$

$$q = 1.00$$

$$\Delta K_0 = 2.70 \text{ ksi}\sqrt{\text{in}}$$

$$K_c = 51.8 \text{ ksi}\sqrt{\text{in}}$$

### F6.2 SIMPLE COUPON ANALYSIS RESULTS

The results of the simple coupon crack growth analysis are plotted against the measured crack growth data for coupon SS-3 in Figure F6.2 demonstrating excellent agreement between analysis and test. This good level of agreement was obtained without using a retardation model and without using the closure model contained in NASGRO. Therefore, it can be concluded that load

test results obtained from coupon SS-2 were deemed anomalous due to the microstructural differences discussed in Section F5.2.3 and were not used for comparison.

### F6.3 COMPLEX COUPON ANALYSIS RESULTS

The results of the complex coupon crack growth analysis are plotted against the measured crack growth data from coupons CS-1, 2 and 3 in Figure F6.3. Excellent agreement is demonstrated between analysis and test for the shortest lived test results (CS-1 and CS-3) without the use of a retardation or closure model.

The analysis of the complex coupon geometry using the NASGRO TC03 model considers only in-plane tension and pin loads and does not account for the bending that actually occurred in the test specimen. Hence, this through-crack model uses a straight crack front. The curved crack fronts shown in Figure F5.12 and the strain gage measurements shown in Figure F5.9 are indicative of the amount of bending that was present in the complex coupon as a result of the shift in the neutral axis caused by the titanium straps. The crack growth test data plotted in Figure F6.3 are those measured at the point of maximum crack length (along the lower sides of the specimens in the photographs in Figure F5.12). Thus, the comparison shown in Figure F6.3 is actually a comparison between the maximum measured crack lengths and predicted (straight front) through-crack lengths. This analysis approach is conservative in terms of life since the largest crack size is used in the model representing a straight crack front.

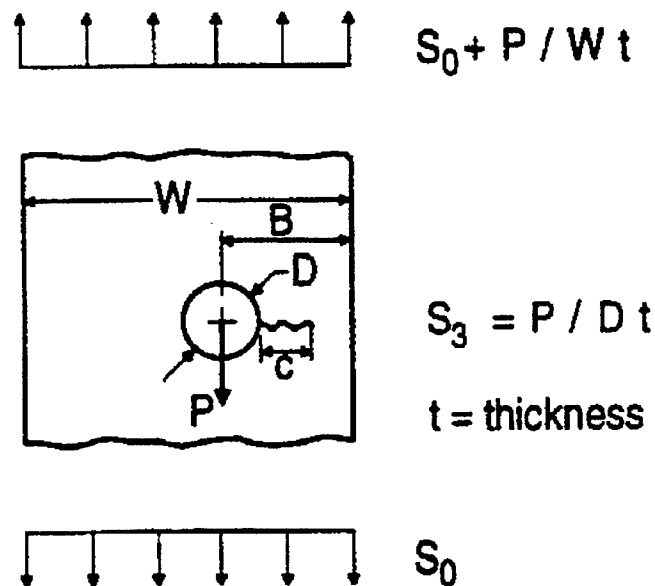


Figure F6.1 NASGRO Model TC03 for a Through-Crack From an Offset Hole in a Plate

**FCL W1 Simple Coupon Analysis  
2014-T6511**

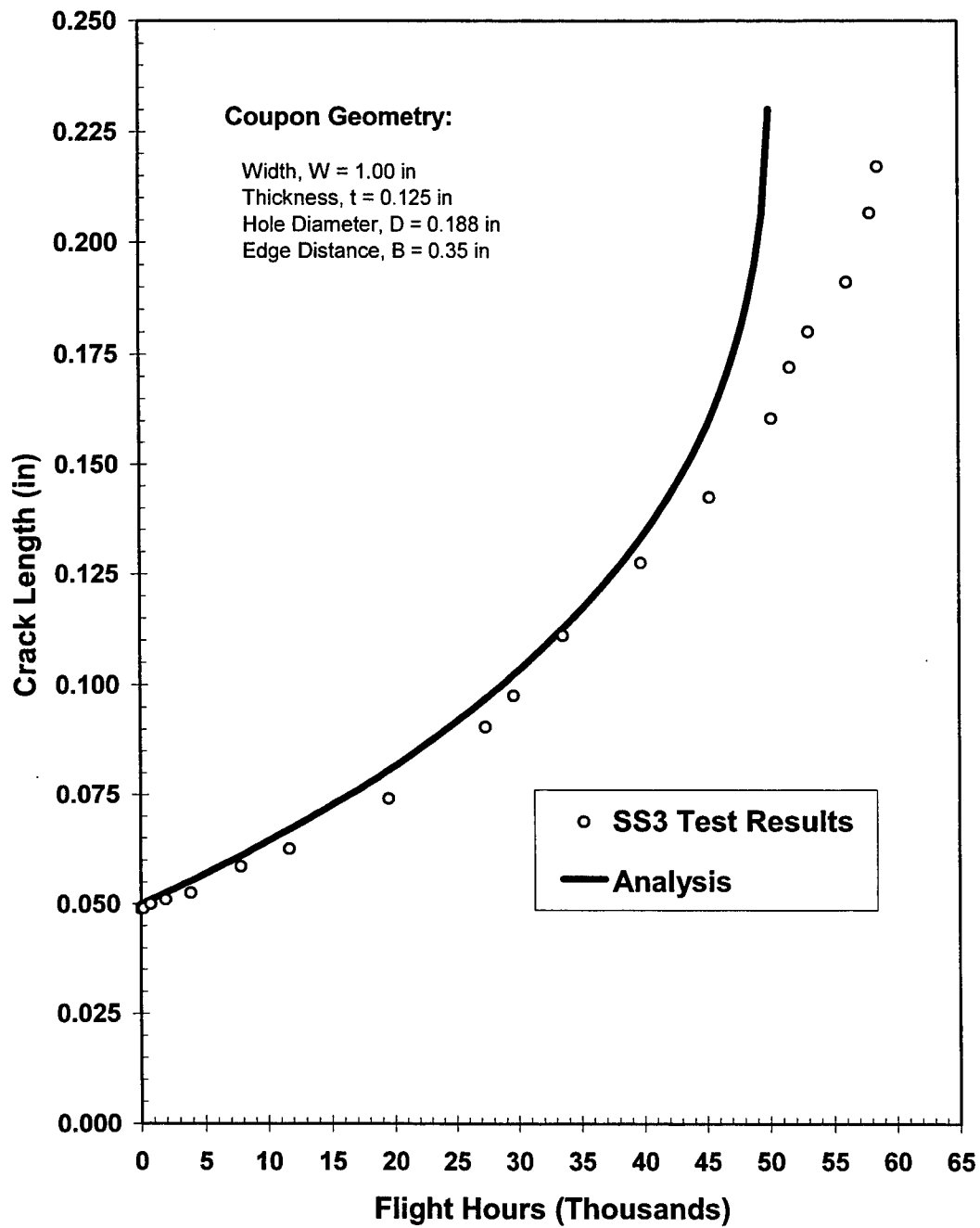


**Figure F6.2 Comparison of Analysis Results with Coupon Test Results for the Simple FCL W1 Coupon Geometry**

**FCL W1 Complex Coupon Analysis  
2014-T6511**

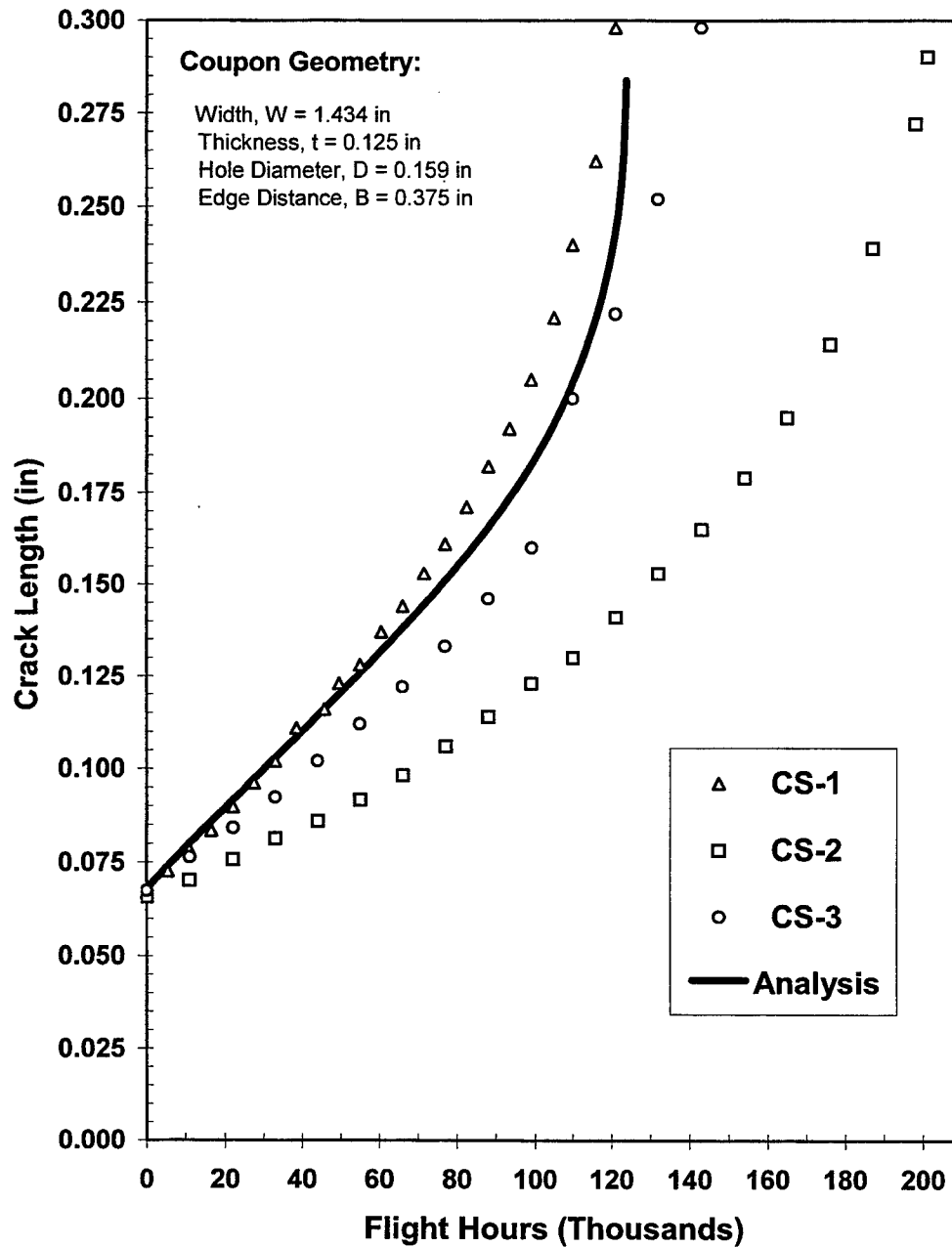


**Figure F6.3 Comparison of Analysis Results With Coupon Test Results for the Complex FCL W1 Coupon Geometry**

## **F7.0 RECOMMENDATIONS FOR DTA**

Using the crack growth material properties generated in this program and the NASGRO TC03 fracture mechanics model, it was possible to accurately predict the results of both the simple and complex coupons representing FCL W1. These predictions were made without the need for invoking a retardation model indicating that load interaction effects for FCL W1 under this spectrum are not significant. These favorable results provide confidence in using the NASGRO software and these material properties in the DTA of the 2014-T6511 wing spar components on the SA226/SA227 aircraft. However, it is important to emphasize that the spectra developed for the analysis of the simple and complex coupons were specifically developed to conduct and analyze the coupon tests and should not be used for the final DTA. The original analysis spectrum should be used in the DTA.

These coupon tests and the subsequent crack growth analyses were conducted assuming the existence of a through-thickness flaw emanating from the fastener hole at FCL W1. In the DTA, additional life could be demonstrated by beginning the analyses assuming that the initial flaw was a quarter-circular corner crack having a radius of 0.05 inch. Such an analysis would be performed using NASGRO model CC02 for a corner crack growing from an offset hole in a plate. The assumption of an initial corner crack would be consistent with the recommendations made in the USAF Damage Tolerant Design Handbook [F10]. This initial flaw shape and size philosophy is also echoed in the FAA Damage Tolerance Assessment Handbook [F11].

In addition to the assumption of an initial corner crack, the DTA could also make use of the continuing damage concept where additional life beyond the failure of the short ligament is computed assuming the crack initiates on the opposite side of the hole. This analysis procedure, which is also documented in References [F10] and [F11], could be used in conjunction with a model that accounts for load redistribution into the adjacent spar structure to demonstrate additional life beyond that computed using simply NASGRO models TC03 or CC02.

## F8.0 REFERENCES

- F1. Dwyer, W., "Development of a Supplemental Inspection Document for SA226/SA227 Aircraft, Interim Report I," Report No. R1517, Fairchild Aircraft, May 1997.
- F2. Brooks, C.L., "An Engineering Procedure to Select and Prioritize Component Evaluation under USAF Structural Integrity Requirements," McDonnell Aircraft Company, McDonnell Douglas Corporation, 1990.
- F3. Forman, R.G., et al., "Fatigue Crack Growth Computer Program NASGRO," Version 2.03, JSC-22267A, NASA-JSC, May 1994.
- F4. Annual Book of ASTM Standards, Section 3: Metals Test Methods and Analytical Procedures, Vol. 3.01 Metals – Mechanical Testing; Elevated and Low-Temperature Tests; Metallography, 1997.
- F5. Piascik, R.S. and Newman, Jr., J.C., "An Extended Compact Tension Specimen for Fatigue Crack Growth and Fracture Testing," *International Journal of Fracture*, Vol. 76, pp. R43-R48, 1996.
- F6. Military Handbook: Metallic Materials and Elements for Aerospace Vehicle Structures, MIL-HNDBK-5G, United States Department of Defense, Wright-Patterson AFB, November 1994.
- F7. Donald, J.K. and Schmidt, D.W., "Computer-Controlled Stress Intensity Gradient Technique for High Rate Fatigue Crack Growth Testing," *Journal of Testing and Evaluation, JTEVA*, Vol. 8, No. 1, pp. 19-24, 1980.
- F8. McKeighan, P.C. and Smith, D.J., "Determining the Potential Drop Calibration of a Fatigue Crack Growth Specimen Subjected to Limited Experimental Observations," *Journal of Testing and Evaluation, JTEVA*, Vol. 22, No. 4, pp. 291-301, 1994.
- F9. Donald, J.K. and Ruschau, J., "Direct Current Potential Difference Crack Length Measurement Techniques," from *Fatigue Crack Measurement: Techniques and Applications*, K.J. Marsh, R.O. Ritchie, and R.A. Smith, Eds., EMAS, 1990.
- F10. Gallagher, J.P., et al., "USAF Damage Tolerant Design Handbook," AFWAL-TR-82-3073, May 1984.
- F11. Damage Tolerance Assessment Handbook, Vols. I and II, DOT-VNTSC-FAA-93-13.I, October 1993.

## APPENDIX G

### Testing and Analysis for DTA of Fairchild SA226 Main Wing Spar Lower Cap at WS99

FINAL REPORT  
SwRI Project No. 06-8520

*prepared by*

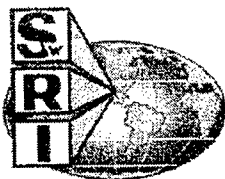
Joseph W. Cardinal  
Fraser J. McMaster  
Peter C. McKeighan

*prepared for*

Fairchild Aircraft, Inc.  
San Antonio, Texas

January 1999

APPROVED:



  
Hal Burnside, Ph.D., P.E., Director  
Structural Engineering Department

**APPENDIX G TESTING AND ANALYSIS FOR DTA OF FAIRCHILD  
SA226 MAIN WING SPAR LOWER CAP AT WS 99**

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| G2    Spectrum Crack Growth Tests .....         | G2-1        |
| G3    Crack Growth Analysis Data Files .....    | G3-1        |

## **APPENDIX G1**

### **Material Characterization Properties**

Data:       Tensile Test Results  
              Fracture Toughness Results  
              Fatigue Crack Growth Results

Contents:    Tensile Tests

- Data Sheet for each Test

              Fracture Tests

- Load versus Displacement (CMOD) Response
- Analysis of Test Data

              Fatigue Crack Growth Tests

- Crack Growth Plots (R-ratio)
- Crack Growth Plots (individual tests)
- Test Conditions
- Tabulated Data

### **Tensil Tests**

7 tests:        TE-1 to -4  
                  TA-1 to -3

RECEIVED  
ACCTS PAID



CHARLES C. KAWIN COMPANY  
METALLURGICAL LABORATORIES

97 NOV 24 MAILING ADDRESS / P.O. BOX 310 / MAYWOOD, ILLINOIS 60153

SOUTHWEST RESEARCH INST. 7010  
6220 CULEBRA RD  
P. O. DRAWER 28510  
SAN ANTONIO TX 78284  
FRASER MCMASTER

P. O. # 50138

DESCR 2014-T6511 ALUMINUM  
EXTRUSION

REPORT DATE: 11/17/97

LAB NO: 1110-076 / 01

JOB NO:

SAMPLE TE-1

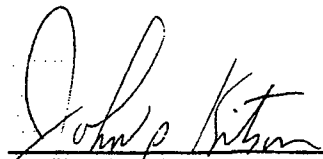
#### MECHANICAL TESTING RESULTS

|                     |             |                             |
|---------------------|-------------|-----------------------------|
| THKNS: .130         | WIDTH: .505 | AREA: .0657                 |
| YIELD STRENGTH: lbs | 3,984.      | YIELD STRENGTH psi : 60,685 |
| ULT STRENGTH: lbs   | 4,359.      | TENSILE psi : 66,398        |
| ELONG ON 2.00 IN.   | .20         | ELONGATION % : 10.00        |
|                     |             | REDUCTION OF AREA % : 24.21 |

YIELD STRENGTH BY EXTENSOMETER 0.2% OFFSET

TEST METHODS: ASTM B557 ;

MODULUS OF ELASTICITY - 10,450,000 PSI

  
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PAGE 1 OF 7

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SAN ANTONIO TX 78284  
FRASER MCMASTER

P.O. # 50138

DESCR 2014-T6511 ALUMINUM  
EXTRUSION

REPORT DATE: 11/17/97

=====

LAB NO: 1110-076 / 02

=====

JOB NO:

SAMPLE TE-2

MECHANICAL TESTING RESULTS

THKNS: .131 WIDTH: .505

YIELD STRENGTH: lbs

4,116.

ULT STRENGTH: lbs

4,420.

ELONG ON 2.00 IN.

.21

AREA:

.0662

YIELD STRENGTH psi :

62,218

TENSILE psi :

66,813

ELONGATION % :

10.50

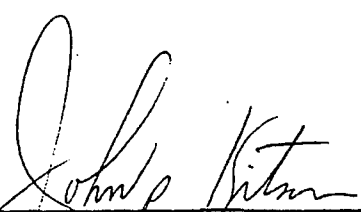
REDUCTION OF AREA % :

27.01

YIELD STRENGTH BY EXTENSOMETER 0.2% OFFSET

TEST METHODS: ASTM B557 ;

MODULUS OF ELASTICITY - 10,750,000

  
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DESCR 2014-T6511 ALUMINUM  
EXTRUSION

REPORT DATE: 11/17/97

LAB NO: 1110-076 / 03

JOB NO:

SAMPLE TE-3

### MECHANICAL TESTING RESULTS

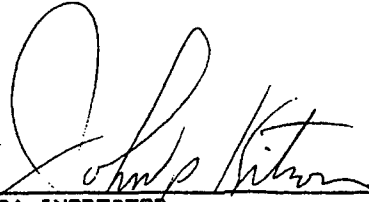
THKNS: .129 WIDTH: .502  
YIELD STRENGTH: lbs 3,960.  
ULT STRENGTH: lbs 4,266.  
ELONG ON 2.00 IN. .22

AREA: .0646  
YIELD STRENGTH psi : 61,151  
TENSILE psi : 65,876  
ELONGATION % : 11.00  
REDUCTION OF AREA % : 23.05

YIELD STRENGTH BY EXTENSOMETER 0.2% OFFSET

TEST METHODS: ASTM B557

MODULUS OF ELASTICITY - 10,730,000 PSI

  
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PAGE 3 OF 7

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DESCR 2014-T6511 ALUMINUM  
EXTRUSION

REPORT DATE: 11/17/97

LAB NO: 1110-076 / 04

JOB NO:

SAMPLE TE-4

### MECHANICAL TESTING RESULTS

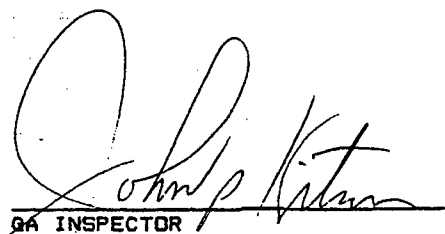
THKNS: .130 WIDTH: .505  
YIELD STRENGTH: lbs 3,660.  
ULT STRENGTH: lbs 4,354.  
ELONG ON 2.00 IN. .23

AREA: .0657  
YIELD STRENGTH psi : 55,750  
TENSILE psi : 66,321  
ELONGATION % : 11.50  
REDUCTION OF AREA % : 29.24

YIELD STRENGTH BY EXTENSOMETER 0.2% OFFSET

TEST METHODS: ASTM B557 ;

MODULUS OF ELASTICITY - 10,930,000 PSI

  
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PAGE 4 OF 7

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REPORT DATE: 11/17/97

LAB NO: 1110-076 / 05

JOB NO:

SAMPLE TA-1

### MECHANICAL TESTING RESULTS

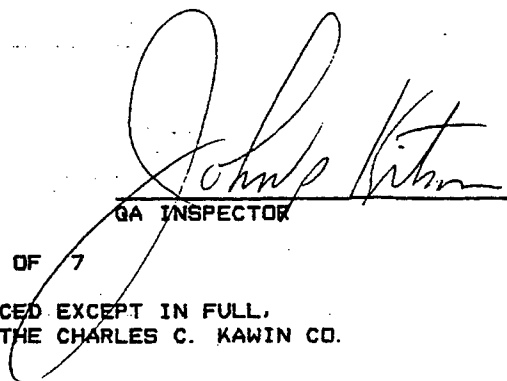
THKNS: .127 WIDTH: .502  
YIELD STRENGTH: lbs 3,936.  
ULT STRENGTH: lbs 4,181.  
ELONG ON 2.00 IN. .20

AREA: .0638  
YIELD STRENGTH psi : 61,737  
TENSILE psi : 65,580  
ELONGATION % : 10.00  
REDUCTION OF AREA % : 20.59

FIELD STRENGTH BY EXTENSOMETER 0.2% OFFSET

TEST METHODS: ASTM B557 ;

MODULUS OF ELASTICITY - 11,740,000 PSI

  
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REPORT DATE: 11/17/97

LAB NO: 1110-076 / 06

JOB NO:

SAMPLE TA-2

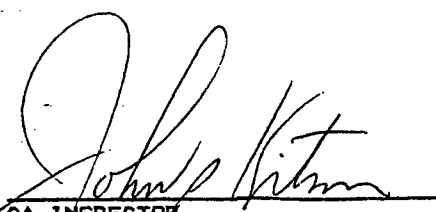
### MECHANICAL TESTING RESULTS

|                     |             |                             |
|---------------------|-------------|-----------------------------|
| THKNS: .125         | WIDTH: .501 | AREA: .062                  |
| YIELD STRENGTH: lbs | 3,840.      | YIELD STRENGTH psi : 61,317 |
| ULT STRENGTH: lbs   | 4,095.      | TENSILE psi : 65,389        |
| ELONG ON 2.00 IN.   | .21         | ELONGATION % : 10.50        |
|                     |             | REDUCTION OF AREA % : 25.49 |

FIELD STRENGTH BY EXTENSOMETER 0.2% OFFSET

TEST METHODS: ASTM B557

MODULUS OF ELASTICITY - 11,250,000 PSI

  
QA INSPECTOR

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FRASER MCMASTER

P. O. # 50138

DESCR 2014-T6511 ALUMINUM  
EXTRUSION

REPORT DATE: 11/17/97

LAB NO: 1110-076 / 07

JOB NO:

SAMPLE TA-3

#### MECHANICAL TESTING RESULTS

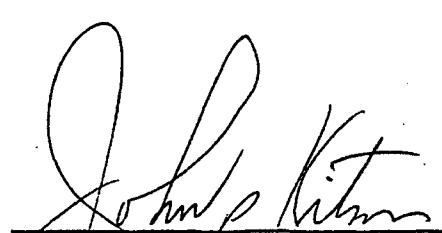
THKNS: .127 WIDTH: .506  
YIELD STRENGTH: lbs 3,990.  
ULT STRENGTH: lbs 4,171.  
ELONG ON 2.00 IN. : .22

AREA: .064:  
YIELD STRENGTH psi : 62,090  
TENSILE psi : 64,906  
ELONGATION % : 11.00  
REDUCTION OF AREA % : 33.37

FIELD STRENGTH BY EXTENSOMETER 0.2% OFFSET

TEST METHODS: ASTM B557 ;

MODULUS OF ELASTICITY - 11,034,000 PSI

  
G. A. INSPECTOR

PAGE 7 OF 7

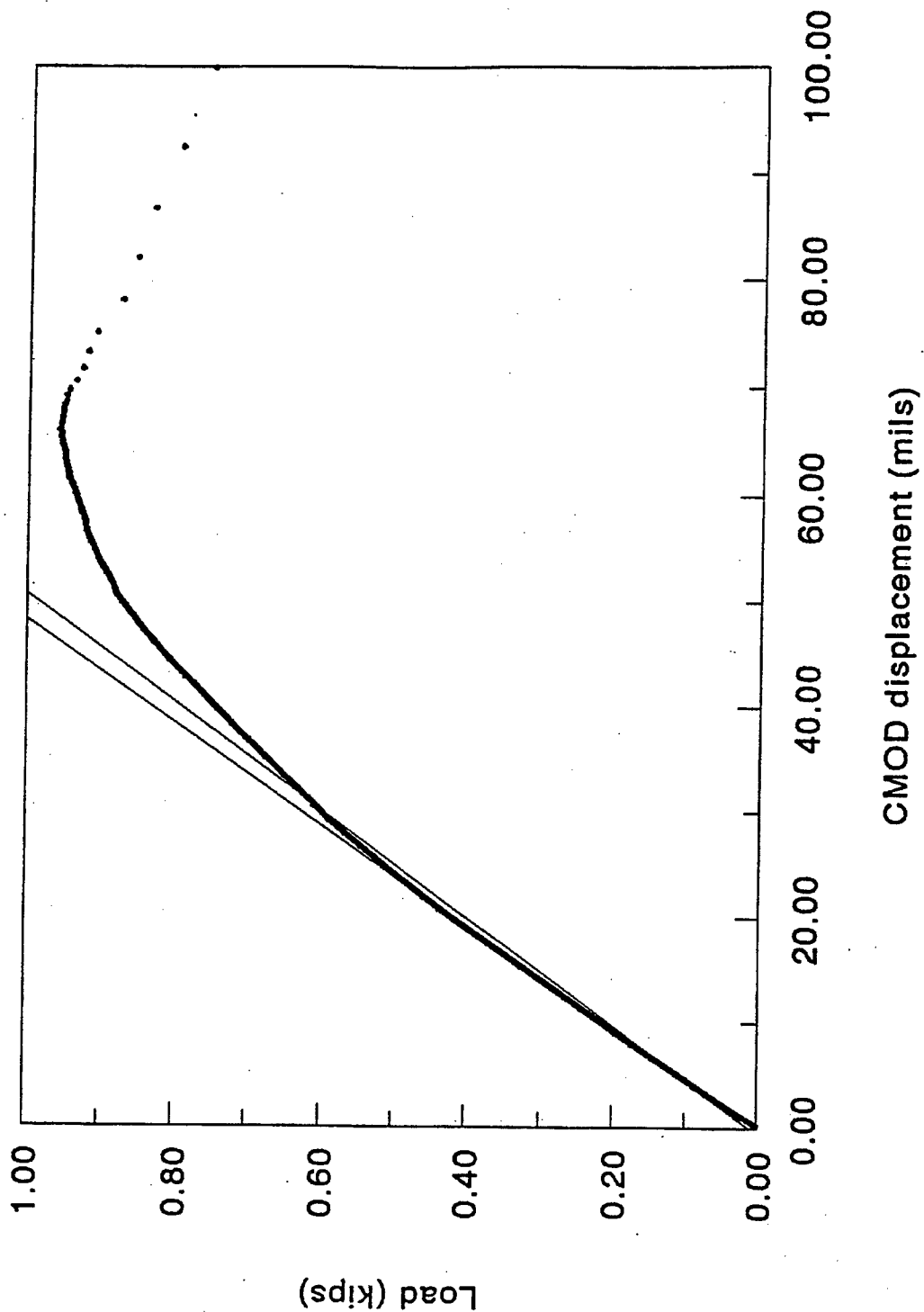
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### **Fracture Toughness Tests**

4 tests: FC-1 to -4

# Fairchild DTA

FC1



\*\*\*\*\* KIC DIGITAL DATA ANALYZER \*\*\*\*\*  
Version 3.0

TEST: Fairchild  
PROJ: 06-8520  
SPEC: fc1]

SPECIMEN/MATERIAL PROPERTIES:

Width W = 2.001 in  
Thickness B = .121 in  
Crack Length = 1.019 in  
Youngs Modulus = 11.000 10<sup>3</sup> ksi  
Yield Strength = 60.700 ksi

I/O PARAMETERS:

Analysis File = fc1.txt  
Data/Plot File = fc1.asc  
Input Data File = fc1.dat  
Header = 3 rows  
Data = 2 cols  
LOAD: Col 1 with .200 kips/volt  
CMOD: Col 2 with 10.000 mil/volt and Offset = .37 mil

=== INPUT DATA SCAN ===

Total Points = 3502  
Pmax = .958 kips imax = 3479  
Pmean = .494 kips  
Pmin = .000 kips imin = 3  
  
CMODmax = 99.883 mil  
CMODmean = 26.279 mil  
CMODmin = .273 mil

=== LINEARITY SUMMARY ===

Offset based on 20.0%-40.0% slope  
Compliance = 48.624 mil/kip  
Stan. Dev. = .02022

| SEG | Pt Range   | # PTS | % LOAD       | Std    | SL OFF % |
|-----|------------|-------|--------------|--------|----------|
| 1   | 3107 -3479 | 373   | 90.0 - 100.0 | .71673 | 247.5    |
| 2   | 3020 -3380 | 361   | 87.5 - 97.5  | .50598 | 164.7    |
| 3   | 2931 -3288 | 358   | 85.0 - 95.0  | .32137 | 109.2    |
| 4   | 2842 -3199 | 358   | 82.5 - 92.5  | .15681 | 74.7     |
| 5   | 2753 -3107 | 355   | 80.0 - 90.0  | .10095 | 57.8     |
| 6   | 2663 -3020 | 358   | 77.5 - 87.5  | .05437 | 48.9     |
| 7   | 2573 -2931 | 359   | 75.0 - 85.0  | .02703 | 45.5     |
| 8   | 2483 -2842 | 360   | 72.5 - 82.5  | .02567 | 45.8     |
| 9   | 2392 -2753 | 362   | 70.0 - 80.0  | .03266 | 44.0     |
| 10  | 2307 -2663 | 357   | 67.5 - 77.5  | .02993 | 41.6     |
| 11  | 2217 -2573 | 357   | 64.9 - 75.0  | .02578 | 38.7     |
| 12  | 2131 -2483 | 353   | 62.5 - 72.5  | .02849 | 38.1     |
| 13  | 2041 -2392 | 352   | 60.0 - 70.0  | .03847 | 38.7     |
| 14  | 1952 -2307 | 356   | 57.5 - 67.5  | .07515 | 34.1     |
| 15  | 1863 -2217 | 355   | 55.0 - 64.9  | .08702 | 25.6     |
| 16  | 1773 -2131 | 359   | 52.5 - 62.5  | .03512 | 17.4     |

|    |      |       |     |      |   |      |        |      |
|----|------|-------|-----|------|---|------|--------|------|
| 17 | 1684 | -2041 | 358 | 50.0 | - | 60.0 | .02281 | 14.5 |
| 18 | 1593 | -1952 | 360 | 47.5 | - | 57.5 | .02499 | 11.9 |
| 19 | 1506 | -1863 | 358 | 45.0 | - | 55.0 | .02599 | 9.3  |
| 20 | 1418 | -1773 | 356 | 42.5 | - | 52.5 | .02230 | 6.7  |
| 21 | 1328 | -1684 | 357 | 40.0 | - | 50.0 | .02076 | 4.9  |
| 22 | 1240 | -1593 | 354 | 37.5 | - | 47.5 | .01556 | 3.5  |
| 23 | 1153 | -1506 | 354 | 35.0 | - | 45.0 | .01509 | 2.5  |
| 24 | 1067 | -1418 | 352 | 32.5 | - | 42.5 | .01410 | 1.7  |
| 25 | 979  | -1328 | 350 | 30.0 | - | 40.0 | .01409 | 1.1  |
| 26 | 893  | -1240 | 348 | 27.5 | - | 37.5 | .01483 | .5   |
| 27 | 804  | -1153 | 350 | 25.0 | - | 35.0 | .01472 | -.1  |
| 28 | 717  | -1067 | 351 | 22.5 | - | 32.5 | .01460 | -.6  |
| 29 | 630  | -979  | 350 | 20.0 | - | 30.0 | .01458 | -1.0 |
| 30 | 544  | -893  | 350 | 17.5 | - | 27.5 | .01438 | -1.5 |
| 31 | 461  | -804  | 344 | 15.0 | - | 25.0 | .01506 | -2.2 |
| 32 | 379  | -717  | 339 | 12.5 | - | 22.5 | .01728 | -3.5 |
| 33 | 295  | -630  | 336 | 10.0 | - | 20.0 | .01533 | -4.7 |
| 34 | 219  | -544  | 326 | 7.5  | - | 17.5 | .01378 | -5.6 |
| 35 | 140  | -461  | 322 | 5.0  | - | 15.0 | .01361 | -5.8 |
| 36 | 71   | -379  | 309 | 2.4  | - | 12.5 | .01732 | -6.6 |

=== LINEAR P-CMOD ANALYSIS ===

Range = 20.0 to 40.0 (% of Pmax)  
 = .191 to .383 (kips)  
 = 630 to 1328 (points)

Compliance = 48.624 mil/kip  
 Intercept = -.475 mil  
 Coef Var = .72

Predicted Crack Length (in):

| Modulus   | 0.9E  | E     | 1.1E  | 1.2E  |
|-----------|-------|-------|-------|-------|
| ACTUAL    |       | 1.019 |       |       |
| PREDICTED | 1.028 | 1.074 | 1.113 | 1.148 |
| PRED:ACT  | 1.009 | 1.054 | 1.092 | 1.127 |

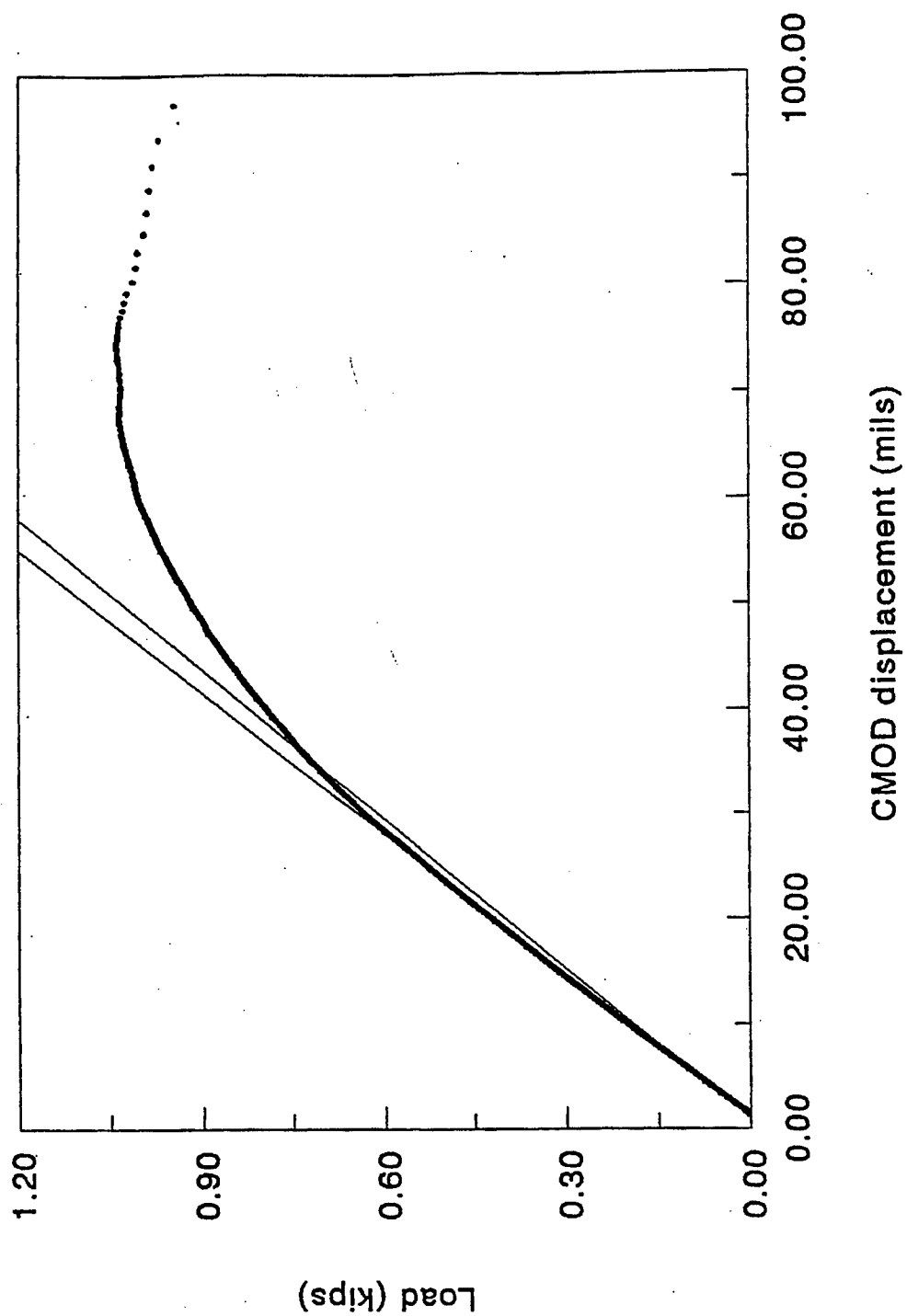
=== TOUGHNESS ANALYSIS ===

Pmax = .958 kips  
 Line Fit:  
     slope = .02057 kips/mil  
     intercept = .00977 kips  
 P5 = .609 kips  
 Pq = .609 kips  
 Kq = 35.380 ksi-in<sup>0.5</sup>

STATUS:

|               |                    |                   |
|---------------|--------------------|-------------------|
| Crack Length  | OK                 |                   |
| Thickness     | INVALID (too thin) |                   |
| Pmax:Pq Ratio | INVALID            | Pmax/Pq= 1.572160 |

# Fairchild DTA FC2



\*\*\*\*\* KIC DIGITAL DATA ANALYZER \*\*\*\*\*  
Version 3.0

TEST: FAIRCHILD  
PROJ: 06-8520  
SPEC: FC2

SPECIMEN/MATERIAL PROPERTIES:

Width W = 1.998 in  
Thickness B = .123 in  
Crack Length = .990 in  
Youngs Modulus = 11.000 10<sup>3</sup> ksi  
Yield Strength = 60.700 ksi

I/O PARAMETERS:

Analysis File = FC2.TXT  
Data/Plot File = FC2.ASC  
Input Data File = FC2.DAT  
Header = 3 rows  
Data = 2 cols  
LOAD: Col 1 with .200 kips/volt  
CMOD: Col 2 with 10.000 mil/volt and Offset = .57 mil

=== INPUT DATA SCAN ===

Total Points = 3592  
Pmax = 1.040 kips imax = 3572  
Pmean = .496 kips  
Pmin = .004 kips imin = 216  
  
CMODmax = 100.563 mil  
CMODmean = 25.924 mil  
CMODmin = 1.515 mil

=== LINEARITY SUMMARY ===

Offset based on 10.0%-50.0% slope  
Compliance = 45.141 mil/kip  
Stan. Dev. = .06371

| SEG | Pt   | Range | # PTS | % LOAD       | Std     | SL OFF % |
|-----|------|-------|-------|--------------|---------|----------|
| 1   | 3218 | -3572 | 355   | 90.0 - 100.0 | 1.52103 | 276.1    |
| 2   | 3134 | -3473 | 340   | 87.5 - 97.5  | .38387  | 162.0    |
| 3   | 3050 | -3384 | 335   | 85.0 - 95.0  | .17129  | 127.1    |
| 4   | 2968 | -3300 | 333   | 82.5 - 92.5  | .10325  | 108.9    |
| 5   | 2884 | -3218 | 335   | 80.0 - 90.0  | .13883  | 93.3     |
| 6   | 2801 | -3134 | 334   | 77.5 - 87.5  | .11239  | 79.1     |
| 7   | 2717 | -3050 | 334   | 75.1 - 85.0  | .06662  | 66.2     |
| 8   | 2634 | -2968 | 335   | 72.6 - 82.5  | .07659  | 57.6     |
| 9   | 2551 | -2884 | 334   | 70.1 - 80.0  | .03619  | 51.7     |
| 10  | 2468 | -2801 | 334   | 67.6 - 77.5  | .05242  | 47.8     |
| 11  | 2384 | -2717 | 334   | 65.1 - 75.1  | .06766  | 42.6     |
| 12  | 2302 | -2634 | 333   | 62.6 - 72.6  | .05851  | 35.3     |
| 13  | 2217 | -2551 | 335   | 60.1 - 70.1  | .03468  | 30.7     |
| 14  | 2134 | -2468 | 335   | 57.6 - 67.6  | .05790  | 24.9     |
| 15  | 2052 | -2384 | 333   | 55.1 - 65.1  | .07628  | 16.7     |
| 16  | 1969 | -2302 | 334   | 52.6 - 62.6  | .05721  | 8.2      |

|    |      |       |     |      |   |      |        |      |
|----|------|-------|-----|------|---|------|--------|------|
| 17 | 1888 | -2217 | 330 | 50.2 | - | 60.1 | .02388 | 4.4  |
| 18 | 1802 | -2134 | 333 | 47.7 | - | 57.6 | .01928 | 4.5  |
| 19 | 1720 | -2052 | 333 | 45.2 | - | 55.1 | .01523 | 5.6  |
| 20 | 1638 | -1969 | 332 | 42.7 | - | 52.6 | .01528 | 5.7  |
| 21 | 1554 | -1888 | 335 | 40.2 | - | 50.2 | .01662 | 4.4  |
| 22 | 1469 | -1802 | 334 | 37.7 | - | 47.7 | .01623 | 3.3  |
| 23 | 1387 | -1720 | 334 | 35.2 | - | 45.2 | .01415 | 2.4  |
| 24 | 1303 | -1638 | 336 | 32.7 | - | 42.7 | .01504 | 1.6  |
| 25 | 1221 | -1554 | 334 | 30.2 | - | 40.2 | .01567 | .6   |
| 26 | 1138 | -1469 | 332 | 27.7 | - | 37.7 | .01346 | -.1  |
| 27 | 1054 | -1387 | 334 | 25.3 | - | 35.2 | .01380 | -.4  |
| 28 | 971  | -1303 | 333 | 22.7 | - | 32.7 | .01493 | -.8  |
| 29 | 888  | -1221 | 334 | 20.3 | - | 30.2 | .01372 | -1.1 |
| 30 | 804  | -1138 | 335 | 17.8 | - | 27.7 | .01359 | -1.4 |
| 31 | 722  | -1054 | 333 | 15.3 | - | 25.3 | .01405 | -1.8 |
| 32 | 637  | - 971 | 335 | 12.8 | - | 22.7 | .01393 | -2.4 |
| 33 | 555  | - 888 | 334 | 10.3 | - | 20.3 | .01368 | -2.6 |
| 34 | 472  | - 804 | 333 | 7.8  | - | 17.8 | .01432 | -2.6 |
| 35 | 400  | - 722 | 323 | 5.3  | - | 15.3 | .01493 | -2.7 |
| 36 | 306  | - 637 | 332 | 2.8  | - | 12.8 | .01917 | -3.9 |

=== LINEAR P-CMOD ANALYSIS ===

Range = 10.0 to 50.0 (% of Pmax)  
 = .104 to .520 (kips)  
 = 543 to 1882 (points)

Compliance = 45.141 mil/kip  
 Intercept = .958 mil  
 Coef Var = 1.52

Predicted Crack Length (in):

| Modulus   | 0.9E  | E     | 1.1E  | 1.2E  |
|-----------|-------|-------|-------|-------|
| ACTUAL    |       | .990  |       |       |
| PREDICTED | 1.001 | 1.047 | 1.088 | 1.123 |
| PRED:ACT  | 1.011 | 1.058 | 1.099 | 1.135 |

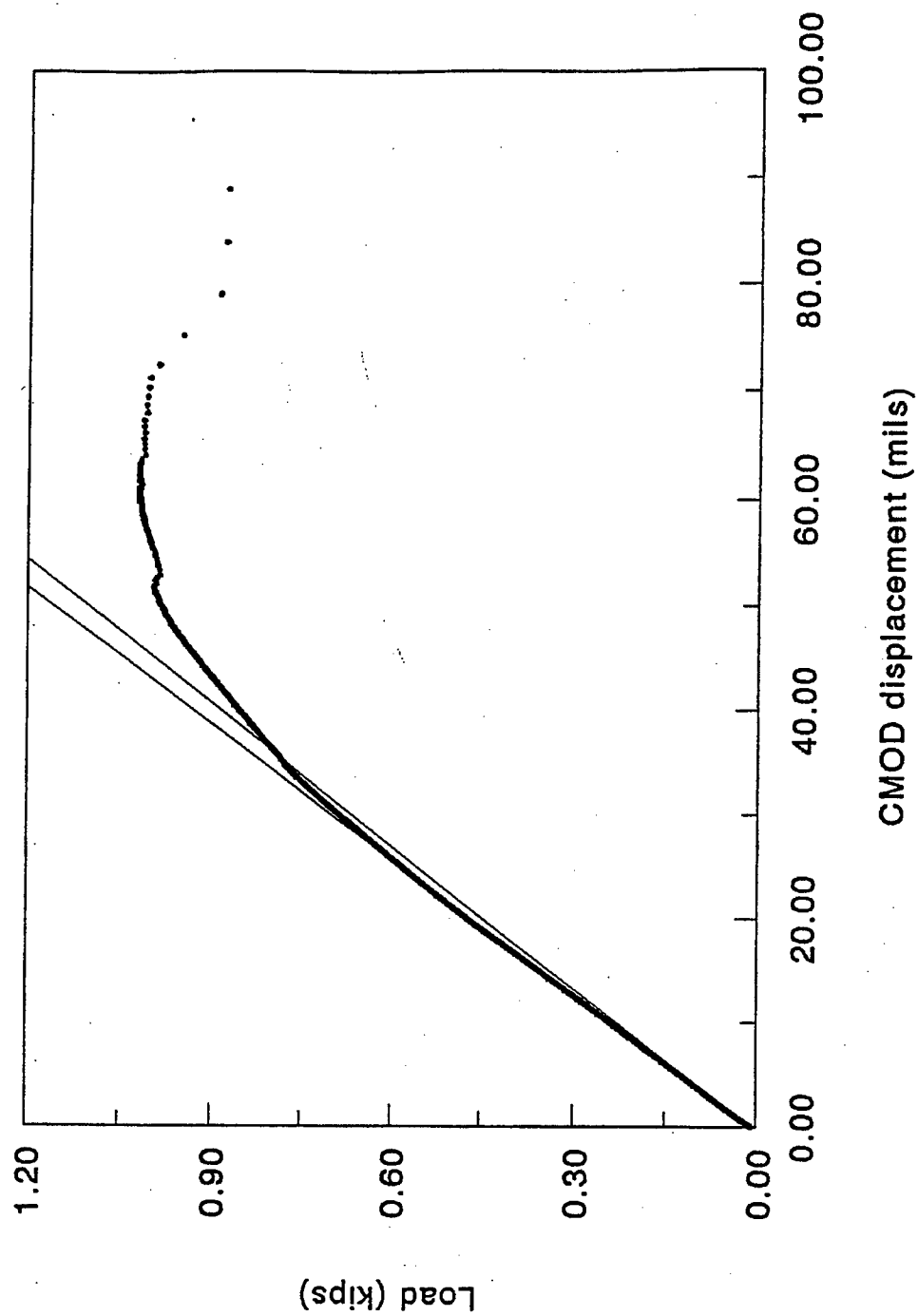
=== TOUGHNESS ANALYSIS ===

Pmax = 1.040 kips  
 Line Fit:  
     slope = .02215 kips/mil  
     intercept = -.02122 kips  
 P5 = .725 kips  
 Pq = .725 kips  
 Kq = 39.742 ksi-in<sup>0.5</sup>

STATUS:

|               |                     |          |
|---------------|---------------------|----------|
| Crack Length  | INVALID (too short) |          |
| Thickness     | INVALID (too thin)  |          |
| Pmax:Pq Ratio | INVALID Pmax/Pq=    | 1.434481 |

# Fairchild DTA FC3



\*\*\*\*\* KIC DIGITAL DATA ANALYZER \*\*\*\*\*  
Version 3.0

TEST: Fairchild  
PROJ: 06-8520  
SPEC: fc4

SPECIMEN/MATERIAL PROPERTIES:

Width W = 1.996 in  
Thickness B = .121 in  
Crack Length = .978 in  
Youngs Modulus = 11.000 10<sup>3</sup> ksi  
Yield Strength = 60.700 ksi

I/O PARAMETERS:

Analysis File = fc4.txt  
Data/Plot File = fc4.asc  
Input Data File = fc4.dat  
Header = 3 rows  
Data = 2 cols  
LOAD: Col 1 with .200 kips/volt  
CMOD: Col 2 with 10.000 mil/volt and Offset = .52 mil

=== INPUT DATA SCAN ===

Total Points = 3734  
Pmax = 1.055 kips imax = 3720  
Pmean = .489 kips  
Pmin = .008 kips imin = 265  
  
CMODmax = 100.517 mil  
CMODmean = 24.288 mil  
CMODmin = .651 mil

=== LINEARITY SUMMARY ===

Offset based on 10.0%-50.0% slope  
Compliance = 44.994 mil/kip  
Stan. Dev. = .06466

| SEG | Pt Range   | # PTS | % LOAD       | Std     | SL OFF % |
|-----|------------|-------|--------------|---------|----------|
| 1   | 3362 -3720 | 359   | 90.0 - 100.0 | 2.13790 | 275.3    |
| 2   | 3284 -3617 | 334   | 87.5 - 97.5  | .22909  | 144.7    |
| 3   | 3194 -3530 | 337   | 85.1 - 95.0  | .34981  | 155.7    |
| 4   | 3110 -3447 | 338   | 82.6 - 92.5  | .38573  | 151.4    |
| 5   | 3025 -3362 | 338   | 80.2 - 90.0  | .53876  | 125.1    |
| 6   | 2941 -3284 | 344   | 77.7 - 87.5  | .27335  | 74.6     |
| 7   | 2858 -3194 | 337   | 75.2 - 85.1  | .06848  | 54.9     |
| 8   | 2773 -3110 | 338   | 72.7 - 82.6  | .04269  | 47.9     |
| 9   | 2690 -3025 | 336   | 70.2 - 80.2  | .04108  | 42.6     |
| 10  | 2606 -2941 | 336   | 67.8 - 77.7  | .04648  | 37.1     |
| 11  | 2523 -2858 | 336   | 65.3 - 75.2  | .03866  | 35.0     |
| 12  | 2438 -2773 | 336   | 62.8 - 72.7  | .04204  | 32.7     |
| 13  | 2353 -2690 | 338   | 60.3 - 70.2  | .08245  | 27.2     |
| 14  | 2269 -2606 | 338   | 57.8 - 67.8  | .08282  | 17.2     |
| 15  | 2186 -2523 | 338   | 55.3 - 65.3  | .03813  | 9.5      |
| 16  | 2101 -2438 | 338   | 52.8 - 62.8  | .01666  | 7.1      |

|    |      |       |     |      |   |      |        |      |
|----|------|-------|-----|------|---|------|--------|------|
| 17 | 2017 | -2353 | 337 | 50.3 | - | 60.3 | .01670 | 7.4  |
| 18 | 1933 | -2269 | 337 | 47.9 | - | 57.8 | .01585 | 7.6  |
| 19 | 1848 | -2186 | 339 | 45.4 | - | 55.3 | .01711 | 6.7  |
| 20 | 1767 | -2101 | 335 | 42.9 | - | 52.8 | .01592 | 5.3  |
| 21 | 1681 | -2017 | 337 | 40.4 | - | 50.3 | .01472 | 4.2  |
| 22 | 1597 | -1933 | 337 | 37.9 | - | 47.9 | .01452 | 3.3  |
| 23 | 1512 | -1848 | 337 | 35.5 | - | 45.4 | .01385 | 2.4  |
| 24 | 1428 | -1767 | 340 | 33.0 | - | 42.9 | .01450 | 1.5  |
| 25 | 1345 | -1681 | 337 | 30.5 | - | 40.4 | .01466 | .8   |
| 26 | 1262 | -1597 | 336 | 28.0 | - | 37.9 | .01385 | .3   |
| 27 | 1177 | -1512 | 336 | 25.6 | - | 35.5 | .01390 | -.2  |
| 28 | 1092 | -1428 | 337 | 23.0 | - | 33.0 | .01315 | -.6  |
| 29 | 1008 | -1345 | 338 | 20.6 | - | 30.5 | .01269 | -.9  |
| 30 | 926  | -1262 | 337 | 18.1 | - | 28.0 | .01357 | -1.3 |
| 31 | 842  | -1177 | 336 | 15.7 | - | 25.6 | .01448 | -1.9 |
| 32 | 757  | -1092 | 336 | 13.1 | - | 23.0 | .01442 | -2.5 |
| 33 | 673  | -1008 | 336 | 10.7 | - | 20.6 | .01459 | -2.9 |
| 34 | 589  | -926  | 338 | 8.2  | - | 18.1 | .01561 | -3.5 |
| 35 | 507  | -842  | 336 | 5.7  | - | 15.7 | .01517 | -4.3 |
| 36 | 422  | -757  | 336 | 3.2  | - | 13.1 | .01574 | -5.0 |

=== LINEAR P-CMOD ANALYSIS ===

Range = 10.0 to 50.0 (% of Pmax)  
 = .105 to .527 (kips)  
 = 650 to 2004 (points)

Compliance = 44.994 mil/kip  
 Intercept = -.162 mil  
 Coef Var = 2.14

Predicted Crack Length (in):

|           |       |       |       |       |
|-----------|-------|-------|-------|-------|
| Modulus   | 0.9E  | E     | 1.1E  | 1.2E  |
| ACTUAL    |       | .978  |       |       |
| PREDICTED | .991  | 1.038 | 1.078 | 1.114 |
| PRED:ACT  | 1.013 | 1.061 | 1.103 | 1.139 |

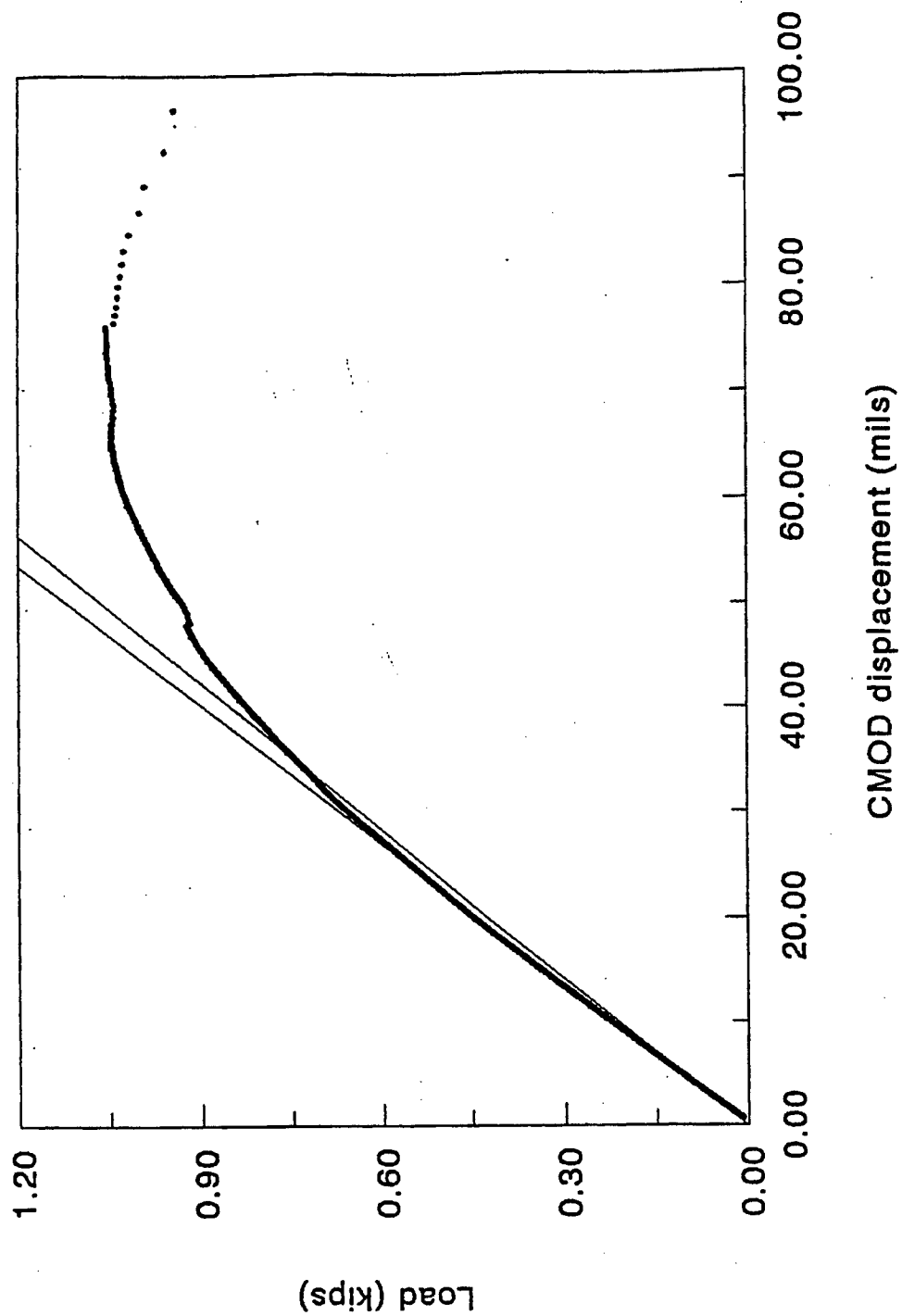
=== TOUGHNESS ANALYSIS ===

Pmax = 1.055 kips  
 Line Fit:  
     slope = .02223 kips/mil  
     intercept = .00360 kips  
 P5 = .742 kips  
 Pq = .742 kips  
 Kq = 40.645 ksi-in<sup>0.5</sup>

STATUS:

|               |                     |          |
|---------------|---------------------|----------|
| Crack Length  | INVALID (too short) |          |
| Thickness     | INVALID (too thin)  |          |
| Pmax:Pq Ratio | INVALID Pmax/Pq=    | 1.422361 |

# Fairchild DTA FC4



\*\*\*\*\* KIC DIGITAL DATA ANALYZER \*\*\*\*\*  
Version 3.0

TEST: Fairchild  
PROJ: 06-8520  
SPEC: fc3

SPECIMEN/MATERIAL PROPERTIES:

Width W = 1.997 in  
Thickness B = .121 in  
Crack Length = .988 in  
Youngs Modulus = 11.000 10<sup>3</sup> ksi  
Yield Strength = 60.700 ksi

I/O PARAMETERS:

Analysis File = fc3.txt  
Data/Plot File = fc3.asc  
Input Data File = fc3.dat  
Header = 3 rows  
Data = 2 cols  
LOAD: Col 1 with .200 kips/volt  
CMOD: Col 2 with 10.000 mil/volt and Offset = -10.25 mil

=== INPUT DATA SCAN ===

Total Points = 3504  
Pmax = 1.020 kips imax = 3473  
Pmean = .488 kips  
Pmin = .009 kips imin = 219  
  
CMODmax = 88.929 mil  
CMODmean = 22.285 mil  
CMODmin = -.005 mil

=== LINEARITY SUMMARY ===

Offset based on 5.0%-55.0% slope  
Compliance = 43.566 mil/kip  
Stan. Dev. = .02913

| SEG | Pt   | Range | # PTS | % LOAD       | Std     | SL OFF % |
|-----|------|-------|-------|--------------|---------|----------|
| 1   | 3142 | -3473 | 332   | 90.1 - 100.0 | 1.53316 | 240.1    |
| 2   | 3059 | -3402 | 344   | 87.6 - 97.5  | .61249  | 103.3    |
| 3   | 2980 | -3305 | 326   | 85.1 - 95.0  | .06718  | 68.6     |
| 4   | 2898 | -3221 | 324   | 82.6 - 92.5  | .04025  | 62.9     |
| 5   | 2817 | -3142 | 326   | 80.2 - 90.1  | .02531  | 59.3     |
| 6   | 2735 | -3059 | 325   | 77.7 - 87.6  | .04159  | 56.8     |
| 7   | 2653 | -2980 | 328   | 75.2 - 85.1  | .04664  | 54.4     |
| 8   | 2572 | -2898 | 327   | 72.7 - 82.6  | .07425  | 48.9     |
| 9   | 2491 | -2817 | 327   | 70.2 - 80.2  | .11206  | 37.6     |
| 10  | 2411 | -2735 | 325   | 67.7 - 77.7  | .10495  | 24.7     |
| 11  | 2330 | -2653 | 324   | 65.3 - 75.2  | .03600  | 14.6     |
| 12  | 2251 | -2572 | 322   | 62.8 - 72.7  | .02184  | 11.7     |
| 13  | 2168 | -2491 | 324   | 60.3 - 70.2  | .01632  | 11.0     |
| 14  | 2087 | -2411 | 325   | 57.9 - 67.7  | .01627  | 11.0     |
| 15  | 2006 | -2330 | 325   | 55.3 - 65.3  | .01793  | 10.2     |
| 16  | 1924 | -2251 | 328   | 52.9 - 62.8  | .01690  | 8.6      |

|    |      |       |     |      |   |      |        |      |
|----|------|-------|-----|------|---|------|--------|------|
| 17 | 1842 | -2168 | 327 | 50.4 | - | 60.3 | .01906 | 7.0  |
| 18 | 1762 | -2087 | 326 | 47.9 | - | 57.9 | .01894 | 5.2  |
| 19 | 1681 | -2006 | 326 | 45.5 | - | 55.3 | .01689 | 3.6  |
| 20 | 1600 | -1924 | 325 | 43.0 | - | 52.9 | .01729 | 1.8  |
| 21 | 1518 | -1842 | 325 | 40.5 | - | 50.4 | .02136 | -.4  |
| 22 | 1436 | -1762 | 327 | 38.0 | - | 47.9 | .01788 | -2.5 |
| 23 | 1356 | -1681 | 326 | 35.5 | - | 45.5 | .01826 | -2.5 |
| 24 | 1275 | -1600 | 326 | 33.1 | - | 43.0 | .02105 | -1.0 |
| 25 | 1192 | -1518 | 327 | 30.6 | - | 40.5 | .01403 | .5   |
| 26 | 1111 | -1436 | 326 | 28.1 | - | 38.0 | .01356 | .3   |
| 27 | 1031 | -1356 | 326 | 25.6 | - | 35.5 | .01330 | .0   |
| 28 | 949  | -1275 | 327 | 23.2 | - | 33.1 | .01359 | .0   |
| 29 | 870  | -1192 | 323 | 20.7 | - | 30.6 | .01351 | .4   |
| 30 | 789  | -1111 | 323 | 18.2 | - | 28.1 | .01348 | .5   |
| 31 | 707  | -1031 | 325 | 15.7 | - | 25.6 | .01308 | .5   |
| 32 | 626  | -949  | 324 | 13.2 | - | 23.2 | .01370 | .2   |
| 33 | 544  | -870  | 327 | 10.7 | - | 20.7 | .01364 | .0   |
| 34 | 464  | -789  | 326 | 8.3  | - | 18.2 | .01425 | .1   |
| 35 | 381  | -707  | 327 | 5.7  | - | 15.7 | .01419 | .4   |
| 36 | 302  | -626  | 325 | 3.3  | - | 13.2 | .01897 | -.5  |

=== LINEAR P-CMOD ANALYSIS ===

Range = 5.0 to 55.0 (% of Pmax)  
 = .051 to .561 (kips)  
 = 356 to 1993 (points)

Compliance = 43.566 mil/kip  
 Intercept = -.517 mil  
 Coef Var = 1.53

Predicted Crack Length (in):

|           | Modulus | 0.9E  | E     | 1.1E  | 1.2E |
|-----------|---------|-------|-------|-------|------|
| ACTUAL    |         |       | .988  |       |      |
| PREDICTED | .977    | 1.024 | 1.065 | 1.102 |      |
| PRED:ACT  | .989    | 1.037 | 1.078 | 1.115 |      |

=== TOUGHNESS ANALYSIS ===

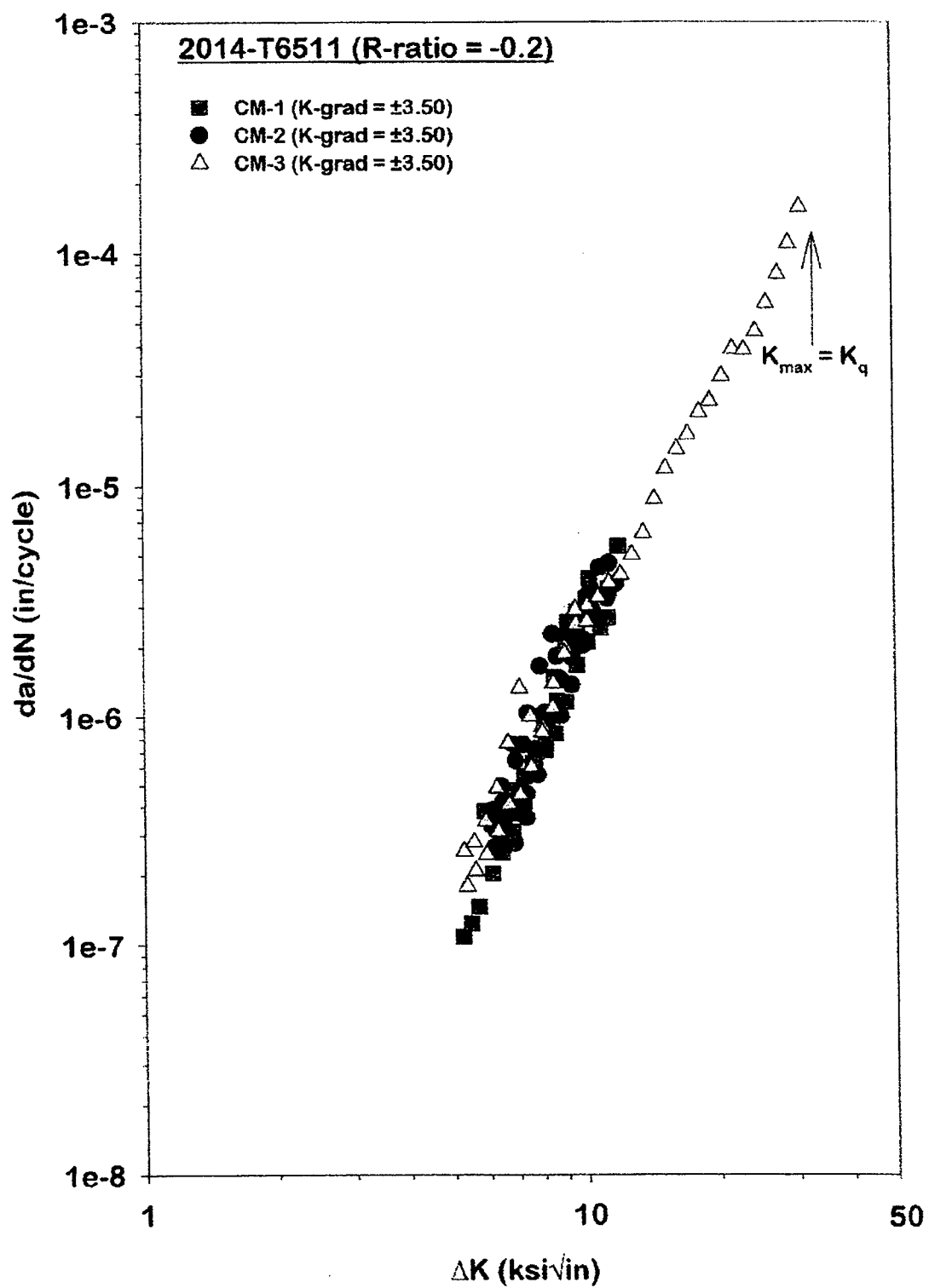
Pmax = 1.020 kips  
 Line Fit:  
     slope = .02295 kips/mil  
     intercept = .01186 kips  
 P5 = .787 kips  
 Pq = .787 kips  
 Kq = 43.763 ksi-in<sup>0.5</sup>

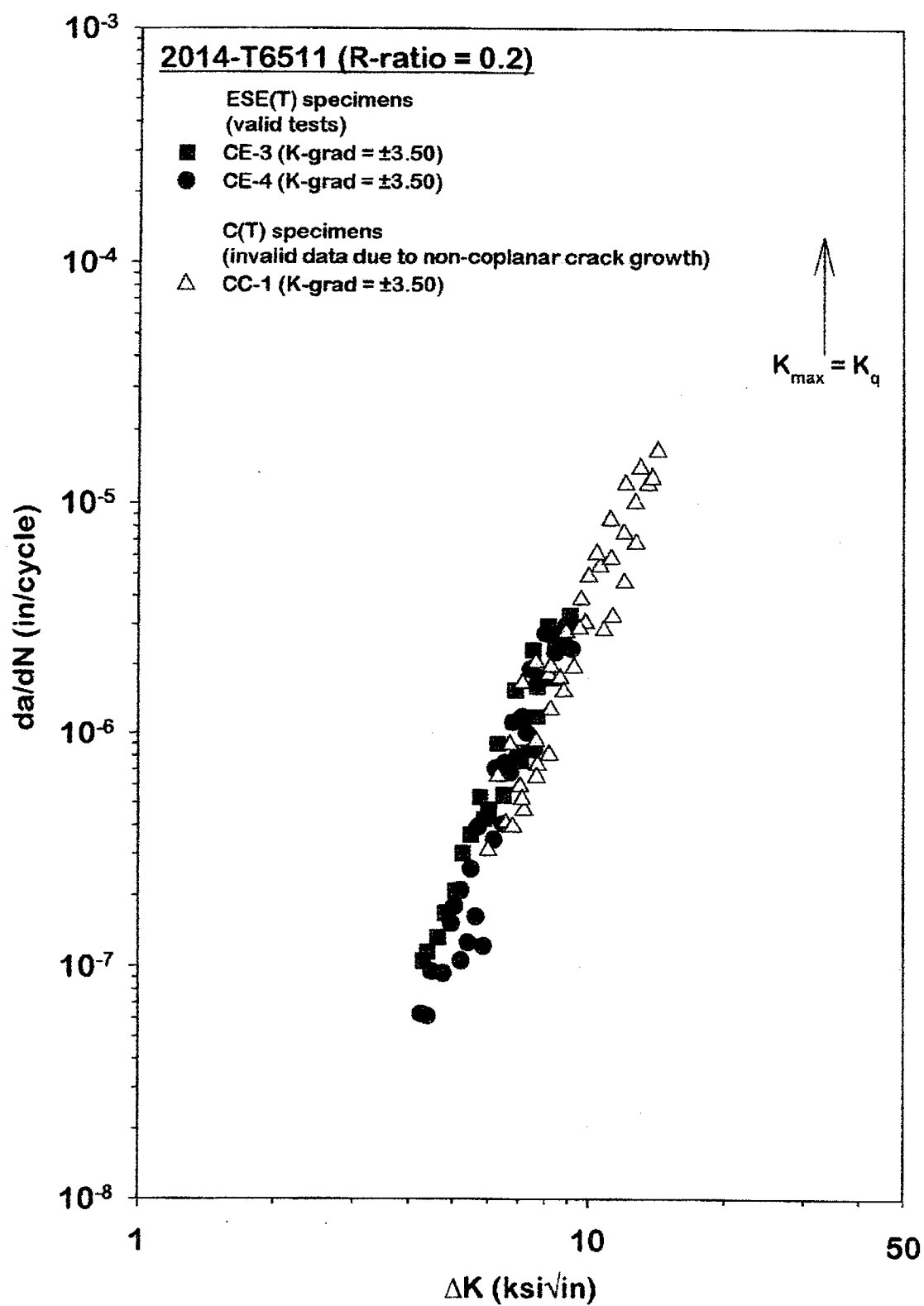
STATUS:

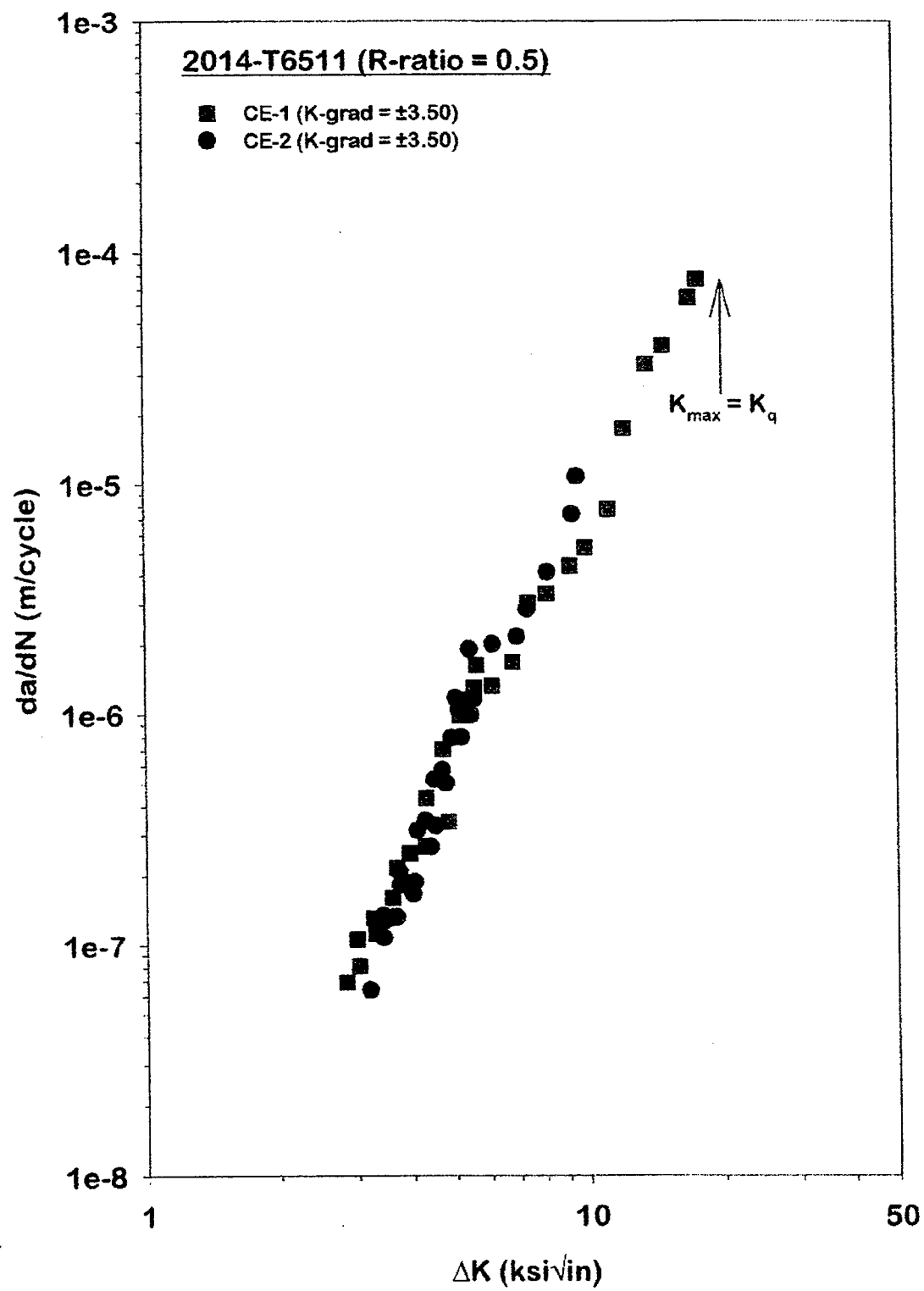
|               |                     |                   |
|---------------|---------------------|-------------------|
| Crack Length  | INVALID (too short) |                   |
| Thickness     | INVALID (too thin)  |                   |
| Pmax:Pq Ratio | INVALID             | Pmax/Pq= 1.295897 |

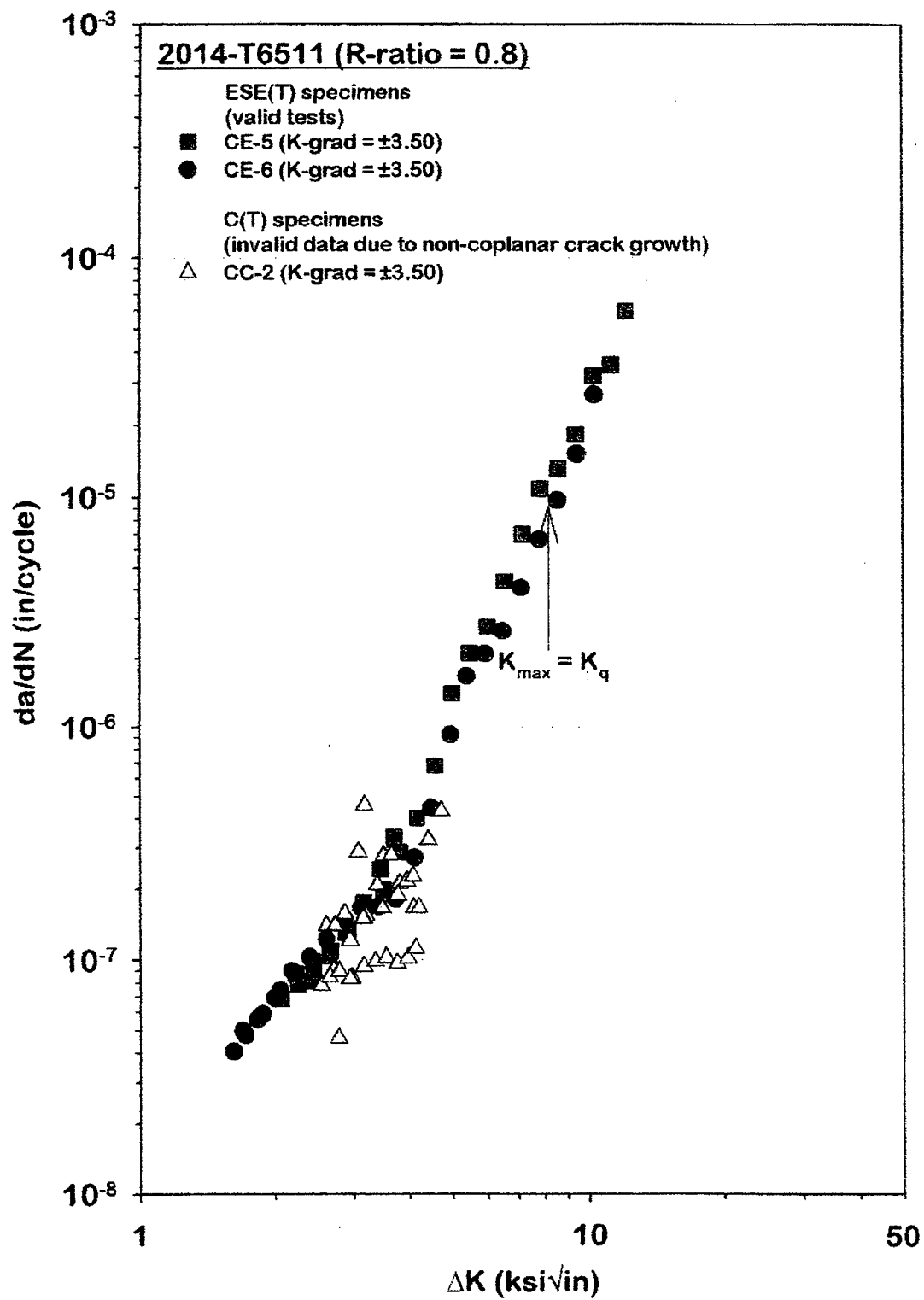
### **Fatigue Crack Growth Tests**

|           |            |        |
|-----------|------------|--------|
| 11 tests: | CC-1 to -2 | C(T)   |
|           | CM-1 to -3 | M(T)   |
|           | CE-1 to -6 | ESE(T) |

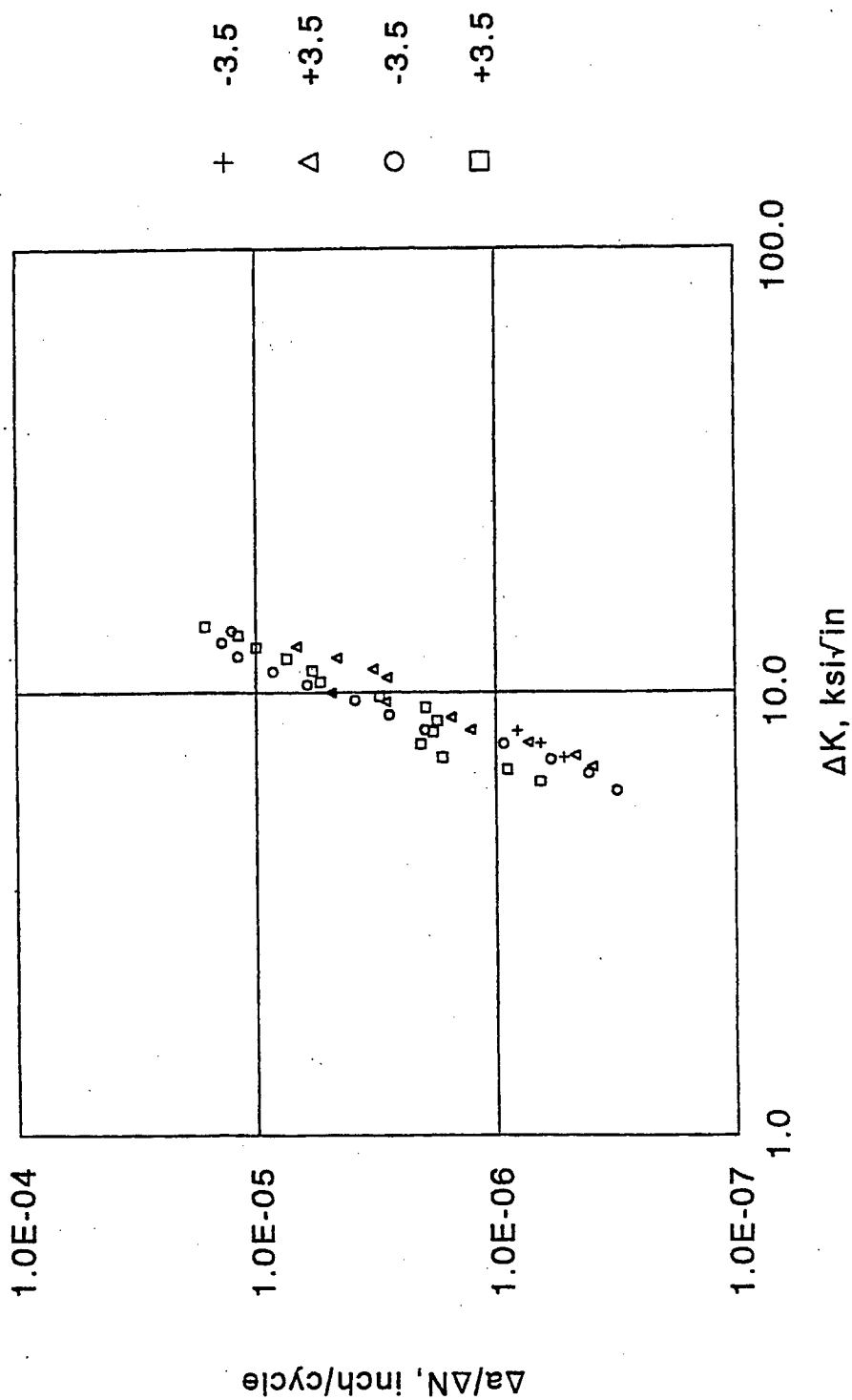








Fairchild DTA 06-8520 CC1  
 2014-T65121 EXTR CT SPEC. R=0.2



# AUTOMATED FATIGUE CRACK GROWTH RATE ANALYSIS

|                 |            |                      |          |
|-----------------|------------|----------------------|----------|
| Specimen Id.    | CC1        | Geometr <sup>y</sup> | CT       |
| Contract #      | 06-8520    | Orientation          | LT       |
| Material        | 2014-T6511 | Yield (ksi)          | 60.7     |
| Temperature (F) | 75         | Initial A0 (PD)      | 0.534    |
| Environment     | LA         | Initial PD           | %1000.00 |

## Specimen Dimensions (in)

|           |       |             |       |
|-----------|-------|-------------|-------|
| Thickness | 0.124 | Notch depth | 0.525 |
| Width     | 2.002 | Gage length | 0.000 |
| Height    | 0.000 |             |       |

## Precrack Parameters

|              |       |                  |       |
|--------------|-------|------------------|-------|
| Pmax (lbs)   | 350.0 | Stress ratio (R) | 0.20  |
| Final a (in) | 0.584 | Kmax             | 10.92 |

## Test Parameters

|                |       |                  |       |
|----------------|-------|------------------|-------|
| Initial a (in) | 0.584 | Initial K        | 10.90 |
| K-gradient     | -3.50 | Stress ratio (R) | 0.20  |

|            |          |                |
|------------|----------|----------------|
| K Coeff    | PD Coeff | Analysis Codes |
| 0.886000   | 0.272840 | KRPP 1 0       |
| 4.640000   | 0.488940 |                |
| -13.320000 | 0.000000 |                |
| 14.720000  | 0.000000 |                |
| -5.600000  | 0.000000 |                |
| 0.000000   | 0.000000 |                |

## Visual Observations

|        |            |                |       |       |
|--------|------------|----------------|-------|-------|
| PD     | Crack (PD) | Crack (visual) | Error | PDAF  |
| 38.26  | 0.583      | 0.584          | 0.000 | 0.995 |
| 127.74 | 0.664      | 0.664          | 0.000 | 0.942 |

## Comments

Date of test: 12-12-1997

Specimen Id. CC1

Page 1

| Pmax<br>(lbs) | PD<br>(1E-6) | a<br>(in) | N<br>(X1) | da<br>(in) | dN<br>(X1) | da/dN<br>(in/cyc) | dK<br>(ksi/in) |
|---------------|--------------|-----------|-----------|------------|------------|-------------------|----------------|
|               | 38.3         | 0.5835    | 6         |            |            |                   |                |
| 321           | 54.6         | 0.5989    | 13722     | 0.0333     | 41236      | 8.087E-07         | 8.18           |
| 295           | 74.1         | 0.6168    | 41241     | 0.0356     | 55111      | 6.454E-07         | 7.69           |
| 268           | 93.6         | 0.6344    | 68833     | 0.0364     | 70670      | 5.158E-07         | 7.15           |
|               | 115.2        | 0.6533    | 111911    |            |            |                   |                |

# GROWTH RATE ANALYSIS

|                 |            |                 |          |
|-----------------|------------|-----------------|----------|
| Specimen Id.    | CC1A       | Geometry        | CT       |
| Contract #      | 06-8520    | Orientation     | LT       |
| Material        | 2014-T6511 | Yield (ksi)     | 60.7     |
| Temperature (F) | 75         | Initial A0 (PD) | 0.534    |
| Environment     | LA         | Initial PD      | %1000.00 |

## Specimen Dimensions (in)

|           |       |             |       |
|-----------|-------|-------------|-------|
| Thickness | 0.124 | Notch depth | 0.525 |
| Width     | 2.002 | Gage length | 0.000 |
| Height    | 0.000 |             |       |

## Precrack Parameters

|              |       |                  |      |
|--------------|-------|------------------|------|
| Pmax (lbs)   | 0.0   | Stress ratio (R) | 0.00 |
| Final a (in) | 0.000 | Kmax             | 0.00 |

## Test Parameters

|                |       |                  |      |
|----------------|-------|------------------|------|
| Initial a (in) | 0.664 | Initial K        | 8.00 |
| K-gradient     | 3.50  | Stress ratio (R) | 0.20 |

|            |          |                |
|------------|----------|----------------|
| K Coeff    | PD Coeff | Analysis Codes |
| 0.886000   | 0.269210 | KRPP 1 0       |
| 4.640000   | 0.488940 |                |
| -13.320000 | 0.000000 |                |
| 14.720000  | 0.000000 |                |
| -5.600000  | 0.000000 |                |
| 0.000000   | 0.000000 |                |

## Visual Observations

| PD     | Crack (PD) | Crack (visual) | Error | PDAF  |
|--------|------------|----------------|-------|-------|
| 127.63 | 0.664      | 0.664          | 0.000 | 1.001 |
| 376.79 | 0.841      | 0.841          | 0.000 | 0.819 |

## Comments

Date of test: 12-12-1997

| Pmax<br>(lbs) | PD<br>(1E-6) | a<br>(in) | N<br>(X1) | da<br>(in) | dN<br>(X1) | da/dN<br>(in/cyc) | dK<br>(ksi/in) <sup>1/2</sup> |
|---------------|--------------|-----------|-----------|------------|------------|-------------------|-------------------------------|
|               | 127.5        | 0.6639    | 52        |            |            |                   |                               |
| 240           | 143.0        | 0.6775    | 37121     | 0.0310     | 78742      | 3.932E-07         | 6.78                          |
| 250           | 163.4        | 0.6948    | 78794     | 0.0341     | 73321      | 4.644E-07         | 7.19                          |
| 261           | 183.6        | 0.7115    | 110442    | 0.0336     | 46294      | 7.268E-07         | 7.69                          |
| 273           | 205.0        | 0.7285    | 125087    | 0.0329     | 25876      | 1.270E-06         | 8.21                          |
| 286           | 225.9        | 0.7444    | 136318    | 0.0312     | 20455      | 1.526E-06         | 8.77                          |
| 302           | 246.8        | 0.7597    | 145542    | 0.0363     | 12599      | 2.881E-06         | 9.49                          |
| 312           | 276.9        | 0.7807    | 148917    | 0.0274     | 5650       | 4.853E-06         | 9.95                          |
| 329           | 286.5        | 0.7871    | 151192    | 0.0202     | 7089       | 2.843E-06         | 10.75                         |
| 340           | 307.8        | 0.8008    | 156006    | 0.0263     | 8089       | 3.254E-06         | 11.23                         |
| 355           | 328.2        | 0.8134    | 159281    | 0.0245     | 5348       | 4.583E-06         | 11.93                         |
| 370           | 348.5        | 0.8253    | 161355    | 0.0231     | 3418       | 6.753E-06         | 12.65                         |
|               | 368.5        | 0.8365    | 162699    |            |            |                   |                               |

# AUTOMATED FATIGUE CRACK GROWTH RATE ANALYSIS

|                 |            |                 |          |
|-----------------|------------|-----------------|----------|
| Specimen Id.    | CC1B       | Geometry        | CT       |
| Contract #      | 06-8520    | Orientation     | LT       |
| Material        | 2014-T6511 | Yield (ksi)     | 60.7     |
| Temperature (F) | 75         | Initial A0 (PD) | 0.534    |
| Environment     | LA         | Initial PD      | *1000.00 |

## Specimen Dimensions (in)

|           |       |             |       |
|-----------|-------|-------------|-------|
| Thickness | 0.124 | Notch depth | 0.525 |
| Width     | 2.002 | Gage length | 0.000 |
| Height    | 0.000 |             |       |

## Precrack Parameters

|              |       |                  |      |
|--------------|-------|------------------|------|
| Pmax (lbs)   | 0.0   | Stress ratio (R) | 0.00 |
| Final a (in) | 0.000 | Kmax             | 0.00 |

## Test Parameters

|                |       |                  |       |
|----------------|-------|------------------|-------|
| Initial a (in) | 0.841 | Initial K        | 18.80 |
| K-gradient     | -3.50 | Stress ratio (R) | 0.20  |

|            |          |                |
|------------|----------|----------------|
| K Coeff    | PD Coeff | Analysis Codes |
| 0.886000   | 0.228800 | KRPP 1 0       |
| 4.640000   | 0.491630 |                |
| -13.320000 | 0.000000 |                |
| 14.720000  | 0.000000 |                |
| -5.600000  | 0.000000 |                |
| 0.000000   | 0.000000 |                |

## Visual Observations

|        |            |                |       |       |
|--------|------------|----------------|-------|-------|
| PD     | Crack (PD) | Crack (visual) | Error | PDAF  |
| 393.45 | 0.841      | 0.841          | 0.000 | 0.989 |
| 662.40 | 1.048      | 1.048          | 0.000 | 0.905 |

## Comments

Date of test: 12-15-1997

| Pmax<br>(lbs) | PD<br>(1E-6) | a<br>(in) | N<br>(X1) | da<br>(in) | dN<br>(X1) | da/dN<br>(in/cyc) | dK<br>(ksi[in] <sup>.5</sup> ) |
|---------------|--------------|-----------|-----------|------------|------------|-------------------|--------------------------------|
|               | 393.4        | 0.8410    | 12        |            |            |                   |                                |
| 387           | 407.2        | 0.8527    | 1013      | 0.0304     | 2397       | 1.267E-05         | 13.79                          |
| 357           | 429.5        | 0.8714    | 2409      | 0.0351     | 2510       | 1.398E-05         | 12.97                          |
| 324           | 449.5        | 0.8878    | 3522      | 0.0310     | 2597       | 1.196E-05         | 12.04                          |
| 293           | 467.5        | 0.9024    | 5006      | 0.0321     | 3794       | 8.473E-06         | 11.14                          |
| 268           | 489.4        | 0.9199    | 7316      | 0.0328     | 5372       | 6.097E-06         | 10.39                          |
| 241           | 508.7        | 0.9352    | 10378     | 0.0312     | 8074       | 3.863E-06         | 9.60                           |
| 219           | 529.3        | 0.9511    | 15391     | 0.0315     | 11311      | 2.789E-06         | 8.90                           |
| 198           | 549.8        | 0.9667    | 21689     | 0.0307     | 15616      | 1.965E-06         | 8.24                           |
| 180           | 569.9        | 0.9818    | 31007     | 0.0283     | 30616      | 9.249E-07         | 7.65                           |
| 162           | 587.8        | 0.9950    | 52305     | 0.0292     | 49852      | 5.865E-07         | 7.05                           |
| 147           | 609.8        | 1.0110    | 80858     | 0.0297     | 72866      | 4.076E-07         | 6.56                           |
| 131           | 629.0        | 1.0247    | 125171    | 0.0301     | 96920      | 3.111E-07         | 5.99                           |
|               | 652.5        | 1.0412    | 177779    |            |            |                   |                                |

# AUTOMATED FATIGUE CRACK GROWTH RATE ANALYSIS

|                 |            |                 |          |
|-----------------|------------|-----------------|----------|
| Specimen Id.    | CC1C       | Geometry        | CT       |
| Contract #      | 06-8520    | Orientation     | LT       |
| Material        | 2014-T6511 | Yield (ksi)     | 60.7     |
| Temperature (F) | 75         | Initial A0 (PD) | 0.534    |
| Environment     | LA         | Initial PD      | %1000.00 |

## Specimen Dimensions (in)

|           |       |             |       |
|-----------|-------|-------------|-------|
| Thickness | 0.124 | Notch depth | 0.525 |
| Width     | 2.002 | Gage length | 0.000 |
| Height    | 0.000 |             |       |

## Precrack Parameters

|              |       |                  |      |
|--------------|-------|------------------|------|
| Pmax (lbs)   | 0.0   | Stress ratio (R) | 0.00 |
| Final a (in) | 0.000 | Kmax             | 0.00 |

## Test Parameters

|                |       |                  |      |
|----------------|-------|------------------|------|
| Initial a (in) | 1.048 | Initial K        | 7.40 |
| K-gradient     | 3.50  | Stress ratio (R) | 0.20 |

| K Coeff    | PD Coeff | Analysis Codes |
|------------|----------|----------------|
| 0.886000   | 0.202560 | KRPP 1 0       |
| 4.640000   | 0.488940 |                |
| -13.320000 | 0.000000 |                |
| 14.720000  | 0.000000 |                |
| -5.600000  | 0.000000 |                |
| 0.000000   | 0.000000 |                |

## Visual Observations

| PD     | Crack (PD) | Crack (visual) | Error | PDAF  |
|--------|------------|----------------|-------|-------|
| 657.49 | 1.048      | 1.048          | 0.000 | 0.998 |
| 924.94 | 1.273      | 1.273          | 0.000 | 0.959 |

## Comments

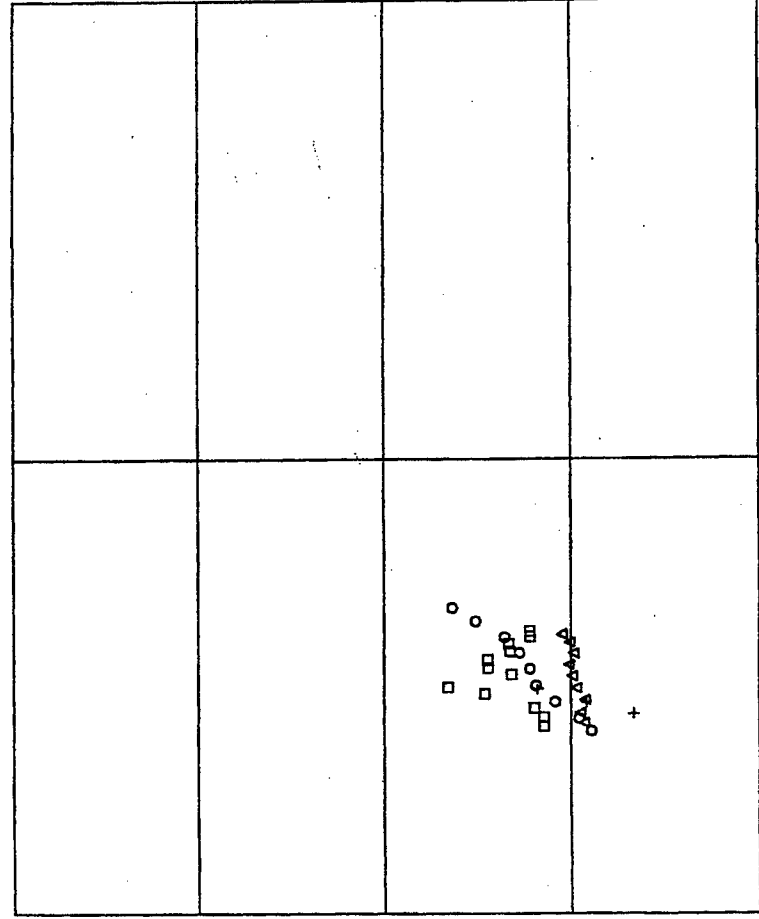
Date of test: 12-14-1997

Specimen Id. CC1C

Page 1

|     | Pmax<br>(lbs) | PD<br>(1E-6) | a<br>(in) | N<br>(X1) | da<br>(in) | dN<br>(X1) | da/dN<br>(in/cyc) | dK<br>(ksi[in] <sup>1.5</sup> ) |
|-----|---------------|--------------|-----------|-----------|------------|------------|-------------------|---------------------------------|
|     | 657.5         | 1.0480       |           | 5         |            |            |                   |                                 |
| 129 | 672.1         | 1.0608       |           | 19488     | 0.0282     | 43446      | 6.501E-07         | 6.25                            |
| 134 | 689.7         | 1.0762       |           | 43451     | 0.0361     | 40448      | 8.923E-07         | 6.65                            |
| 139 | 713.5         | 1.0969       |           | 59936     | 0.0393     | 23657      | 1.661E-06         | 7.09                            |
| 144 | 735.1         | 1.1155       |           | 67109     | 0.0348     | 17014      | 2.047E-06         | 7.59                            |
| 149 | 754.0         | 1.1317       |           | 76950     | 0.0317     | 17503      | 1.810E-06         | 8.09                            |
| 153 | 772.2         | 1.1472       |           | 84612     | 0.0308     | 17626      | 1.746E-06         | 8.58                            |
| 159 | 790.3         | 1.1625       |           | 94576     | 0.0377     | 19369      | 1.948E-06         | 9.20                            |
| 163 | 817.0         | 1.1849       |           | 103980    | 0.0385     | 12608      | 3.053E-06         | 9.75                            |
| 169 | 836.3         | 1.2010       |           | 107183    | 0.0336     | 6255       | 5.373E-06         | 10.50                           |
| 174 | 857.5         | 1.2186       |           | 110235    | 0.0328     | 5664       | 5.791E-06         | 11.13                           |
| 179 | 876.1         | 1.2338       |           | 112847    | 0.0327     | 4398       | 7.434E-06         | 11.87                           |
| 183 | 897.5         | 1.2512       |           | 114633    | 0.0337     | 3373       | 1.001E-05         | 12.58                           |
| 188 | 917.6         | 1.2676       |           | 116220    | 0.0346     | 2896       | 1.193E-05         | 13.41                           |
| 192 | 938.1         | 1.2858       |           | 117530    | 0.0298     | 1816       | 1.641E-05         | 14.08                           |
|     | 950.4         | 1.2973       |           | 118036    |            |            |                   |                                 |

Fairchild DTA 06-8520 CC2



# AUTOMATED FATIGUE CRACK GROWTH RATE ANALYSIS

|                 |            |                 |           |
|-----------------|------------|-----------------|-----------|
| Specimen Id.    | CC2        | Geometry        | CT        |
| Contract #      | 06-8520    | Orientation     | LT        |
| Material        | 2014-T6511 | Yield (ksi)     | 60.7      |
| Temperature (F) | 75         | Initial AO (PD) | 0.553     |
| Environment     | LA         | Initial PD      | \$1000.00 |

## Specimen Dimensions (in)

|           |       |             |       |
|-----------|-------|-------------|-------|
| Thickness | 0.124 | Notch depth | 0.518 |
| Width     | 1.995 | Gage length | 0.000 |
| Height    | 0.000 |             |       |

## Precrack Parameters

|              |       |                  |       |
|--------------|-------|------------------|-------|
| Pmax (lbs)   | 500.0 | Stress ratio (R) | 0.80  |
| Final a (in) | 0.614 | Kmax             | 16.42 |

## Test Parameters

|                |       |                  |       |
|----------------|-------|------------------|-------|
| Initial a (in) | 0.614 | Initial K        | 16.40 |
| K-gradient     | -3.50 | Stress ratio (R) | 0.80  |

|            |          |                |
|------------|----------|----------------|
| K Coeff    | PD Coeff | Analysis Codes |
| 0.886000   | 0.282770 | KRPP 1 0       |
| 4.640000   | 0.490560 |                |
| -13.320000 | 0.000000 |                |
| 14.720000  | 0.000000 |                |
| -5.600000  | 0.000000 |                |
| 0.000000   | 0.000000 |                |

## Visual Observations

|        |            |                |       |       |
|--------|------------|----------------|-------|-------|
| PD     | Crack (PD) | Crack (visual) | Error | PDAF  |
| 50.94  | 0.632      | 0.632          | 0.000 | 1.357 |
| 130.54 | 0.680      | 0.680          | 0.000 | 0.907 |

## Comments

Date of test: 12-16-1997

| Pmax<br>(lbs) | PD<br>(1E-6) | a<br>(in) | N<br>(X1) | da<br>(in) | dN<br>(X1) | da/dN<br>(in/cyc) | dK<br>(ksi[in] <sup>.5</sup> ) |
|---------------|--------------|-----------|-----------|------------|------------|-------------------|--------------------------------|
|               | 50.9         | 0.6318    | 9         |            |            |                   |                                |
| 459           | 66.1         | 0.6464    | 78443     | 0.0302     | 201476     | 1.501E-07         | 3.15                           |
| 422           | 86.5         | 0.6620    | 201484    | 0.0267     | 321480     | 8.298E-08         | 2.94                           |
| 393           | 107.1        | 0.6731    | 399923    | 0.0147     | 317380     | 4.642E-08         | 2.77                           |
|               | 116.9        | 0.6767    | 518864    |            |            |                   |                                |

# AUTOMATED FATIGUE CRACK GROWTH RATE ANALYSIS

|                     |                       |
|---------------------|-----------------------|
| Specimen Id. CC2A   | Geometry CT           |
| Contract # 06-8520  | Orientation LT        |
| Material 2014-T6511 | Yield (ksi) 60.7      |
| Temperature (F) 75  | Initial AO (PD) 0.553 |
| Environment LA      | Initial PD \$1000.00  |

## Specimen Dimensions (in)

|                 |                   |
|-----------------|-------------------|
| Thickness 0.124 | Notch depth 0.518 |
| Width 1.995     | Gage length 0.000 |
| Height 0.000    |                   |

## Precrack Parameters

|                    |                       |
|--------------------|-----------------------|
| Pmax (lbs) 500.0   | Stress ratio (R) 0.80 |
| Final a (in) 0.614 | Kmax 16.42            |

## Test Parameters

|                      |                       |
|----------------------|-----------------------|
| Initial a (in) 0.680 | Initial K 12.50       |
| K-gradient 3.50      | Stress ratio (R) 0.80 |

| K Coeff    | PD Coeff | Analysis Codes |
|------------|----------|----------------|
| 0.886000   | 0.276820 | KRPP 1 0       |
| 4.640000   | 0.490560 |                |
| -13.320000 | 0.000000 |                |
| 14.720000  | 0.000000 |                |
| -5.600000  | 0.000000 |                |
| 0.000000   | 0.000000 |                |

## Visual Observations

| PD     | Crack (PD) | Crack (visual) | Error | PDAF  |
|--------|------------|----------------|-------|-------|
| 131.37 | 0.680      | 0.680          | 0.000 | 0.994 |
| 333.77 | 0.788      | 0.789          | 0.000 | 0.723 |

## Comments

Date of test: 12-17-1997

| Pmax<br>(lbs) | PD<br>(1E-6) | a<br>(in) | N<br>(X1) | da<br>(in) | dN<br>(X1) | da/dN<br>(in/cyc) | dK<br>(ksi[in] <sup>.5</sup> ) |
|---------------|--------------|-----------|-----------|------------|------------|-------------------|--------------------------------|
|               | 131.4        | 0.6800    | 33        |            |            |                   |                                |
| 364           | 143.7        | 0.6896    | 146929    | 0.0265     | 312882     | 8.468E-08         | 2.65                           |
| 377           | 166.5        | 0.7065    | 312915    | 0.0308     | 345515     | 8.920E-08         | 2.78                           |
| 395           | 187.0        | 0.7205    | 492444    | 0.0270     | 322234     | 8.380E-08         | 2.97                           |
| 413           | 207.7        | 0.7335    | 635149    | 0.0245     | 261307     | 9.361E-08         | 3.16                           |
| 431           | 227.6        | 0.7449    | 753752    | 0.0223     | 226967     | 9.842E-08         | 3.35                           |
| 450           | 248.5        | 0.7558    | 862116    | 0.0205     | 200374     | 1.022E-07         | 3.55                           |
| 471           | 268.9        | 0.7654    | 954126    | 0.0181     | 188106     | 9.629E-08         | 3.76                           |
| 492           | 289.6        | 0.7739    | 1050222   | 0.0161     | 158383     | 1.015E-07         | 3.97                           |
| 508           | 310.5        | 0.7815    | 1112509   | 0.0108     | 96344      | 1.118E-07         | 4.13                           |
|               | 320.6        | 0.7847    | 1146566   |            |            |                   |                                |

# AUTOMATED FATIGUE CRACK GROWTH RATE ANALYSIS

|                               |                                 |
|-------------------------------|---------------------------------|
| Specimen Id.      CC2B        | Geometry              CT        |
| Contract #        06-8520     | Orientation          LT         |
| Material           2014-T6511 | Yield (ksi)          60.7       |
| Temperature (F)    75         | Initial AO (PD)      0.553      |
| Environment        LA         | Initial PD            \$1000.00 |

## Specimen Dimensions (in)

|                            |                            |
|----------------------------|----------------------------|
| Thickness           0.124  | Notch depth          0.518 |
| Width                1.995 | Gage length          0.000 |
| Height               0.000 |                            |

## Precrack Parameters

|                            |                             |
|----------------------------|-----------------------------|
| Pmax (lbs)           500.0 | Stress ratio (R) 0.80       |
| Final a (in)        0.614  | Kmax                  16.42 |

## Test Parameters

|                            |                              |
|----------------------------|------------------------------|
| Initial a (in)       0.789 | Initial K              25.00 |
| K-gradient          -3.50  | Stress ratio (R) 0.80        |

| K Coeff    | PD Coeff | Analysis Codes        |
|------------|----------|-----------------------|
| 0.886000   | 0.227670 | KRPP            1   0 |
| 4.640000   | 0.490560 |                       |
| -13.320000 | 0.000000 |                       |
| 14.720000  | 0.000000 |                       |
| -5.600000  | 0.000000 |                       |
| 0.000000   | 0.000000 |                       |

## Visual Observations

| PD     | Crack (PD) | Crack (visual) | Error | PDAF  |
|--------|------------|----------------|-------|-------|
| 339.13 | 0.788      | 0.789          | 0.000 | 1.007 |
| 541.49 | 0.902      | 0.902          | 0.000 | 0.846 |

## Comments

Date of test: 12-18-1997

| Pmax<br>(lbs) | PD<br>(1E-6) | a<br>(in) | N<br>(X1) | da<br>(in) | dN<br>(X1) | da/dN<br>(in/cyc) | dK<br>(ksi[in] <sup>.5</sup> ) |
|---------------|--------------|-----------|-----------|------------|------------|-------------------|--------------------------------|
|               | 339.7        | 0.7889    | 86        |            |            |                   |                                |
| 563           | 354.1        | 0.7991    | 26913     | 0.0246     | 56864      | 4.325E-07         | 4.72                           |
| 519           | 375.2        | 0.8135    | 56949     | 0.0273     | 84182      | 3.239E-07         | 4.42                           |
| 471           | 395.1        | 0.8264    | 111095    | 0.0254     | 112192     | 2.266E-07         | 4.08                           |
| 428           | 415.3        | 0.8389    | 169142    | 0.0247     | 130720     | 1.886E-07         | 3.77                           |
| 388           | 436.0        | 0.8511    | 241815    | 0.0232     | 139951     | 1.655E-07         | 3.48                           |
| 352           | 455.9        | 0.8621    | 309093    | 0.0218     | 141648     | 1.536E-07         | 3.20                           |
| 319           | 476.4        | 0.8728    | 383463    | 0.0207     | 170920     | 1.211E-07         | 2.95                           |
| 290           | 496.7        | 0.8828    | 480013    | 0.0192     | 212994     | 9.015E-08         | 2.71                           |
| 269           | 516.8        | 0.8920    | 596458    | 0.0138     | 178282     | 7.768E-08         | 2.54                           |
|               | 527.4        | 0.8966    | 658294    |            |            |                   |                                |

# AUTOMATED FATIGUE CRACK GROWTH RATE ANALYSIS

|                               |                             |
|-------------------------------|-----------------------------|
| Specimen Id.      CC2C        | Geometry            CT      |
| Contract #        06-8520     | Orientation        LT       |
| Material           2014-T6511 | Yield (ksi)        60.7     |
| Temperature (F)   75          | Initial AO (PD)   0.553     |
| Environment       LA          | Initial PD        \$1000.00 |

## Specimen Dimensions (in)

|                           |                          |
|---------------------------|--------------------------|
| Thickness           0.124 | Notch depth        0.518 |
| Width               1.995 | Gage length        0.000 |
| Height              0.000 |                          |

## Precrack Parameters

|                            |                           |
|----------------------------|---------------------------|
| Pmax (lbs)           500.0 | Stress ratio (R) 0.80     |
| Final a (in)        0.614  | Kmax                16.42 |

## Test Parameters

|                            |                            |
|----------------------------|----------------------------|
| Initial a (in)       0.902 | Initial K            12.50 |
| K-gradient          3.50   | Stress ratio (R) 0.80      |

| K Coeff    | PD Coeff | Analysis Codes        |
|------------|----------|-----------------------|
| 0.886000   | 0.185250 | KRPP            1   0 |
| 4.640000   | 0.490560 |                       |
| -13.320000 | 0.000000 |                       |
| 14.720000  | 0.000000 |                       |
| -5.600000  | 0.000000 |                       |
| 0.000000   | 0.000000 |                       |

## Visual Observations

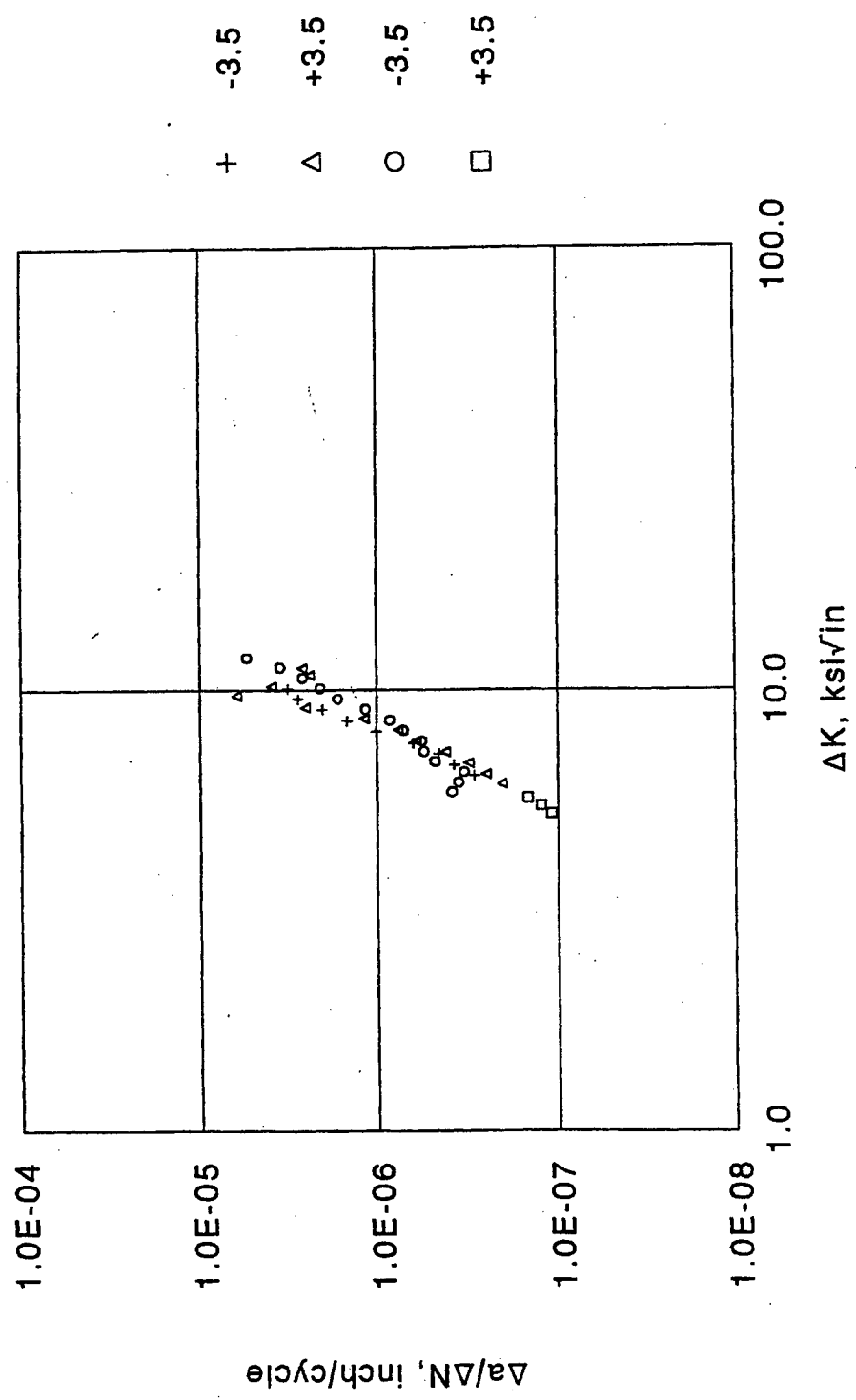
| PD     | Crack (PD) | Crack (visual) | Error | PDAF  |
|--------|------------|----------------|-------|-------|
| 541.26 | 0.902      | 0.902          | 0.000 | 1.006 |
| 795.97 | 0.967      | 0.967          | 0.000 | 0.768 |

## Comments

Date of test: 12-18-1997

| Pmax<br>(lbs) | PD<br>(1E-6) | a<br>(in) | N<br>(X1) | da<br>(in) | dN<br>(X1) | da/dN<br>(in/cyc) | dK<br>(ksi[in] <sup>1.5</sup> ) |
|---------------|--------------|-----------|-----------|------------|------------|-------------------|---------------------------------|
|               | 541.8        | 0.9027    | 17        |            |            |                   |                                 |
| 267           | 556.4        | 0.9097    | 43485     | 0.0154     | 110626     | 1.394E-07         | 2.60                            |
| 277           | 575.5        | 0.9182    | 110643    | 0.0171     | 122202     | 1.396E-07         | 2.73                            |
| 288           | 596.6        | 0.9267    | 165687    | 0.0155     | 98782      | 1.571E-07         | 2.86                            |
| 304           | 615.4        | 0.9337    | 209425    | 0.0184     | 63786      | 2.888E-07         | 3.07                            |
| 312           | 651.2        | 0.9451    | 229473    | 0.0136     | 29696      | 4.567E-07         | 3.17                            |
| 329           | 658.7        | 0.9472    | 239121    | 0.0071     | 34078      | 2.083E-07         | 3.38                            |
| 338           | 678.3        | 0.9522    | 263551    | 0.0098     | 35314      | 2.776E-07         | 3.50                            |
| 350           | 700.4        | 0.9570    | 274435    | 0.0081     | 29020      | 2.793E-07         | 3.64                            |
| 364           | 718.8        | 0.9603    | 292571    | 0.0062     | 29302      | 2.111E-07         | 3.81                            |
| 376           | 738.7        | 0.9632    | 303737    | 0.0049     | 22863      | 2.159E-07         | 3.95                            |
| 388           | 757.4        | 0.9653    | 315434    | 0.0034     | 20272      | 1.659E-07         | 4.09                            |
| 399           | 774.5        | 0.9666    | 324009    | 0.0020     | 11907      | 1.660E-07         | 4.21                            |
|               | 788.3        | 0.9673    | 327341    |            |            |                   |                                 |

Fairchild DTA 06-8520 CM1  
 2014-T65121 EXTR CT SPEC. R= -0.2



# **AUTOMATED FATIGUE CRACK GROWTH RATE ANALYSIS**

|                 |            |                 |           |
|-----------------|------------|-----------------|-----------|
| Specimen Id.    | CM1        | Geometry        | MT        |
| Contract #      | 06-8520    | Orientation     | LT        |
| Material        | 2014-T6511 | Yield (ksi)     | 60.7      |
| Temperature (F) | 75         | Initial AO (PD) | 0.364     |
| Environment     | LA         | Initial PD      | \$1000.00 |

## Specimen Dimensions (in)

|           |       |             |       |
|-----------|-------|-------------|-------|
| Thickness | 0.114 | Notch depth | 0.403 |
| Width     | 1.700 | Gage length | 0.000 |
| Height    | 0.000 |             |       |

## Precrack Parameters

|              |        |                  |       |
|--------------|--------|------------------|-------|
| Pmax (lbs)   | 3300.0 | Stress ratio (R) | -0.20 |
| Final a (in) | 0.459  | Kmax             | 10.74 |

## Test Parameters

|                |       |                  |       |
|----------------|-------|------------------|-------|
| Initial a (in) | 0.459 | Initial K        | 10.70 |
| K-gradient     | -3.50 | Stress ratio (R) | -0.20 |

|         |          |                |
|---------|----------|----------------|
| K Coeff | PD Coeff | Analysis Codes |
|         | 0.223282 | KRCP 1 0       |
|         | 0.578970 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |

## Visual Observations

| PD     | Crack (PD) | Crack (visual) | Error | PDAF  |
|--------|------------|----------------|-------|-------|
| 80.58  | 0.454      | 0.454          | 0.000 | 0.936 |
| 257.14 | 0.641      | 0.641          | 0.000 | 1.034 |

## Comments

Date of test: 12-18-1997

| Pmax<br>(lbs) | PD<br>(1E-6) | a<br>(in) | N<br>(X1) | da<br>(in) | dN<br>(X1) | da/dN<br>(in/cyc) | dK<br>(ksi[in]^5) |
|---------------|--------------|-----------|-----------|------------|------------|-------------------|-------------------|
|               | 80.6         | 0.4538    | 12        |            |            |                   |                   |
| 3055          | 94.7         | 0.4675    | 4092      | 0.0303     | 9287       | 3.265E-06         | 10.08             |
| 2838          | 111.5        | 0.4841    | 9299      | 0.0341     | 11932      | 2.855E-06         | 9.55              |
| 2624          | 128.8        | 0.5016    | 16024     | 0.0349     | 16916      | 2.061E-06         | 9.02              |
| 2417          | 145.7        | 0.5190    | 26215     | 0.0364     | 24558      | 1.482E-06         | 8.49              |
| 2238          | 163.9        | 0.5380    | 40582     | 0.0363     | 36028      | 1.008E-06         | 8.03              |
| 2062          | 180.1        | 0.5553    | 62243     | 0.0364     | 57824      | 6.286E-07         | 7.56              |
| 1911          | 197.7        | 0.5743    | 98405     | 0.0379     | 83507      | 4.535E-07         | 7.15              |
| 1763          | 214.8        | 0.5932    | 145750    | 0.0387     | 103274     | 3.749E-07         | 6.75              |
| 1632          | 232.5        | 0.6131    | 201679    | 0.0391     | 135016     | 2.899E-07         | 6.38              |
|               | 249.4        | 0.6323    | 280766    |            |            |                   |                   |

# AUTOMATED FATIGUE CRACK GROWTH RATE ANALYSIS

|                 |            |                 |           |
|-----------------|------------|-----------------|-----------|
| Specimen Id.    | CM1A       | Geometry        | MT        |
| Contract #      | 06-8520    | Orientation     | LT        |
| Material        | 2014-T6511 | Yield (ksi)     | 60.7      |
| Temperature (F) | 75         | Initial AO (PD) | 0.364     |
| Environment     | LA         | Initial PD      | \$1000.00 |

## Specimen Dimensions (in)

|           |       |             |       |
|-----------|-------|-------------|-------|
| Thickness | 0.114 | Notch depth | 0.403 |
| Width     | 1.700 | Gage length | 0.000 |
| Height    | 0.000 |             |       |

## Precrack Parameters

|              |        |                  |       |
|--------------|--------|------------------|-------|
| Pmax (lbs)   | 3300.0 | Stress ratio (R) | -0.20 |
| Final a (in) | 0.459  | Kmax             | 10.74 |

## Test Parameters

|                |       |                  |       |
|----------------|-------|------------------|-------|
| Initial a (in) | 0.641 | Initial K        | 5.80  |
| K-gradient     | 3.50  | Stress ratio (R) | -0.20 |

|         |          |                  |
|---------|----------|------------------|
| K Coeff | PD Coeff | Analysis Codes   |
|         | 0.228290 | KRCP      1    0 |
|         | 0.578970 |                  |
|         | 0.000000 |                  |
|         | 0.000000 |                  |
|         | 0.000000 |                  |
|         | 0.000000 |                  |

## Visual Observations

| PD     | Crack (PD) | Crack (visual) | Error | PDAF  |
|--------|------------|----------------|-------|-------|
| 257.50 | 0.641      | 0.641          | 0.000 | 0.999 |
| 480.61 | 0.834      | 0.834          | 0.000 | 0.942 |

## Comments

Date of test: 12-19-1997

## Specimen Id.

## CM1A

## Page 1

| Pmax<br>(lbs) | PD<br>(1E-6) | a<br>(in) | N<br>(X1) | da<br>(in) | dN<br>(X1) | da/dN<br>(in/cyc) | dK<br>(ksi[in] <sup>0.5</sup> ) |
|---------------|--------------|-----------|-----------|------------|------------|-------------------|---------------------------------|
|               | 257.5        | 0.6413    | 6         |            |            |                   |                                 |
| 1491          | 269.9        | 0.6527    | 62443     | 0.0275     | 134667     | 2.039E-07         | 6.11                            |
| 1545          | 287.6        | 0.6688    | 134673    | 0.0317     | 126773     | 2.501E-07         | 6.42                            |
| 1611          | 305.0        | 0.6844    | 189216    | 0.0312     | 100539     | 3.107E-07         | 6.81                            |
| 1679          | 322.5        | 0.7000    | 235212    | 0.0309     | 73765      | 4.183E-07         | 7.22                            |
| 1750          | 339.8        | 0.7152    | 262981    | 0.0301     | 49803      | 6.036E-07         | 7.64                            |
| 1826          | 356.8        | 0.7301    | 285015    | 0.0302     | 39666      | 7.610E-07         | 8.10                            |
| 1907          | 374.6        | 0.7454    | 302647    | 0.0316     | 26743      | 1.180E-06         | 8.60                            |
| 1988          | 393.5        | 0.7616    | 311757    | 0.0305     | 11826      | 2.576E-06         | 9.11                            |
| 2080          | 410.4        | 0.7759    | 314473    | 0.0298     | 4751       | 6.281E-06         | 9.69                            |
| 2159          | 429.0        | 0.7915    | 316509    | 0.0271     | 6776       | 3.992E-06         | 10.19                           |
| 2256          | 442.8        | 0.8029    | 321248    | 0.0261     | 10684      | 2.439E-06         | 10.82                           |
| 2318          | 460.6        | 0.8175    | 327193    | 0.0216     | 8046       | 2.683E-06         | 11.23                           |
|               | 469.2        | 0.8245    | 329295    |            |            |                   |                                 |

# AUTOMATED FATIGUE CRACK GROWTH RATE ANALYSIS

|                            |                             |
|----------------------------|-----------------------------|
| Specimen Id.    CM1B       | Geometry            MT      |
| Contract #      06-8520    | Orientation        LT       |
| Material        2014-T6511 | Yield (ksi)        60.7     |
| Temperature (F) 75         | Initial AO (PD)    0.364    |
| Environment    LA          | Initial PD        \$1000.00 |

## Specimen Dimensions (in)

|                        |                          |
|------------------------|--------------------------|
| Thickness        0.114 | Notch depth        0.403 |
| Width            1.700 | Gage length        0.000 |
| Height           0.000 |                          |

## Precrack Parameters

|                          |                           |
|--------------------------|---------------------------|
| Pmax (lbs)        3300.0 | Stress ratio (R)-0.20     |
| Final a (in)      0.459  | Kmax                10.74 |

## Test Parameters

|                         |                            |
|-------------------------|----------------------------|
| Initial a (in)    0.834 | Initial K            12.50 |
| K-gradient       -3.50  | Stress ratio (R)-0.20      |

|         |          |                    |
|---------|----------|--------------------|
| K Coeff | PD Coeff | Analysis Codes     |
|         | 0.212230 | KRCP        1    0 |
|         | 0.578970 |                    |
|         | 0.000000 |                    |
|         | 0.000000 |                    |
|         | 0.000000 |                    |
|         | 0.000000 |                    |

## Visual Observations

| PD     | Crack (PD) | Crack (visual) | Error | PDAF  |
|--------|------------|----------------|-------|-------|
| 481.21 | 0.834      | 0.834          | 0.000 | 0.999 |
| 746.94 | 1.154      | 1.155          | 0.000 | 1.080 |

## Comments

Date of test: 12-21-1997

## Specimen Id.

## CM1B

## Page 1

| Pmax<br>(lbs) | PD<br>(1E-6) | a<br>(in) | N<br>(X1) | da<br>(in) | dN<br>(X1) | da/dN<br>(in/cyc) | dK<br>(ksi[in] <sup>-0.5</sup> ) |
|---------------|--------------|-----------|-----------|------------|------------|-------------------|----------------------------------|
|               | 481.2        | 0.8338    | 9         |            |            |                   |                                  |
| 2355          | 494.5        | 0.8488    | 1900      | 0.0343     | 6242       | 5.494E-06         | 11.86                            |
| 2200          | 511.4        | 0.8681    | 6251      | 0.0392     | 10915      | 3.591E-06         | 11.28                            |
| 2037          | 528.7        | 0.8879    | 12815     | 0.0399     | 14868      | 2.684E-06         | 10.67                            |
| 1886          | 545.9        | 0.9080    | 21120     | 0.0402     | 18936      | 2.122E-06         | 10.09                            |
| 1746          | 563.1        | 0.9281    | 31750     | 0.0403     | 24028      | 1.677E-06         | 9.54                             |
| 1616          | 580.2        | 0.9483    | 45148     | 0.0407     | 35068      | 1.161E-06         | 9.03                             |
| 1492          | 597.4        | 0.9688    | 66818     | 0.0425     | 50239      | 8.469E-07         | 8.53                             |
| 1382          | 615.7        | 0.9908    | 95387     | 0.0421     | 59184      | 7.111E-07         | 8.08                             |
| 1278          | 632.3        | 1.0109    | 126003    | 0.0402     | 71384      | 5.625E-07         | 7.65                             |
| 1181          | 648.7        | 1.0310    | 166771    | 0.0425     | 77524      | 5.487E-07         | 7.24                             |
| 1094          | 666.9        | 1.0535    | 203527    | 0.0438     | 92065      | 4.761E-07         | 6.87                             |
| 1010          | 684.1        | 1.0748    | 258836    | 0.0425     | 128468     | 3.308E-07         | 6.50                             |
| 932           | 701.0        | 1.0960    | 331995    | 0.0438     | 123551     | 3.544E-07         | 6.16                             |
| 862           | 718.9        | 1.1186    | 382387    | 0.0444     | 114852     | 3.866E-07         | 5.85                             |
|               | 736.0        | 1.1404    | 446847    |            |            |                   |                                  |

# AUTOMATED FATIGUE CRACK GROWTH RATE ANALYSIS

|                               |                             |
|-------------------------------|-----------------------------|
| Specimen Id.      CM1C        | Geometry            MT      |
| Contract #        06-8520     | Orientation        LT       |
| Material           2014-T6511 | Yield (ksi)        60.7     |
| Temperature (F)   75          | Initial AO (PD)   0.364     |
| Environment       LA          | Initial PD        \$1000.00 |

## Specimen Dimensions (in)

|                           |                          |
|---------------------------|--------------------------|
| Thickness           0.114 | Notch depth        0.403 |
| Width               1.700 | Gage length        0.000 |
| Height              0.000 |                          |

## Precrack Parameters

|                            |                           |
|----------------------------|---------------------------|
| Pmax (lbs)          3300.0 | Stress ratio (R) -0.20    |
| Final a (in)        0.459  | Kmax                10.74 |

## Test Parameters

|                            |                           |
|----------------------------|---------------------------|
| Initial a (in)       1.155 | Initial K            5.00 |
| K-gradient          3.50   | Stress ratio (R) -0.20    |

|         |          |                        |
|---------|----------|------------------------|
| K Coeff | PD Coeff | Analysis Codes         |
|         | 0.246650 | KRCP            1    0 |
|         | 0.578970 |                        |
|         | 0.000000 |                        |
|         | 0.000000 |                        |
|         | 0.000000 |                        |
|         | 0.000000 |                        |

## Visual Observations

| PD     | Crack (PD) | Crack (visual) | Error | PDAF  |
|--------|------------|----------------|-------|-------|
| 747.19 | 1.154      | 1.155          | 0.000 | 1.000 |
| 814.34 | 1.192      | 1.192          | 0.000 | 0.964 |

## Comments

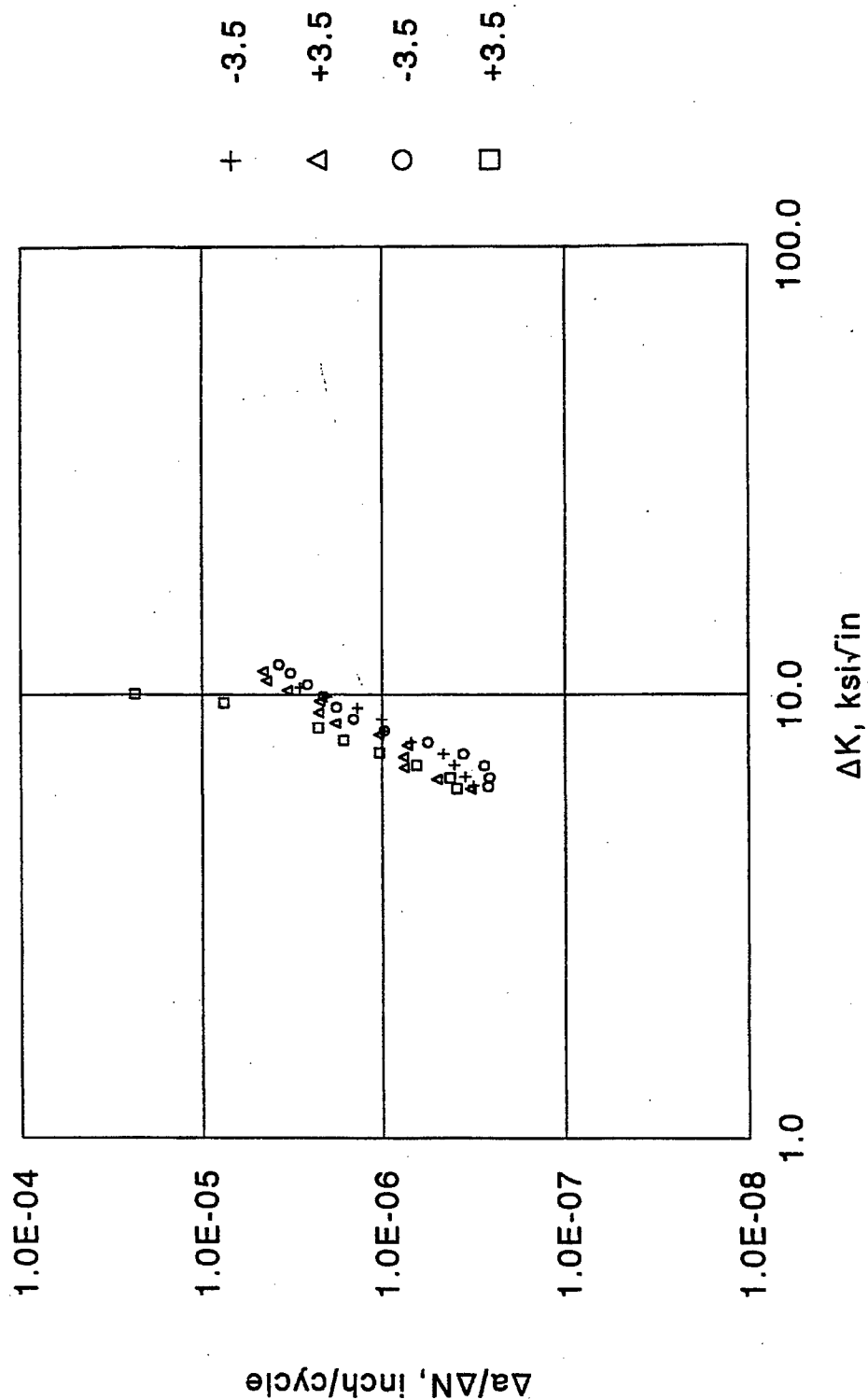
Date of test: 12-22-1997

## Specimen Id.

## CM1C

## Page 1

| Pmax<br>(lbs) | PD<br>(1E-6) | a<br>(in) | N<br>(X1) | da<br>(in) | dN<br>(X1) | da/dN<br>(in/cyc) | dK<br>(ksi[in] <sup>1.5</sup> ) |
|---------------|--------------|-----------|-----------|------------|------------|-------------------|---------------------------------|
|               | 747.2        | 1.1545    | 9         |            |            |                   |                                 |
| 729           | 760.0        | 1.1620    | 76931     | 0.0177     | 162558     | 1.088E-07         | 5.23                            |
| 753           | 777.8        | 1.1722    | 162567    | 0.0195     | 156917     | 1.241E-07         | 5.46                            |
| 775           | 794.6        | 1.1814    | 233848    | 0.0143     | 97977      | 1.463E-07         | 5.68                            |
|               | 804.0        | 1.1865    | 260544    |            |            |                   |                                 |



# AUTOMATED FATIGUE CRACK GROWTH RATE ANALYSIS

|                               |                             |
|-------------------------------|-----------------------------|
| Specimen Id.      CM2         | Geometry            MT      |
| Contract #        06-8520     | Orientation        LT       |
| Material           2014-T6511 | Yield (ksi)        60.7     |
| Temperature (F)   75          | Initial AO (PD)   0.350     |
| Environment       LA          | Initial PD        \$1000.00 |

## Specimen Dimensions (in)

|                           |                          |
|---------------------------|--------------------------|
| Thickness           0.105 | Notch depth        0.405 |
| Width               1.699 | Gage length        0.000 |
| Height              0.000 |                          |

## Precrack Parameters

|                            |                           |
|----------------------------|---------------------------|
| Pmax (lbs)          3050.0 | Stress ratio (R) -0.20    |
| Final a (in)        0.476  | Kmax                11.00 |

## Test Parameters

|                            |                            |
|----------------------------|----------------------------|
| Initial a (in)       0.476 | Initial K            11.00 |
| K-gradient         -3.50   | Stress ratio (R) -0.20     |

|         |          |                        |
|---------|----------|------------------------|
| K Coeff | PD Coeff | Analysis Codes         |
|         | 0.208740 | KRCP            1    0 |
|         | 0.579310 |                        |
|         | 0.000000 |                        |
|         | 0.000000 |                        |
|         | 0.000000 |                        |
|         | 0.000000 |                        |

## Visual Observations

| PD     | Crack (PD) | Crack (visual) | Error | PDAF  |
|--------|------------|----------------|-------|-------|
| 124.13 | 0.476      | 0.476          | 0.000 | 0.993 |
| 307.92 | 0.654      | 0.654          | 0.000 | 0.987 |

## Comments

Date of test: 12-23-1997

| Pmax<br>(lbs) | PD<br>(1E-6) | a<br>(in) | N<br>(X1) | da<br>(in) | dN<br>(X1) | da/dN<br>(in/cyc) | dK<br>(ksi[in] <sup>.5</sup> ) |
|---------------|--------------|-----------|-----------|------------|------------|-------------------|--------------------------------|
|               | 125.5        | 0.4774    | 287       |            |            |                   |                                |
| 2825          | 137.2        | 0.4887    | 3761      | 0.0274     | 9480       | 2.894E-06         | 10.38                          |
| 2639          | 153.7        | 0.5048    | 9767      | 0.0332     | 16269      | 2.038E-06         | 9.87                           |
| 2440          | 171.3        | 0.5219    | 20030     | 0.0339     | 24645      | 1.376E-06         | 9.31                           |
| 2255          | 188.7        | 0.5387    | 34412     | 0.0328     | 32596      | 1.007E-06         | 8.78                           |
| 2080          | 205.2        | 0.5547    | 52625     | 0.0332     | 34098      | 9.744E-07         | 8.26                           |
| 1927          | 223.0        | 0.5719    | 68509     | 0.0335     | 48494      | 6.913E-07         | 7.80                           |
| 1777          | 239.9        | 0.5882    | 101119    | 0.0334     | 72894      | 4.582E-07         | 7.33                           |
| 1645          | 257.6        | 0.6053    | 141403    | 0.0336     | 84285      | 3.988E-07         | 6.91                           |
| 1520          | 274.7        | 0.6218    | 185404    | 0.0329     | 94112      | 3.493E-07         | 6.51                           |
| 1433          | 291.7        | 0.6382    | 235516    | 0.0252     | 79951      | 3.155E-07         | 6.22                           |
|               | 300.9        | 0.6471    | 265354    |            |            |                   |                                |

# AUTOMATED FATIGUE CRACK GROWTH RATE ANALYSIS

|                 |            |                 |           |
|-----------------|------------|-----------------|-----------|
| Specimen Id.    | CM2A       | Geometry        | MT        |
| Contract #      | 06-8520    | Orientation     | LT        |
| Material        | 2014-T6511 | Yield (ksi)     | 60.7      |
| Temperature (F) | 75         | Initial AO (PD) | 0.350     |
| Environment     | LA         | Initial PD      | \$1000.00 |

## Specimen Dimensions (in)

|           |       |             |       |
|-----------|-------|-------------|-------|
| Thickness | 0.105 | Notch depth | 0.405 |
| Width     | 1.699 | Gage length | 0.000 |
| Height    | 0.000 |             |       |

## Precrack Parameters

|              |        |                  |       |
|--------------|--------|------------------|-------|
| Pmax (lbs)   | 3050.0 | Stress ratio (R) | -0.20 |
| Final a (in) | 0.476  | Kmax             | 11.00 |

## Test Parameters

|                |       |                  |       |
|----------------|-------|------------------|-------|
| Initial a (in) | 0.654 | Initial K        | 5.80  |
| K-gradient     | 3.50  | Stress ratio (R) | -0.20 |

|         |          |                |
|---------|----------|----------------|
| K Coeff | PD Coeff | Analysis Codes |
|         | 0.206430 | KRCP 1 0       |
|         | 0.579310 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |

## Visual Observations

| PD     | Crack (PD) | Crack (visual) | Error | PDAF  |
|--------|------------|----------------|-------|-------|
| 308.20 | 0.654      | 0.654          | 0.000 | 0.999 |
| 538.84 | 0.853      | 0.854          | 0.000 | 0.948 |

## Comments

Date of test: 12-28-1997

| Pmax<br>(lbs) | PD<br>(1E-6) | a<br>(in) | N<br>(X1) | da<br>(in) | dN<br>(X1) | da/dN<br>(in/cyc) | dK<br>(ksi[in]^5) |
|---------------|--------------|-----------|-----------|------------|------------|-------------------|-------------------|
|               | 308.2        | 0.6538    | 9         |            |            |                   |                   |
| 1357          | 320.3        | 0.6648    | 43198     | 0.0272     | 83304      | 3.265E-07         | 6.10              |
| 1406          | 338.1        | 0.6810    | 83313     | 0.0321     | 64748      | 4.955E-07         | 6.42              |
| 1469          | 355.8        | 0.6969    | 107946    | 0.0325     | 43071      | 7.555E-07         | 6.82              |
| 1528          | 374.5        | 0.7135    | 126384    | 0.0302     | 39946      | 7.571E-07         | 7.21              |
| 1597          | 389.9        | 0.7272    | 147892    | 0.0291     | 40390      | 7.215E-07         | 7.66              |
| 1662          | 407.6        | 0.7427    | 166774    | 0.0309     | 29586      | 1.043E-06         | 8.10              |
| 1737          | 425.2        | 0.7580    | 177477    | 0.0316     | 17276      | 1.832E-06         | 8.60              |
| 1808          | 444.2        | 0.7743    | 184050    | 0.0298     | 13120      | 2.274E-06         | 9.10              |
| 1888          | 460.0        | 0.7878    | 190597    | 0.0277     | 12278      | 2.254E-06         | 9.65              |
| 1970          | 476.7        | 0.8020    | 196327    | 0.0304     | 8928       | 3.401E-06         | 10.22             |
| 2047          | 496.1        | 0.8182    | 199525    | 0.0289     | 6530       | 4.427E-06         | 10.78             |
| 2122          | 511.3        | 0.8309    | 202857    | 0.0213     | 4612       | 4.614E-06         | 11.32             |
|               | 521.7        | 0.8395    | 204137    |            |            |                   |                   |

# AUTOMATED FATIGUE CRACK GROWTH RATE ANALYSIS

|                 |            |                 |           |
|-----------------|------------|-----------------|-----------|
| Specimen Id.    | CM2B       | Geometry        | MT        |
| Contract #      | 06-8520    | Orientation     | LT        |
| Material        | 2014-T6511 | Yield (ksi)     | 60.7      |
| Temperature (F) | 75         | Initial AO (PD) | 0.350     |
| Environment     | LA         | Initial PD      | \$1000.00 |

## Specimen Dimensions (in)

|           |       |             |       |
|-----------|-------|-------------|-------|
| Thickness | 0.105 | Notch depth | 0.405 |
| Width     | 1.699 | Gage length | 0.000 |
| Height    | 0.000 |             |       |

## Precrack Parameters

|              |        |                  |       |
|--------------|--------|------------------|-------|
| Pmax (lbs)   | 3050.0 | Stress ratio (R) | -0.20 |
| Final a (in) | 0.476  | Kmax             | 11.00 |

## Test Parameters

|                |       |                  |       |
|----------------|-------|------------------|-------|
| Initial a (in) | 0.854 | Initial K        | 12.50 |
| K-gradient     | -3.50 | Stress ratio (R) | -0.20 |

|         |          |                |
|---------|----------|----------------|
| K Coeff | PD Coeff | Analysis Codes |
|         | 0.190180 | KRCP 1 0       |
|         | 0.579310 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |

## Visual Observations

| PD     | Crack (PD) | Crack (visual) | Error | PDAF  |
|--------|------------|----------------|-------|-------|
| 543.01 | 0.853      | 0.854          | 0.000 | 0.992 |
| 760.15 | 1.051      | 1.051          | 0.000 | 0.973 |

## Comments

Date of test: 12-29-1997

| Pmax<br>(lbs) | PD<br>(1E-6) | a<br>(in) | N<br>(X1) | da<br>(in) | dN<br>(X1) | da/dN<br>(in/cyc) | dK<br>(ksi[in] <sup>-.5</sup> ) |
|---------------|--------------|-----------|-----------|------------|------------|-------------------|---------------------------------|
|               | 543.0        | 0.8535    | 11        |            |            |                   |                                 |
| 2115          | 551.7        | 0.8615    | 1992      | 0.0241     | 6394       | 3.771E-06         | 11.72                           |
| 1996          | 569.0        | 0.8776    | 6405      | 0.0318     | 9746       | 3.261E-06         | 11.20                           |
| 1847          | 586.1        | 0.8933    | 11738     | 0.0317     | 12064      | 2.631E-06         | 10.54                           |
| 1709          | 603.5        | 0.9093    | 18468     | 0.0320     | 14919      | 2.143E-06         | 9.92                            |
| 1582          | 620.9        | 0.9253    | 26656     | 0.0314     | 17320      | 1.811E-06         | 9.34                            |
| 1462          | 637.8        | 0.9407    | 35789     | 0.0314     | 21614      | 1.454E-06         | 8.78                            |
| 1353          | 655.4        | 0.9567    | 48270     | 0.0317     | 32640      | 9.713E-07         | 8.27                            |
| 1251          | 672.7        | 0.9724    | 68429     | 0.0311     | 56031      | 5.557E-07         | 7.78                            |
| 1157          | 689.7        | 0.9878    | 104301    | 0.0310     | 86626      | 3.574E-07         | 7.32                            |
| 1070          | 707.0        | 1.0034    | 155055    | 0.0310     | 112255     | 2.764E-07         | 6.88                            |
| 989           | 724.2        | 1.0189    | 216556    | 0.0312     | 119903     | 2.601E-07         | 6.47                            |
| 931           | 741.7        | 1.0346    | 274958    | 0.0236     | 89454      | 2.639E-07         | 6.18                            |
|               | 750.6        | 1.0425    | 306010    |            |            |                   |                                 |

# AUTOMATED FATIGUE CRACK GROWTH RATE ANALYSIS

|                               |                             |
|-------------------------------|-----------------------------|
| Specimen Id.      CM2C        | Geometry            MT      |
| Contract #        06-8520     | Orientation        LT       |
| Material           2014-T6511 | Yield (ksi)        60.7     |
| Temperature (F)   75          | Initial AO (PD)   0.350     |
| Environment       LA          | Initial PD        \$1000.00 |

## Specimen Dimensions (in)

|                           |                          |
|---------------------------|--------------------------|
| Thickness           0.105 | Notch depth        0.405 |
| Width               1.699 | Gage length        0.000 |
| Height              0.000 |                          |

## Precrack Parameters

|                            |                           |
|----------------------------|---------------------------|
| Pmax (lbs)          3050.0 | Stress ratio (R)-0.20     |
| Final a (in)        0.476  | Kmax                11.00 |

## Test Parameters

|                            |                           |
|----------------------------|---------------------------|
| Initial a (in)       1.051 | Initial K            5.80 |
| K-gradient          3.50   | Stress ratio (R)-0.20     |

|         |          |                       |
|---------|----------|-----------------------|
| K Coeff | PD Coeff | Analysis Codes        |
|         | 0.178280 | KRCP            1   0 |
|         | 0.579310 |                       |
|         | 0.000000 |                       |
|         | 0.000000 |                       |
|         | 0.000000 |                       |
|         | 0.000000 |                       |

## Visual Observations

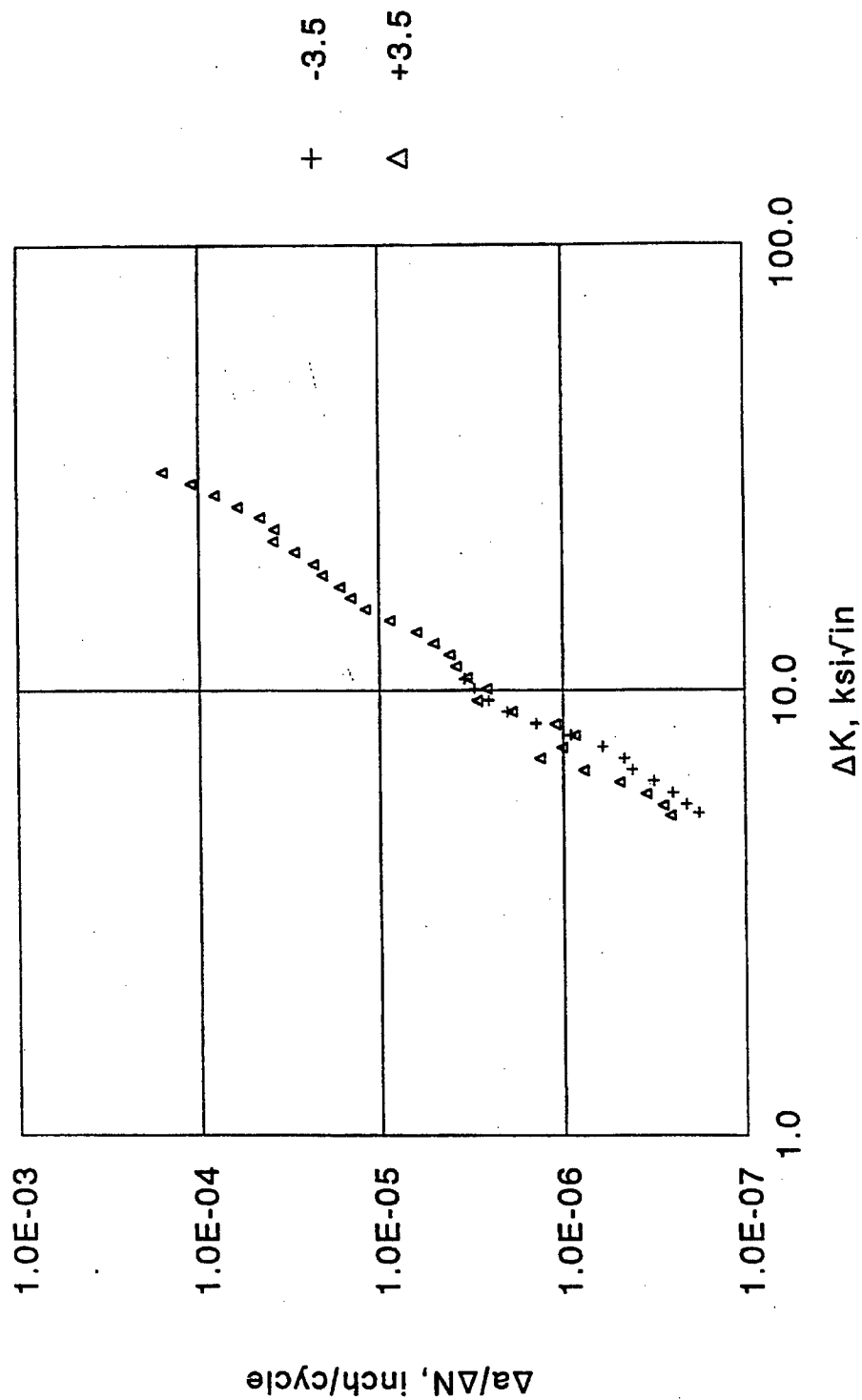
| PD     | Crack (PD) | Crack (visual) | Error | PDAF  |
|--------|------------|----------------|-------|-------|
| 760.27 | 1.051      | 1.051          | 0.000 | 1.000 |
| 935.32 | 1.265      | 1.265          | 0.000 | 1.045 |

## Comments

Date of test: 12-30-1997

| Pmax<br>(lbs) | PD<br>(1E-6) | a<br>(in) | N<br>(X1) | da<br>(in) | dN<br>(X1) | da/dN<br>(in/cyc) | dK<br>(ksi[in] <sup>.5</sup> ) |
|---------------|--------------|-----------|-----------|------------|------------|-------------------|--------------------------------|
|               | 760.3        | 1.0510    | 25        |            |            |                   |                                |
| 884           | 772.2        | 1.0650    | 31232     | 0.0347     | 89417      | 3.880E-07         | 6.12                           |
| 915           | 789.5        | 1.0857    | 89442     | 0.0420     | 100117     | 4.199E-07         | 6.47                           |
| 953           | 807.4        | 1.1071    | 131348    | 0.0438     | 68246      | 6.420E-07         | 6.92                           |
| 991           | 826.0        | 1.1295    | 157688    | 0.0429     | 41398      | 1.035E-06         | 7.38                           |
| 1030          | 842.8        | 1.1500    | 172746    | 0.0400     | 24141      | 1.657E-06         | 7.87                           |
| 1070          | 858.8        | 1.1695    | 181828    | 0.0418     | 18265      | 2.287E-06         | 8.41                           |
| 1153          | 876.8        | 1.1917    | 191012    | 0.0875     | 11533      | 7.590E-06         | 9.58                           |
| 1183          | 929.0        | 1.2570    | 193361    | 0.0733     | 3084       | 2.375E-05         | 10.04                          |
|               | 935.3        | 1.2650    | 194096    |            |            |                   |                                |

Fairchild DTA 06-8520 CM3  
 2014-T65121 EXTR MT SPEC. R= -0.2



# AUTOMATED FATIGUE CRACK GROWTH RATE ANALYSIS

|                 |            |                 |           |
|-----------------|------------|-----------------|-----------|
| Specimen Id.    | CM3        | Geometry        | MT        |
| Contract #      | 06-8520    | Orientation     | LT        |
| Material        | 2014-T6511 | Yield (ksi)     | 60.7      |
| Temperature (F) | 75         | Initial A0 (PD) | 0.345     |
| Environment     | LA         | Initial PD      | \$1000.00 |

## Specimen Dimensions (in)

|           |       |             |       |
|-----------|-------|-------------|-------|
| Thickness | 0.109 | Notch depth | 0.404 |
| Width     | 1.701 | Gage length | 0.000 |
| Height    | 0.000 |             |       |

## Precrack Parameters

|              |        |                  |       |
|--------------|--------|------------------|-------|
| Pmax (lbs)   | 3300.0 | Stress ratio (R) | -0.20 |
| Final a (in) | 0.492  | Kmax             | 11.64 |

## Test Parameters

|                |       |                  |       |
|----------------|-------|------------------|-------|
| Initial a (in) | 0.492 | Initial K        | 11.20 |
| K-gradient     | -3.50 | Stress ratio (R) | -0.20 |

|         |          |                |
|---------|----------|----------------|
| K Coeff | PD Coeff | Analysis Codes |
|         | 0.213290 | KRCP 1 0       |
|         | 0.578630 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |

## Visual Observations

|        |            |                |       |       |
|--------|------------|----------------|-------|-------|
| PD     | Crack (PD) | Crack (visual) | Error | PDAF  |
| 131.98 | 0.492      | 0.492          | 0.000 | 0.997 |
| 366.06 | 0.727      | 0.727          | 0.000 | 1.011 |

## Comments

Date of test: 01-05-1998

| Pmax<br>(lbs) | PD<br>(1E-6) | a<br>(in) | N<br>(X1) | da<br>(in) | dN<br>(X1) | da/dN<br>(in/cyc) | dK<br>(ksi[in] <sup>.5</sup> ) |
|---------------|--------------|-----------|-----------|------------|------------|-------------------|--------------------------------|
|               | 132.0        | 0.4923    | 9         |            |            |                   |                                |
| 2952          | 145.1        | 0.5053    | 3457      | 0.0300     | 8766       | 3.425E-06         | 10.61                          |
| 2755          | 162.3        | 0.5223    | 8774      | 0.0337     | 11075      | 3.039E-06         | 10.08                          |
| 2544          | 179.0        | 0.5389    | 14532     | 0.0339     | 13384      | 2.533E-06         | 9.50                           |
| 2354          | 196.4        | 0.5562    | 22159     | 0.0343     | 17101      | 2.007E-06         | 8.96                           |
| 2175          | 213.5        | 0.5733    | 31633     | 0.0342     | 24444      | 1.400E-06         | 8.45                           |
| 2009          | 230.7        | 0.5904    | 46602     | 0.0348     | 38352      | 9.069E-07         | 7.96                           |
| 1859          | 248.2        | 0.6080    | 69985     | 0.0347     | 57610      | 6.024E-07         | 7.51                           |
| 1717          | 265.3        | 0.6252    | 104212    | 0.0345     | 75637      | 4.565E-07         | 7.07                           |
| 1589          | 282.6        | 0.6426    | 145621    | 0.0350     | 84652      | 4.129E-07         | 6.67                           |
| 1472          | 300.0        | 0.6601    | 188864    | 0.0343     | 109454     | 3.133E-07         | 6.29                           |
| 1359          | 316.6        | 0.6769    | 255075    | 0.0349     | 141131     | 2.472E-07         | 5.92                           |
| 1259          | 334.5        | 0.6950    | 329995    | 0.0358     | 171276     | 2.091E-07         | 5.59                           |
| 1187          | 352.0        | 0.7127    | 426351    | 0.0262     | 146036     | 1.795E-07         | 5.34                           |
|               | 360.4        | 0.7212    | 476031    |            |            |                   |                                |

# AUTOMATED FATIGUE CRACK GROWTH RATE ANALYSIS

|                           |                              |
|---------------------------|------------------------------|
| Specimen Id.    CM3A      | Geometry            MT       |
| Contract #    06-8520     | Orientation        LT        |
| Material       2014-T6511 | Yield (ksi)        60.7      |
| Temperature (F) 75        | Initial A0 (PD)    0.345     |
| Environment    LA         | Initial PD         \$1000.00 |

## Specimen Dimensions (in)

|                        |                         |
|------------------------|-------------------------|
| Thickness        0.109 | Notch depth       0.404 |
| Width            1.701 | Gage length       0.000 |
| Height           0.000 |                         |

## Precrack Parameters

|                         |                          |
|-------------------------|--------------------------|
| Pmax (lbs)       3300.0 | Stress ratio (R) -0.20   |
| Final a (in)    0.492   | Kmax               11.64 |

## Test Parameters

|                         |                          |
|-------------------------|--------------------------|
| Initial a (in)    0.727 | Initial K           5.00 |
| K-gradient       3.50   | Stress ratio (R) -0.20   |

|         |          |                    |
|---------|----------|--------------------|
| K Coeff | PD Coeff | Analysis Codes     |
|         | 0.215586 | KRCP        1    0 |
|         | 0.578630 |                    |
|         | 0.000000 |                    |
|         | 0.000000 |                    |
|         | 0.000000 |                    |
|         | 0.000000 |                    |

## Visual Observations

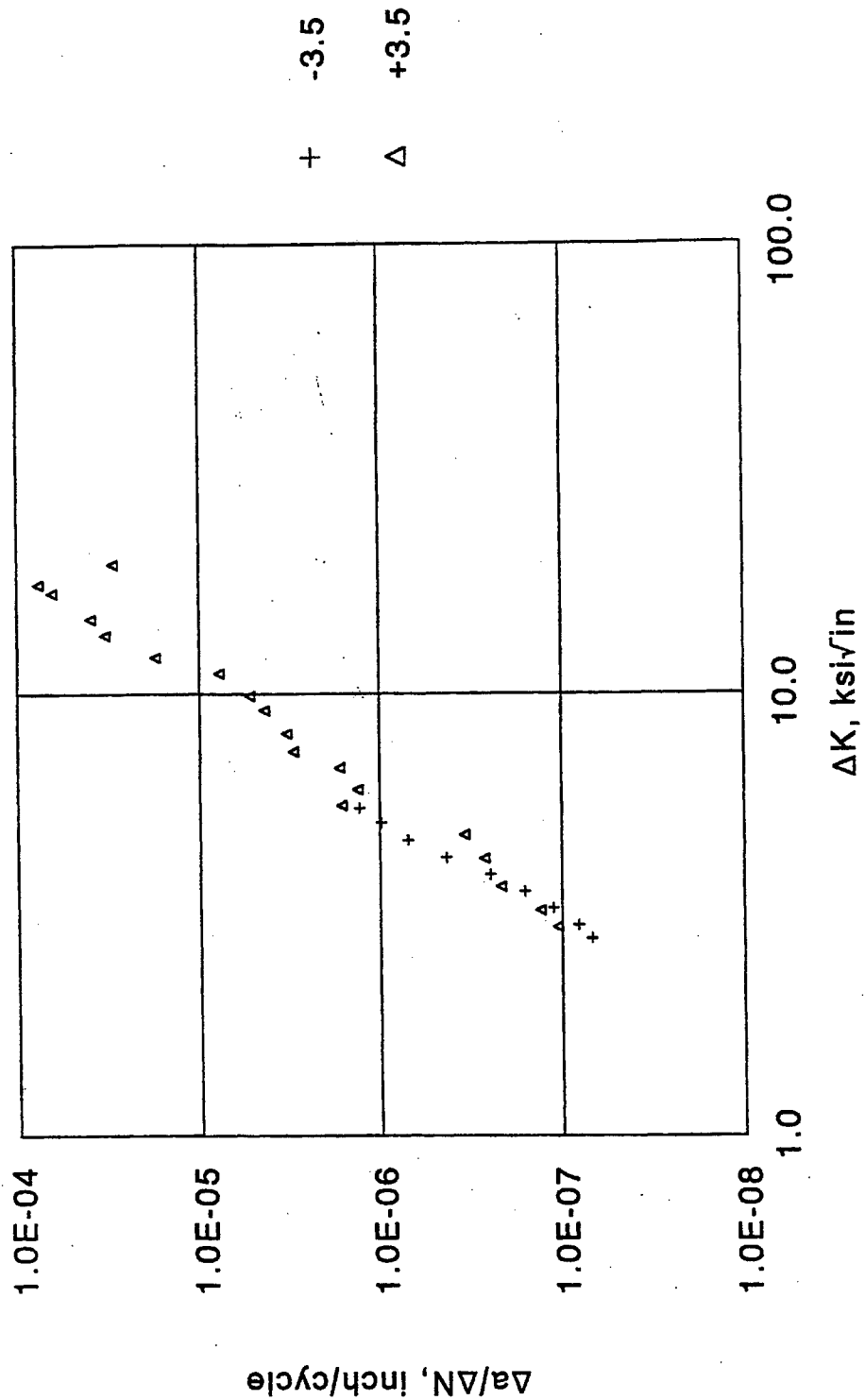
| PD     | Crack (PD) | Crack (visual) | Error  | PDAF  |
|--------|------------|----------------|--------|-------|
| 366.10 | 0.725      | 0.727          | 0.002  | 0.994 |
| 632.05 | 0.984      | 0.977          | -0.007 | 0.992 |
| 878.64 | 1.223      | 1.228          | 0.005  | 0.990 |

## Comments

Date of test: 01-06-1998

| Pmax<br>(lbs) | PD<br>(1E-6) | a<br>(in) | N<br>(X1) | da<br>(in) | dN<br>(X1) | da/dN<br>(in/cyc) | dK<br>(ksi[in] <sup>1.5</sup> ) |
|---------------|--------------|-----------|-----------|------------|------------|-------------------|---------------------------------|
|               | 366.1        | 0.7251    | 384       |            |            |                   |                                 |
| 1130          | 379.3        | 0.7379    | 55125     | 0.0301     | 118310     | 2.543E-07         | 5.26                            |
| 1172          | 397.0        | 0.7552    | 118694    | 0.0340     | 121744     | 2.796E-07         | 5.54                            |
| 1223          | 414.2        | 0.7720    | 176869    | 0.0341     | 98363      | 3.462E-07         | 5.89                            |
| 1276          | 431.9        | 0.7892    | 217058    | 0.0344     | 70659      | 4.865E-07         | 6.25                            |
| 1331          | 449.5        | 0.8063    | 247527    | 0.0339     | 44024      | 7.704E-07         | 6.64                            |
| 1390          | 466.7        | 0.8232    | 261081    | 0.0345     | 25824      | 1.337E-06         | 7.06                            |
| 1446          | 484.9        | 0.8409    | 273351    | 0.0330     | 32689      | 1.008E-06         | 7.47                            |
| 1511          | 500.6        | 0.8561    | 293770    | 0.0329     | 38357      | 8.584E-07         | 7.95                            |
| 1571          | 518.8        | 0.8738    | 311708    | 0.0343     | 31243      | 1.097E-06         | 8.41                            |
| 1642          | 535.8        | 0.8904    | 325014    | 0.0342     | 18081      | 1.893E-06         | 8.95                            |
| 1708          | 554.0        | 0.9080    | 329789    | 0.0333     | 11417      | 2.920E-06         | 9.48                            |
| 1782          | 570.1        | 0.9237    | 336431    | 0.0324     | 12501      | 2.589E-06         | 10.07                           |
| 1855          | 587.2        | 0.9404    | 342290    | 0.0337     | 10156      | 3.317E-06         | 10.67                           |
| 1931          | 604.7        | 0.9574    | 346587    | 0.0333     | 8723       | 3.815E-06         | 11.31                           |
| 2012          | 621.5        | 0.9737    | 351013    | 0.0330     | 7989       | 4.132E-06         | 12.00                           |
| 2096          | 638.7        | 0.9904    | 354575    | 0.0342     | 6793       | 5.034E-06         | 12.74                           |
| 2183          | 656.7        | 1.0079    | 357806    | 0.0342     | 5470       | 6.253E-06         | 13.51                           |
| 2275          | 673.9        | 1.0246    | 360045    | 0.0334     | 3812       | 8.762E-06         | 14.35                           |
| 2366          | 691.1        | 1.0413    | 361618    | 0.0329     | 2777       | 1.185E-05         | 15.21                           |
| 2465          | 707.8        | 1.0575    | 362822    | 0.0338     | 2357       | 1.434E-05         | 16.16                           |
| 2561          | 726.0        | 1.0751    | 363975    | 0.0338     | 2040       | 1.656E-05         | 17.11                           |
| 2669          | 742.7        | 1.0913    | 364862    | 0.0339     | 1648       | 2.060E-05         | 18.21                           |
| 2768          | 761.0        | 1.1090    | 365623    | 0.0327     | 1417       | 2.308E-05         | 19.24                           |
| 2886          | 776.4        | 1.1240    | 366279    | 0.0333     | 1132       | 2.943E-05         | 20.50                           |
| 2991          | 795.4        | 1.1423    | 366754    | 0.0347     | 900        | 3.860E-05         | 21.67                           |
| 3109          | 812.3        | 1.1587    | 367179    | 0.0324     | 847        | 3.819E-05         | 23.02                           |
| 3231          | 828.8        | 1.1747    | 367601    | 0.0340     | 740        | 4.591E-05         | 24.46                           |
| 3346          | 847.4        | 1.1927    | 367918    | 0.0337     | 553        | 6.106E-05         | 25.86                           |
| 3475          | 863.6        | 1.2084    | 368154    | 0.0324     | 397        | 8.162E-05         | 27.49                           |
| 3601          | 880.8        | 1.2250    | 368315    | 0.0341     | 310        | 1.100E-04         | 29.14                           |
| 3732          | 898.8        | 1.2425    | 368464    | 0.0351     | 223        | 1.578E-04         | 30.94                           |
|               | 916.8        | 1.2602    | 368537    |            |            |                   |                                 |

Fairchild DTA 06-8520 CE1  
 2014-T65121 EXTR ECT SPEC: R=0.5



# AUTOMATED FATIGUE CRACK GROWTH RATE ANALYSIS

|                 |            |                 |           |
|-----------------|------------|-----------------|-----------|
| Specimen Id.    | CE1        | Geometry        | ECT       |
| Contract #      | 06-8520    | Orientation     | LT        |
| Material        | 2024-T6511 | Yield (ksi)     | 60.7      |
| Temperature (F) | 74         | Initial AO (PD) | 0.576     |
| Environment     | LA         | Initial PD      | \$1000.00 |

## Specimen Dimensions (in)

|           |       |             |       |
|-----------|-------|-------------|-------|
| Thickness | 0.116 | Notch depth | 0.614 |
| Width     | 2.506 | Gage length | 0.000 |
| Height    | 0.000 |             |       |

## Precrack Parameters

|              |       |                  |       |
|--------------|-------|------------------|-------|
| Pmax (lbs)   | 600.0 | Stress ratio (R) | 0.50  |
| Final a (in) | 0.760 | Kmax             | 11.79 |

## Test Parameters

|                |       |                  |       |
|----------------|-------|------------------|-------|
| Initial a (in) | 0.760 | Initial K        | 12.00 |
| K-gradient     | -3.50 | Stress ratio (R) | 0.50  |

|         |          |                |
|---------|----------|----------------|
| K Coeff | PD Coeff | Analysis Codes |
|         | 0.237470 | KREP 1 0       |
|         | 0.471310 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |

## Visual Observations

|        |            |                |       |       |
|--------|------------|----------------|-------|-------|
| PD     | Crack (PD) | Crack (visual) | Error | PDAF  |
| 139.74 | 0.759      | 0.760          | 0.000 | 0.996 |
| 347.07 | 0.999      | 0.999          | 0.000 | 0.987 |

## Comments

Date of test: 01-21-1998

Specimen Id. CE1

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| Pmax<br>(lbs) | PD<br>(1E-6) | a<br>(in) | N<br>(X1) | da<br>(in) | dN<br>(X1) | da/dN<br>(in/cyc) | dK<br>(ksi[in]^0.5) |
|---------------|--------------|-----------|-----------|------------|------------|-------------------|---------------------|
|               | 139.7        | 0.7595    | 6         |            |            |                   |                     |
| 548           | 155.3        | 0.7777    | 11881     | 0.0433     | 33230      | 1.303E-06         | 5.54                |
| 495           | 176.9        | 0.8028    | 33236     | 0.0493     | 50020      | 9.849E-07         | 5.14                |
| 438           | 197.6        | 0.8269    | 61901     | 0.0494     | 70453      | 7.017E-07         | 4.69                |
| 389           | 219.4        | 0.8522    | 103688    | 0.0499     | 115354     | 4.325E-07         | 4.30                |
| 345           | 240.6        | 0.8768    | 177255    | 0.0488     | 196114     | 2.487E-07         | 3.94                |
| 306           | 261.5        | 0.9010    | 299802    | 0.0490     | 305322     | 1.605E-07         | 3.60                |
| 272           | 283.0        | 0.9258    | 482577    | 0.0489     | 439348     | 1.113E-07         | 3.30                |
| 241           | 303.9        | 0.9499    | 739150    | 0.0484     | 598821     | 8.084E-08         | 3.02                |
| 220           | 325.0        | 0.9742    | 1081398   | 0.0371     | 540329     | 6.868E-08         | 2.82                |
|               | 336.2        | 0.9870    | 1279479   |            |            |                   |                     |

# AUTOMATED FATIGUE CRACK GROWTH RATE ANALYSIS

|                 |            |                 |           |
|-----------------|------------|-----------------|-----------|
| Specimen Id.    | CE1A       | Geometry        | ECT       |
| Contract #      | 06-8520    | Orientation     | LT        |
| Material        | 2024-T6511 | Yield (ksi)     | 60.7      |
| Temperature (F) | 74         | Initial A0 (PD) | 0.576     |
| Environment     | LA         | Initial PD      | \$1000.00 |

## Specimen Dimensions (in)

|           |       |             |       |
|-----------|-------|-------------|-------|
| Thickness | 0.116 | Notch depth | 0.614 |
| Width     | 2.506 | Gage length | 0.000 |
| Height    | 0.000 |             |       |

## Precrack Parameters

|              |       |                  |       |
|--------------|-------|------------------|-------|
| Pmax (lbs)   | 600.0 | Stress ratio (R) | 0.50  |
| Final a (in) | 0.760 | Kmax             | 11.79 |

## Test Parameters

|                |       |                  |      |
|----------------|-------|------------------|------|
| Initial a (in) | 0.999 | Initial K        | 5.30 |
| K-gradient     | 3.50  | Stress ratio (R) | 0.50 |

|         |          |                |
|---------|----------|----------------|
| K Coeff | PD Coeff | Analysis Codes |
|         | 0.218000 | KREP 1 0       |
|         | 0.471310 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |

## Visual Observations

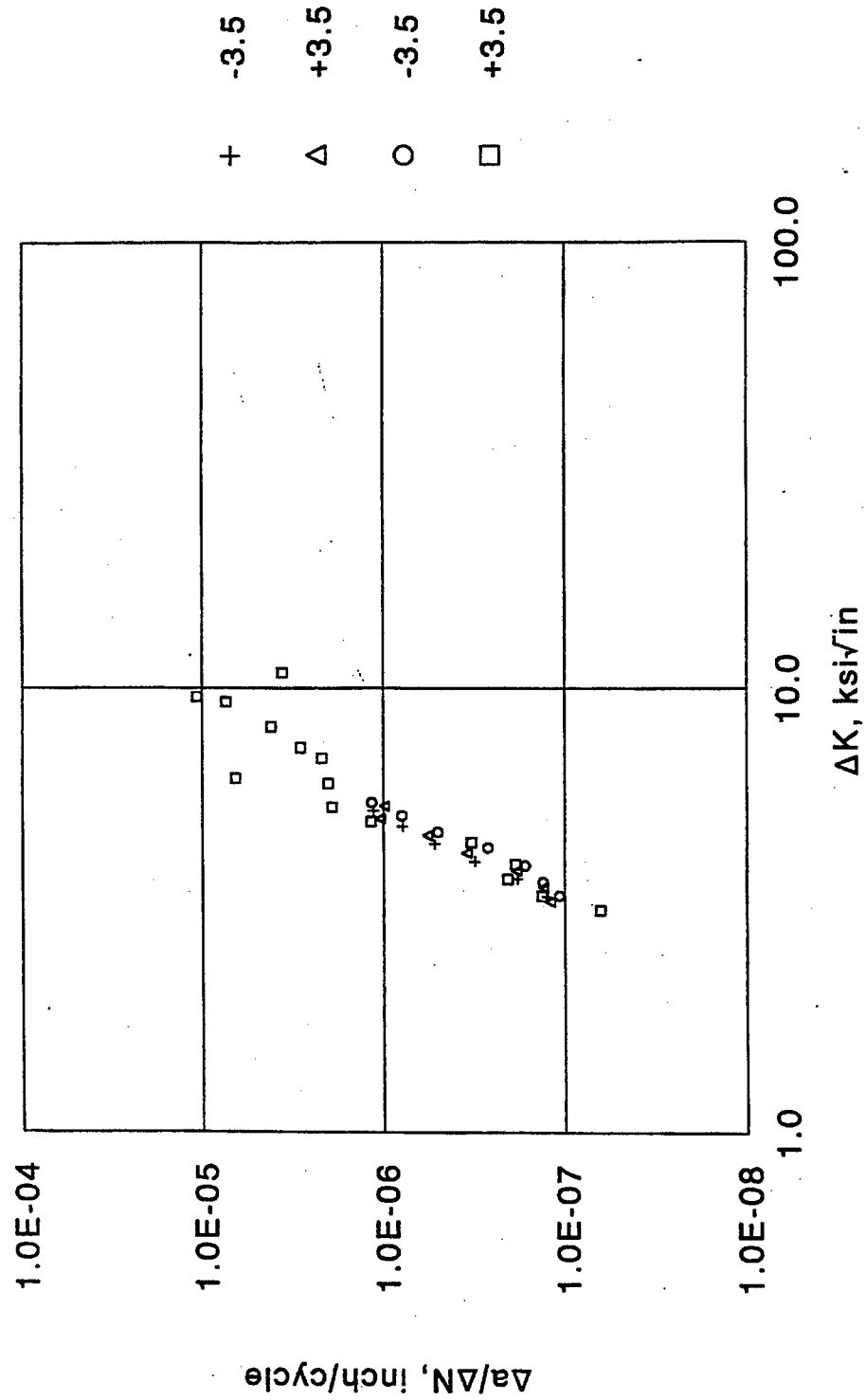
| PD     | Crack (PD) | Crack (visual) | Error | PDAF  |
|--------|------------|----------------|-------|-------|
| 347.16 | 0.964      | 0.999          | 0.036 | 1.018 |
| 619.73 | 1.295      | 1.164          | -.131 | 1.023 |
| 876.25 | 1.610      | 1.706          | 0.096 | 1.028 |

## Comments

Date of test: 01-23-1998

| Pmax<br>(lbs) | PD<br>(1E-6) | a<br>(in) | N<br>(X1) | da<br>(in) | dN<br>(X1) | da/dN<br>(in/cyc) | dK<br>(ksi[in] <sup>.5</sup> ) |
|---------------|--------------|-----------|-----------|------------|------------|-------------------|--------------------------------|
|               | 388.2        | 1.0136    | 1080      |            |            |                   |                                |
| 212           | 405.7        | 1.0347    | 231489    | 0.0528     | 500066     | 1.055E-07         | 2.99                           |
| 224           | 431.7        | 1.0663    | 501145    | 0.0602     | 458825     | 1.311E-07         | 3.26                           |
| 241           | 455.3        | 1.0949    | 690314    | 0.0691     | 318767     | 2.169E-07         | 3.69                           |
| 263           | 488.6        | 1.1354    | 819912    | 0.0974     | 363821     | 2.676E-07         | 4.27                           |
| 283           | 535.3        | 1.1923    | 1054136   | 0.0869     | 253439     | 3.430E-07         | 4.83                           |
| 309           | 560.0        | 1.2224    | 1073351   | 0.0602     | 36941      | 1.630E-06         | 5.61                           |
| 324           | 584.7        | 1.2525    | 1091076   | 0.0476     | 35935      | 1.326E-06         | 6.09                           |
| 346           | 599.0        | 1.2700    | 1109286   | 0.0517     | 30847      | 1.678E-06         | 6.80                           |
| 363           | 627.0        | 1.3042    | 1121923   | 0.0654     | 21543      | 3.034E-06         | 7.39                           |
| 382           | 652.5        | 1.3354    | 1130829   | 0.0507     | 15285      | 3.315E-06         | 8.11                           |
| 409           | 668.4        | 1.3549    | 1137209   | 0.0591     | 13500      | 4.378E-06         | 9.16                           |
| 427           | 700.7        | 1.3945    | 1144328   | 0.0641     | 12144      | 5.277E-06         | 9.89                           |
| 455           | 720.7        | 1.4190    | 1149352   | 0.0538     | 6947       | 7.741E-06         | 11.13                          |
| 476           | 744.6        | 1.4482    | 1151275   | 0.0538     | 3082       | 1.744E-05         | 12.12                          |
| 506           | 764.5        | 1.4727    | 1152434   | 0.0630     | 1909       | 3.299E-05         | 13.62                          |
| 529           | 795.8        | 1.5112    | 1153184   | 0.0645     | 1627       | 3.966E-05         | 14.87                          |
| 566           | 817.0        | 1.5373    | 1154061   | 0.0657     | 1026       | 6.400E-05         | 17.02                          |
| 578           | 849.1        | 1.5769    | 1154210   | 0.0382     | 500        | 7.636E-05         | 17.76                          |
| 608           | 848.0        | 1.5754    | 1154561   | 0.0199     | 667        | 2.987E-05         | 19.74                          |
|               | 865.3        | 1.5968    | 1154877   |            |            |                   |                                |

Fairchild DTA 06-8520 CE2  
 2014-T65121 EXTR ECT SPEC. R=0.5



# AUTOMATED FATIGUE CRACK GROWTH RATE ANALYSIS

|                 |            |                 |           |
|-----------------|------------|-----------------|-----------|
| Specimen Id.    | CE2        | Geometry        | ECT       |
| Contract #      | 06-8520    | Orientation     | LT        |
| Material        | 2024-T6511 | Yield (ksi)     | 60.7      |
| Temperature (F) | 74         | Initial A0 (PD) | 0.539     |
| Environment     | LA         | Initial PD      | \$1000.00 |

## Specimen Dimensions (in)

|           |       |             |       |
|-----------|-------|-------------|-------|
| Thickness | 0.116 | Notch depth | 0.614 |
| Width     | 2.503 | Gage length | 0.000 |
| Height    | 0.000 |             |       |

## Precrack Parameters

|              |       |                  |       |
|--------------|-------|------------------|-------|
| Pmax (lbs)   | 600.0 | Stress ratio (R) | 0.50  |
| Final a (in) | 0.737 | Kmax             | 11.43 |

## Test Parameters

|                |       |                  |       |
|----------------|-------|------------------|-------|
| Initial a (in) | 0.737 | Initial K        | 11.50 |
| K-gradient     | -3.50 | Stress ratio (R) | 0.50  |

|         |          |                |
|---------|----------|----------------|
| K Coeff | PD Coeff | Analysis Codes |
|         | 0.219250 | KREP 1 0       |
|         | 0.471870 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |

## Visual Observations

| PD     | Crack (PD) | Crack (visual) | Error | PDAF  |
|--------|------------|----------------|-------|-------|
| 159.60 | 0.737      | 0.737          | 0.000 | 0.998 |
| 307.72 | 0.898      | 0.898          | 0.000 | 0.961 |

## Comments

Date of test: 01-15-1998

Specimen Id. CE2

Page 1

| Pmax<br>(lbs) | PD<br>(1E-6) | a<br>(in) | N<br>(X1) | da<br>(in) | dN<br>(X1) | da/dN<br>(in/cyc) | dK<br>(ksi[in]^0.5) |
|---------------|--------------|-----------|-----------|------------|------------|-------------------|---------------------|
|               | 159.6        | 0.7370    | 6         |            |            |                   |                     |
| 543           | 175.6        | 0.7550    | 13269     | 0.0414     | 36496      | 1.135E-06         | 5.31                |
| 489           | 196.6        | 0.7784    | 36502     | 0.0468     | 59548      | 7.854E-07         | 4.91                |
| 434           | 217.7        | 0.8017    | 72817     | 0.0467     | 89919      | 5.196E-07         | 4.49                |
| 385           | 239.2        | 0.8251    | 126421    | 0.0465     | 148354     | 3.133E-07         | 4.10                |
| 342           | 260.6        | 0.8482    | 221171    | 0.0447     | 245600     | 1.822E-07         | 3.75                |
| 303           | 281.0        | 0.8699    | 372021    | 0.0448     | 359374     | 1.246E-07         | 3.42                |
|               | 302.9        | 0.8930    | 580545    |            |            |                   |                     |

# AUTOMATED FATIGUE CRACK GROWTH RATE ANALYSIS

|                 |            |                 |           |
|-----------------|------------|-----------------|-----------|
| Specimen Id.    | CE2A       | Geometry        | ECT       |
| Contract #      | 06-8520    | Orientation     | LT        |
| Material        | 2024-T6511 | Yield (ksi)     | 60.7      |
| Temperature (F) | 74         | Initial A0 (PD) | 0.539     |
| Environment     | LA         | Initial PD      | \$1000.00 |

## Specimen Dimensions (in)

|           |       |             |       |
|-----------|-------|-------------|-------|
| Thickness | 0.116 | Notch depth | 0.614 |
| Width     | 2.503 | Gage length | 0.000 |
| Height    | 0.000 |             |       |

## Precrack Parameters

|              |       |                  |       |
|--------------|-------|------------------|-------|
| Pmax (lbs)   | 600.0 | Stress ratio (R) | 0.50  |
| Final a (in) | 0.737 | Kmax             | 11.43 |

## Test Parameters

|                |       |                  |      |
|----------------|-------|------------------|------|
| Initial a (in) | 0.898 | Initial K        | 6.20 |
| K-gradient     | 3.50  | Stress ratio (R) | 0.50 |

|         |          |                |
|---------|----------|----------------|
| K Coeff | PD Coeff | Analysis Codes |
|         | 0.213520 | KREP 1 0       |
|         | 0.471870 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |

## Visual Observations

| PD     | Crack (PD) | Crack (visual) | Error | PDAF |
|--------|------------|----------------|-------|------|
| 307.67 | 0.898      | 0.898          |       |      |
| 469.67 | 1.073      | 1.073          |       |      |

## Comments

Date of test: 01-15-1998

Specimen Id. CE2A

Page 1

| Pmax<br>(lbs) | PD<br>(1E-6) | a<br>(in) | N<br>(X1) | da<br>(in) | dN<br>(X1) | da dN<br>(in/cyc) | $\frac{dK}{(ksi[in]^{.5})}$ |
|---------------|--------------|-----------|-----------|------------|------------|-------------------|-----------------------------|
|               | 397.7        | 0.8960    | 6         |            |            |                   |                             |
| 273           | 325.0        | 0.9150    | 151705    | 0.0402     | 333904     | 1.205E-07         | 3.33                        |
| 292           | 344.0        | 0.9382    | 333910    | 0.0473     | 361550     | 1.309E-07         | 3.60                        |
| 308           | 366.0        | 0.9623    | 513256    | 0.0462     | 250717     | 1.844E-07         | 3.91                        |
| 327           | 386.4        | 0.9844    | 584627    | 0.0476     | 137943     | 3.450E-07         | 4.28                        |
| 346           | 410.1        | 1.0099    | 651199    | 0.0519     | 90970      | 5.701E-07         | 4.68                        |
| 366           | 434.8        | 1.0363    | 675598    | 0.0471     | 45131      | 1.044E-06         | 5.11                        |
| 381           | 454.5        | 1.0570    | 696330    | 0.0286     | 28926      | 9.884E-07         | 5.44                        |
|               | 461.9        | 1.0649    | 704523    |            |            |                   |                             |

# **AUTOMATED FATIGUE CRACK GROWTH RATE ANALYSIS**

|                 |            |                 |           |
|-----------------|------------|-----------------|-----------|
| Specimen Id.    | CE2B       | Geometry        | ECT       |
| Contract #      | 06-8520    | Orientation     | LT        |
| Material        | 2024-T6511 | Yield (ksi)     | 60.7      |
| Temperature (F) | 74         | Initial AO (PD) | 0.539     |
| Environment     | LA         | Initial PD      | \$1000.00 |

## Specimen Dimensions (in)

|           |       |             |       |
|-----------|-------|-------------|-------|
| Thickness | 0.116 | Notch depth | 0.614 |
| Width     | 2.503 | Gage length | 0.000 |
| Height    | 0.000 |             |       |

## Precrack Parameters

|              |       |                  |       |
|--------------|-------|------------------|-------|
| Pmax (lbs)   | 600.0 | Stress ratio (R) | 0.50  |
| Final a (in) | 0.737 | Kmax             | 11.43 |

## Test Parameters

|                |       |                  |       |
|----------------|-------|------------------|-------|
| Initial a (in) | 1.073 | Initial K        | 12.00 |
| K-gradient     | -3.50 | Stress ratio (R) | 0.50  |

|         |          |                |
|---------|----------|----------------|
| K Coeff | PD Coeff | Analysis Codes |
|         | 0.206000 | KREP 1 0       |
|         | 0.471870 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |

## Visual Observations

| PD     | Crack (PD) | Crack (visual) | Error | PD AF |
|--------|------------|----------------|-------|-------|
| 473.99 | 1.073      | 1.073          | 0.000 | 0.996 |
| 640.99 | 1.275      | 1.275          | 0.000 | 1.003 |

## Comments

Date of test: 01-18-1998

| Pmax<br>(lbs) | PD<br>(1E-6) | a<br>(in) | N<br>(X1) | da<br>(in) | dN<br>(X1) | da/dN<br>(in/cyc) | dK<br>(ksi[in]^0.5) |
|---------------|--------------|-----------|-----------|------------|------------|-------------------|---------------------|
|               | 474.0        | 1.0730    | 8         |            |            |                   |                     |
| 367           | 487.5        | 1.0893    | 10427     | 0.0394     | 33950      | 1.162E-06         | 5.54                |
| 333           | 506.8        | 1.1124    | 33957     | 0.0470     | 59286      | 7.926E-07         | 5.18                |
| 297           | 526.6        | 1.1363    | 69713     | 0.0496     | 99180      | 5.003E-07         | 4.76                |
| 265           | 547.9        | 1.1620    | 133138    | 0.0486     | 183014     | 2.656E-07         | 4.40                |
| 233           | 566.8        | 1.1849    | 252728    | 0.0518     | 312694     | 1.658E-07         | 4.01                |
| 206           | 590.7        | 1.2139    | 445831    | 0.0564     | 427524     | 1.318E-07         | 3.69                |
| 187           | 613.3        | 1.2412    | 680252    | 0.0398     | 371747     | 1.071E-07         | 3.44                |
|               | 623.5        | 1.2537    | 817578    |            |            |                   |                     |

# AUTOMATED FATIGUE CRACK GROWTH RATE ANALYSIS

|                 |            |                 |           |
|-----------------|------------|-----------------|-----------|
| Specimen Id.    | CE2C       | Geometry        | ECT       |
| Contract #      | 06-8520    | Orientation     | LT        |
| Material        | 2024-T6511 | Yield (ksi)     | 60.7      |
| Temperature (F) | 74         | Initial AO (PD) | 0.539     |
| Environment     | LA         | Initial PD      | \$1000.00 |

## Specimen Dimensions (in)

|           |       |             |       |
|-----------|-------|-------------|-------|
| Thickness | 0.116 | Notch depth | 0.614 |
| Width     | 2.503 | Gage length | 0.000 |
| Height    | 0.000 |             |       |

## Precrack Parameters

|              |       |                  |       |
|--------------|-------|------------------|-------|
| Pmax (lbs)   | 600.0 | Stress ratio (R) | 0.50  |
| Final a (in) | 0.737 | Kmax             | 11.43 |

## Test Parameters

|                |       |                  |      |
|----------------|-------|------------------|------|
| Initial a (in) | 1.275 | Initial K        | 6.00 |
| K-gradient     | 3.50  | Stress ratio (R) | 0.50 |

|         |          |                |
|---------|----------|----------------|
| K Coeff | PD Coeff | Analysis Codes |
|         | 0.202000 | KREP     1   0 |
|         | 0.471870 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |

## Visual Observations

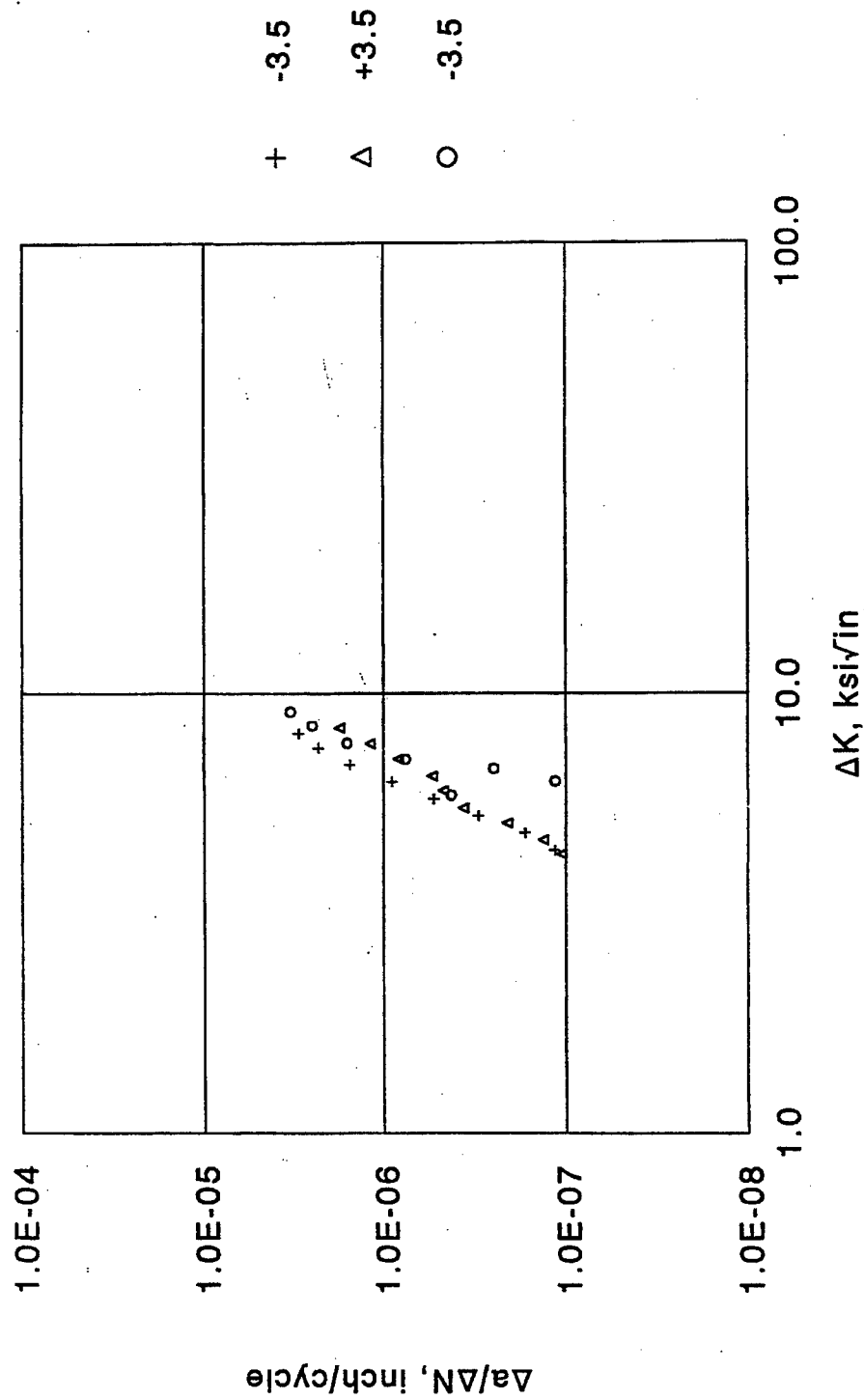
| PD     | Crack (PD) | Crack (visual) | Error | PDAF  |
|--------|------------|----------------|-------|-------|
| 652.42 | 1.275      | 1.275          | 0.000 | 0.998 |
| 819.83 | 1.456      | 1.457          | 0.000 | 0.982 |

## Comments

Date of test: 01-19-1998

| Pmax<br>(lbs) | PD<br>(1E-6) | a<br>(in) | N<br>(X1) | da<br>(in) | dN<br>(X1) | da/dN<br>(in/cyc) | dK<br>(ksi[in] <sup>0.5</sup> ) |
|---------------|--------------|-----------|-----------|------------|------------|-------------------|---------------------------------|
|               | 652.4        | 1.2750    | 15        |            |            |                   |                                 |
| 160           | 662.2        | 1.2858    | 289322    | 0.0332     | 524120     | 6.335E-08         | 3.19                            |
| 167           | 682.6        | 1.3082    | 524134    | 0.0510     | 381326     | 1.338E-07         | 3.43                            |
| 175           | 708.8        | 1.3368    | 670648    | 0.0534     | 258002     | 2.071E-07         | 3.74                            |
| 183           | 731.6        | 1.3616    | 782136    | 0.0386     | 206551     | 1.871E-07         | 4.04                            |
| 195           | 744.4        | 1.3754    | 877199    | 0.0494     | 150724     | 3.275E-07         | 4.52                            |
| 208           | 777.3        | 1.4110    | 932860    | 0.0798     | 68167      | 1.170E-06         | 5.03                            |
| 216           | 818.7        | 1.4552    | 945366    | 0.0489     | 25614      | 1.910E-06         | 5.41                            |
| 231           | 822.8        | 1.4599    | 958474    | 0.0284     | 14132      | 2.007E-06         | 6.12                            |
| 234           | 843.2        | 1.4836    | 959498    | 0.0334     | 5134       | 6.498E-06         | 6.27                            |
| 247           | 851.6        | 1.4932    | 963607    | 0.0453     | 20929      | 2.163E-06         | 6.96                            |
| 254           | 882.2        | 1.5288    | 980427    | 0.0572     | 20139      | 2.842E-06         | 7.35                            |
| 268           | 900.9        | 1.5505    | 983747    | 0.0460     | 11231      | 4.099E-06         | 8.17                            |
| 285           | 921.9        | 1.5749    | 991657    | 0.0772     | 10501      | 7.349E-06         | 9.30                            |
| 289           | 967.4        | 1.6276    | 994248    | 0.0427     | 3976       | 1.074E-05         | 9.54                            |
| 306           | 958.7        | 1.6176    | 995634    | 0.0100     | 2801       | 3.570E-06         | 10.83                           |
|               | 976.1        | 1.6376    | 997048    |            |            |                   |                                 |

Fairchild DTA 06-8520 CE3  
 2014-T65121 EXTR ECT SPEC. R=0.2



# AUTOMATED FATIGUE CRACK GROWTH RATE ANALYSIS

|                 |            |                 |           |
|-----------------|------------|-----------------|-----------|
| Specimen Id.    | CE3        | Geometry        | ECT       |
| Contract #      | 06-8520    | Orientation     | LT        |
| Material        | 2024-T6511 | Yield (ksi)     | 60.7      |
| Temperature (F) | 74         | Initial A0 (PD) | 0.537     |
| Environment     | LA         | Initial PD      | \$1000.00 |

## Specimen Dimensions (in)

|           |       |             |       |
|-----------|-------|-------------|-------|
| Thickness | 0.116 | Notch depth | 0.618 |
| Width     | 2.504 | Gage length | 0.000 |
| Height    | 0.000 |             |       |

## Precrack Parameters

|              |       |                  |       |
|--------------|-------|------------------|-------|
| Pmax (lbs)   | 600.0 | Stress ratio (R) | 0.20  |
| Final a (in) | 0.717 | Kmax             | 11.18 |

## Test Parameters

|                |       |                  |       |
|----------------|-------|------------------|-------|
| Initial a (in) | 0.717 | Initial K        | 11.00 |
| K-gradient     | -3.50 | Stress ratio (R) | 0.20  |

|         |          |                |
|---------|----------|----------------|
| K Coeff | PD Coeff | Analysis Codes |
|         | 0.220500 | KREP 1 0       |
|         | 0.471690 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |

## Visual Observations

| PD     | Crack (PD) | Crack (visual) | Error | PDAF  |
|--------|------------|----------------|-------|-------|
| 140.33 | 0.717      | 0.717          | 0.000 | 0.995 |
| 329.82 | 0.928      | 0.929          | 0.000 | 0.966 |

## Comments

Date of test: 01-12-1998

Specimen Id. CE3

Page 1

| Pmax<br>(lbs) | PD<br>(1E-6) | a<br>(in) | N<br>(X1) | da<br>(in) | dN<br>(X1) | da/dN<br>(in/cyc) | dK<br>(ksi[in] <sup>.5</sup> ) |
|---------------|--------------|-----------|-----------|------------|------------|-------------------|--------------------------------|
|               | 140.3        | 0.7170    | 6         |            |            |                   |                                |
| 531           | 155.0        | 0.7339    | 5128      | 0.0414     | 13927      | 2.975E-06         | 8.12                           |
| 479           | 176.6        | 0.7584    | 13933     | 0.0493     | 21281      | 2.315E-06         | 7.53                           |
| 425           | 198.4        | 0.7831    | 26409     | 0.0483     | 31300      | 1.544E-06         | 6.88                           |
| 377           | 219.4        | 0.8068    | 45232     | 0.0470     | 52245      | 9.003E-07         | 6.29                           |
| 335           | 240.3        | 0.8302    | 78654     | 0.0467     | 88480      | 5.283E-07         | 5.76                           |
| 297           | 261.3        | 0.8535    | 133713    | 0.0470     | 155979     | 3.013E-07         | 5.27                           |
| 264           | 282.8        | 0.8771    | 234633    | 0.0465     | 277737     | 1.676E-07         | 4.82                           |
| 234           | 303.7        | 0.9001    | 411450    | 0.0461     | 401232     | 1.150E-07         | 4.40                           |
|               | 325.0        | 0.9233    | 635865    |            |            |                   |                                |

# AUTOMATED FATIGUE CRACK GROWTH RATE ANALYSIS

|                 |            |                 |           |
|-----------------|------------|-----------------|-----------|
| Specimen Id.    | CE3A       | Geometry        | ECT       |
| Contract #      | 06-8520    | Orientation     | LT        |
| Material        | 2024-T6511 | Yield (ksi)     | 60.7      |
| Temperature (F) | 74         | Initial AO (PD) | 0.537     |
| Environment     | LA         | Initial PD      | \$1000.00 |

## Specimen Dimensions (in)

|           |       |             |       |
|-----------|-------|-------------|-------|
| Thickness | 0.116 | Notch depth | 0.618 |
| Width     | 2.504 | Gage length | 0.000 |
| Height    | 0.000 |             |       |

## Precrack Parameters

|              |       |                  |       |
|--------------|-------|------------------|-------|
| Pmax (lbs)   | 600.0 | Stress ratio (R) | 0.20  |
| Final a (in) | 0.717 | Kmax             | 11.18 |

## Test Parameters

|                |       |                  |      |
|----------------|-------|------------------|------|
| Initial a (in) | 0.929 | Initial K        | 5.00 |
| K-gradient     | 3.50  | Stress ratio (R) | 0.20 |

|         |          |                |
|---------|----------|----------------|
| K Coeff | PD Coeff | Analysis Codes |
|         | 0.215210 | KREP 1 0       |
|         | 0.471690 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |

## Visual Observations

| PD     | Crack (PD) | Crack (visual) | Error | PDAF  |
|--------|------------|----------------|-------|-------|
| 329.86 | 0.928      | 0.929          | 0.000 | 1.000 |
| 552.00 | 1.157      | 1.158          | 0.000 | 0.949 |

## Comments

Date of test: 01-13-1998

| Pmax<br>(lbs) | PD<br>(1E-6) | a<br>(in) | N<br>(X1) | da<br>(in) | dN<br>(X1) | da/dN<br>(in/cyc) | dK<br>(ksi[in] <sup>.5</sup> ) |
|---------------|--------------|-----------|-----------|------------|------------|-------------------|--------------------------------|
|               | 329.8        | 0.9284    | 12        |            |            |                   |                                |
| 215           | 345.9        | 0.9460    | 182953    | 0.0401     | 381472     | 1.052E-07         | 4.31                           |
| 226           | 366.9        | 0.9686    | 381484    | 0.0454     | 342180     | 1.326E-07         | 4.64                           |
| 239           | 388.3        | 0.9913    | 525133    | 0.0478     | 228116     | 2.095E-07         | 5.07                           |
| 252           | 412.1        | 1.0164    | 609601    | 0.0438     | 120666     | 3.626E-07         | 5.49                           |
| 267           | 430.0        | 1.0351    | 645799    | 0.0421     | 90257      | 4.664E-07         | 6.01                           |
| 281           | 452.7        | 1.0584    | 699858    | 0.0444     | 82423      | 5.392E-07         | 6.49                           |
| 297           | 473.4        | 1.0795    | 728221    | 0.0441     | 53272      | 8.283E-07         | 7.09                           |
| 314           | 496.3        | 1.1026    | 753129    | 0.0442     | 37256      | 1.187E-06         | 7.69                           |
| 331           | 517.6        | 1.1237    | 765478    | 0.0409     | 23276      | 1.758E-06         | 8.36                           |
|               | 537.6        | 1.1435    | 776405    |            |            |                   |                                |

# AUTOMATED FATIGUE CRACK GROWTH RATE ANALYSIS

|                 |            |                 |           |
|-----------------|------------|-----------------|-----------|
| Specimen Id.    | CE3B       | Geometry        | ECT       |
| Contract #      | 06-8520    | Orientation     | LT        |
| Material        | 2024-T6511 | Yield (ksi)     | 60.7      |
| Temperature (F) | 74         | Initial AO (PD) | 0.537     |
| Environment     | LA         | Initial PD      | \$1000.00 |

## Specimen Dimensions (in)

|           |       |             |       |
|-----------|-------|-------------|-------|
| Thickness | 0.116 | Notch depth | 0.618 |
| Width     | 2.504 | Gage length | 0.000 |
| Height    | 0.000 |             |       |

## Precrack Parameters

|              |       |                  |       |
|--------------|-------|------------------|-------|
| Pmax (lbs)   | 600.0 | Stress ratio (R) | 0.20  |
| Final a (in) | 0.717 | Kmax             | 11.18 |

## Test Parameters

|                |       |                  |       |
|----------------|-------|------------------|-------|
| Initial a (in) | 1.158 | Initial K        | 12.30 |
| K-gradient     | -3.50 | Stress ratio (R) | 0.20  |

|         |          |                |
|---------|----------|----------------|
| K Coeff | PD Coeff | Analysis Codes |
|         | 0.201870 | KREP 1 0       |
|         | 0.471690 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |

## Visual Observations

|        |            |                |       |       |
|--------|------------|----------------|-------|-------|
| PD     | Crack (PD) | Crack (visual) | Error | PDAF  |
| 552.32 | 1.157      | 1.158          | 0.000 | 0.999 |
| 723.78 | 1.354      | 1.354          | 0.000 | 0.993 |

## Comments

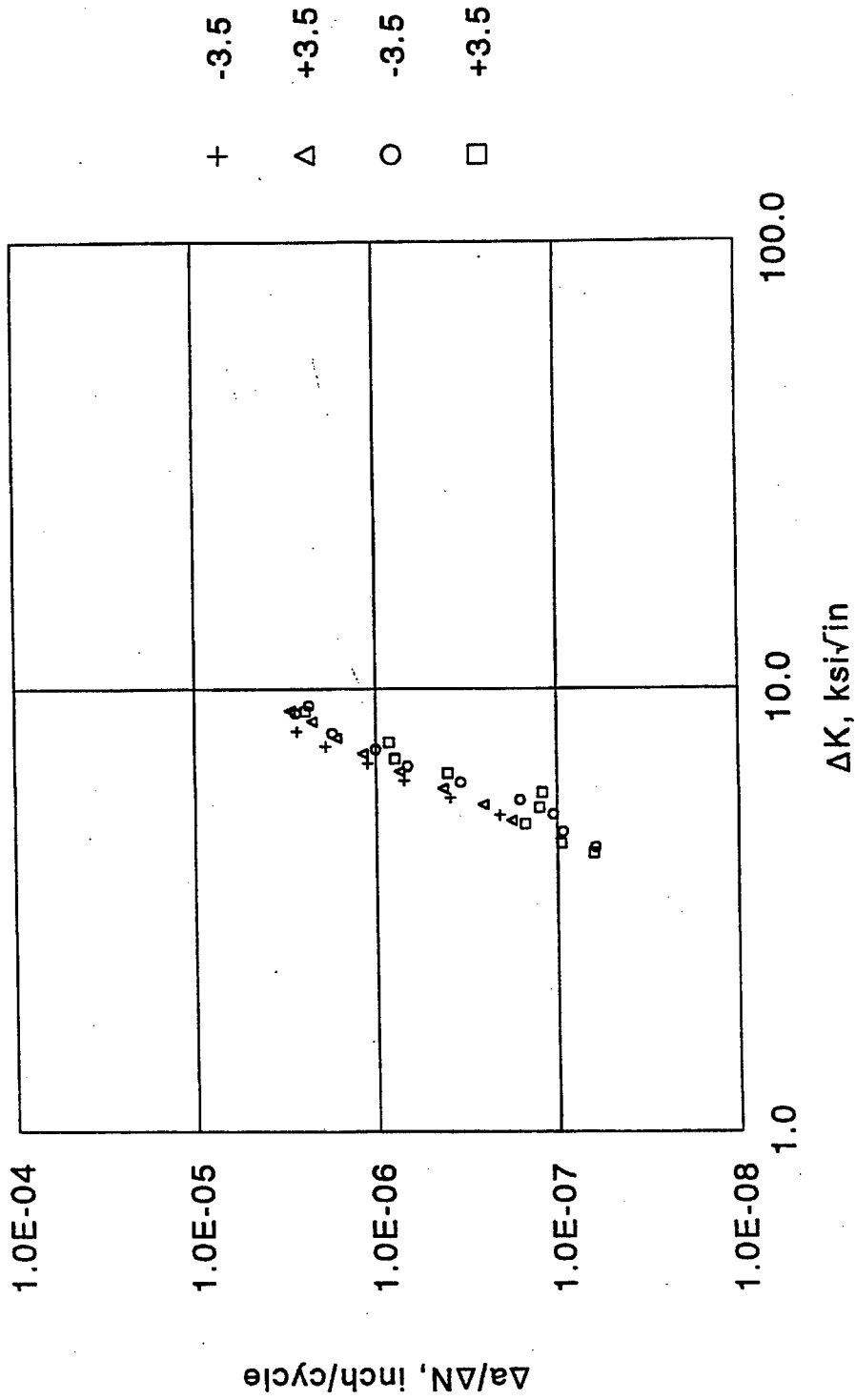
Date of test: 01-13-1998

Specimen Id. CE3B

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| Pmax<br>(lbs) | PD<br>(1E-6) | a<br>(in) | N<br>(X1) | da<br>(in) | dN<br>(X1) | da/dN<br>(in/cyc) | dK<br>(ksi[in] <sup>-.5</sup> ) |
|---------------|--------------|-----------|-----------|------------|------------|-------------------|---------------------------------|
|               | 552.3        | 1.1575    | 7         |            |            |                   |                                 |
| 333           | 564.7        | 1.1717    | 3204      | 0.0434     | 13147      | 3.299E-06         | 9.08                            |
| 301           | 590.0        | 1.2009    | 13153     | 0.0543     | 21708      | 2.499E-06         | 8.46                            |
| 265           | 611.8        | 1.2260    | 24912     | 0.0468     | 29229      | 1.600E-06         | 7.71                            |
| 235           | 630.7        | 1.2476    | 42383     | 0.0431     | 56966      | 7.573E-07         | 7.08                            |
| 220           | 649.4        | 1.2691    | 81878     | 0.0264     | 106504     | 2.480E-07         | 6.75                            |
| 200           | 653.7        | 1.2740    | 148887    | 0.0197     | 171986     | 1.144E-07         | 6.31                            |
| 181           | 666.6        | 1.2888    | 253863    | 0.0495     | 116699     | 4.244E-07         | 5.87                            |
|               | 697.1        | 1.3236    | 265586    |            |            |                   |                                 |

Fairchild DTA 06-8520 CE4  
 2014-T65121 EXTR ECT SPEC. R=0.2



# **AUTOMATED FATIGUE CRACK GROWTH RATE ANALYSIS**

|                 |            |                 |           |
|-----------------|------------|-----------------|-----------|
| Specimen Id.    | CE4        | Geometry        | ECT       |
| Contract #      | 06-8520    | Orientation     | LT        |
| Material        | 2024-T6511 | Yield (ksi)     | 60.7      |
| Temperature (F) | 74         | Initial A0 (PD) | 0.561     |
| Environment     | LA         | Initial PD      | \$1000.00 |

## **Specimen Dimensions (in)**

|           |       |             |       |
|-----------|-------|-------------|-------|
| Thickness | 0.116 | Notch depth | 0.623 |
| Width     | 2.503 | Gage length | 0.000 |
| Height    | 0.000 |             |       |

## **Precrack Parameters**

|              |       |                  |       |
|--------------|-------|------------------|-------|
| Pmax (lbs)   | 600.0 | Stress ratio (R) | 0.20  |
| Final a (in) | 0.717 | Kmax             | 11.12 |

## **Test Parameters**

|                |       |                  |       |
|----------------|-------|------------------|-------|
| Initial a (in) | 0.717 | Initial K        | 10.90 |
| K-gradient     | -3.50 | Stress ratio (R) | 0.20  |

|         |          |                |
|---------|----------|----------------|
| K Coeff | PD Coeff | Analysis Codes |
|         | 0.231786 | KREP 1 0       |
|         | 0.471870 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |

## **Visual Observations**

| PD     | Crack (PD) | Crack (visual) | Error | PDAF  |
|--------|------------|----------------|-------|-------|
| 117.30 | 0.717      | 0.717          | 0.000 | 0.991 |
| 264.58 | 0.883      | 0.883          | 0.000 | 0.971 |

## **Comments**

Date of test: 12-31-1997

Specimen Id. CE4

Page 1

| Pmax<br>(lbs) | PD<br>(1E-6) | a<br>(in) | N<br>(X1) | da<br>(in) | dN<br>(X1) | da/dN<br>(in/cyc) | dK<br>(ksi[in]^0.5) |
|---------------|--------------|-----------|-----------|------------|------------|-------------------|---------------------|
|               | 117.3        | 0.7175    | 5         |            |            |                   |                     |
| 527           | 132.1        | 0.7345    | 5932      | 0.0419     | 15316      | 2.733E-06         | 8.03                |
| 476           | 153.9        | 0.7594    | 15321     | 0.0491     | 25790      | 1.903E-06         | 7.45                |
| 422           | 175.2        | 0.7836    | 31722     | 0.0479     | 43042      | 1.113E-06         | 6.81                |
| 375           | 196.2        | 0.8073    | 58363     | 0.0474     | 67584      | 7.015E-07         | 6.23                |
| 333           | 217.3        | 0.8310    | 99306     | 0.0473     | 120706     | 3.921E-07         | 5.70                |
| 296           | 238.5        | 0.8546    | 179069    | 0.0467     | 223013     | 2.092E-07         | 5.22                |
|               | 259.3        | 0.8777    | 322319    |            |            |                   |                     |

# AUTOMATED FATIGUE CRACK GROWTH RATE ANALYSIS

|                 |            |                 |           |
|-----------------|------------|-----------------|-----------|
| Specimen Id.    | CE4A       | Geometry        | ECT       |
| Contract #      | 06-8520    | Orientation     | LT        |
| Material        | 2024-T6511 | Yield (ksi)     | 60.7      |
| Temperature (F) | 74         | Initial A0 (PD) | 0.561     |
| Environment     | LA         | Initial PD      | \$1000.00 |

## Specimen Dimensions (in)

|           |       |             |       |
|-----------|-------|-------------|-------|
| Thickness | 0.116 | Notch depth | 0.623 |
| Width     | 2.503 | Gage length | 0.000 |
| Height    | 0.000 |             |       |

## Precrack Parameters

|              |       |                  |       |
|--------------|-------|------------------|-------|
| Pmax (lbs)   | 600.0 | Stress ratio (R) | 0.20  |
| Final a (in) | 0.717 | Kmax             | 11.12 |

## Test Parameters

|                |       |                  |      |
|----------------|-------|------------------|------|
| Initial a (in) | 0.883 | Initial K        | 5.90 |
| K-gradient     | 3.50  | Stress ratio (R) | 0.20 |

|         |          |                |
|---------|----------|----------------|
| K Coeff | PD Coeff | Analysis Codes |
|         | 0.228170 | KREP 1 0       |
|         | 0.471870 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |

## Visual Observations

| PD     | Crack (PD) | Crack (visual) | Error | PDAF  |
|--------|------------|----------------|-------|-------|
| 264.71 | 0.883      | 0.883          | 0.000 | 0.999 |
| 448.23 | 1.079      | 1.079          | 0.000 | 0.959 |

## Comments

Date of test: 01-05-1998

Specimen Id. CE4A

Page 1

| Pmax<br>(lbs) | PD<br>(1E-6) | a<br>(in) | N<br>(X1) | da<br>(in) | dN<br>(X1) | da/dN<br>(in/cyc) | dK<br>(ksi[in] <sup>1.5</sup> ) |
|---------------|--------------|-----------|-----------|------------|------------|-------------------|---------------------------------|
|               | 264.7        | 0.8835    | 5         |            |            |                   |                                 |
| 270           | 280.7        | 0.9012    | 110465    | 0.0375     | 209195     | 1.794E-07         | 5.06                            |
| 284           | 298.7        | 0.9210    | 209200    | 0.0472     | 183100     | 2.579E-07         | 5.49                            |
| 301           | 323.9        | 0.9484    | 293565    | 0.0536     | 124894     | 4.295E-07         | 5.98                            |
| 318           | 348.3        | 0.9747    | 334093    | 0.0464     | 62591      | 7.413E-07         | 6.53                            |
| 338           | 367.2        | 0.9948    | 356156    | 0.0433     | 36611      | 1.183E-06         | 7.16                            |
| 356           | 389.2        | 1.0180    | 370705    | 0.0452     | 27235      | 1.658E-06         | 7.76                            |
| 376           | 410.3        | 1.0400    | 383392    | 0.0444     | 19711      | 2.254E-06         | 8.45                            |
| 390           | 432.0        | 1.0624    | 390416    | 0.0289     | 9755       | 2.963E-06         | 8.92                            |
|               | 438.4        | 1.0689    | 393146    |            |            |                   |                                 |

# AUTOMATED FATIGUE CRACK GROWTH RATE ANALYSIS

|                 |            |                 |           |
|-----------------|------------|-----------------|-----------|
| Specimen Id.    | CE4B       | Geometry        | ECT       |
| Contract #      | 06-8520    | Orientation     | LT        |
| Material        | 2024-T6511 | Yield (ksi)     | 60.7      |
| Temperature (F) | 74         | Initial AO (PD) | 0.561     |
| Environment     | LA         | Initial PD      | \$1000.00 |

## Specimen Dimensions (in)

|           |       |             |       |
|-----------|-------|-------------|-------|
| Thickness | 0.116 | Notch depth | 0.623 |
| Width     | 2.503 | Gage length | 0.000 |
| Height    | 0.000 |             |       |

## Precrack Parameters

|              |       |                  |       |
|--------------|-------|------------------|-------|
| Pmax (lbs)   | 600.0 | Stress ratio (R) | 0.20  |
| Final a (in) | 0.717 | Kmax             | 11.12 |

## Test Parameters

|                |       |                  |       |
|----------------|-------|------------------|-------|
| Initial a (in) | 1.079 | Initial K        | 12.60 |
| K-gradient     | -3.50 | Stress ratio (R) | 0.20  |

|         |          |                |
|---------|----------|----------------|
| K Coeff | PD Coeff | Analysis Codes |
|         | 0.219550 | KREP 1 0       |
|         | 0.471870 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |

## Visual Observations

|        |            |                |       |       |
|--------|------------|----------------|-------|-------|
| PD     | Crack (PD) | Crack (visual) | Error | PDAF  |
| 452.17 | 1.079      | 1.079          | 0.000 | 0.991 |
| 681.39 | 1.366      | 1.366          | 0.000 | 1.015 |

## Comments

Date of test: 01-07-1998

Specimen Id. CE4B

Page 1

| Pmax<br>(lbs) | PD<br>(1E-6) | a<br>(in) | N<br>(X1) | da<br>(in) | dN<br>(X1) | da/dN<br>(in/cyc) | dK<br>(ksi[in] <sup>.5</sup> ) |
|---------------|--------------|-----------|-----------|------------|------------|-------------------|--------------------------------|
|               | 453.9        | 1.0811    | 23        |            |            |                   |                                |
| 376           | 455.5        | 1.0830    | 4619      | 0.0395     | 16882      | 2.340E-06         | 9.17                           |
| 356           | 486.0        | 1.1206    | 16904     | 0.0591     | 21321      | 2.770E-06         | 8.82                           |
| 307           | 503.4        | 1.1421    | 25940     | 0.0471     | 26979      | 1.746E-06         | 7.95                           |
| 273           | 524.1        | 1.1677    | 43883     | 0.0550     | 54875      | 1.002E-06         | 7.32                           |
| 241           | 547.7        | 1.1970    | 80814     | 0.0566     | 84170      | 6.723E-07         | 6.71                           |
| 214           | 569.5        | 1.2243    | 128052    | 0.0493     | 143490     | 3.439E-07         | 6.18                           |
| 187           | 587.1        | 1.2464    | 224304    | 0.0526     | 325195     | 1.618E-07         | 5.63                           |
| 168           | 611.3        | 1.2769    | 453247    | 0.0556     | 529532     | 1.051E-07         | 5.22                           |
| 147           | 631.2        | 1.3020    | 753836    | 0.0520     | 560671     | 9.280E-08         | 4.77                           |
| 130           | 652.4        | 1.3289    | 1013918   | 0.0526     | 860338     | 6.113E-08         | 4.40                           |
|               | 672.5        | 1.3546    | 1614174   |            |            |                   |                                |

# AUTOMATED FATIGUE CRACK GROWTH RATE ANALYSIS

|                 |            |                 |          |
|-----------------|------------|-----------------|----------|
| Specimen Id.    | CE4C       | Geometry        | ECT      |
| Contract #      | 06-8520    | Orientation     | LT       |
| Material        | 2024-T6511 | Yield (ksi)     | 60.7     |
| Temperature (F) | 74         | Initial A0 (PD) | 0.561    |
| Environment     | LA         | Initial PD      | %1000.00 |

## Specimen Dimensions (in)

|           |       |             |       |
|-----------|-------|-------------|-------|
| Thickness | 0.116 | Notch depth | 0.623 |
| Width     | 2.503 | Gage length | 0.000 |
| Height    | 0.000 |             |       |

## Precrack Parameters

|              |       |                  |       |
|--------------|-------|------------------|-------|
| Pmax (lbs)   | 600.0 | Stress ratio (R) | 0.20  |
| Final a (in) | 0.717 | Kmax             | 11.12 |

## Test Parameters

|                |       |                  |      |
|----------------|-------|------------------|------|
| Initial a (in) | 1.366 | Initial K        | 5.00 |
| K-gradient     | 3.50  | Stress ratio (R) | 0.20 |

|         |          |                |
|---------|----------|----------------|
| K Coeff | PD Coeff | Analysis Codes |
|         | 0.224500 | KREP 1 0       |
|         | 0.471870 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |

## Visual Observations

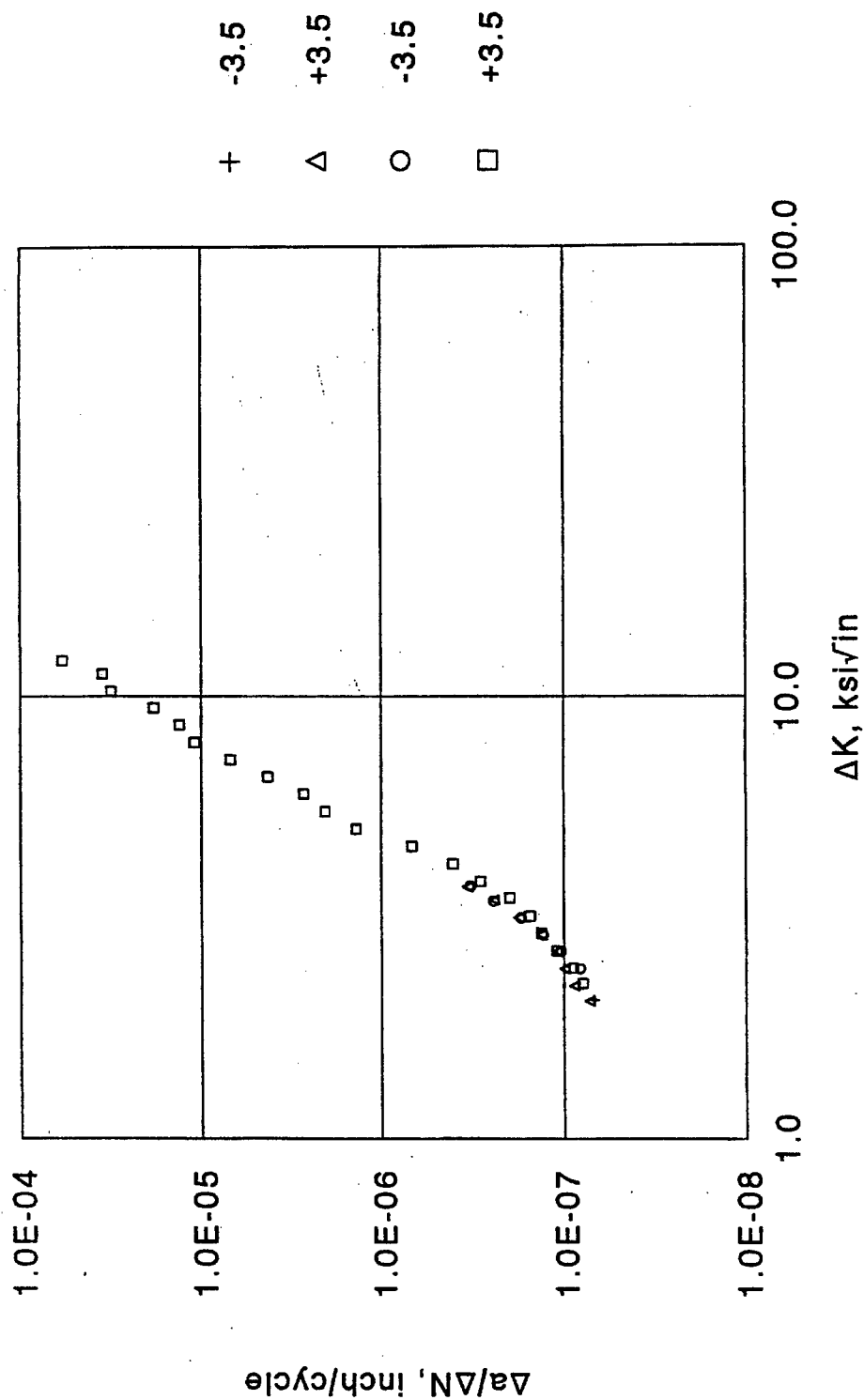
| PD     | Crack (PD) | Crack (visual) | Error | PDAF  |
|--------|------------|----------------|-------|-------|
| 680.85 | 1.367      | 1.367          | 0.000 | 1.001 |
| 918.21 | 1.625      | 1.625          | 0.000 | 0.981 |

## Comments

Date of test: 01-11-1998

| Pmax<br>(lbs) | PD<br>(1E-6) | a<br>(in) | N<br>(X1) | da<br>(in) | dN<br>(X1) | da/dN<br>(in/cyc) | dK<br>(ksi[in] <sup>.5</sup> ) |
|---------------|--------------|-----------|-----------|------------|------------|-------------------|--------------------------------|
|               | 680.3        | 1.3659    | 21        |            |            |                   |                                |
| 116           | 684.0        | 1.3701    | 198568    | 0.0366     | 588487     | 6.227E-08         | 4.27                           |
| 120           | 713.2        | 1.4026    | 588508    | 0.0574     | 607488     | 9.452E-08         | 4.50                           |
| 126           | 735.8        | 1.4275    | 806056    | 0.0479     | 316526     | 1.515E-07         | 4.98                           |
| 132           | 756.7        | 1.4505    | 905034    | 0.0446     | 355765     | 1.255E-07         | 5.41                           |
| 138           | 776.4        | 1.4721    | 1161821   | 0.0421     | 346490     | 1.214E-07         | 5.86                           |
| 146           | 795.1        | 1.4926    | 1251524   | 0.0543     | 134882     | 4.022E-07         | 6.48                           |
| 152           | 826.1        | 1.5264    | 1296703   | 0.0548     | 69480      | 7.887E-07         | 6.99                           |
| 159           | 845.5        | 1.5474    | 1321004   | 0.0328     | 38631      | 8.481E-07         | 7.59                           |
| 172           | 856.4        | 1.5591    | 1335334   | 0.0781     | 31993      | 2.442E-06         | 8.90                           |
|               | 918.2        | 1.6255    | 1352997   |            |            |                   |                                |

Fairchild DTA 06-8520 CE5  
 2014-T65121 EXTR ECT SPEC. R=0.8



# AUTOMATED FATIGUE CRACK GROWTH RATE ANALYSIS

|                     |                       |
|---------------------|-----------------------|
| Specimen Id. CE5    | Geometry ECT          |
| Contract # 06-8520  | Orientation LT        |
| Material 2024-T6511 | Yield (ksi) 60.7      |
| Temperature (F) 74  | Initial A0 (PD) 0.587 |
| Environment LA      | Initial PD \$1000.00  |

## Specimen Dimensions (in)

|                 |                   |
|-----------------|-------------------|
| Thickness 0.116 | Notch depth 0.614 |
| Width 2.506     | Gage length 0.000 |
| Height 0.000    |                   |

## Precrack Parameters

|                    |                       |
|--------------------|-----------------------|
| Pmax (lbs) 600.0   | Stress ratio (R) 0.80 |
| Final a (in) 0.717 | Kmax 11.14            |

## Test Parameters

|                      |                       |
|----------------------|-----------------------|
| Initial a (in) 0.717 | Initial K 11.20       |
| K-gradient -3.50     | Stress ratio (R) 0.80 |

|         |          |                |
|---------|----------|----------------|
| K Coeff | PD Coeff | Analysis Codes |
|         | 0.243010 | KREP 1 0       |
|         | 0.471310 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |

## Visual Observations

| PD     | Crack (PD) | Crack (visual) | Error | PDAF  |
|--------|------------|----------------|-------|-------|
| 92.02  | 0.717      | 0.717          | 0.000 | 0.998 |
| 134.33 | 0.762      | 0.762          | 0.000 | 0.968 |

## Comments

Date of test: 01-07-1998

Specimen Id. CE5

Page 1

| Pmax<br>(lbs) | PD<br>(1E-6) | a<br>(in) | N<br>(X1) | da<br>(in) | dN<br>(X1) | da/dN<br>(in/cyc) | dK<br>(ksi[in] <sup>.5</sup> ) |
|---------------|--------------|-----------|-----------|------------|------------|-------------------|--------------------------------|
|               | 92.0         | 0.7175    | 10        |            |            |                   |                                |
| 542           | 108.1        | 0.7349    | 234398    | 0.0405     | 595311     | 6.797E-08         | 2.06                           |
|               | 129.9        | 0.7580    | 595320    |            |            |                   |                                |

# **AUTOMATED FATIGUE CRACK GROWTH RATE ANALYSIS**

|                 |            |                 |           |
|-----------------|------------|-----------------|-----------|
| Specimen Id.    | CE5A       | Geometry        | ECT       |
| Contract #      | 06-8520    | Orientation     | LT        |
| Material        | 2024-T6511 | Yield (ksi)     | 60.7      |
| Temperature (F) | 74         | Initial A0 (PD) | 0.587     |
| Environment     | LA         | Initial PD      | \$1000.00 |

## **Specimen Dimensions (in)**

|           |       |             |       |
|-----------|-------|-------------|-------|
| Thickness | 0.116 | Notch depth | 0.614 |
| Width     | 2.506 | Gage length | 0.000 |
| Height    | 0.000 |             |       |

## **Precrack Parameters**

|              |       |                  |       |
|--------------|-------|------------------|-------|
| Pmax (lbs)   | 600.0 | Stress ratio (R) | 0.80  |
| Final a (in) | 0.717 | Kmax             | 11.14 |

## **Test Parameters**

|                |       |                  |      |
|----------------|-------|------------------|------|
| Initial a (in) | 0.762 | Initial K        | 9.50 |
| K-gradient     | 3.50  | Stress ratio (R) | 0.80 |

|         |          |                |
|---------|----------|----------------|
| K Coeff | PD Coeff | Analysis Codes |
|         | 0.240980 | KREP 1 0       |
|         | 0.471310 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |

## **Visual Observations**

| PD     | Crack (PD) | Crack (visual) | Error | PDAF  |
|--------|------------|----------------|-------|-------|
| 134.38 | 0.762      | 0.762          | 0.000 | 0.999 |
| 314.70 | 0.977      | 0.977          | 0.000 | 1.003 |

## **Comments**

Date of test: 01-09-1998

| Pmax<br>(lbs) | PD<br>(1E-6) | a<br>(in) | N<br>(X1) | da<br>(in) | dN<br>(X1) | da/dN<br>(in/cyc) | dK<br>(ksi[in] <sup>.5</sup> ) |
|---------------|--------------|-----------|-----------|------------|------------|-------------------|--------------------------------|
|               | 134.4        | 0.7625    | 76        |            |            |                   |                                |
| 507           | 150.0        | 0.7809    | 297445    | 0.0436     | 611395     | 7.136E-08         | 2.05                           |
| 533           | 171.2        | 0.8061    | 611470    | 0.0512     | 588225     | 8.710E-08         | 2.22                           |
| 564           | 193.2        | 0.8322    | 885670    | 0.0512     | 520967     | 9.831E-08         | 2.42                           |
| 597           | 214.4        | 0.8573    | 1132437   | 0.0500     | 459873     | 1.088E-07         | 2.65                           |
| 631           | 235.3        | 0.8822    | 1345543   | 0.0509     | 382641     | 1.331E-07         | 2.89                           |
| 667           | 257.2        | 0.9083    | 1515078   | 0.0515     | 293322     | 1.756E-07         | 3.16                           |
| 706           | 278.6        | 0.9337    | 1638865   | 0.0508     | 210509     | 2.415E-07         | 3.45                           |
| 737           | 299.9        | 0.9591    | 1725587   | 0.0389     | 116000     | 3.357E-07         | 3.70                           |
|               | 311.2        | 0.9726    | 1754865   |            |            |                   |                                |

# AUTOMATED FATIGUE CRACK GROWTH RATE ANALYSIS

|                 |            |                 |           |
|-----------------|------------|-----------------|-----------|
| Specimen Id.    | CE5B       | Geometry        | ECT       |
| Contract #      | 06-8520    | Orientation     | LT        |
| Material        | 2024-T6511 | Yield (ksi)     | 60.7      |
| Temperature (F) | 74         | Initial AO (PD) | 0.587     |
| Environment     | LA         | Initial PD      | \$1000.00 |

## Specimen Dimensions (in)

|           |       |             |       |
|-----------|-------|-------------|-------|
| Thickness | 0.116 | Notch depth | 0.614 |
| Width     | 2.506 | Gage length | 0.000 |
| Height    | 0.000 |             |       |

## Precrack Parameters

|              |       |                  |       |
|--------------|-------|------------------|-------|
| Pmax (lbs)   | 600.0 | Stress ratio (R) | 0.80  |
| Final a (in) | 0.717 | Kmax             | 11.14 |

## Test Parameters

|                |       |                  |       |
|----------------|-------|------------------|-------|
| Initial a (in) | 0.977 | Initial K        | 20.00 |
| K-gradient     | -3.50 | Stress ratio (R) | 0.80  |

|         |          |                |
|---------|----------|----------------|
| K Coeff | PD Coeff | Analysis Codes |
|         | 0.240980 | KREP 1 0       |
|         | 0.471310 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |

## Visual Observations

| PD     | Crack (PD) | Crack (visual) | Error | PDAF  |
|--------|------------|----------------|-------|-------|
| 314.70 | 0.977      | 0.977          | 0.000 | 1.003 |
| 473.40 | 1.167      | 1.168          | 0.000 | 1.008 |

## Comments

Date of test: 01-11-1998

Specimen Id. CE5B

Page 1

| Pmax<br>(lbs) | PD<br>(1E-6) | a<br>(in) | N<br>(X1) | da<br>(in) | dN<br>(X1) | da/dN<br>(in/cyc) | dK<br>(ksi[in]^0.5) |
|---------------|--------------|-----------|-----------|------------|------------|-------------------|---------------------|
|               | 315.5        | 0.9777    | 773       |            |            |                   |                     |
| 696           | 332.0        | 0.9974    | 49157     | 0.0450     | 138597     | 3.248E-07         | 3.71                |
| 626           | 353.1        | 1.0228    | 139370    | 0.0503     | 207592     | 2.425E-07         | 3.44                |
| 554           | 374.0        | 1.0478    | 256748    | 0.0504     | 293562     | 1.718E-07         | 3.15                |
| 491           | 395.1        | 1.0732    | 432932    | 0.0518     | 398702     | 1.299E-07         | 2.89                |
| 435           | 417.1        | 1.0996    | 655450    | 0.0513     | 495089     | 1.036E-07         | 2.65                |
| 384           | 437.7        | 1.1245    | 928021    | 0.0510     | 630304     | 8.097E-08         | 2.42                |
|               | 459.4        | 1.1506    | 1285755   |            |            |                   |                     |

# AUTOMATED FATIGUE CRACK GROWTH RATE ANALYSIS

|                 |            |                 |           |
|-----------------|------------|-----------------|-----------|
| Specimen Id.    | CE5C       | Geometry        | ECT       |
| Contract #      | 06-8520    | Orientation     | LT        |
| Material        | 2024-T6511 | Yield (ksi)     | 60.7      |
| Temperature (F) | 74         | Initial AO (PD) | 0.587     |
| Environment     | LA         | Initial PD      | \$1000.00 |

## Specimen Dimensions (in)

|           |       |             |       |
|-----------|-------|-------------|-------|
| Thickness | 0.116 | Notch depth | 0.614 |
| Width     | 2.506 | Gage length | 0.000 |
| Height    | 0.000 |             |       |

## Precrack Parameters

|              |       |                  |       |
|--------------|-------|------------------|-------|
| Pmax (lbs)   | 600.0 | Stress ratio (R) | 0.80  |
| Final a (in) | 0.717 | Kmax             | 11.14 |

## Test Parameters

|                |       |                  |       |
|----------------|-------|------------------|-------|
| Initial a (in) | 1.168 | Initial K        | 10.40 |
| K-gradient     | 3.50  | Stress ratio (R) | 0.80  |

|         |          |                |
|---------|----------|----------------|
| K Coeff | PD Coeff | Analysis Codes |
|         | 0.242760 | KREP 1 0       |
|         | 0.471310 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |

## Visual Observations

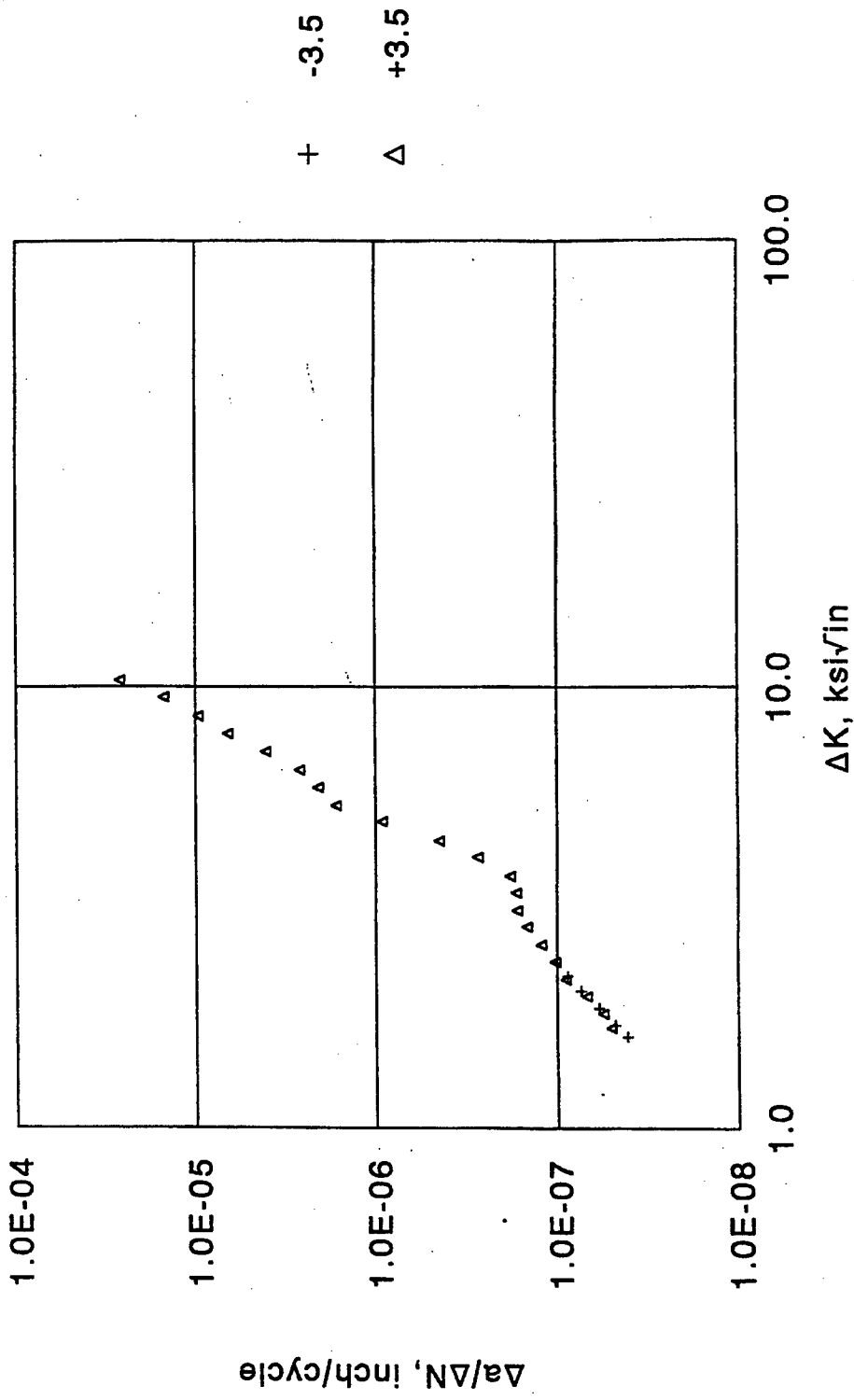
|        |            |                |       |       |
|--------|------------|----------------|-------|-------|
| PD     | Crack (PD) | Crack (visual) | Error | PDAF  |
| 473.46 | 1.168      | 1.168          | -.001 | 1.001 |
| 686.94 | 1.430      | 1.433          | 0.003 | 1.013 |
| 799.51 | 1.571      | 1.569          | -.002 | 1.019 |

## Comments

Date of test: 01-13-1998

| Pmax<br>(lbs) | PD<br>(1E-6) | a<br>(in) | N<br>(X1) | da<br>(in) | dN<br>(X1) | da/dN<br>(in/cyc) | dK<br>(ksi[in] <sup>.5</sup> ) |
|---------------|--------------|-----------|-----------|------------|------------|-------------------|--------------------------------|
|               | 473.5        | 1.1681    | 11        |            |            |                   |                                |
| 326           | 489.7        | 1.1879    | 255607    | 0.0450     | 574805     | 7.835E-08         | 2.25                           |
| 341           | 510.5        | 1.2131    | 574816    | 0.0515     | 581824     | 8.847E-08         | 2.43                           |
| 359           | 531.9        | 1.2393    | 837431    | 0.0526     | 482024     | 1.092E-07         | 2.66                           |
| 379           | 553.6        | 1.2658    | 1056840   | 0.0538     | 406754     | 1.324E-07         | 2.92                           |
| 398           | 575.9        | 1.2932    | 1244185   | 0.0518     | 338043     | 1.534E-07         | 3.18                           |
| 420           | 595.8        | 1.3176    | 1394882   | 0.0519     | 263265     | 1.973E-07         | 3.50                           |
| 440           | 618.1        | 1.3451    | 1507450   | 0.0529     | 184323     | 2.868E-07         | 3.81                           |
| 463           | 638.7        | 1.3705    | 1579205   | 0.0502     | 124673     | 4.026E-07         | 4.16                           |
| 486           | 658.7        | 1.3953    | 1632122   | 0.0536     | 79355      | 6.755E-07         | 4.57                           |
| 510           | 681.9        | 1.4241    | 1658560   | 0.0561     | 40264      | 1.393E-06         | 4.99                           |
| 535           | 703.9        | 1.4514    | 1672387   | 0.0521     | 24885      | 2.093E-06         | 5.47                           |
| 561           | 723.8        | 1.4762    | 1683445   | 0.0509     | 18528      | 2.745E-06         | 6.00                           |
| 587           | 744.7        | 1.5023    | 1690914   | 0.0533     | 12303      | 4.335E-06         | 6.55                           |
| 614           | 766.4        | 1.5295    | 1695748   | 0.0545     | 7857       | 6.936E-06         | 7.18                           |
| 642           | 788.2        | 1.5568    | 1698771   | 0.0522     | 4802       | 1.087E-05         | 7.85                           |
| 670           | 808.4        | 1.5817    | 1700549   | 0.0507     | 3856       | 1.315E-05         | 8.61                           |
| 699           | 829.8        | 1.6075    | 1702627   | 0.0520     | 2847       | 1.826E-05         | 9.41                           |
| 728           | 851.6        | 1.6337    | 1703396   | 0.0507     | 1595       | 3.175E-05         | 10.28                          |
| 757           | 871.9        | 1.6581    | 1704222   | 0.0495     | 1402       | 3.530E-05         | 11.24                          |
| 782           | 892.7        | 1.6832    | 1704798   | 0.0425     | 721        | 5.889E-05         | 12.10                          |
|               | 907.1        | 1.7006    | 1704944   |            |            |                   |                                |

Fairchild DTA 06-8520 CE6  
 2014-T65121 EXTR ECT SPEC. R=0.8



# AUTOMATED FATIGUE CRACK GROWTH RATE ANALYSIS

|                 |            |                 |          |
|-----------------|------------|-----------------|----------|
| Specimen Id.    | CE6        | Geometry        | ECT      |
| Contract #      | 06-8520    | Orientation     | LT       |
| Material        | 2024-T6511 | Yield (ksi)     | 60.7     |
| Temperature (F) | 74         | Initial A0 (PD) | 0.599    |
| Environment     | LA         | Initial PD      | %1000.00 |

## Specimen Dimensions (in)

|           |       |             |       |
|-----------|-------|-------------|-------|
| Thickness | 0.116 | Notch depth | 0.620 |
| Width     | 2.503 | Gage length | 0.000 |
| Height    | 0.000 |             |       |

## Precrack Parameters

|              |       |                  |       |
|--------------|-------|------------------|-------|
| Pmax (lbs)   | 600.0 | Stress ratio (R) | 0.80  |
| Final a (in) | 0.717 | Kmax             | 11.16 |

## Test Parameters

|                |       |                  |       |
|----------------|-------|------------------|-------|
| Initial a (in) | 0.768 | Initial K        | 12.00 |
| K-gradient     | -3.50 | Stress ratio (R) | 0.80  |

|         |          |                |
|---------|----------|----------------|
| K Coeff | PD Coeff | Analysis Codes |
|         | 0.247340 | KREP 1 0       |
|         | 0.471870 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |

## Visual Observations

|        |            |                |       |       |
|--------|------------|----------------|-------|-------|
| PD     | Crack (PD) | Crack (visual) | Error | PDAF  |
| 126.52 | 0.768      | 0.768          | 0.000 | 1.000 |
| 238.54 | 0.897      | 0.897          | 0.000 | 0.986 |

## Comments

Date of test: 01-26-1998

Specimen Id. CE6

Page 1

| Pmax<br>(lbs) | PD<br>(1E-6) | a<br>(in) | N<br>(X1) | da<br>(in) | dN<br>(X1) | da/dN<br>(in/cyc) | dK<br>(ksi[in] <sup>1.5</sup> ) |
|---------------|--------------|-----------|-----------|------------|------------|-------------------|---------------------------------|
|               | 126.5        | 0.7685    | 5         |            |            |                   |                                 |
| 544           | 142.5        | 0.7870    | 204076    | 0.0433     | 495287     | 8.735E-08         | 2.22                            |
| 490           | 163.9        | 0.8118    | 495291    | 0.0492     | 669261     | 7.358E-08         | 2.05                            |
| 435           | 185.2        | 0.8362    | 873337    | 0.0488     | 834159     | 5.849E-08         | 1.88                            |
| 386           | 206.5        | 0.8606    | 1329450   | 0.0480     | 1012256    | 4.744E-08         | 1.72                            |
| 355           | 227.3        | 0.8843    | 1885593   | 0.0330     | 815777     | 4.050E-08         | 1.62                            |
|               | 235.5        | 0.8936    | 2145227   |            |            |                   |                                 |

# AUTOMATED FATIGUE CRACK GROWTH RATE ANALYSIS

|                 |            |                 |           |
|-----------------|------------|-----------------|-----------|
| Specimen Id.    | CE6A       | Geometry        | ECT       |
| Contract #      | 06-8520    | Orientation     | LT        |
| Material        | 2024-T6511 | Yield (ksi)     | 60.7      |
| Temperature (F) | 74         | Initial AO (PD) | 0.599     |
| Environment     | LA         | Initial PD      | \$1000.00 |

## Specimen Dimensions (in)

|           |       |             |       |
|-----------|-------|-------------|-------|
| Thickness | 0.116 | Notch depth | 0.620 |
| Width     | 2.503 | Gage length | 0.000 |
| Height    | 0.000 |             |       |

## Precrack Parameters

|              |       |                  |       |
|--------------|-------|------------------|-------|
| Pmax (lbs)   | 600.0 | Stress ratio (R) | 0.80  |
| Final a (in) | 0.717 | Kmax             | 11.16 |

## Test Parameters

|                |       |                  |      |
|----------------|-------|------------------|------|
| Initial a (in) | 0.897 | Initial K        | 7.80 |
| K-gradient     | 3.50  | Stress ratio (R) | 0.80 |

|         |          |                |
|---------|----------|----------------|
| K Coeff | PD Coeff | Analysis Codes |
|         | 0.247340 | KREP 1 0       |
|         | 0.471870 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |
|         | 0.000000 |                |

## Visual Observations

| PD     | Crack (PD) | Crack (visual) | Error  | PDAF  |
|--------|------------|----------------|--------|-------|
| 238.51 | 0.896      | 0.897          | 0.001  | 0.981 |
| 466.43 | 1.179      | 1.172          | -0.007 | 1.015 |
| 635.18 | 1.400      | 1.405          | 0.005  | 1.041 |

## Comments

Date of test: 01-30-1998

| Pmax<br>(lbs) | PD<br>(1E-6) | a<br>(in) | N<br>(X1) | da<br>(in) | dN<br>(X1) | da/dN<br>(in/cyc) | dK<br>(ksi[in] <sup>-.5</sup> ) |
|---------------|--------------|-----------|-----------|------------|------------|-------------------|---------------------------------|
|               | 238.5        | 0.8956    | 6         |            |            |                   |                                 |
| 353           | 254.0        | 0.9142    | 410374    | 0.0441     | 886120     | 4.973E-08         | 1.69                            |
| 370           | 275.0        | 0.9396    | 886126    | 0.0506     | 912919     | 5.540E-08         | 1.83                            |
| 391           | 295.6        | 0.9647    | 1323292   | 0.0519     | 757716     | 6.855E-08         | 2.00                            |
| 413           | 317.5        | 0.9916    | 1643841   | 0.0529     | 593149     | 8.924E-08         | 2.18                            |
| 437           | 338.7        | 1.0177    | 1916441   | 0.0529     | 517766     | 1.023E-07         | 2.39                            |
| 461           | 360.3        | 1.0445    | 2161608   | 0.0524     | 430368     | 1.219E-07         | 2.61                            |
| 487           | 380.8        | 1.0701    | 2346809   | 0.0534     | 364743     | 1.464E-07         | 2.86                            |
| 513           | 403.0        | 1.0979    | 2526351   | 0.0529     | 319007     | 1.659E-07         | 3.12                            |
| 542           | 422.9        | 1.1230    | 2665816   | 0.0521     | 311023     | 1.675E-07         | 3.42                            |
| 570           | 444.1        | 1.1500    | 2837374   | 0.0541     | 300463     | 1.801E-07         | 3.73                            |
| 604           | 465.4        | 1.1772    | 2966279   | 0.0591     | 217838     | 2.715E-07         | 4.12                            |
| 635           | 490.2        | 1.2091    | 3055212   | 0.0562     | 126822     | 4.431E-07         | 4.49                            |
| 672           | 509.0        | 1.2334    | 3093100   | 0.0527     | 57272      | 9.202E-07         | 4.96                            |
| 704           | 530.9        | 1.2618    | 3112483   | 0.0541     | 32740      | 1.653E-06         | 5.39                            |
| 743           | 550.5        | 1.2875    | 3125840   | 0.0548     | 26417      | 2.075E-06         | 5.93                            |
| 780           | 572.6        | 1.3167    | 3138900   | 0.0574     | 21967      | 2.613E-06         | 6.48                            |
| 821           | 594.0        | 1.3449    | 3147807   | 0.0571     | 14145      | 4.037E-06         | 7.14                            |
| 863           | 615.7        | 1.3738    | 3153045   | 0.0569     | 8651       | 6.581E-06         | 7.83                            |
| 906           | 636.8        | 1.4018    | 3156457   | 0.0534     | 5539       | 9.645E-06         | 8.58                            |
| 954           | 657.4        | 1.4272    | 3158584   | 0.0550     | 3643       | 1.511E-05         | 9.47                            |
| 1000          | 681.6        | 1.4569    | 3160100   | 0.0549     | 2073       | 2.650E-05         | 10.33                           |
|               | 702.1        | 1.4821    | 3160658   |            |            |                   |                                 |

## **APPENDIX G2**

### **Spectrum Crack Growth Tests**

Data:        Simple Coupon Geometry Results  
              Complex Coupon Geometry Results

Data:        Simple Coupon Geometry Results

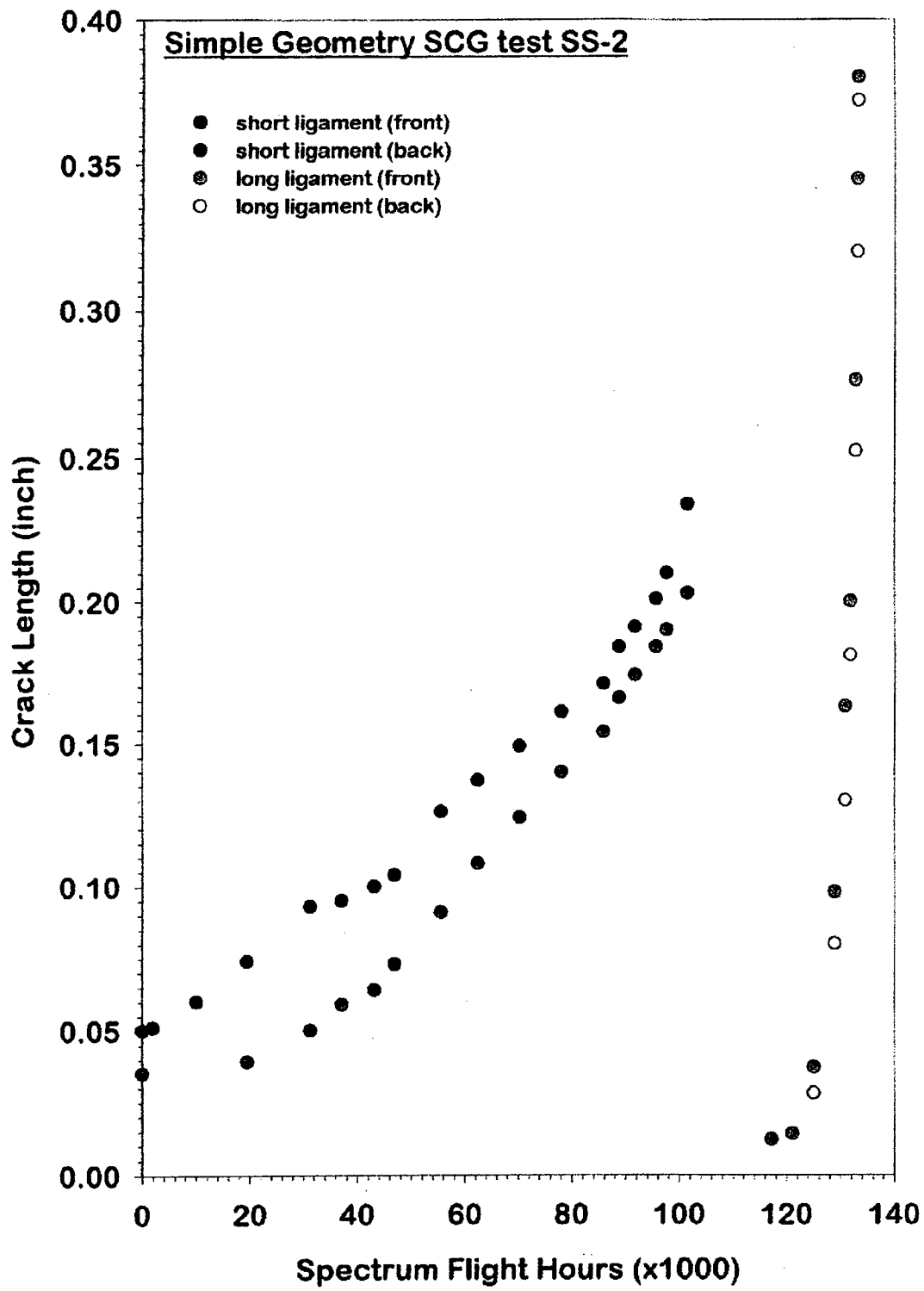
- Spectrum Crack Growth Plots (a vs SFH)

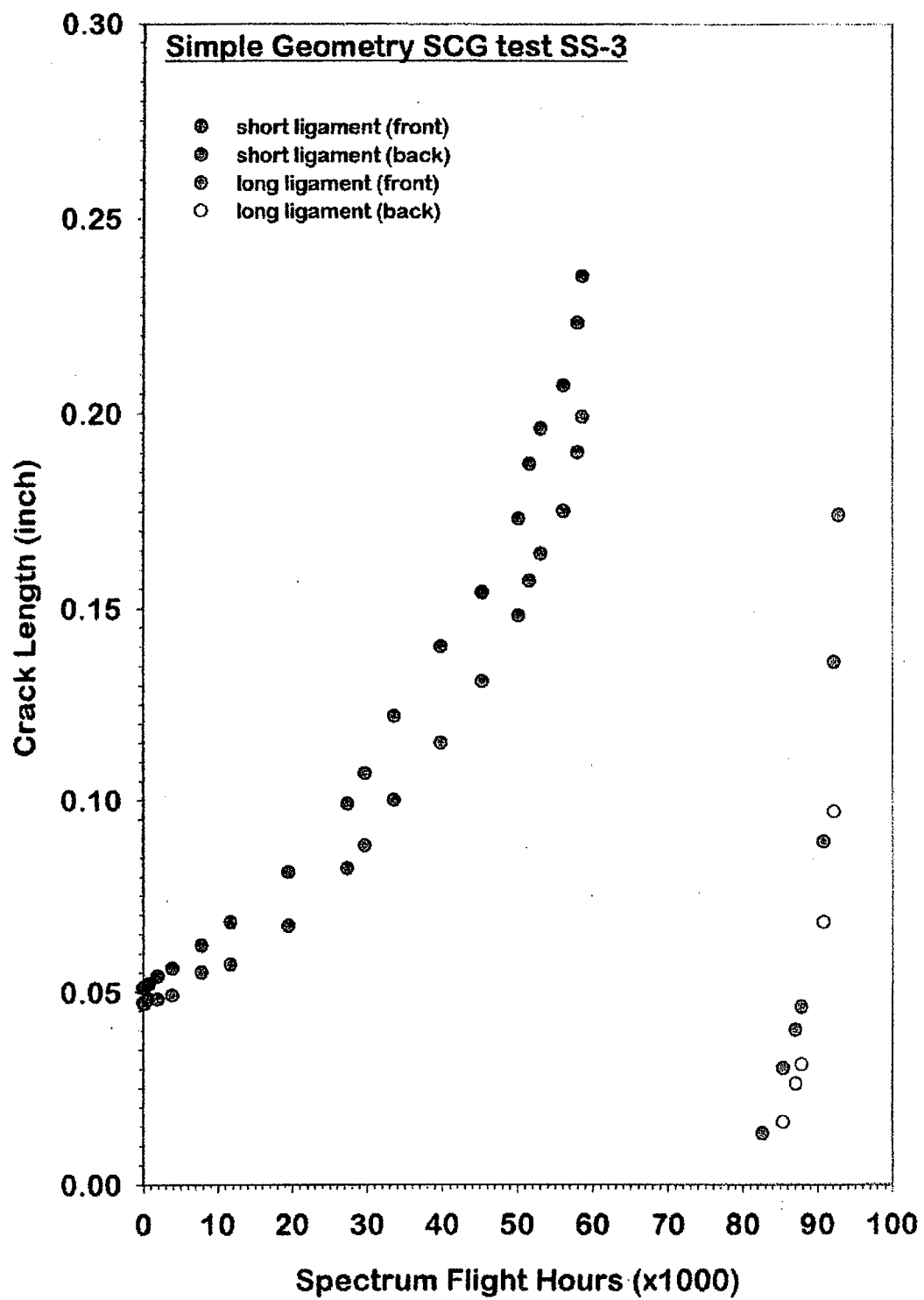
Complex Coupon Geometry Results

- Spectrum Crack Growth Plots (a vs SFH)
- Analysis of Non-Visual Crack Length Measurements
- Graphical Compliance and Strain Data
- Analyzed Compliance Data

### **Simple Coupon Geometry Tests**

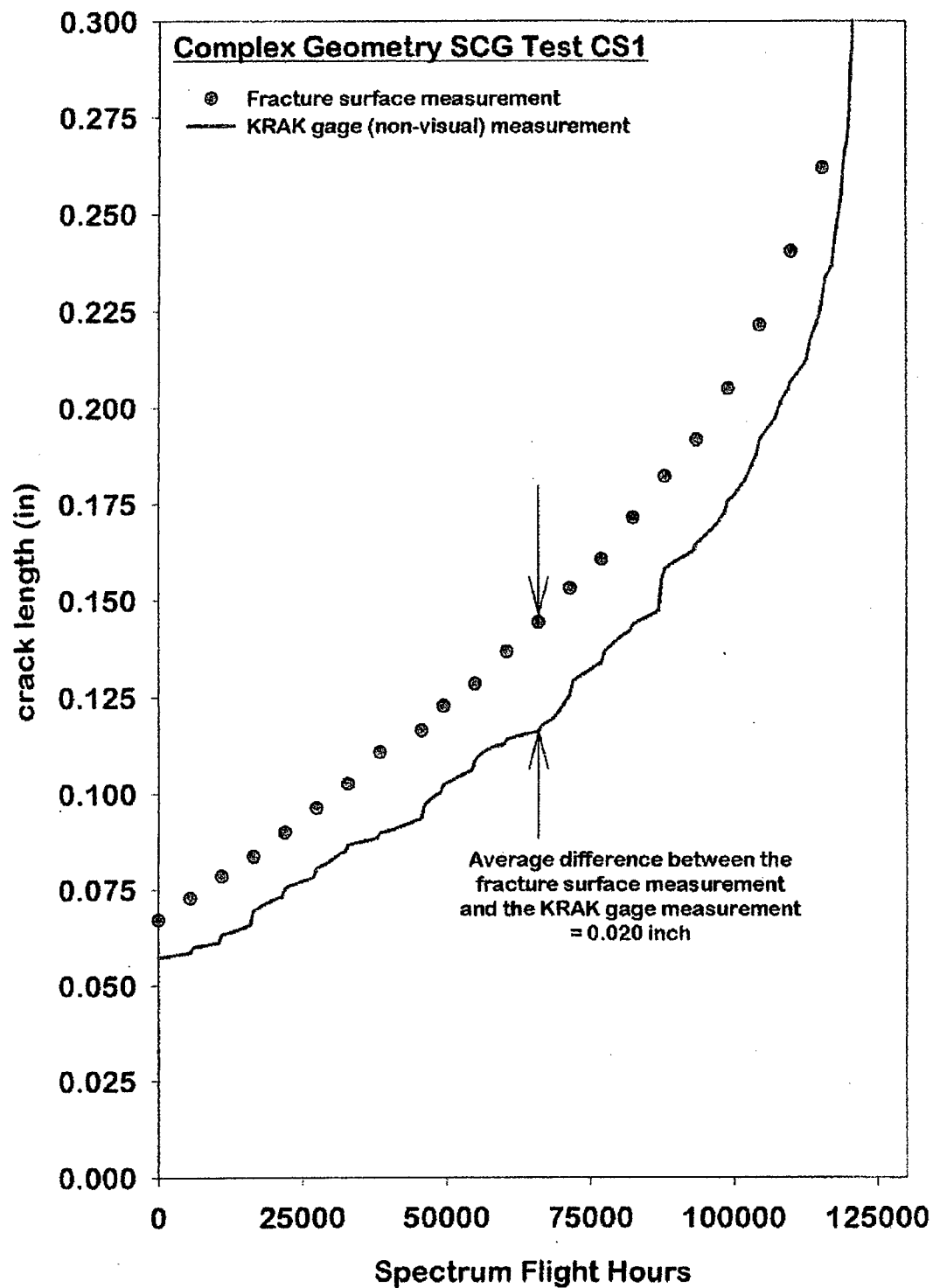
2 tests:       SS-2  
                  SS-3

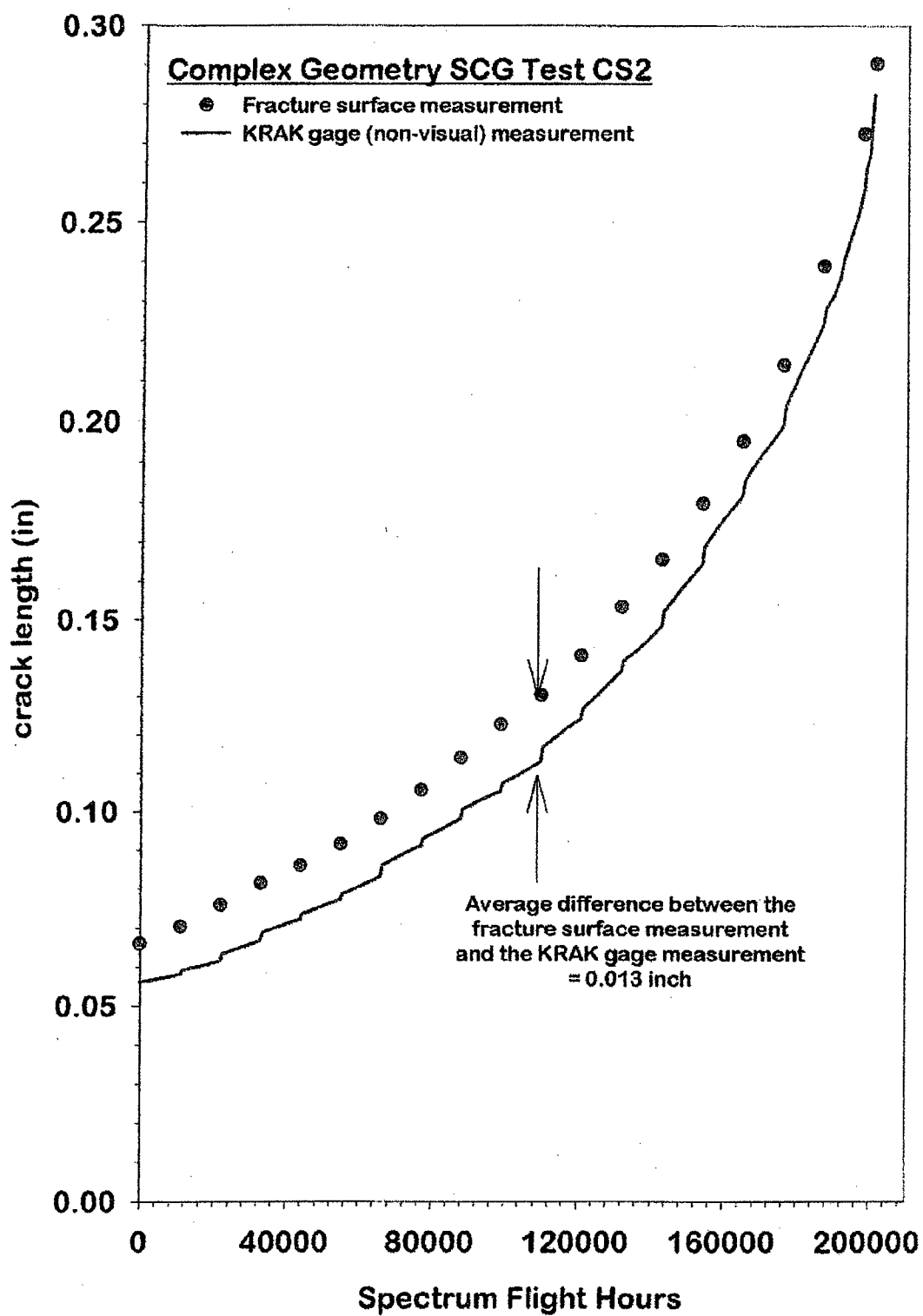


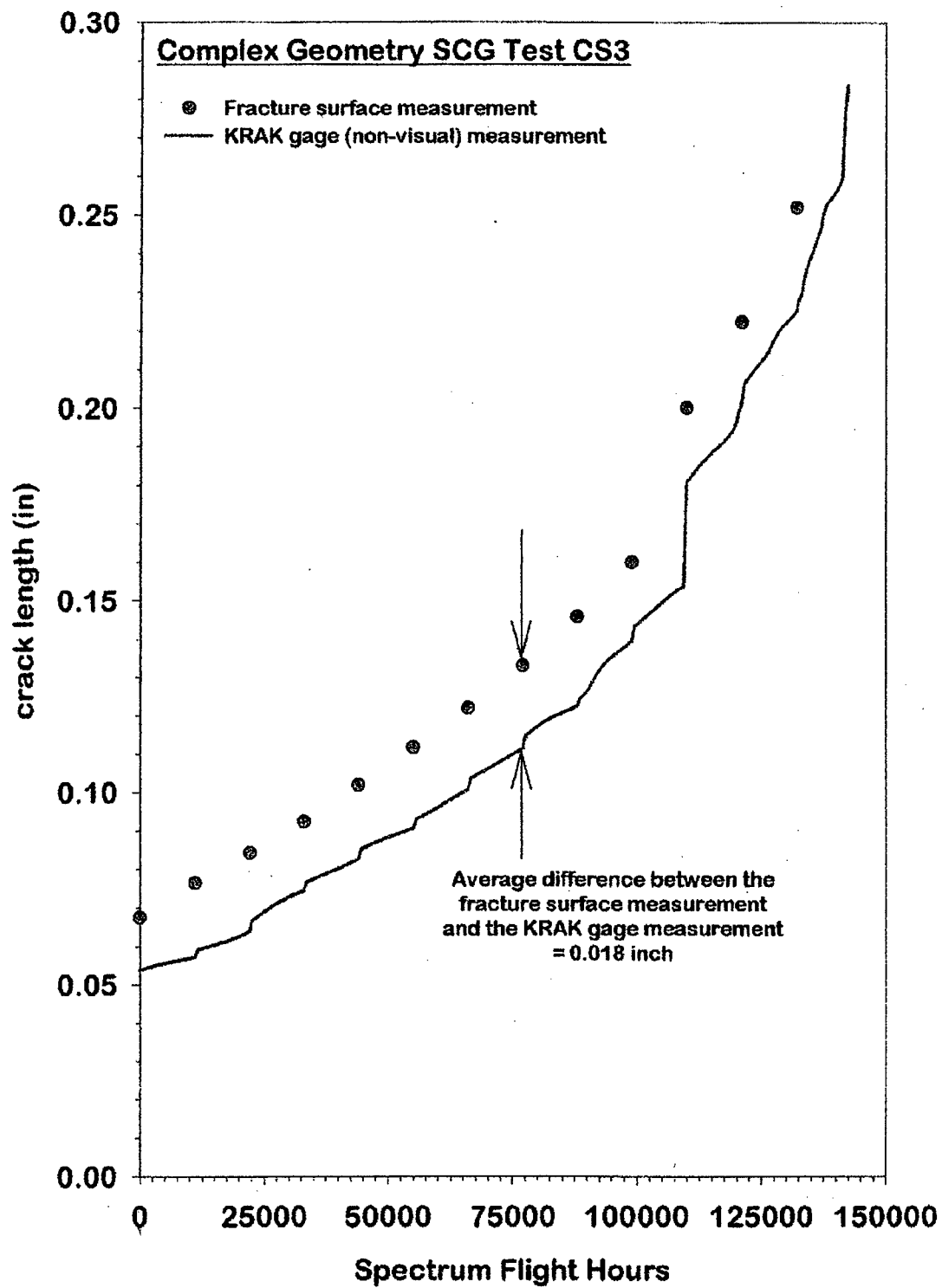


**Complex Coupon Geometry Tests**

3 tests: CS-1 to -3







## **Analysis of Non-Visual Crack Length Measurements**

Due to the unusually large difference found between the KRAK gage and markerband measurements, an investigation into possible causes for this discrepancy was undertaken. The KRAK gage position relative to the fastener hole was measured and the resulting offset added to the non-visual crack length measurements.

Balancing or zeroing of all KRAK gages was performed after the complex joint had been assembled but prior to any applied loading cycles. Fractomat output was checked by performing a controlled crack growth experiment using a KRAK gage and two Fractomats (one of which was the Fractomat use for this project). Both Fractomats were zeroed using the gage, and then the KRAK gage was cut incrementally using a scalpel, with indicated voltage output measured for both Fractomats. Only an average difference of 0.001-inch was measured between the two Fractomats. Therefore the Fractomat was not considered a contributor to the crack length offsets found.

Upon further investigation of the procedure used to attach the gages to the test section of the complex joint, it was found that on two of the three test coupons the front of the foil gage was trimmed back from the fastener hole. A comparison of an original gage and that found on the test coupon CS1 is shown in Figure B.1. Clearly there is a difference in the initial portion of the KRAK gage. For tests CS1 and CS3 the amount of foil removed on the mid-section was measured as 0.013 inch and 0.005 inch, respectively.

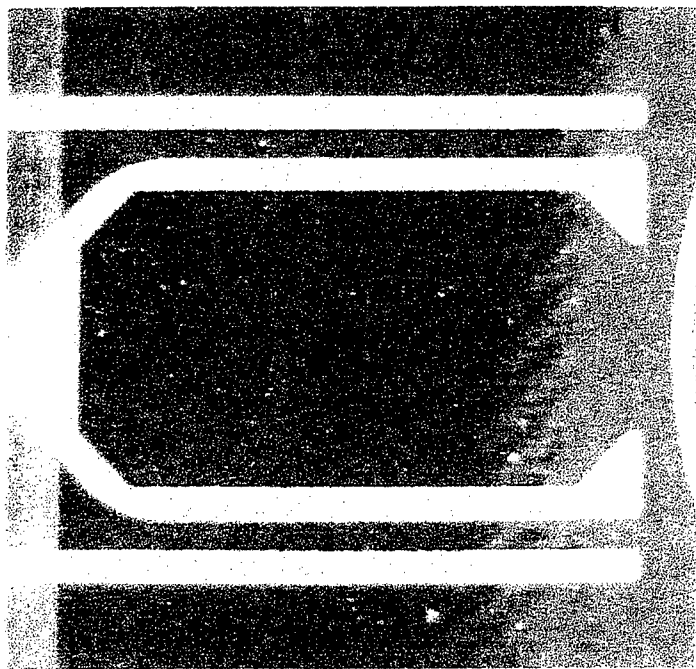
However, damage or cutting of the foil gage could result in incorrect crack lengths, when using the assigned calibration coefficients for this gage. A controlled experiment found that after trimming approximately 0.012 inch of foil from the KRAK gage, an average error of approximately 0.010 inch was found between the physical crack lengths and those calculated using the calibration coefficients, as shown in Figure B.2. All procedures mirrored those used in the complex geometry tests. When the crack length error in the controlled experiment is compared with the error obtained in the complex tests (Figure B.3), it is apparent that trimming the gages does not account for the total error observed. Also the gage on coupon CS2 was not trimmed and an error was still recorded.

It is also possible for the crack in the gage to lag behind the physical crack on the specimen if the glue line between the KRAK gage and the specimen is larger than normal, for example, not enough clamping force is used during attachment of the gages. This also relates to the type of backing used on the KRAK gage. The backing used for the complex geometry test was an epoxy-phenolic with fiberglass reinforcement. In hindsight it may have been advisable to use the -CE (or cast epoxy) backing. This backing is a very thin and brittle cast epoxy with no reinforcement, and is used for crack growth testing requiring utmost response and sensitivity such as in near-threshold testing or possibly when using benign civil aircraft spectra. However, due to its inherent fragility it was decided against using the -CE backing.

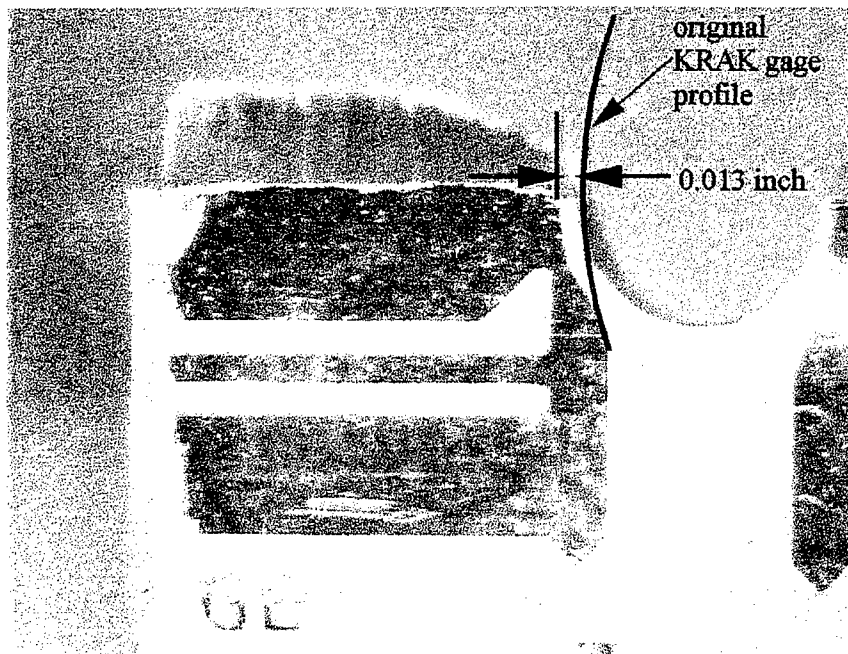
One final point with regard to the attachment method used in the complex geometry testing, is that a thin layer of teflon tape was placed between the extension tab and the KRAK gage, so that the gage was only attached to the test section and not the extension tab. This could possibly have wedged the gage away from the test section, resulting in a thicker glue line being applied. This may then have resulted in a crack length lag between the non-visual and physical crack length during spectrum testing.

In conclusion, the differences found between the non-visual (KRAK gage) and visual (markerband) crack length measurements could be explained in terms of the following:

- For tests CS1 and CS3, cutting of the foil gage resulted in incorrect crack length calculations using the supplied calibration equation.
- It is possible that a combination of glue line thickness and KRAK gage backing material decreased the sensitivity of the KRAK gage to measure the physical crack length accurately.



(a)



(b)

**Figure B.1. Comparison of KRAK gages KG-BH5616-X08 (a) unused and (b) test CS1.**

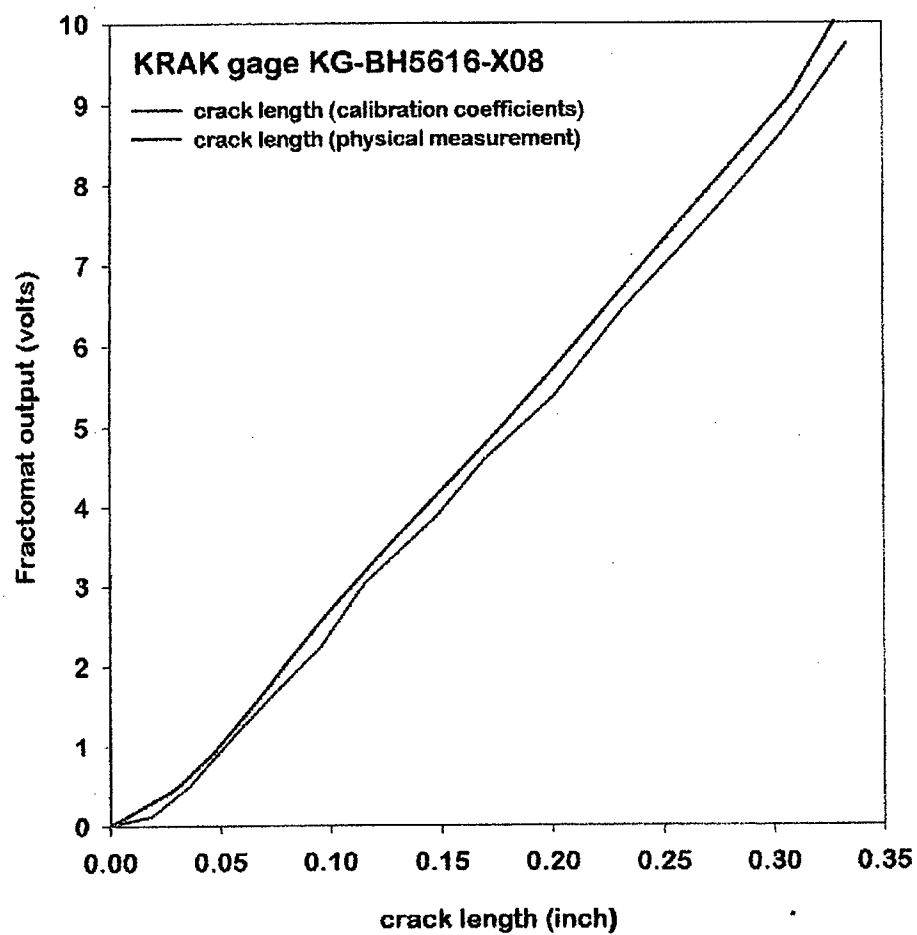


**Figure B.2 Comparison of calculated and physically measured crack length for the controlled KRAK gage experiment**

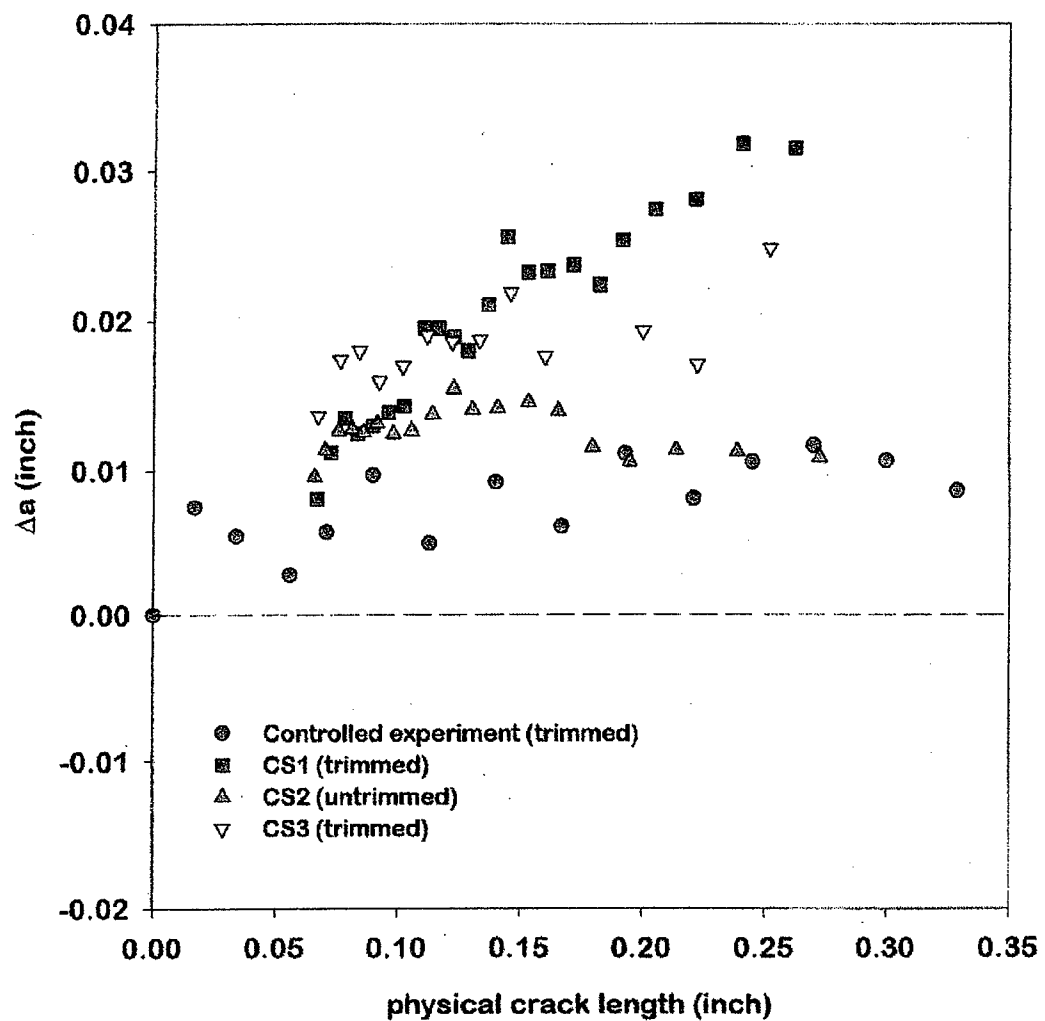
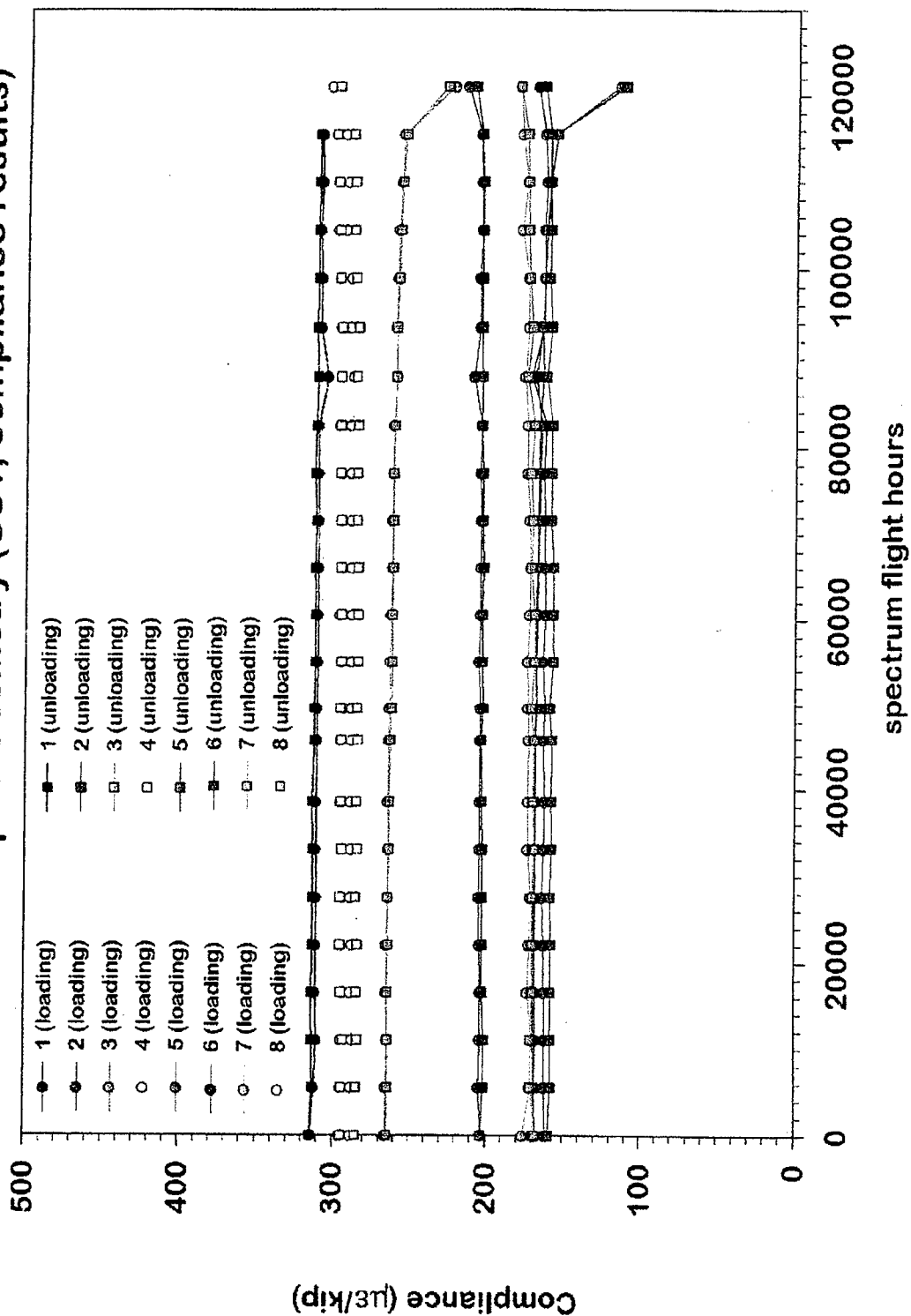


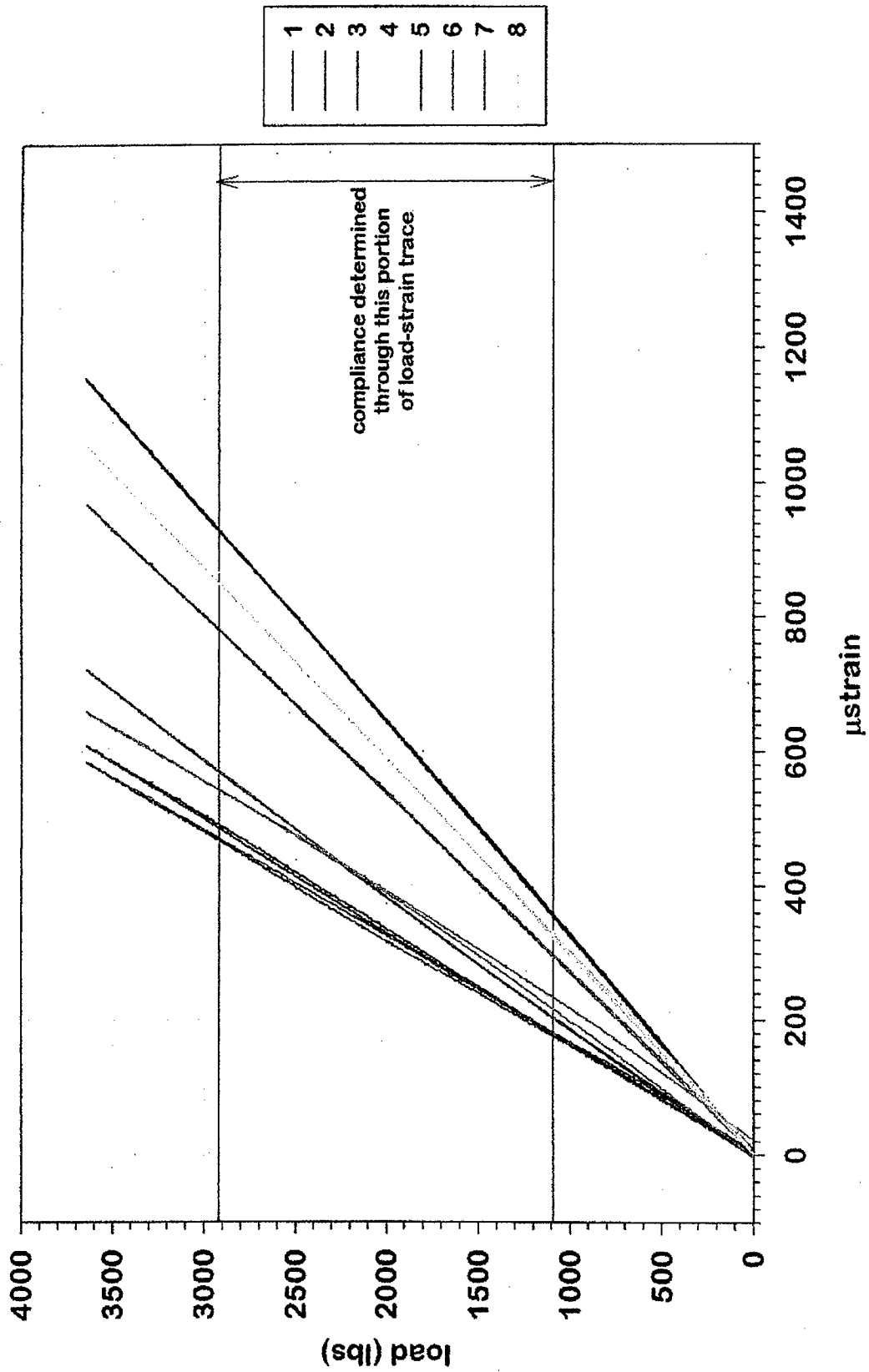
Figure B.3 Comparison of crack length error between markerbands and KRAK gage

**Graphical Compliance and Strain Data**

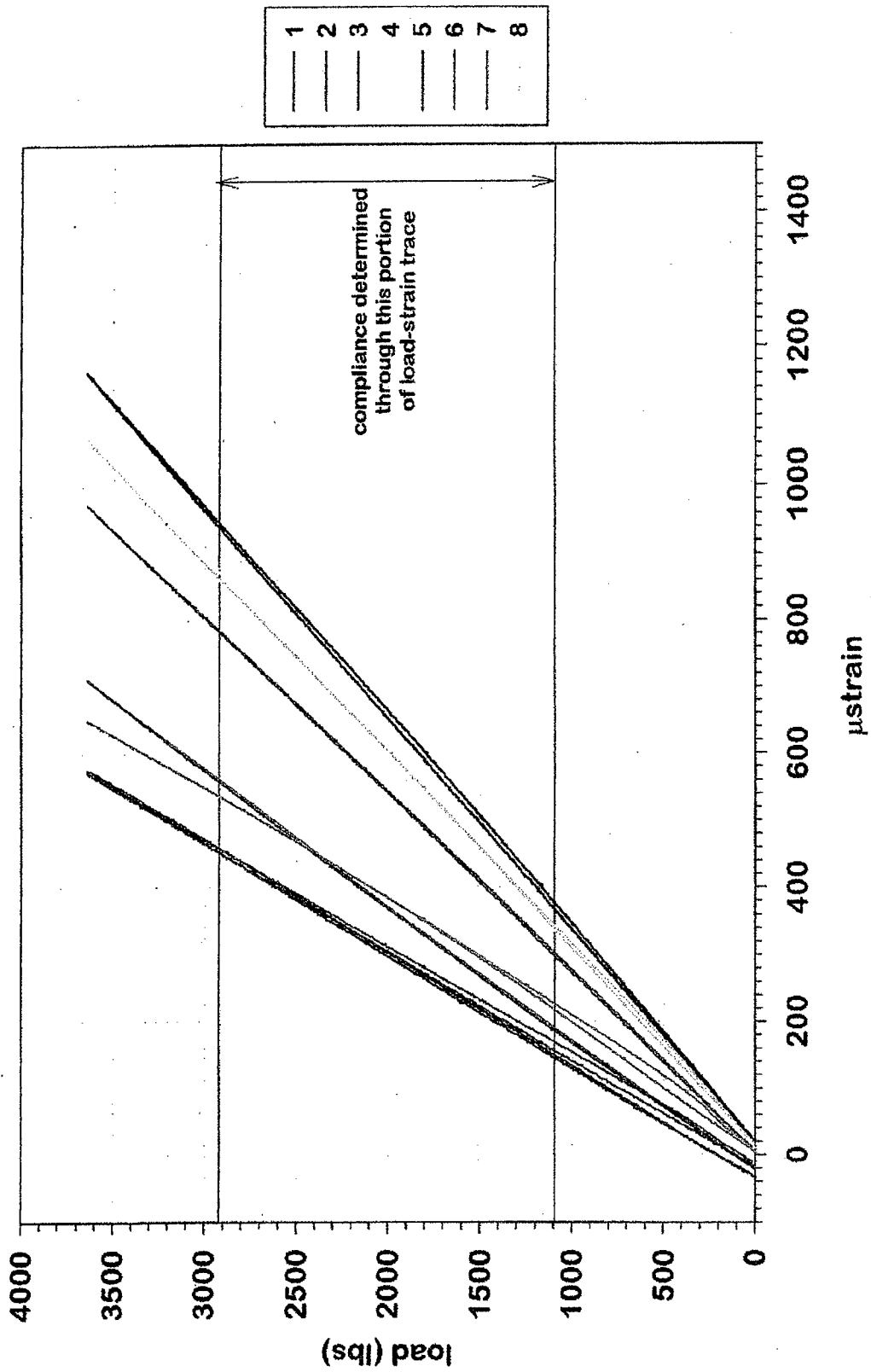
# Fairchild Complex Geometry (CS1, compliance results)



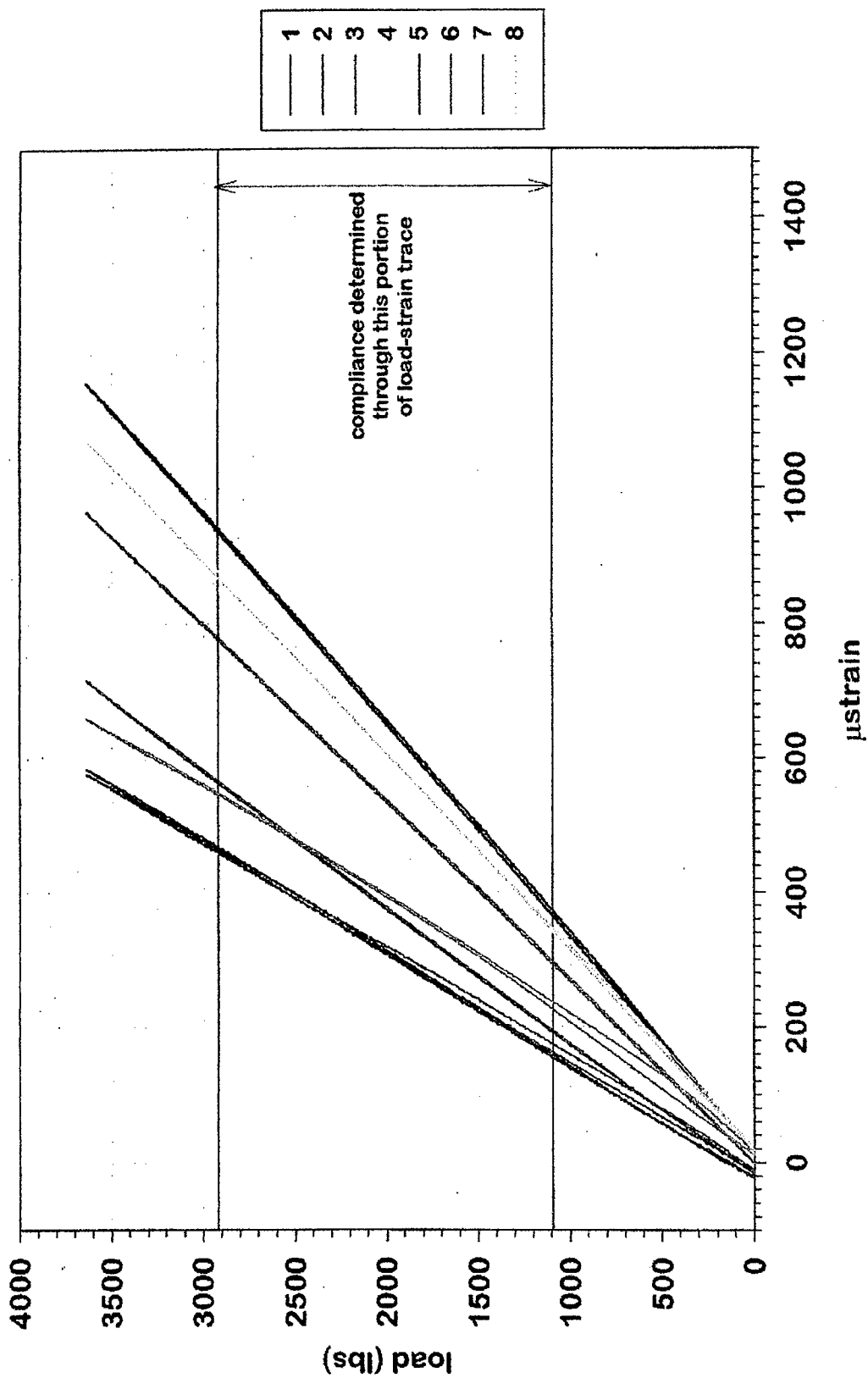
# Specimen CS1 Strain Gage Output (SFH 0)



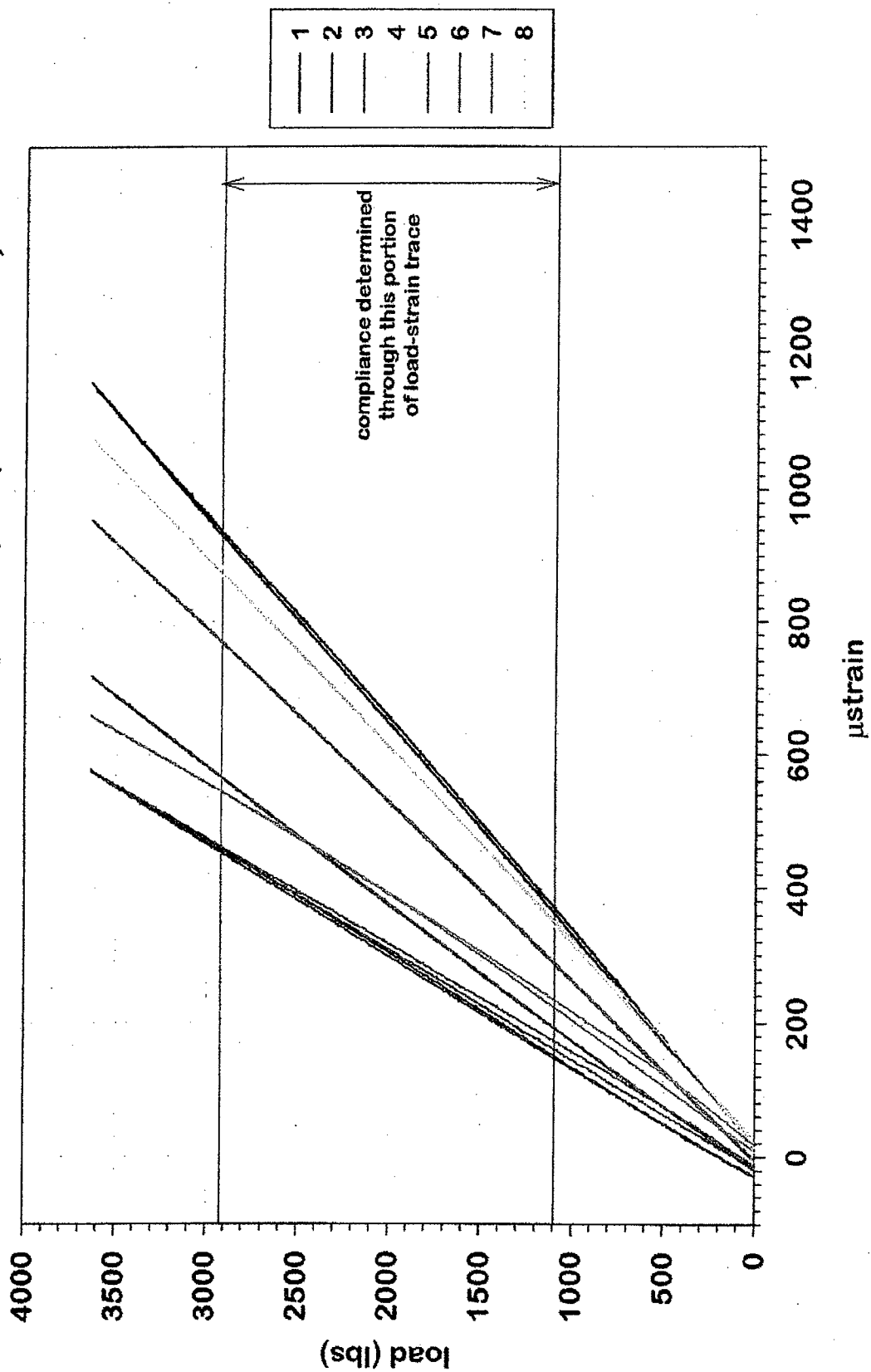
# Specimen CS1 Strain Gage Output (SFH 22013)



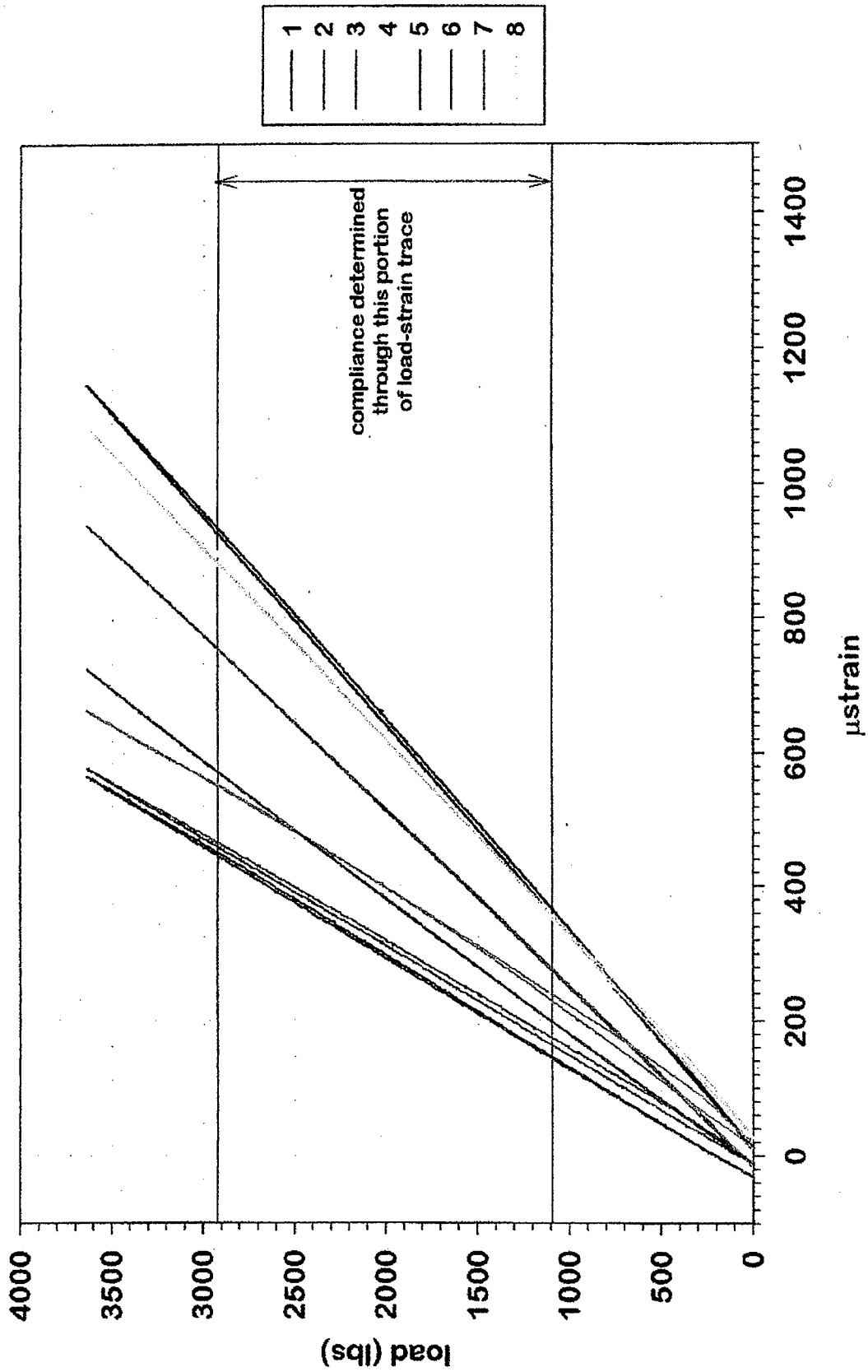
# Specimen CS1 Strain Gage Output (SFH 38515)



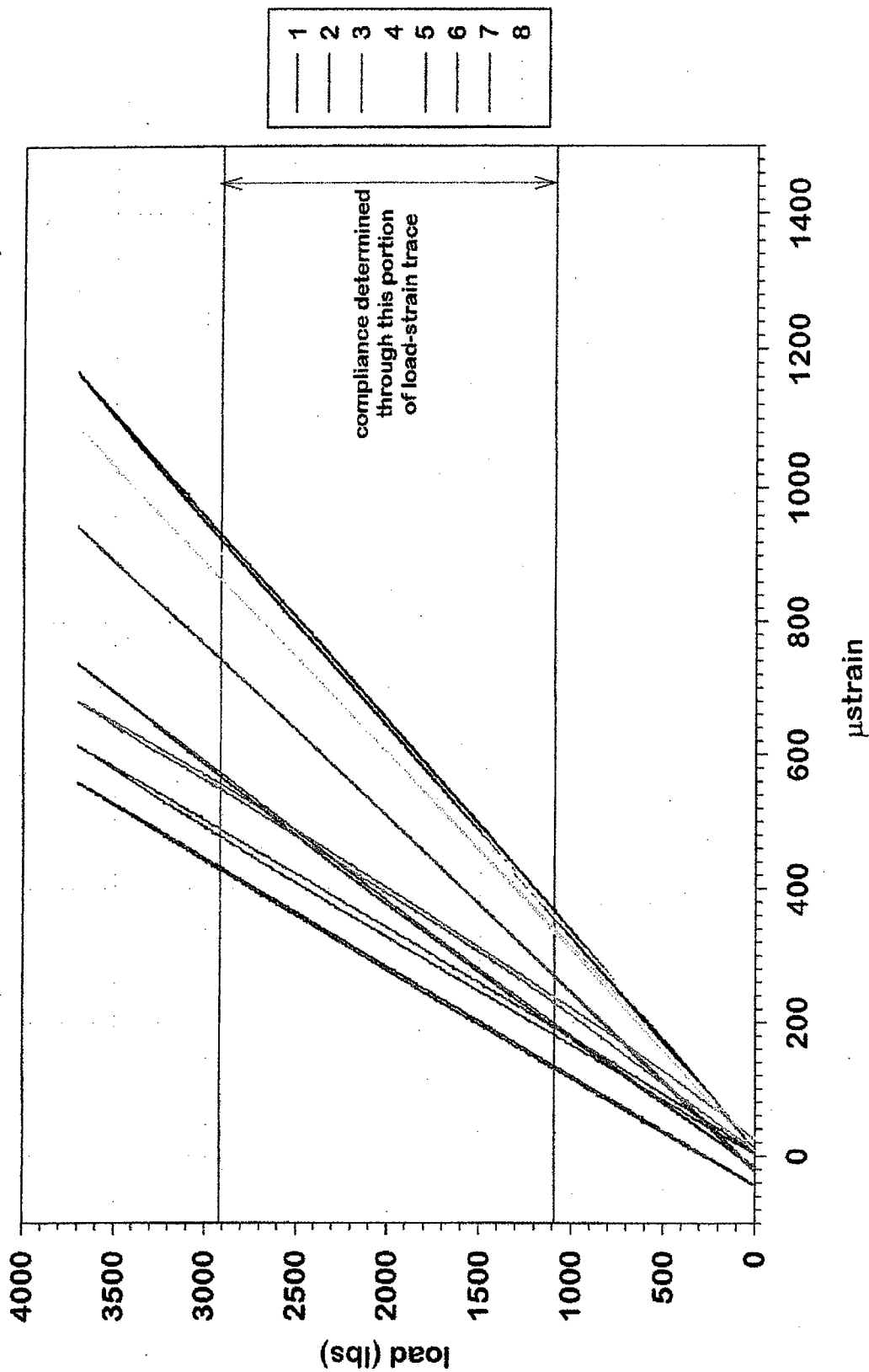
# Specimen CS1 Strain Gage Output (SFH 60520)



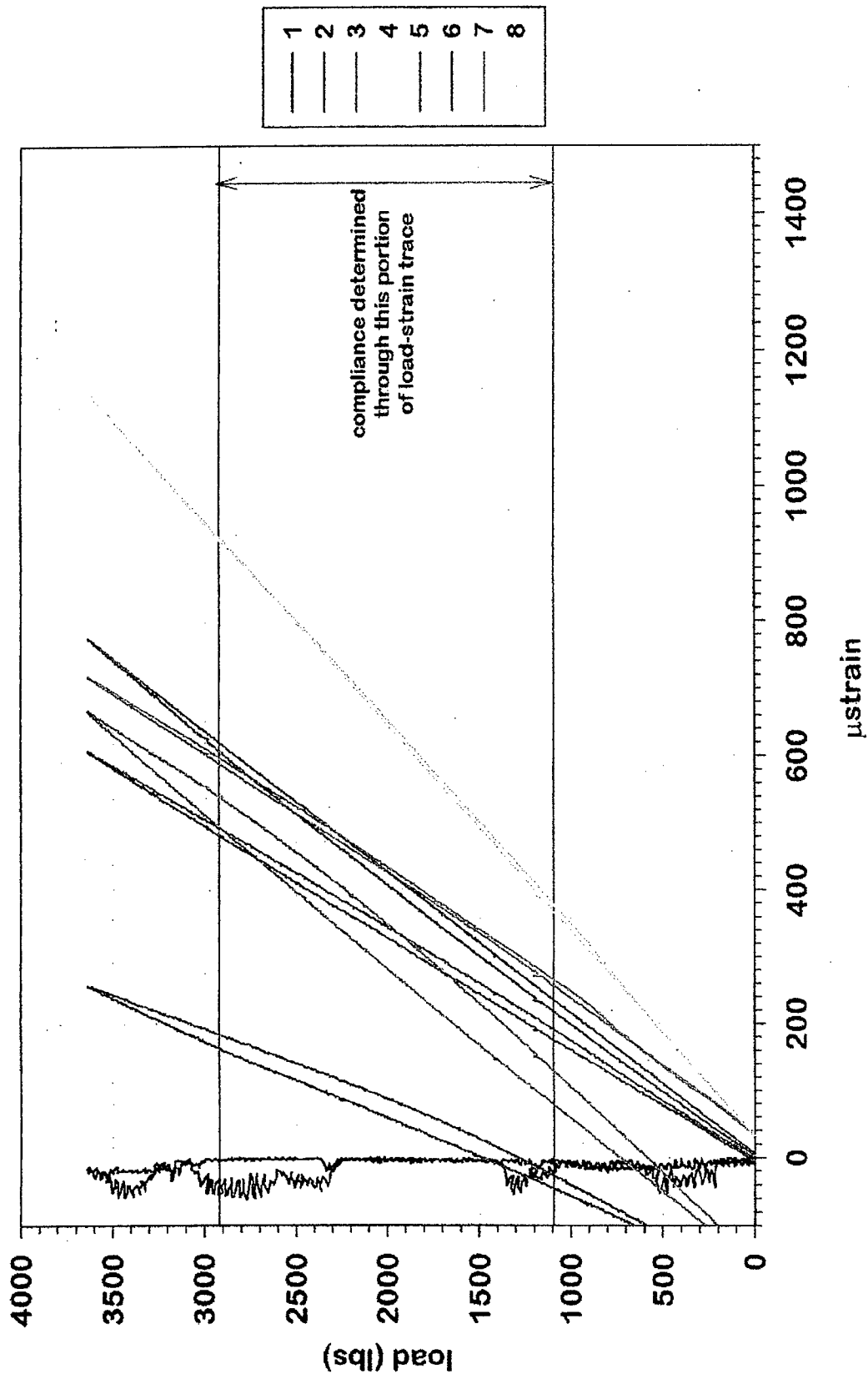
# Specimen CS1 Strain Gage Output (SFH 82521)



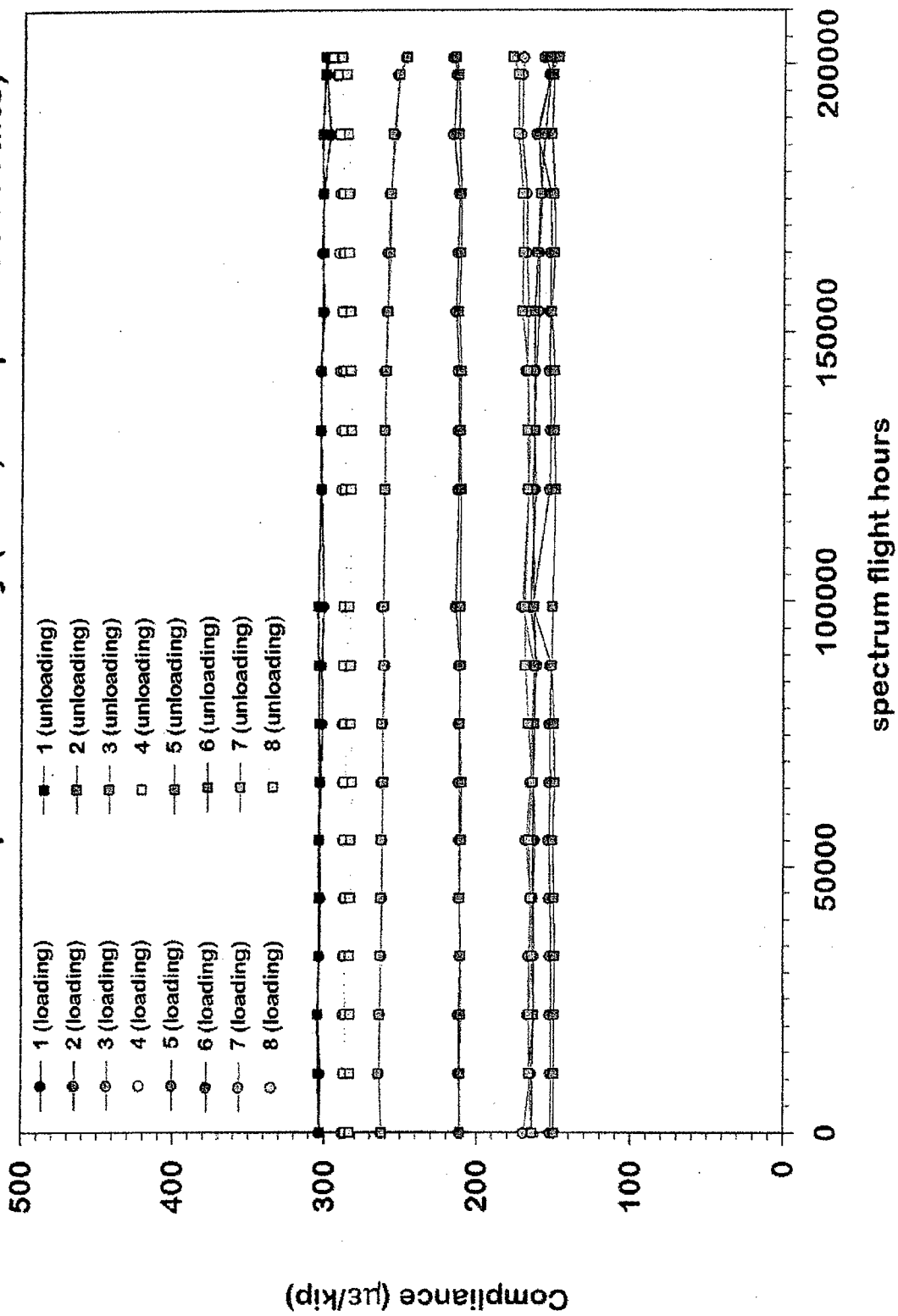
# Specimen CS1 Strain Gage Output (SFH 99022)



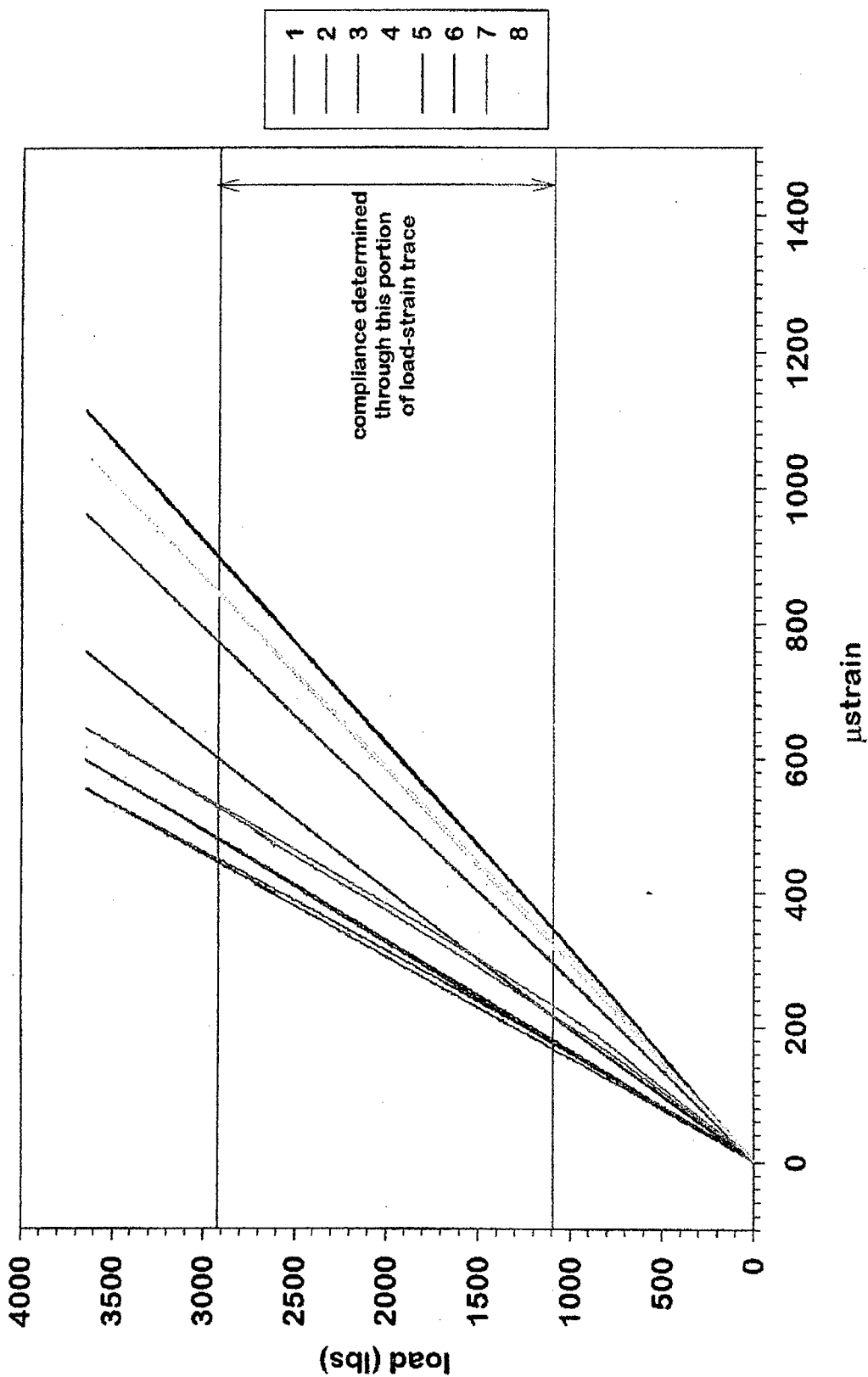
# Specimen CS1 Strain Gage Output (SFH 121018)



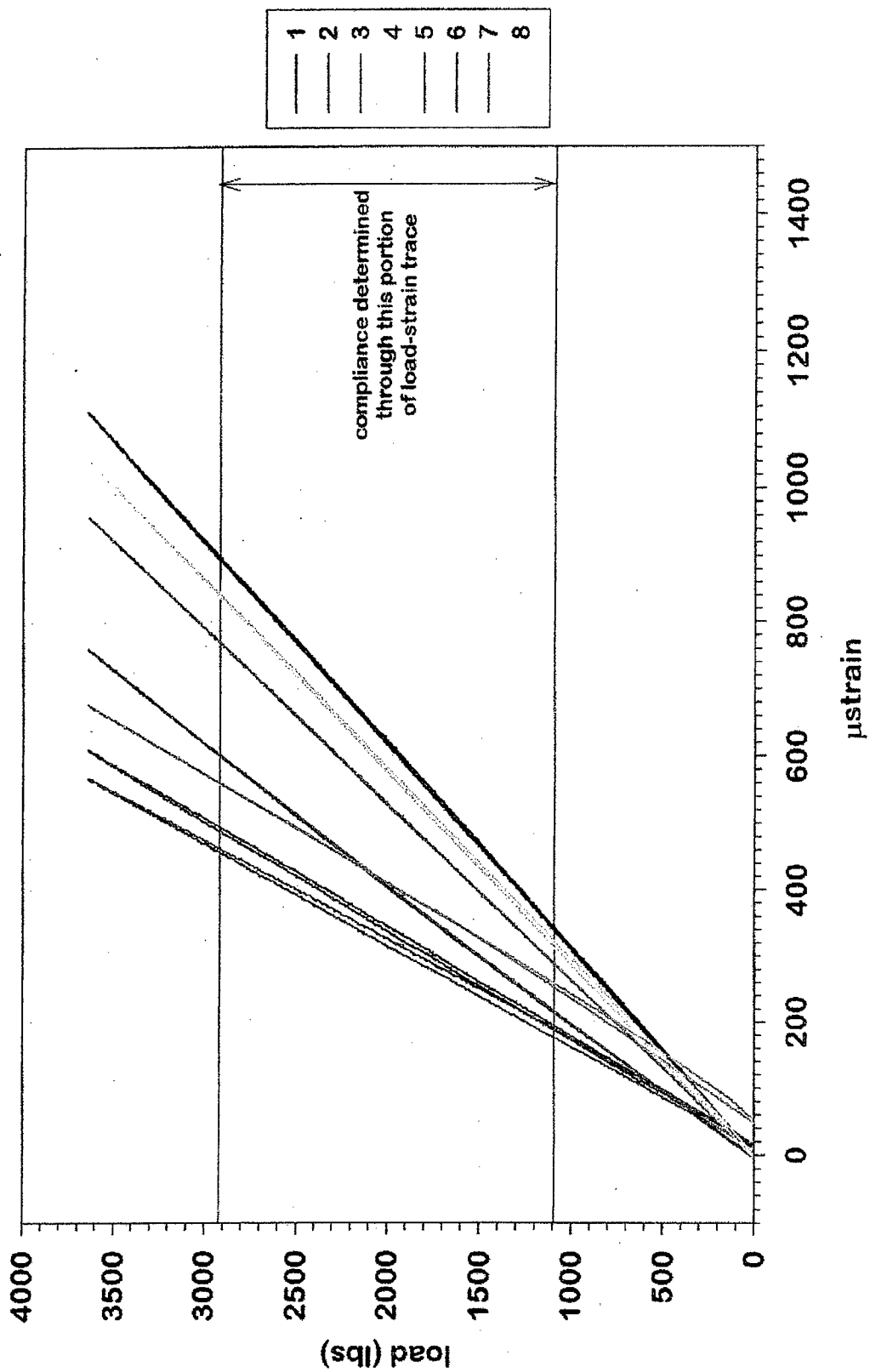
# Fairchild Complex Geometry (CS2, compliance results)



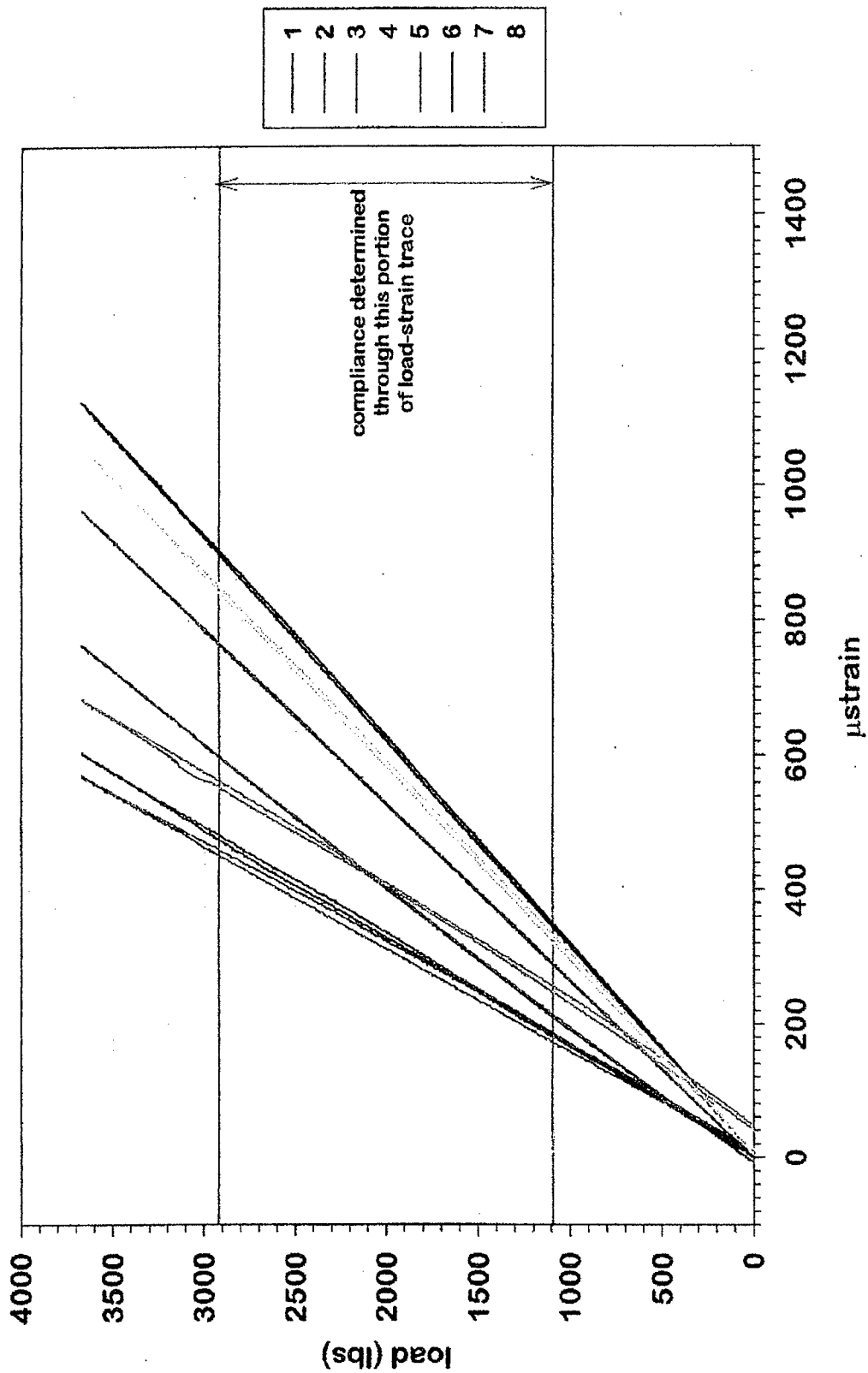
# Specimen CS2 Strain Gage Output (SFH 0)



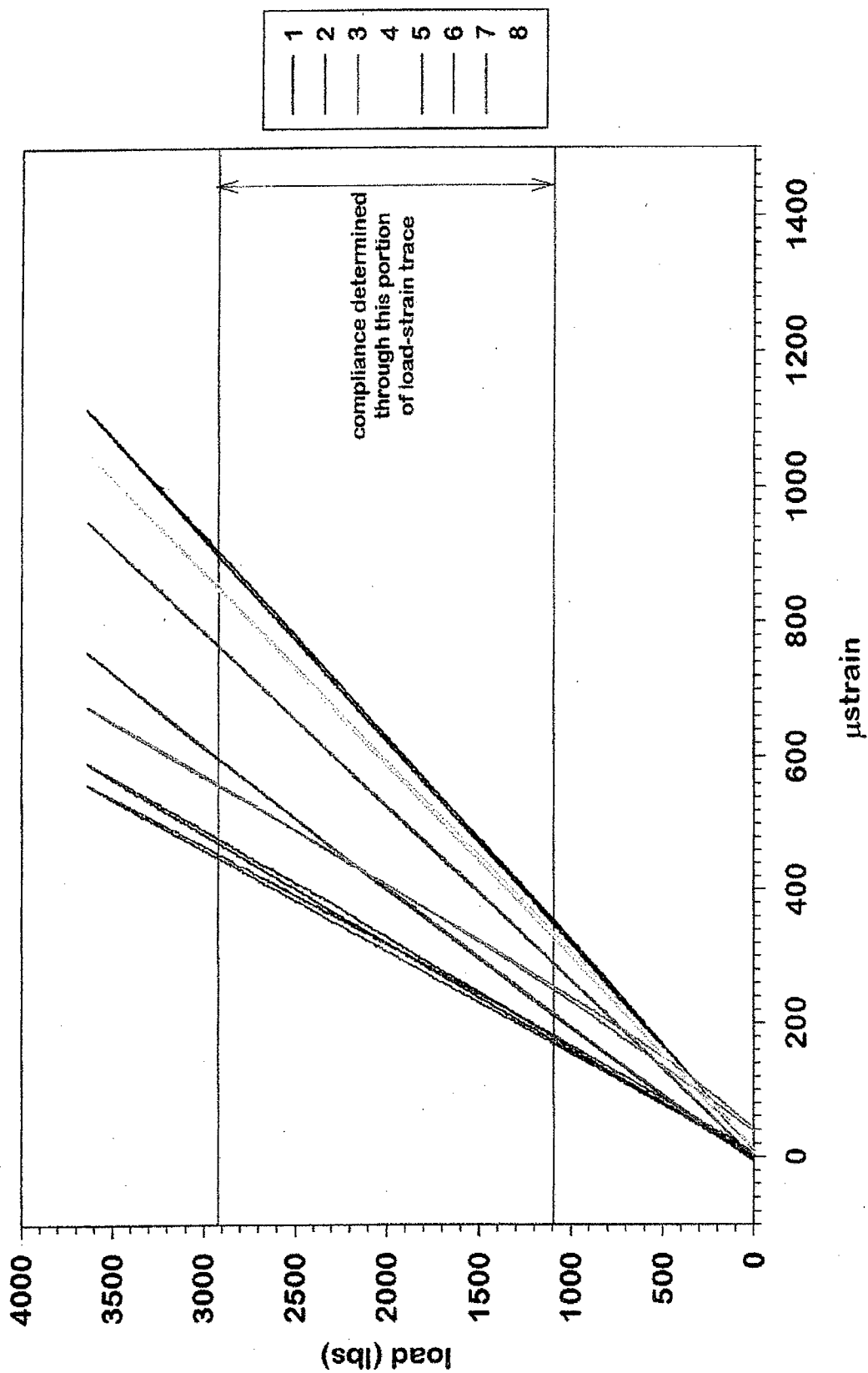
# Specimen CS2 Strain Gage Output (SFH 44019)



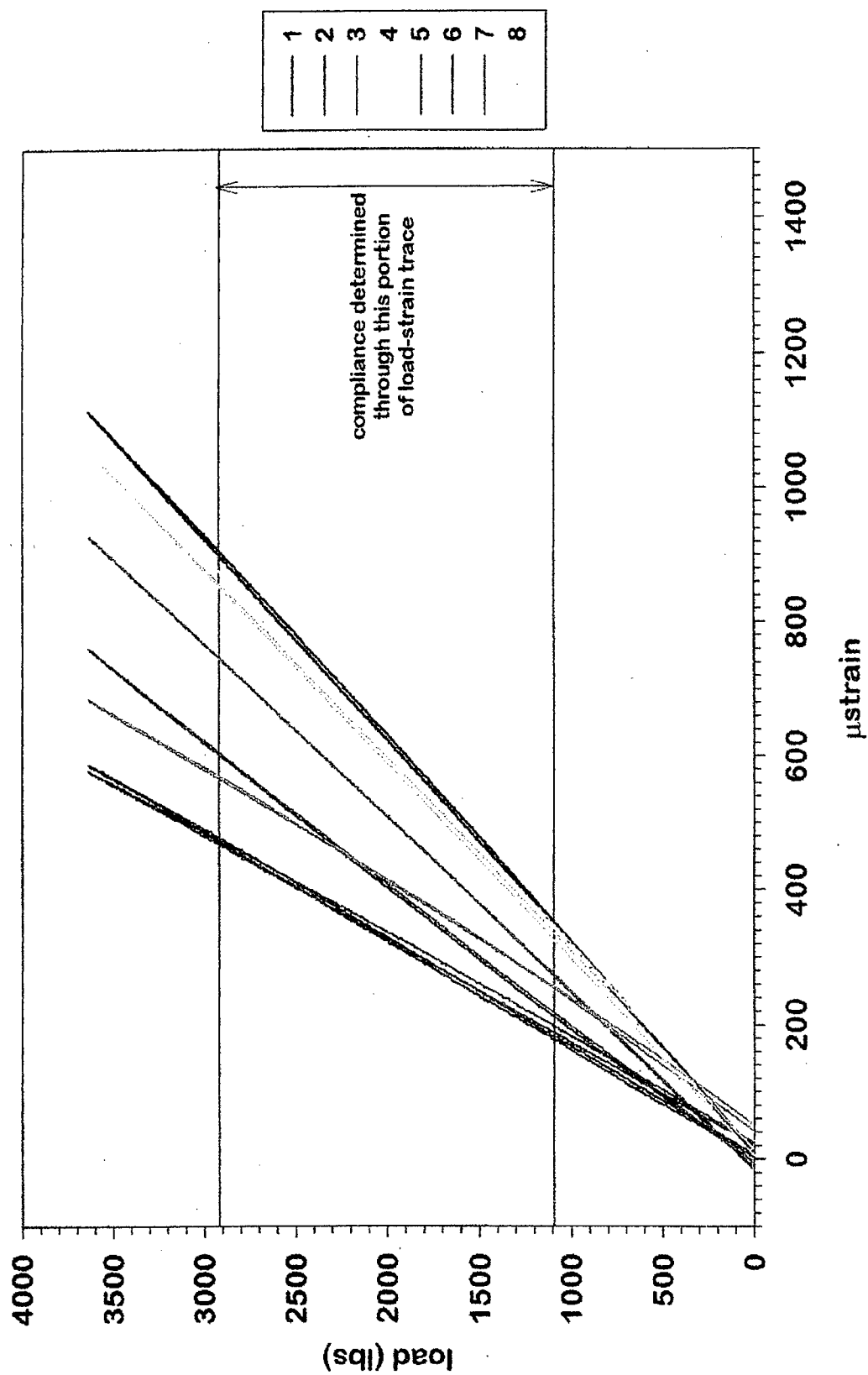
# Specimen CS2 Strain Gage Output (SFH 88041)



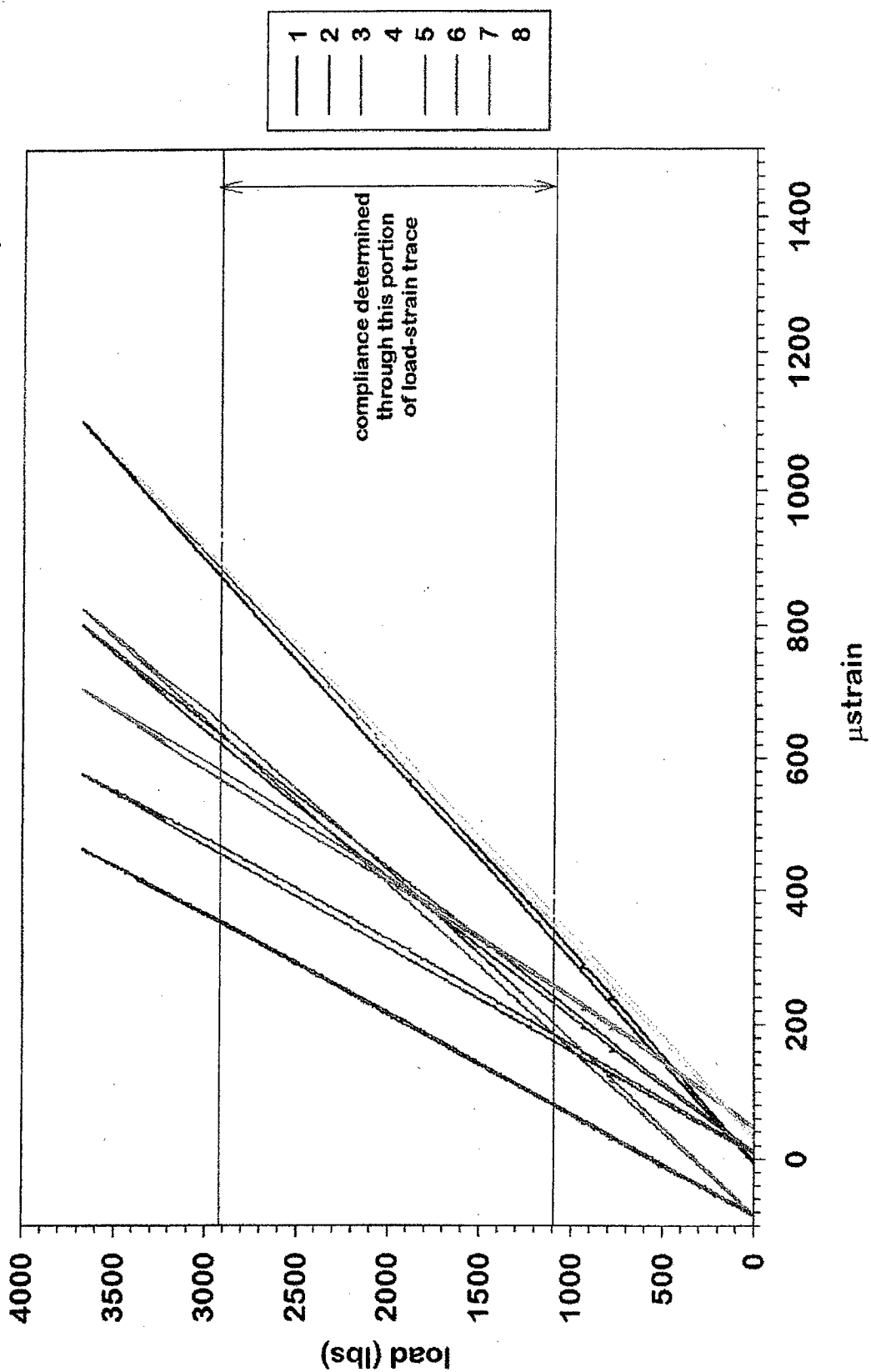
# Specimen CS2 Strain Gage Output (SFH 121036)



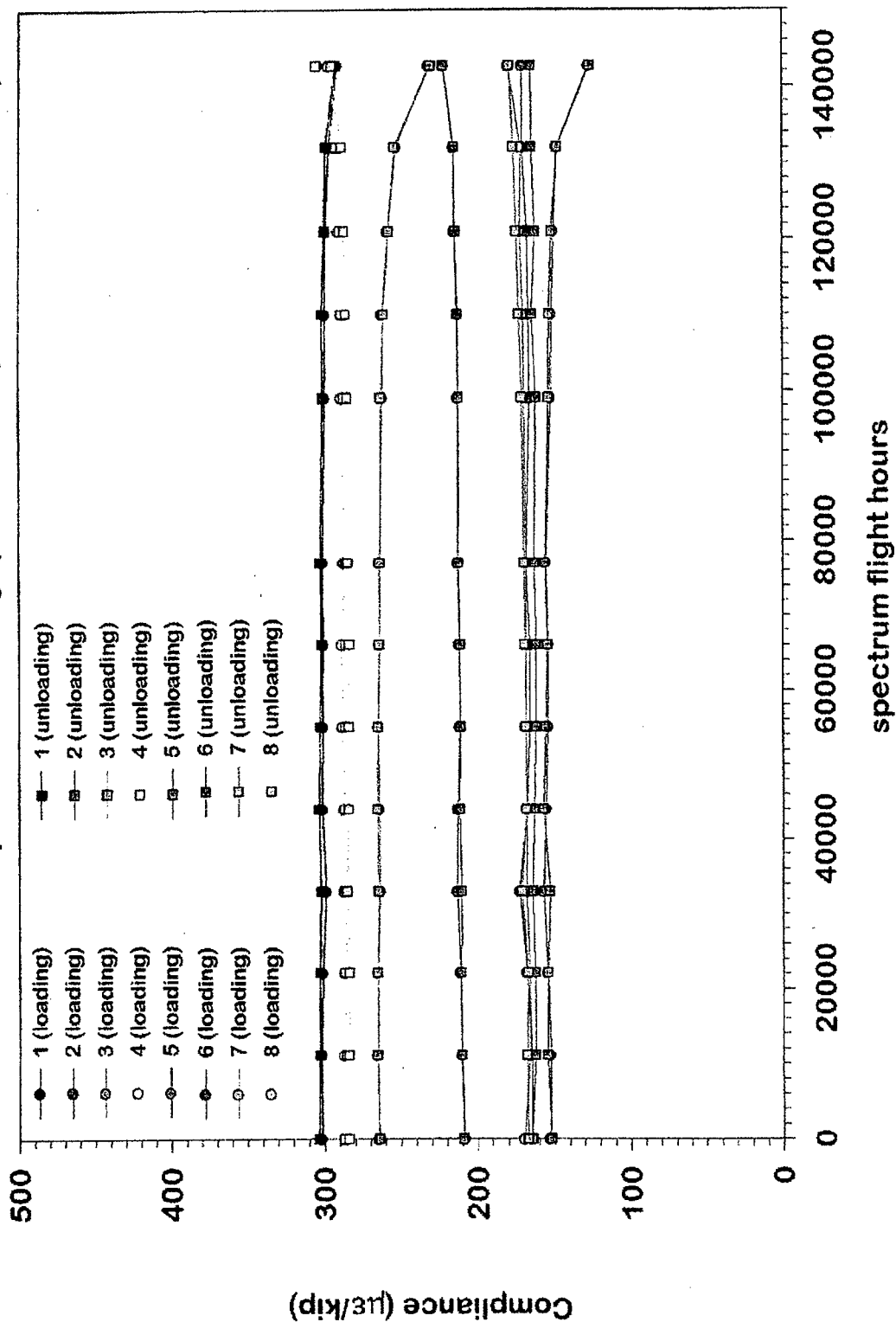
# Specimen CS2 Strain Gage Output (SFH 165002)



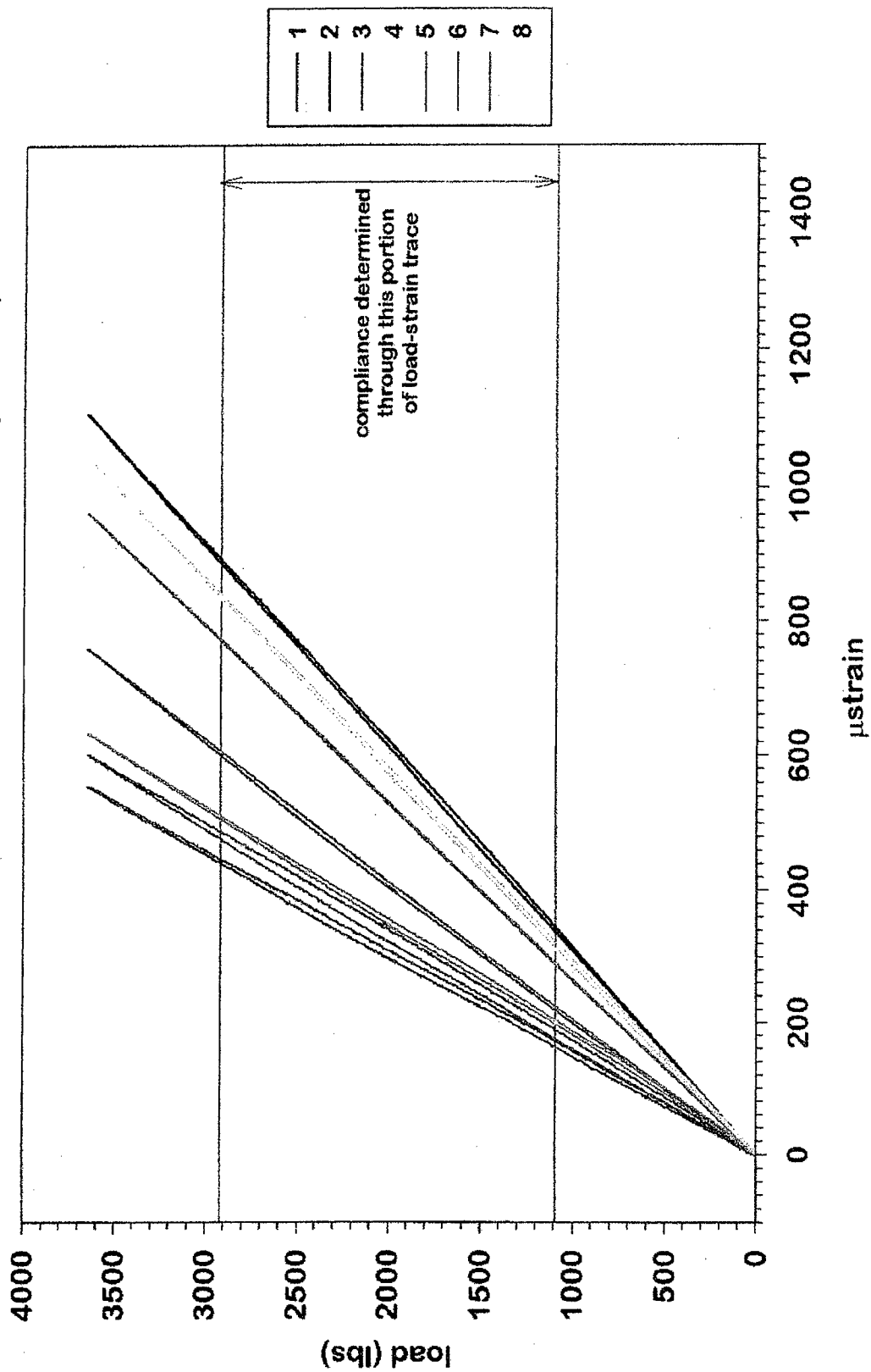
# Specimen CS2 Strain Gage Output (SFH 201229)



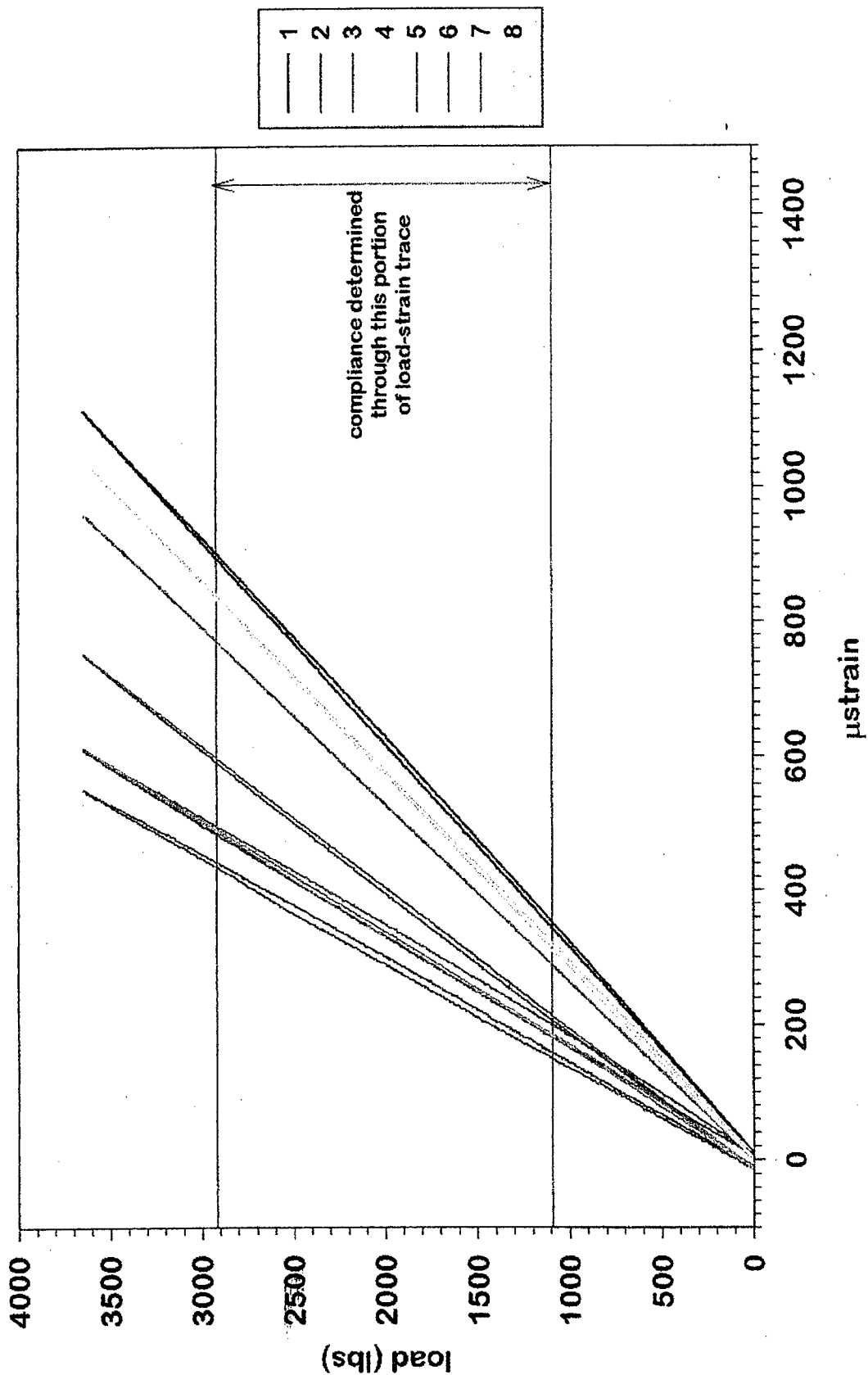
# Fairchild Complex Geometry (CS3, compliance results)



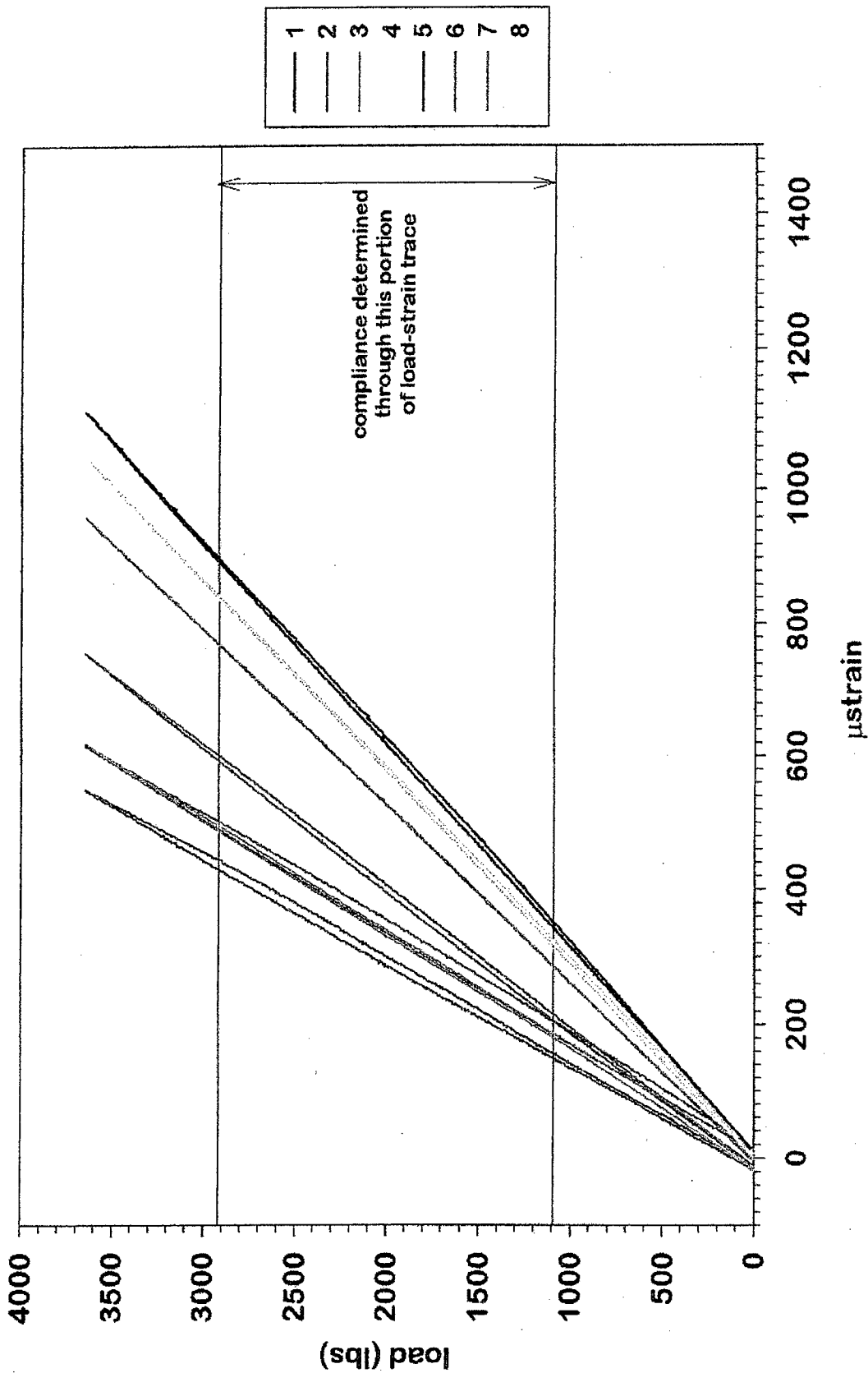
# Specimen CS3 Strain Gage Output (SFH 0)



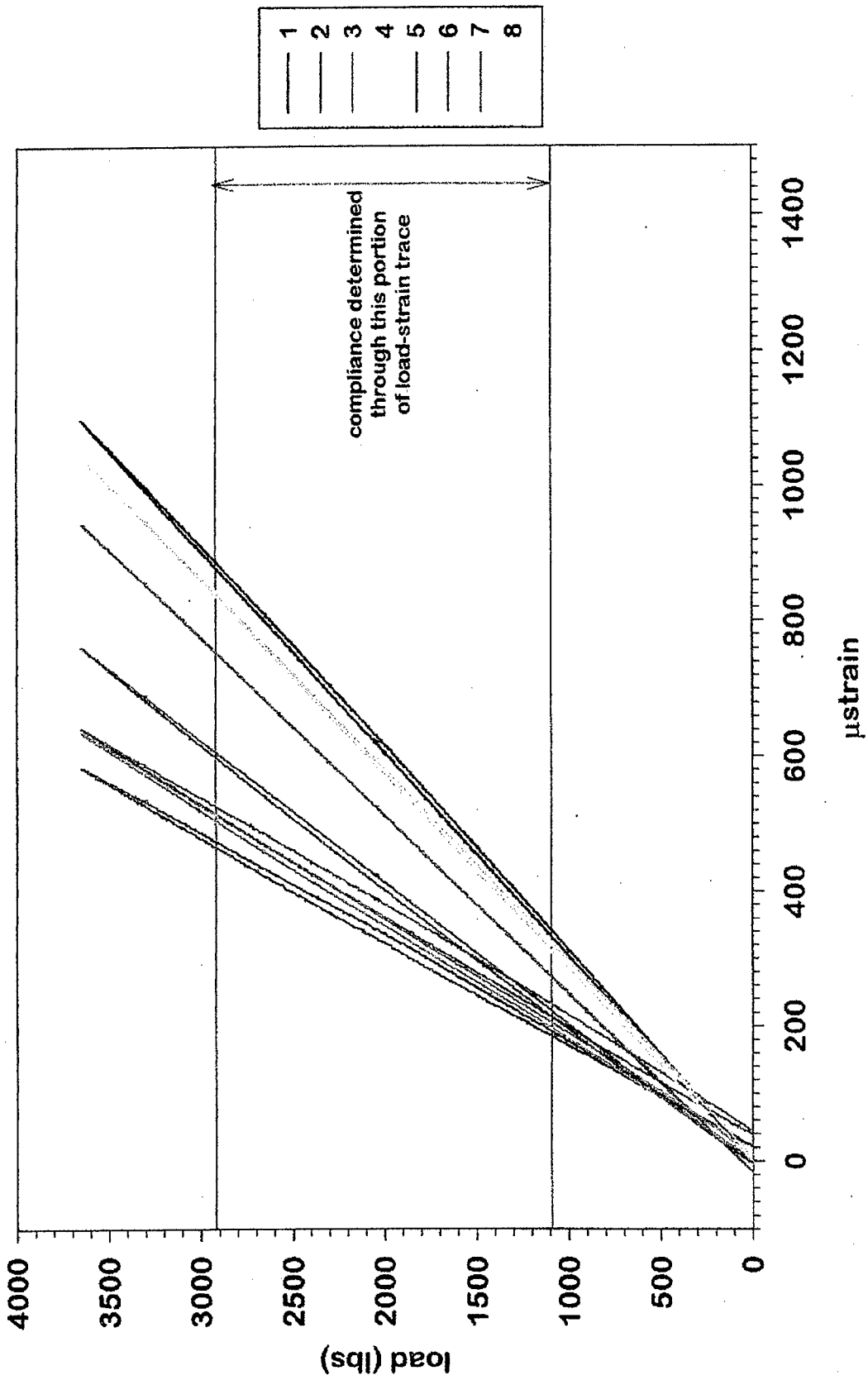
# Specimen CS3 Strain Gage Output (SFH 22126)



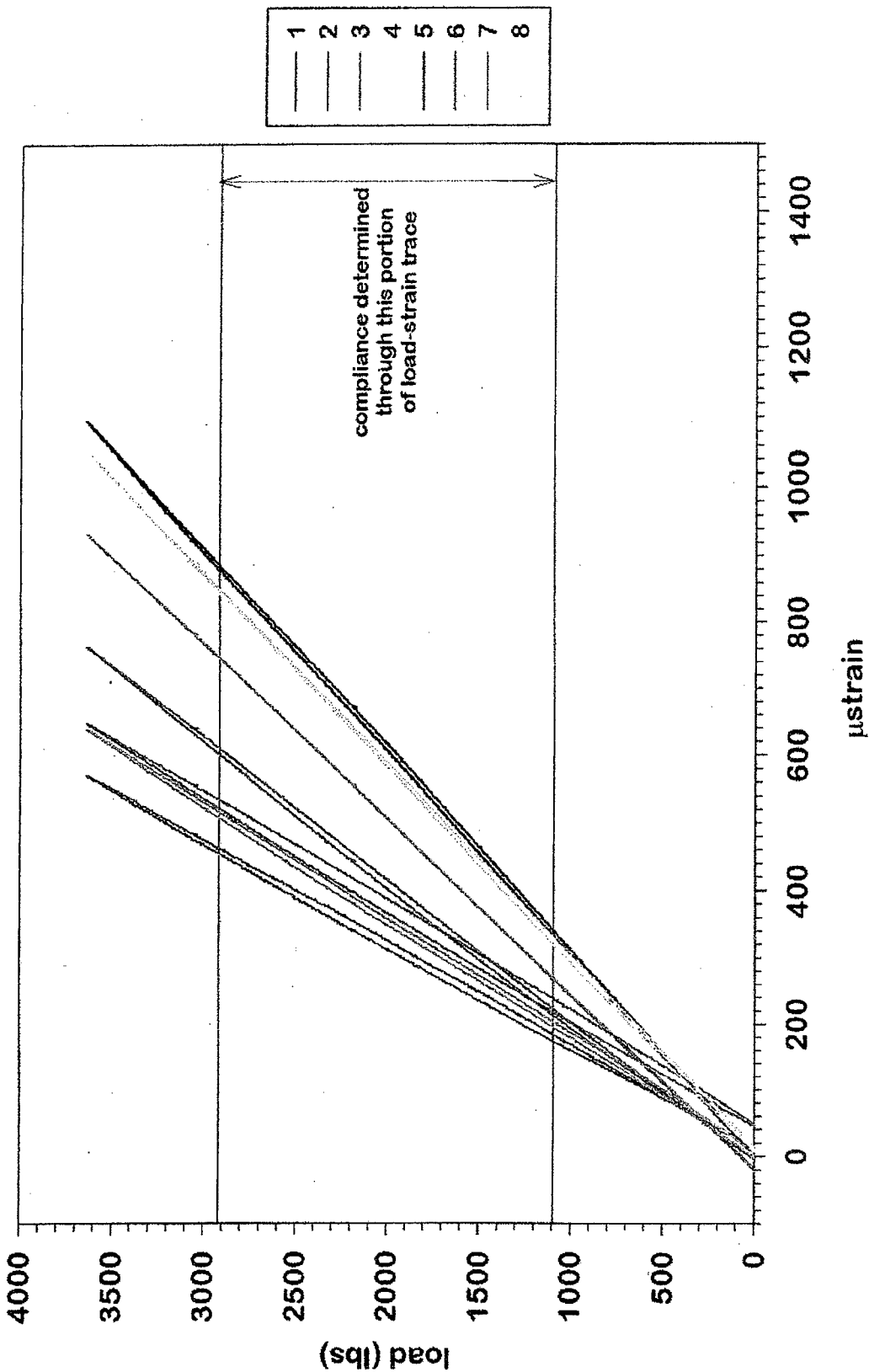
# Specimen CS3 Strain Gage Output (SFH 44026)



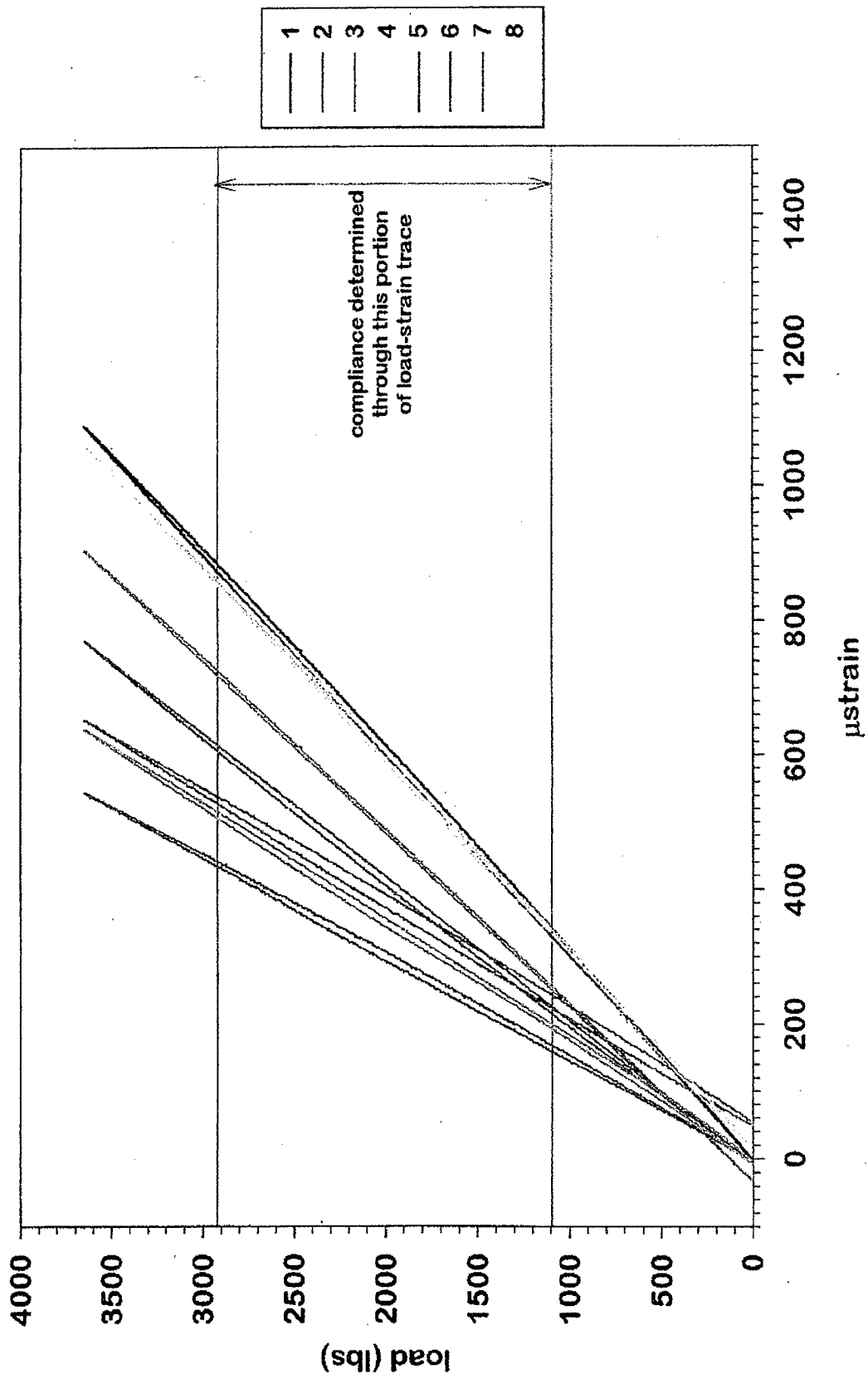
# Specimen CS3 Strain Gage Output (SFH 66046)



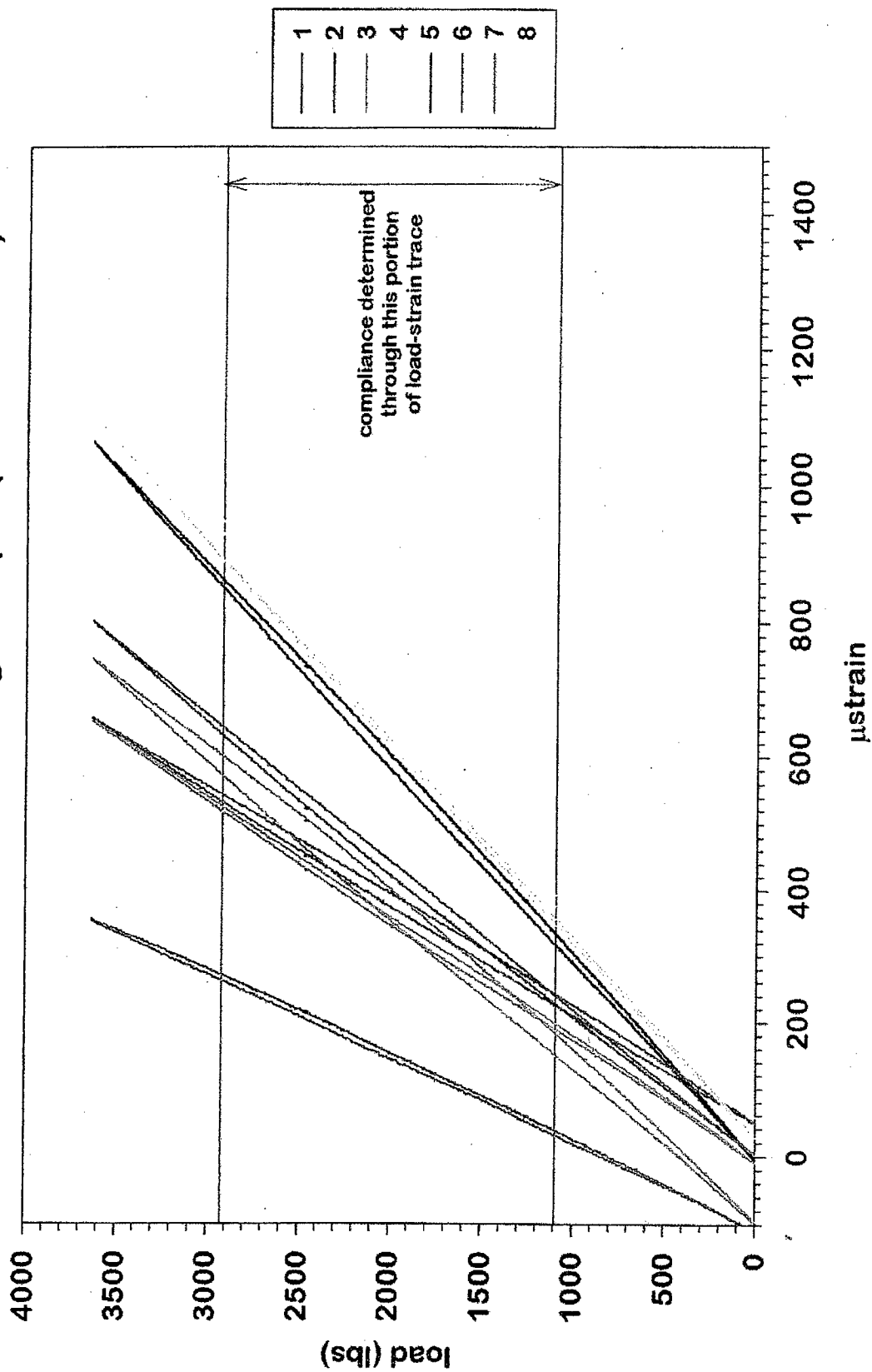
# Specimen CS3 Strain Gage Output (SFH 99052)



# Specimen CS3 Strain Gage Output (SFH 121020)



# Specimen CS3 Strain Gage Output (SFH 142663)



**Analyzed Compliance Data**

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs1-1  
 Current Flight Hours = 0.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 313.9  | 17.5  | 1.419 |
| 2    | 202.8  | -19.5 | 1.554 |
| 3    | 265.4  | 6.1   | 1.175 |
| 4    | 295.1  | 6.6   | 1.338 |
| 5    | 167.6  | -6.6  | 0.990 |
| 6    | 161.1  | -2.4  | 1.136 |
| 7    | 175.8  | 26.3  | 2.562 |
| 8    | 287.8  | 11.0  | 1.620 |

## UNLOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 314.4  | 12.5  | 1.259 |
| 2    | 203.1  | -21.1 | 1.392 |
| 3    | 264.5  | 9.5   | 1.062 |
| 4    | 294.5  | 8.0   | 1.193 |
| 5    | 169.3  | -5.8  | 0.971 |
| 6    | 159.1  | 10.3  | 0.948 |
| 7    | 168.2  | 46.9  | 1.416 |
| 8    | 285.0  | 14.7  | 1.080 |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs1-2  
 Current Flight Hours = 5525.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 312.0  | 38.0  | 1.807 |
| 2    | 204.5  | -42.9 | 1.389 |
| 3    | 265.3  | 10.5  | 1.241 |
| 4    | 294.6  | 13.1  | 1.231 |
| 5    | 168.5  | -37.2 | 1.033 |
| 6    | 162.1  | -28.2 | 1.464 |
| 7    | 171.1  | 38.8  | 2.244 |
| 8    | 287.9  | 20.1  | 1.627 |

## UNLOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 313.0  | 23.1  | 1.214 |
| 2    | 201.6  | -28.7 | 0.957 |
| 3    | 264.2  | 14.2  | 1.117 |
| 4    | 294.3  | 10.1  | 1.288 |
| 5    | 168.9  | -25.1 | 0.985 |
| 6    | 157.9  | -1.9  | 1.085 |
| 7    | 170.9  | 46.1  | 1.714 |
| 8    | 284.7  | 24.9  | 1.214 |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs1-3  
 Current Flight Hours = 11014.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 310.5  | 43.8  | 1.710 |
| 2    | 203.8  | -42.3 | 1.479 |
| 3    | 264.4  | 13.2  | 1.244 |
| 4    | 294.4  | 13.5  | 1.265 |
| 5    | 167.9  | -42.7 | 1.199 |
| 6    | 162.0  | -27.7 | 1.881 |
| 7    | 170.4  | 33.3  | 1.731 |
| 8    | 287.2  | 21.9  | 1.524 |

## UNLOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 313.4  | 23.7  | 1.288 |
| 2    | 201.4  | -29.3 | 1.032 |
| 3    | 264.4  | 14.0  | 1.204 |
| 4    | 293.4  | 12.0  | 1.369 |
| 5    | 169.4  | -30.3 | 1.032 |
| 6    | 158.4  | 0.8   | 0.938 |
| 7    | 171.0  | 38.8  | 1.750 |
| 8    | 284.0  | 24.8  | 1.178 |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs1-4  
 Current Flight Hours = 16515.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 311.4  | 38.4  | 1.641 |
| 2    | 203.7  | -41.4 | 1.636 |
| 3    | 265.0  | 9.3   | 1.158 |
| 4    | 293.6  | 18.0  | 1.200 |
| 5    | 168.3  | -43.5 | 1.146 |
| 6    | 162.3  | -25.8 | 1.598 |
| 7    | 173.2  | 38.9  | 2.449 |
| 8    | 288.5  | 25.6  | 1.668 |

## UNLOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 313.5  | 21.5  | 1.259 |
| 2    | 202.7  | -31.6 | 1.114 |
| 3    | 264.6  | 11.6  | 1.187 |
| 4    | 294.8  | 10.8  | 1.281 |
| 5    | 169.6  | -33.0 | 0.960 |
| 6    | 158.2  | -0.9  | 0.992 |
| 7    | 170.0  | 50.1  | 1.415 |
| 8    | 284.5  | 31.7  | 1.215 |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs1-5  
 Current Flight Hours = 22013.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 311.1  | 42.6  | 1.659 |
| 2    | 204.3  | -44.8 | 1.439 |
| 3    | 265.1  | 10.5  | 1.193 |
| 4    | 294.7  | 15.8  | 1.270 |
| 5    | 168.9  | -50.1 | 1.242 |
| 6    | 162.7  | -29.9 | 1.605 |
| 7    | 172.2  | 33.7  | 2.238 |
| 8    | 287.4  | 27.9  | 1.590 |

## UNLOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 313.3  | 25.1  | 1.042 |
| 2    | 202.7  | -34.0 | 1.356 |
| 3    | 264.0  | 13.7  | 1.017 |
| 4    | 295.5  | 9.8   | 1.252 |
| 5    | 169.3  | -37.2 | 0.915 |
| 6    | 158.0  | -4.9  | 0.944 |
| 7    | 170.3  | 41.0  | 1.286 |
| 8    | 284.1  | 31.5  | 1.041 |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs1-6  
 Current Flight Hours = 27512.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 310.8  | 37.6  | 1.464 |
| 2    | 204.9  | -40.6 | 1.549 |
| 3    | 264.1  | 7.6   | 1.075 |
| 4    | 293.9  | 18.2  | 1.240 |
| 5    | 168.5  | -36.8 | 1.016 |
| 6    | 163.9  | -29.0 | 1.842 |
| 7    | 171.5  | 40.4  | 1.895 |
| 8    | 288.4  | 25.7  | 1.362 |

## UNLOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 313.2  | 20.9  | 1.116 |
| 2    | 203.0  | -28.7 | 1.028 |
| 3    | 264.4  | 9.0   | 1.057 |
| 4    | 295.5  | 12.0  | 1.131 |
| 5    | 169.4  | -24.4 | 0.870 |
| 6    | 158.6  | -0.9  | 0.897 |
| 7    | 170.4  | 47.3  | 1.547 |
| 8    | 285.3  | 29.1  | 0.998 |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = csl-7  
 Current Flight Hours = 33019.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn<br>chan | SLOPE<br>ms/kip | INTER<br>mstrn | STAND<br>DEV |
|--------------|-----------------|----------------|--------------|
| 1            | 311.3           | 39.5           | 1.551        |
| 2            | 204.5           | -43.6          | 1.683        |
| 3            | 264.2           | 8.7            | 1.126        |
| 4            | 294.1           | 18.0           | 1.289        |
| 5            | 168.7           | -51.4          | 1.136        |
| 6            | 163.0           | -27.6          | 1.862        |
| 7            | 173.5           | 35.1           | 2.488        |
| 8            | 288.6           | 30.2           | 1.625        |

## UNLOADING:

| strn<br>chan | SLOPE<br>ms/kip | INTER<br>mstrn | STAND<br>DEV |
|--------------|-----------------|----------------|--------------|
| 1            | 313.2           | 23.9           | 1.155        |
| 2            | 203.0           | -32.8          | 1.028        |
| 3            | 263.7           | 11.5           | 1.123        |
| 4            | 294.7           | 13.4           | 1.178        |
| 5            | 169.6           | -39.8          | 0.912        |
| 6            | 157.8           | -1.6           | 0.968        |
| 7            | 169.2           | 48.1           | 1.522        |
| 8            | 284.3           | 36.4           | 1.104        |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = csl-8  
 Current Flight Hours = 38515.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn<br>chan | SLOPE<br>ms/kip | INTER<br>mstrn | STAND<br>DEV |
|--------------|-----------------|----------------|--------------|
| 1            | 311.2           | 36.5           | 1.338        |
| 2            | 204.4           | -39.0          | 1.387        |
| 3            | 264.5           | 5.3            | 1.090        |
| 4            | 295.3           | 17.5           | 1.170        |
| 5            | 168.3           | -39.8          | 1.018        |
| 6            | 162.5           | -24.0          | 1.654        |
| 7            | 173.4           | 39.6           | 2.211        |
| 8            | 288.7           | 29.0           | 1.492        |

## UNLOADING:

| strn<br>chan | SLOPE<br>ms/kip | INTER<br>mstrn | STAND<br>DEV |
|--------------|-----------------|----------------|--------------|
| 1            | 313.6           | 20.4           | 1.098        |
| 2            | 203.1           | -30.3          | 1.160        |
| 3            | 263.5           | 8.4            | 1.064        |
| 4            | 295.3           | 14.9           | 1.274        |
| 5            | 169.6           | -28.8          | 0.944        |
| 6            | 158.1           | 1.2            | 0.959        |
| 7            | 170.1           | 52.2           | 1.311        |
| 8            | 285.0           | 33.6           | 1.035        |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs1-9  
 Current Flight Hours = 45725.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 310.9  | 42.1  | 1.642 |
| 2    | 204.6  | -46.3 | 1.682 |
| 3    | 264.2  | 7.5   | 1.218 |
| 4    | 295.3  | 16.5  | 1.309 |
| 5    | 168.9  | -56.8 | 1.193 |
| 6    | 163.4  | -31.7 | 1.722 |
| 7    | 173.1  | 32.1  | 2.624 |
| 8    | 288.4  | 31.0  | 1.801 |

## UNLOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 312.4  | 27.7  | 1.357 |
| 2    | 203.8  | -37.6 | 1.095 |
| 3    | 263.3  | 10.8  | 1.113 |
| 4    | 295.4  | 14.1  | 1.215 |
| 5    | 169.6  | -43.1 | 0.924 |
| 6    | 157.9  | -2.7  | 0.951 |
| 7    | 169.5  | 43.8  | 1.367 |
| 8    | 284.6  | 35.2  | 1.118 |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs1-10  
 Current Flight Hours = 49517.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 311.0  | 34.7  | 1.623 |
| 2    | 204.5  | -37.3 | 1.302 |
| 3    | 263.9  | 0.9   | 1.207 |
| 4    | 293.7  | 23.5  | 1.182 |
| 5    | 167.8  | -38.7 | 0.985 |
| 6    | 162.6  | -20.9 | 1.727 |
| 7    | 173.6  | 34.5  | 1.978 |
| 8    | 288.4  | 31.8  | 1.489 |

## UNLOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 312.8  | 17.9  | 1.109 |
| 2    | 202.9  | -27.1 | 1.146 |
| 3    | 262.6  | 4.3   | 1.076 |
| 4    | 296.0  | 16.9  | 1.146 |
| 5    | 168.1  | -24.5 | 0.891 |
| 6    | 159.3  | 6.4   | 0.880 |
| 7    | 171.4  | 49.4  | 1.335 |
| 8    | 285.0  | 36.9  | 1.084 |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs1-11  
 Current Flight Hours = 55014.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 310.6  | 39.7  | 1.761 |
| 2    | 205.7  | -44.6 | 1.337 |
| 3    | 263.5  | 5.6   | 1.302 |
| 4    | 295.4  | 18.8  | 1.238 |
| 5    | 168.1  | -55.0 | 1.396 |
| 6    | 163.9  | -31.0 | 1.926 |
| 7    | 174.0  | 33.2  | 2.457 |
| 8    | 288.5  | 35.0  | 1.854 |

## UNLOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 312.1  | 24.5  | 1.327 |
| 2    | 203.2  | -34.0 | 1.370 |
| 3    | 262.2  | 8.2   | 1.182 |
| 4    | 295.1  | 16.1  | 1.373 |
| 5    | 168.8  | -42.4 | 1.046 |
| 6    | 157.3  | -2.8  | 1.221 |
| 7    | 169.5  | 46.5  | 1.386 |
| 8    | 284.4  | 40.1  | 1.240 |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs1-12  
 Current Flight Hours = 60520.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 310.6  | 35.2  | 1.504 |
| 2    | 204.7  | -39.3 | 1.349 |
| 3    | 263.2  | 0.9   | 1.138 |
| 4    | 296.5  | 16.5  | 1.251 |
| 5    | 167.7  | -46.5 | 1.461 |
| 6    | 162.5  | -25.5 | 1.244 |
| 7    | 173.0  | 38.2  | 2.696 |
| 8    | 288.3  | 34.8  | 1.634 |

## UNLOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 312.2  | 20.7  | 1.143 |
| 2    | 203.6  | -31.8 | 1.123 |
| 3    | 262.4  | 2.6   | 1.088 |
| 4    | 295.5  | 16.4  | 1.169 |
| 5    | 168.8  | -35.5 | 0.932 |
| 6    | 157.6  | 0.6   | 0.880 |
| 7    | 169.5  | 49.4  | 1.274 |
| 8    | 284.5  | 38.9  | 1.103 |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs1-13  
 Current Flight Hours = 66022.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 310.5  | 36.1  | 1.529 |
| 2    | 204.6  | -40.4 | 1.374 |
| 3    | 262.4  | 0.8   | 1.187 |
| 4    | 294.6  | 22.2  | 1.203 |
| 5    | 167.5  | -49.7 | 1.110 |
| 6    | 162.9  | -25.0 | 1.857 |
| 7    | 172.5  | 37.2  | 2.186 |
| 8    | 288.8  | 32.4  | 1.511 |

## UNLOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 312.5  | 18.6  | 1.121 |
| 2    | 202.8  | -27.8 | 1.189 |
| 3    | 261.9  | 1.6   | 1.168 |
| 4    | 295.8  | 17.8  | 1.360 |
| 5    | 167.9  | -30.7 | 0.962 |
| 6    | 157.5  | 9.2   | 0.971 |
| 7    | 171.8  | 44.6  | 1.492 |
| 8    | 284.7  | 36.0  | 1.205 |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs1-14  
 Current Flight Hours = 71527.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 310.3  | 32.6  | 1.433 |
| 2    | 204.5  | -35.3 | 1.510 |
| 3    | 262.7  | -3.4  | 1.158 |
| 4    | 295.8  | 23.1  | 1.246 |
| 5    | 166.7  | -45.5 | 1.016 |
| 6    | 163.2  | -25.3 | 1.560 |
| 7    | 173.1  | 38.8  | 2.260 |
| 8    | 288.9  | 36.9  | 1.513 |

## UNLOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 311.9  | 18.8  | 1.201 |
| 2    | 203.5  | -27.2 | 1.112 |
| 3    | 261.7  | -1.6  | 1.153 |
| 4    | 295.9  | 20.3  | 1.174 |
| 5    | 167.8  | -34.3 | 0.937 |
| 6    | 158.9  | -0.1  | 0.940 |
| 7    | 170.8  | 50.1  | 1.413 |
| 8    | 285.5  | 41.3  | 1.117 |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs1-15  
 Current Flight Hours = 77024.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

| LOADING: |        |       |       | UNLOADING: |        |       |       |
|----------|--------|-------|-------|------------|--------|-------|-------|
| strn     | SLOPE  | INTER | STAND | strn       | SLOPE  | INTER | STAND |
| chan     | ms/kip | mstrn | DEV   | chan       | ms/kip | mstrn | DEV   |
| 1        | 310.8  | 35.2  | 1.696 | 1          | 313.0  | 15.2  | 1.258 |
| 2        | 205.3  | -38.4 | 1.460 | 2          | 203.5  | -24.9 | 1.267 |
| 3        | 262.3  | -4.0  | 1.202 | 3          | 261.7  | -5.2  | 1.170 |
| 4        | 296.2  | 25.2  | 1.265 | 4          | 296.6  | 22.3  | 1.249 |
| 5        | 166.5  | -50.9 | 1.049 | 5          | 167.3  | -33.2 | 0.994 |
| 6        | 164.1  | -26.2 | 1.813 | 6          | 158.8  | 6.9   | 0.986 |
| 7        | 174.8  | 33.0  | 2.416 | 7          | 172.5  | 45.3  | 1.496 |
| 8        | 289.4  | 37.1  | 1.791 | 8          | 285.4  | 40.4  | 1.252 |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs1-16  
 Current Flight Hours = 82521.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

| LOADING: |        |       |       | UNLOADING: |        |       |       |
|----------|--------|-------|-------|------------|--------|-------|-------|
| strn     | SLOPE  | INTER | STAND | strn       | SLOPE  | INTER | STAND |
| chan     | ms/kip | mstrn | DEV   | chan       | ms/kip | mstrn | DEV   |
| 1        | 310.9  | 31.3  | 1.419 | 1          | 312.3  | 15.8  | 1.245 |
| 2        | 204.6  | -32.5 | 1.471 | 2          | 204.4  | -27.1 | 1.109 |
| 3        | 261.9  | -8.8  | 1.160 | 3          | 261.1  | -7.7  | 1.127 |
| 4        | 297.1  | 26.4  | 1.183 | 4          | 296.5  | 25.1  | 1.151 |
| 5        | 165.6  | -47.0 | 0.982 | 5          | 166.8  | -37.3 | 0.918 |
| 6        | 162.6  | -23.1 | 1.282 | 6          | 158.6  | 0.6   | 0.926 |
| 7        | 174.6  | 40.7  | 2.266 | 7          | 170.3  | 54.6  | 1.333 |
| 8        | 289.7  | 39.7  | 1.405 | 8          | 285.1  | 46.1  | 1.181 |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = csl-17  
 Current Flight Hours = 88004.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 304.9  | 55.5  | 1.286 |
| 2    | 209.7  | -52.3 | 1.305 |
| 3    | 259.7  | 4.5   | 1.189 |
| 4    | 296.2  | 35.1  | 1.272 |
| 5    | 169.6  | -75.5 | 1.342 |
| 6    | 172.3  | -31.7 | 1.302 |
| 7    | 176.6  | 27.2  | 1.756 |
| 8    | 288.0  | 22.7  | 1.435 |

## UNLOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 311.6  | 22.8  | 1.424 |
| 2    | 204.3  | -28.8 | 1.129 |
| 3    | 260.3  | -1.9  | 1.247 |
| 4    | 296.5  | 33.7  | 1.382 |
| 5    | 164.8  | -42.0 | 1.055 |
| 6    | 162.4  | 18.2  | 1.118 |
| 7    | 174.9  | 43.9  | 1.578 |
| 8    | 286.5  | 20.8  | 1.375 |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = csl-18  
 Current Flight Hours = 93514.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 309.7  | 34.0  | 1.428 |
| 2    | 206.0  | -39.4 | 1.125 |
| 3    | 260.8  | -10.6 | 1.149 |
| 4    | 296.7  | 28.0  | 1.272 |
| 5    | 165.0  | -49.7 | 0.965 |
| 6    | 164.7  | -9.0  | 1.283 |
| 7    | 174.5  | 43.6  | 2.308 |
| 8    | 290.5  | 14.9  | 1.466 |

## UNLOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 312.3  | 15.6  | 1.109 |
| 2    | 204.7  | -30.1 | 1.108 |
| 3    | 260.3  | -11.0 | 1.242 |
| 4    | 296.1  | 29.5  | 1.157 |
| 5    | 165.4  | -36.9 | 0.900 |
| 6    | 159.3  | 20.2  | 0.889 |
| 7    | 171.9  | 56.6  | 1.501 |
| 8    | 285.5  | 23.3  | 1.324 |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs1-19  
 Current Flight Hours = 99022.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 309.4  | 35.1  | 1.691 |
| 2    | 206.4  | -42.0 | 1.723 |
| 3    | 259.8  | -11.7 | 1.348 |
| 4    | 297.3  | 33.9  | 1.328 |
| 5    | 164.4  | -60.9 | 1.609 |
| 6    | 164.4  | -9.8  | 1.839 |
| 7    | 174.8  | 42.1  | 2.128 |
| 8    | 290.1  | 21.8  | 1.588 |

## UNLOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 311.7  | 15.7  | 1.231 |
| 2    | 204.7  | -29.2 | 1.179 |
| 3    | 259.1  | -14.1 | 1.216 |
| 4    | 297.6  | 33.4  | 1.367 |
| 5    | 163.9  | -46.7 | 0.986 |
| 6    | 161.0  | 17.2  | 1.120 |
| 7    | 174.0  | 51.1  | 1.696 |
| 8    | 287.3  | 25.2  | 1.280 |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs1-20  
 Current Flight Hours = 104501.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 310.6  | 25.4  | 1.658 |
| 2    | 205.2  | -26.7 | 1.289 |
| 3    | 259.4  | -29.2 | 1.204 |
| 4    | 298.9  | 42.2  | 1.105 |
| 5    | 162.9  | -30.7 | 0.937 |
| 6    | 164.7  | 8.0   | 0.888 |
| 7    | 179.4  | 45.4  | 2.587 |
| 8    | 293.7  | 6.7   | 1.477 |

## UNLOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 311.8  | 12.1  | 1.220 |
| 2    | 204.5  | -20.6 | 1.195 |
| 3    | 258.3  | -27.6 | 1.114 |
| 4    | 298.2  | 41.6  | 1.219 |
| 5    | 163.1  | -25.7 | 0.944 |
| 6    | 160.5  | 29.9  | 1.003 |
| 7    | 175.0  | 64.0  | 1.825 |
| 8    | 288.5  | 19.2  | 1.188 |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = csl-21  
 Current Flight Hours = 110003.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn<br>chan | SLOPE<br>ms/kip | INTER<br>mstrn | STAND<br>DEV |
|--------------|-----------------|----------------|--------------|
| 1            | 309.4           | 30.7           | 1.455        |
| 2            | 205.8           | -31.8          | 1.495        |
| 3            | 257.8           | -33.7          | 1.210        |
| 4            | 299.2           | 45.2           | 1.266        |
| 5            | 160.7           | -52.5          | 1.068        |
| 6            | 163.5           | 4.9            | 1.332        |
| 7            | 176.0           | 45.1           | 2.445        |
| 8            | 292.6           | 13.7           | 1.481        |

## UNLOADING:

| strn<br>chan | SLOPE<br>ms/kip | INTER<br>mstrn | STAND<br>DEV |
|--------------|-----------------|----------------|--------------|
| 1            | 311.7           | 12.8           | 1.310        |
| 2            | 204.7           | -22.6          | 1.122        |
| 3            | 257.2           | -35.2          | 1.210        |
| 4            | 299.3           | 44.6           | 1.182        |
| 5            | 160.8           | -48.5          | 0.922        |
| 6            | 161.2           | 24.0           | 0.969        |
| 7            | 175.5           | 53.5           | 1.880        |
| 8            | 288.6           | 23.4           | 1.227        |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = csl-22  
 Current Flight Hours = 115501.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn<br>chan | SLOPE<br>ms/kip | INTER<br>mstrn | STAND<br>DEV |
|--------------|-----------------|----------------|--------------|
| 1            | 310.0           | 21.7           | 1.404        |
| 2            | 206.4           | -23.1          | 1.392        |
| 3            | 256.6           | -52.4          | 1.209        |
| 4            | 300.6           | 53.1           | 1.237        |
| 5            | 157.3           | -54.0          | 0.905        |
| 6            | 164.9           | 7.4            | 0.994        |
| 7            | 179.6           | 47.3           | 1.979        |
| 8            | 294.5           | 16.2           | 1.391        |

## UNLOADING:

| strn<br>chan | SLOPE<br>ms/kip | INTER<br>mstrn | STAND<br>DEV |
|--------------|-----------------|----------------|--------------|
| 1            | 311.6           | 5.2            | 1.121        |
| 2            | 205.8           | -15.2          | 1.162        |
| 3            | 255.2           | -55.0          | 1.149        |
| 4            | 300.6           | 54.9           | 1.220        |
| 5            | 157.2           | -51.8          | 0.907        |
| 6            | 161.0           | 28.2           | 1.019        |
| 7            | 176.2           | 63.8           | 1.785        |
| 8            | 289.8           | 28.4           | 1.251        |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs1-23  
 Current Flight Hours = 121018.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn | SLOPE  | INTER   | STAND |
|------|--------|---------|-------|
| chan | ms/kip | mstrn   | DEV   |
| 1    | -7.1   | 4.0     | 9.787 |
| 2    | 215.3  | -28.6   | 2.269 |
| 3    | 223.7  | -98.7   | 5.874 |
| 4    | 0.0    | -2500.0 | 0.003 |
| 5    | 116.2  | -152.1  | 3.275 |
| 6    | 169.7  | -21.7   | 2.068 |
| 7    | 181.3  | 54.7    | 1.873 |
| 8    | 304.2  | 37.0    | 1.549 |

## UNLOADING:

| strn | SLOPE  | INTER   | STAND |
|------|--------|---------|-------|
| chan | ms/kip | mstrn   | DEV   |
| 1    | 0.7    | -6.9    | 5.027 |
| 2    | 210.1  | 4.5     | 1.032 |
| 3    | 228.5  | -175.6  | 1.480 |
| 4    | 0.0    | -2500.0 | 0.003 |
| 5    | 112.6  | -168.9  | 0.935 |
| 6    | 165.0  | 11.6    | 1.350 |
| 7    | 181.3  | 67.7    | 1.497 |
| 8    | 299.4  | 50.8    | 1.542 |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs2-2  
 Current Flight Hours = 0.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn<br>chan | SLOPE<br>ms/kip | INTER<br>mstrn | STAND<br>DEV |
|--------------|-----------------|----------------|--------------|
| 1            | 303.4           | 15.2           | 1.267        |
| 2            | 211.1           | -18.0          | 0.996        |
| 3            | 262.8           | 4.7            | 1.064        |
| 4            | 288.4           | 0.4            | 1.121        |
| 5            | 163.9           | -3.4           | 1.050        |
| 6            | 152.1           | -1.0           | 0.929        |
| 7            | 169.5           | 31.1           | 1.285        |
| 8            | 286.8           | 5.1            | 1.048        |

## UNLOADING:

| strn<br>chan | SLOPE<br>ms/kip | INTER<br>mstrn | STAND<br>DEV |
|--------------|-----------------|----------------|--------------|
| 1            | 303.0           | 14.2           | 1.284        |
| 2            | 211.1           | -18.0          | 1.063        |
| 3            | 262.6           | 6.5            | 1.039        |
| 4            | 286.8           | 6.8            | 1.166        |
| 5            | 164.2           | -0.8           | 1.044        |
| 6            | 150.0           | 11.5           | 1.048        |
| 7            | 164.1           | 52.5           | 1.265        |
| 8            | 283.8           | 19.1           | 1.200        |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs2-3  
 Current Flight Hours = 11014.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn<br>chan | SLOPE<br>ms/kip | INTER<br>mstrn | STAND<br>DEV |
|--------------|-----------------|----------------|--------------|
| 1            | 302.8           | 28.4           | 1.488        |
| 2            | 211.8           | -33.5          | 1.423        |
| 3            | 264.1           | 13.9           | 1.071        |
| 4            | 287.6           | 4.1            | 1.200        |
| 5            | 164.5           | -43.9          | 1.197        |
| 6            | 152.0           | -16.5          | 1.009        |
| 7            | 165.2           | 33.1           | 1.361        |
| 8            | 286.6           | 2.0            | 1.133        |

## UNLOADING:

| strn<br>chan | SLOPE<br>ms/kip | INTER<br>mstrn | STAND<br>DEV |
|--------------|-----------------|----------------|--------------|
| 1            | 304.3           | 17.7           | 1.064        |
| 2            | 211.2           | -27.6          | 1.257        |
| 3            | 264.8           | 12.6           | 1.131        |
| 4            | 287.2           | 6.8            | 1.120        |
| 5            | 166.2           | -33.6          | 1.163        |
| 6            | 150.3           | 4.2            | 0.978        |
| 7            | 166.3           | 34.1           | 0.929        |
| 8            | 283.3           | 14.6           | 1.119        |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs2-4  
 Current Flight Hours = 22017.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn<br>chan | SLOPE<br>ms/kip | INTER<br>mstrn | STAND<br>DEV |
|--------------|-----------------|----------------|--------------|
| 1            | 304.4           | 9.0            | 1.332        |
| 2            | 211.9           | -19.6          | 1.411        |
| 3            | 263.7           | -1.4           | 1.137        |
| 4            | 287.9           | 0.8            | 1.149        |
| 5            | 163.0           | 7.7            | 0.988        |
| 6            | 152.3           | 13.9           | 0.906        |
| 7            | 166.9           | 78.6           | 1.804        |
| 8            | 287.6           | -7.0           | 1.239        |

## UNLOADING:

| strn<br>chan | SLOPE<br>ms/kip | INTER<br>mstrn | STAND<br>DEV |
|--------------|-----------------|----------------|--------------|
| 1            | 304.6           | 1.5            | 1.335        |
| 2            | 210.7           | -13.4          | 1.149        |
| 3            | 264.2           | -1.2           | 1.145        |
| 4            | 286.6           | 5.6            | 1.124        |
| 5            | 163.2           | 21.2           | 1.156        |
| 6            | 150.0           | 37.8           | 0.993        |
| 7            | 166.5           | 83.2           | 0.884        |
| 8            | 283.3           | 9.4            | 1.325        |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs2-5  
 Current Flight Hours = 33050.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn<br>chan | SLOPE<br>ms/kip | INTER<br>mstrn | STAND<br>DEV |
|--------------|-----------------|----------------|--------------|
| 1            | 303.4           | 11.5           | 1.292        |
| 2            | 210.9           | -21.3          | 1.254        |
| 3            | 262.9           | -0.7           | 1.146        |
| 4            | 287.9           | -1.2           | 1.117        |
| 5            | 163.1           | 5.8            | 1.098        |
| 6            | 152.3           | 9.9            | 0.870        |
| 7            | 166.4           | 73.8           | 2.195        |
| 8            | 287.5           | -4.8           | 1.228        |

## UNLOADING:

| strn<br>chan | SLOPE<br>ms/kip | INTER<br>mstrn | STAND<br>DEV |
|--------------|-----------------|----------------|--------------|
| 1            | 303.9           | 4.6            | 1.219        |
| 2            | 210.9           | -17.2          | 1.277        |
| 3            | 263.7           | -1.2           | 1.096        |
| 4            | 287.4           | 2.3            | 1.115        |
| 5            | 164.4           | 11.8           | 1.053        |
| 6            | 149.9           | 25.6           | 0.919        |
| 7            | 164.4           | 80.5           | 0.910        |
| 8            | 284.1           | 9.3            | 1.237        |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs2-6  
 Current Flight Hours = 44019.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn<br>chan | SLOPE<br>ms/kip | INTER<br>mstrn | STAND<br>DEV |
|--------------|-----------------|----------------|--------------|
| 1            | 302.8           | 16.8           | 1.597        |
| 2            | 211.7           | -23.2          | 1.459        |
| 3            | 262.5           | 0.2            | 1.090        |
| 4            | 287.6           | 2.9            | 1.156        |
| 5            | 163.9           | 1.2            | 1.087        |
| 6            | 152.9           | 1.3            | 1.034        |
| 7            | 165.5           | 72.7           | 1.791        |
| 8            | 286.8           | -0.3           | 1.146        |

## UNLOADING:

| strn<br>chan | SLOPE<br>ms/kip | INTER<br>mstrn | STAND<br>DEV |
|--------------|-----------------|----------------|--------------|
| 1            | 303.8           | 7.1            | 1.125        |
| 2            | 211.6           | -18.9          | 1.256        |
| 3            | 263.4           | -0.4           | 1.100        |
| 4            | 286.8           | 5.9            | 1.192        |
| 5            | 164.5           | 12.9           | 1.291        |
| 6            | 150.1           | 23.5           | 0.959        |
| 7            | 165.4           | 76.8           | 0.924        |
| 8            | 283.5           | 12.6           | 1.222        |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs2-7  
 Current Flight Hours = 55047.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn<br>chan | SLOPE<br>ms/kip | INTER<br>mstrn | STAND<br>DEV |
|--------------|-----------------|----------------|--------------|
| 1            | 303.5           | 12.4           | 1.188        |
| 2            | 211.6           | -20.1          | 1.380        |
| 3            | 262.4           | -3.1           | 1.047        |
| 4            | 287.6           | 3.9            | 1.044        |
| 5            | 162.5           | 10.6           | 1.118        |
| 6            | 153.7           | 10.0           | 1.028        |
| 7            | 168.5           | 70.6           | 1.385        |
| 8            | 288.1           | -5.1           | 1.098        |

## UNLOADING:

| strn<br>chan | SLOPE<br>ms/kip | INTER<br>mstrn | STAND<br>DEV |
|--------------|-----------------|----------------|--------------|
| 1            | 304.1           | 3.3            | 1.141        |
| 2            | 210.9           | -14.2          | 1.271        |
| 3            | 263.0           | -1.7           | 1.078        |
| 4            | 287.8           | 5.6            | 1.096        |
| 5            | 164.0           | 20.3           | 0.954        |
| 6            | 151.1           | 35.9           | 0.910        |
| 7            | 166.9           | 84.7           | 0.897        |
| 8            | 283.4           | 13.6           | 1.188        |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs2-8  
 Current Flight Hours = 66024.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 302.9  | 19.3  | 1.258 |
| 2    | 212.0  | -23.8 | 1.384 |
| 3    | 262.8  | -0.4  | 1.083 |
| 4    | 288.3  | 6.2   | 1.093 |
| 5    | 164.0  | 1.4   | 1.150 |
| 6    | 153.0  | 1.5   | 1.061 |
| 7    | 165.5  | 74.7  | 2.313 |
| 8    | 287.0  | 4.0   | 1.100 |

## UNLOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 303.5  | 9.8   | 0.980 |
| 2    | 210.5  | -16.0 | 1.036 |
| 3    | 262.1  | 2.4   | 1.022 |
| 4    | 288.0  | 8.8   | 1.002 |
| 5    | 163.9  | 12.3  | 1.102 |
| 6    | 149.9  | 24.3  | 0.885 |
| 7    | 164.4  | 79.1  | 0.808 |
| 8    | 282.4  | 19.3  | 1.017 |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs2-9  
 Current Flight Hours = 77074.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 301.8  | 28.4  | 1.586 |
| 2    | 212.0  | -29.5 | 1.262 |
| 3    | 262.3  | 4.7   | 1.077 |
| 4    | 288.6  | 9.7   | 1.183 |
| 5    | 164.5  | -21.5 | 1.318 |
| 6    | 153.1  | -7.6  | 1.127 |
| 7    | 164.4  | 61.5  | 1.732 |
| 8    | 286.8  | 8.0   | 1.174 |

## UNLOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 303.9  | 15.2  | 1.096 |
| 2    | 211.7  | -23.2 | 1.189 |
| 3    | 263.0  | 4.3   | 1.075 |
| 4    | 288.0  | 12.6  | 1.085 |
| 5    | 163.1  | -5.2  | 1.002 |
| 6    | 150.5  | 13.7  | 1.000 |
| 7    | 167.3  | 57.0  | 0.888 |
| 8    | 283.4  | 21.8  | 1.161 |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs2-10  
 Current Flight Hours = 88041.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn<br>chan | SLOPE<br>ms/kip | INTER<br>mstrn | STAND<br>DEV |
|--------------|-----------------|----------------|--------------|
| 1            | 302.3           | 23.8           | 1.366        |
| 2            | 211.8           | -26.9          | 1.496        |
| 3            | 260.8           | 2.3            | 1.108        |
| 4            | 287.1           | 13.6           | 1.128        |
| 5            | 161.4           | -4.1           | 1.305        |
| 6            | 152.4           | -1.5           | 1.220        |
| 7            | 163.6           | 72.5           | 1.474        |
| 8            | 285.9           | 8.5            | 1.112        |

## UNLOADING:

| strn<br>chan | SLOPE<br>ms/kip | INTER<br>mstrn | STAND<br>DEV |
|--------------|-----------------|----------------|--------------|
| 1            | 304.1           | 10.2           | 1.048        |
| 2            | 211.3           | -19.4          | 1.441        |
| 3            | 261.9           | 1.8            | 1.233        |
| 4            | 288.2           | 14.4           | 1.136        |
| 5            | 162.8           | 10.5           | 1.618        |
| 6            | 152.0           | 26.1           | 1.024        |
| 7            | 169.3           | 69.6           | 1.014        |
| 8            | 283.5           | 19.8           | 1.446        |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs2-11  
 Current Flight Hours = 99005.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn<br>chan | SLOPE<br>ms/kip | INTER<br>mstrn | STAND<br>DEV |
|--------------|-----------------|----------------|--------------|
| 1            | 300.9           | 21.7           | 1.322        |
| 2            | 214.6           | -24.4          | 1.104        |
| 3            | 262.8           | -7.6           | 1.181        |
| 4            | 287.6           | 12.1           | 1.188        |
| 5            | 165.7           | -1.4           | 1.278        |
| 6            | 164.4           | -17.1          | 2.467        |
| 7            | 171.0           | 55.9           | 1.290        |
| 8            | 287.0           | -3.5           | 1.084        |

## UNLOADING:

| strn<br>chan | SLOPE<br>ms/kip | INTER<br>mstrn | STAND<br>DEV |
|--------------|-----------------|----------------|--------------|
| 1            | 304.6           | 3.4            | 0.983        |
| 2            | 211.5           | -11.4          | 1.188        |
| 3            | 262.1           | -5.1           | 0.920        |
| 4            | 288.2           | 14.6           | 0.991        |
| 5            | 163.6           | 19.0           | 0.936        |
| 6            | 151.5           | 33.2           | 0.981        |
| 7            | 169.7           | 69.6           | 0.811        |
| 8            | 284.3           | 11.3           | 1.175        |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs2-13  
 Current Flight Hours = 121036.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 302.7  | 26.1  | 1.405 |
| 2    | 212.8  | -28.4 | 1.541 |
| 3    | 261.0  | 2.8   | 1.079 |
| 4    | 289.3  | 11.7  | 1.180 |
| 5    | 162.6  | -10.9 | 1.180 |
| 6    | 153.5  | -7.4  | 1.207 |
| 7    | 167.2  | 68.2  | 1.522 |
| 8    | 287.4  | 10.2  | 1.087 |

## UNLOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 303.0  | 16.8  | 1.159 |
| 2    | 211.2  | -19.5 | 1.147 |
| 3    | 261.3  | 2.7   | 1.115 |
| 4    | 287.7  | 18.2  | 1.181 |
| 5    | 164.4  | -2.1  | 1.161 |
| 6    | 149.6  | 17.5  | 1.032 |
| 7    | 167.7  | 70.0  | 0.886 |
| 8    | 283.5  | 25.3  | 1.218 |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs2-14  
 Current Flight Hours = 132055.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 302.9  | 25.1  | 1.216 |
| 2    | 212.9  | -28.1 | 1.161 |
| 3    | 261.1  | -0.7  | 1.018 |
| 4    | 289.6  | 15.0  | 1.054 |
| 5    | 163.7  | -14.2 | 0.986 |
| 6    | 152.9  | 2.0   | 0.901 |
| 7    | 166.6  | 72.8  | 1.811 |
| 8    | 287.6  | 11.0  | 1.163 |

## UNLOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 303.5  | 14.6  | 1.122 |
| 2    | 211.8  | -21.6 | 1.142 |
| 3    | 261.5  | -1.0  | 1.138 |
| 4    | 288.3  | 20.3  | 1.076 |
| 5    | 163.2  | -1.8  | 1.141 |
| 6    | 150.7  | 25.8  | 1.068 |
| 7    | 168.2  | 70.5  | 0.878 |
| 8    | 283.3  | 25.8  | 1.254 |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs2-15  
 Current Flight Hours = 143035.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 303.5  | 19.6  | 1.463 |
| 2    | 212.9  | -21.5 | 1.187 |
| 3    | 261.2  | -8.2  | 1.194 |
| 4    | 290.3  | 14.4  | 1.212 |
| 5    | 162.8  | -3.3  | 1.544 |
| 6    | 153.8  | 5.1   | 1.067 |
| 7    | 168.8  | 73.4  | 1.771 |
| 8    | 288.6  | 5.2   | 1.324 |

## UNLOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 303.0  | 10.3  | 1.170 |
| 2    | 211.2  | -13.0 | 1.179 |
| 3    | 260.6  | -6.7  | 1.224 |
| 4    | 287.6  | 22.9  | 1.205 |
| 5    | 163.8  | 6.3   | 1.164 |
| 6    | 150.6  | 31.7  | 0.934 |
| 7    | 168.0  | 79.2  | 1.052 |
| 8    | 283.9  | 22.4  | 1.240 |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs2-16  
 Current Flight Hours = 154033.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 301.4  | 31.5  | 1.607 |
| 2    | 214.9  | -32.5 | 1.340 |
| 3    | 260.1  | -2.7  | 1.196 |
| 4    | 289.5  | 21.6  | 1.257 |
| 5    | 160.6  | -21.3 | 1.442 |
| 6    | 153.6  | -0.8  | 1.333 |
| 7    | 167.9  | 41.3  | 1.823 |
| 8    | 287.4  | 8.6   | 1.279 |

## UNLOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 302.5  | 16.2  | 1.160 |
| 2    | 213.1  | -19.7 | 1.083 |
| 3    | 259.8  | -6.4  | 1.094 |
| 4    | 289.6  | 27.3  | 1.077 |
| 5    | 163.7  | -8.2  | 1.352 |
| 6    | 152.7  | 28.8  | 1.003 |
| 7    | 171.9  | 41.8  | 1.029 |
| 8    | 284.2  | 22.7  | 1.268 |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs2-17  
 Current Flight Hours = 165002.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

| LOADING: |        |       |       | UNLOADING: |        |       |       |
|----------|--------|-------|-------|------------|--------|-------|-------|
| strn     | SLOPE  | INTER | STAND | strn       | SLOPE  | INTER | STAND |
| chan     | ms/kip | mstrn | DEV   | chan       | ms/kip | mstrn | DEV   |
| 1        | 303.0  | 24.6  | 1.349 | 1          | 302.2  | 16.9  | 1.126 |
| 2        | 213.8  | -26.8 | 1.585 | 2          | 211.9  | -17.1 | 1.203 |
| 3        | 259.7  | -11.9 | 1.129 | 3          | 258.4  | -9.7  | 1.064 |
| 4        | 291.7  | 22.1  | 1.191 | 4          | 289.1  | 31.4  | 1.204 |
| 5        | 160.8  | -1.0  | 1.117 | 5          | 161.9  | 4.0   | 1.035 |
| 6        | 153.3  | 17.0  | 0.962 | 6          | 150.8  | 32.8  | 0.994 |
| 7        | 169.0  | 72.1  | 1.630 | 7          | 171.4  | 68.3  | 1.010 |
| 8        | 288.7  | 7.6   | 1.170 | 8          | 285.2  | 24.0  | 1.297 |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs2-18  
 Current Flight Hours = 176050.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

| LOADING: |        |       |       | UNLOADING: |        |       |       |
|----------|--------|-------|-------|------------|--------|-------|-------|
| strn     | SLOPE  | INTER | STAND | strn       | SLOPE  | INTER | STAND |
| chan     | ms/kip | mstrn | DEV   | chan       | ms/kip | mstrn | DEV   |
| 1        | 302.4  | 17.5  | 1.500 | 1          | 302.5  | 6.2   | 1.221 |
| 2        | 213.1  | -17.3 | 1.583 | 2          | 211.9  | -7.7  | 1.108 |
| 3        | 258.6  | -20.1 | 1.183 | 3          | 258.0  | -21.5 | 1.162 |
| 4        | 291.0  | 26.8  | 1.134 | 4          | 289.6  | 35.2  | 1.219 |
| 5        | 159.2  | -6.2  | 1.055 | 5          | 160.1  | 2.3   | 1.047 |
| 6        | 153.4  | 7.8   | 1.024 | 6          | 151.1  | 34.5  | 1.133 |
| 7        | 169.1  | 75.4  | 1.402 | 7          | 171.8  | 75.8  | 0.883 |
| 8        | 289.4  | 7.9   | 1.211 | 8          | 285.5  | 24.5  | 1.381 |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs2-19  
 Current Flight Hours = 187008.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 298.1  | 34.9  | 1.499 |
| 2    | 217.1  | -28.3 | 1.303 |
| 3    | 255.6  | -17.1 | 1.281 |
| 4    | 291.6  | 35.9  | 1.360 |
| 5    | 162.0  | -39.8 | 1.015 |
| 6    | 162.7  | -16.2 | 2.214 |
| 7    | 172.6  | 59.1  | 1.745 |
| 8    | 289.9  | 15.9  | 1.105 |

## UNLOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 303.4  | 9.3   | 1.293 |
| 2    | 213.4  | -9.9  | 1.309 |
| 3    | 256.8  | -26.7 | 1.160 |
| 4    | 291.9  | 42.7  | 1.337 |
| 5    | 157.7  | -18.0 | 1.179 |
| 6    | 153.0  | 28.3  | 1.201 |
| 7    | 175.1  | 62.3  | 1.116 |
| 8    | 286.4  | 31.2  | 1.385 |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs2-20  
 Current Flight Hours = 198018.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 301.0  | 16.1  | 1.592 |
| 2    | 215.1  | -14.7 | 1.842 |
| 3    | 253.6  | -45.1 | 1.466 |
| 4    | 294.1  | 44.7  | 1.311 |
| 5    | 154.4  | -41.1 | 1.118 |
| 6    | 153.9  | 4.6   | 1.012 |
| 7    | 171.9  | 71.5  | 1.359 |
| 8    | 292.4  | 14.2  | 1.203 |

## UNLOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 301.7  | 0.4   | 1.248 |
| 2    | 213.7  | -0.2  | 1.088 |
| 3    | 252.8  | -56.9 | 1.171 |
| 4    | 293.2  | 58.4  | 1.235 |
| 5    | 153.9  | -33.0 | 1.044 |
| 6    | 151.9  | 31.6  | 1.141 |
| 7    | 174.9  | 72.1  | 0.903 |
| 8    | 287.9  | 33.3  | 1.462 |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs2-21  
 Current Flight Hours = 201229.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 300.1  | 14.3  | 1.952 |
| 2    | 217.3  | -15.3 | 1.686 |
| 3    | 248.7  | -65.3 | 2.241 |
| 4    | 296.2  | 60.8  | 1.488 |
| 5    | 151.3  | -90.5 | 1.040 |
| 6    | 157.8  | -11.2 | 3.181 |
| 7    | 171.2  | 66.1  | 1.733 |
| 8    | 293.2  | 28.0  | 1.131 |

## UNLOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 301.6  | -6.0  | 1.195 |
| 2    | 215.9  | 2.1   | 1.149 |
| 3    | 248.3  | -88.2 | 1.159 |
| 4    | 297.0  | 75.1  | 1.240 |
| 5    | 148.5  | -80.8 | 0.975 |
| 6    | 154.3  | 16.0  | 1.169 |
| 7    | 178.5  | 60.3  | 1.005 |
| 8    | 290.8  | 43.9  | 1.282 |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs3-4  
 Current Flight Hours = 0.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn<br>chan | SLOPE<br>ms/kip | INTER<br>mstrn | STAND<br>DEV |
|--------------|-----------------|----------------|--------------|
| 1            | 301.8           | 15.2           | 1.575        |
| 2            | 208.5           | -12.9          | 1.335        |
| 3            | 264.7           | -3.4           | 1.114        |
| 4            | 286.3           | -3.9           | 1.096        |
| 5            | 153.1           | -8.7           | 1.306        |
| 6            | 164.6           | -7.1           | 1.186        |
| 7            | 169.8           | 8.9            | 1.253        |
| 8            | 287.2           | -3.3           | 1.052        |

## UNLOADING:

| strn<br>chan | SLOPE<br>ms/kip | INTER<br>mstrn | STAND<br>DEV |
|--------------|-----------------|----------------|--------------|
| 1            | 303.6           | 2.8            | 1.076        |
| 2            | 209.0           | -7.0           | 0.967        |
| 3            | 264.2           | 0.2            | 1.078        |
| 4            | 287.0           | -3.7           | 1.098        |
| 5            | 152.2           | 2.5            | 1.053        |
| 6            | 164.6           | 7.9            | 1.155        |
| 7            | 167.5           | 19.9           | 0.898        |
| 8            | 284.5           | 10.2           | 1.205        |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs3-5  
 Current Flight Hours = 11093.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn<br>chan | SLOPE<br>ms/kip | INTER<br>mstrn | STAND<br>DEV |
|--------------|-----------------|----------------|--------------|
| 1            | 301.8           | 16.9           | 1.464        |
| 2            | 210.2           | -18.3          | 1.319        |
| 3            | 265.4           | -8.2           | 1.180        |
| 4            | 286.5           | -1.7           | 1.177        |
| 5            | 152.7           | 0.5            | 1.299        |
| 6            | 164.9           | -2.4           | 1.112        |
| 7            | 166.2           | 9.6            | 1.048        |
| 8            | 287.0           | -4.8           | 1.207        |

## UNLOADING:

| strn<br>chan | SLOPE<br>ms/kip | INTER<br>mstrn | STAND<br>DEV |
|--------------|-----------------|----------------|--------------|
| 1            | 302.8           | 4.6            | 1.477        |
| 2            | 210.2           | -9.7           | 1.084        |
| 3            | 265.4           | -7.9           | 1.226        |
| 4            | 285.7           | 3.6            | 1.258        |
| 5            | 154.7           | 11.5           | 1.242        |
| 6            | 162.4           | 27.6           | 1.054        |
| 7            | 168.0           | 12.8           | 0.855        |
| 8            | 284.0           | 4.0            | 1.087        |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs3-6  
 Current Flight Hours = 22126.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

| LOADING: |        |       |       | UNLOADING: |        |       |       |
|----------|--------|-------|-------|------------|--------|-------|-------|
| strn     | SLOPE  | INTER | STAND | strn       | SLOPE  | INTER | STAND |
| chan     | ms/kip | mstrn | DEV   | chan       | ms/kip | mstrn | DEV   |
| 1        | 300.9  | 26.4  | 1.553 | 1          | 302.6  | 12.4  | 0.994 |
| 2        | 210.9  | -27.9 | 1.474 | 2          | 210.4  | -17.7 | 0.786 |
| 3        | 265.3  | -2.6  | 1.109 | 3          | 265.3  | -3.2  | 0.983 |
| 4        | 286.8  | 0.7   | 1.153 | 4          | 286.5  | 5.4   | 1.103 |
| 5        | 154.3  | -28.2 | 1.770 | 5          | 154.2  | -9.8  | 1.202 |
| 6        | 167.9  | -14.7 | 2.608 | 6          | 162.6  | 21.8  | 1.072 |
| 7        | 166.2  | -1.8  | 1.510 | 7          | 167.3  | 2.9   | 0.853 |
| 8        | 286.6  | 2.2   | 1.314 | 8          | 283.8  | 10.0  | 1.068 |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs3-7  
 Current Flight Hours = 33001.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

| LOADING: |        |       |       | UNLOADING: |        |       |       |
|----------|--------|-------|-------|------------|--------|-------|-------|
| strn     | SLOPE  | INTER | STAND | strn       | SLOPE  | INTER | STAND |
| chan     | ms/kip | mstrn | DEV   | chan       | ms/kip | mstrn | DEV   |
| 1        | 298.7  | 26.7  | 1.236 | 1          | 302.0  | 8.7   | 1.313 |
| 2        | 213.1  | -27.7 | 1.278 | 2          | 210.0  | -9.7  | 0.940 |
| 3        | 263.4  | -3.0  | 1.151 | 3          | 264.6  | -6.8  | 1.121 |
| 4        | 287.1  | 1.3   | 1.110 | 4          | 286.9  | 6.7   | 1.195 |
| 5        | 157.2  | -20.5 | 1.749 | 5          | 152.8  | 11.9  | 1.136 |
| 6        | 172.4  | -20.1 | 1.414 | 6          | 164.0  | 26.8  | 1.385 |
| 7        | 168.0  | 3.0   | 1.491 | 7          | 171.2  | 8.9   | 1.109 |
| 8        | 285.0  | 9.0   | 1.279 | 8          | 285.2  | 11.2  | 1.395 |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs3-8  
 Current Flight Hours = 44026.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn<br>chan | SLOPE<br>ms/kip | INTER<br>mstrn | STAND<br>DEV |
|--------------|-----------------|----------------|--------------|
| 1            | 301.0           | 24.9           | 1.584        |
| 2            | 212.4           | -31.3          | 1.327        |
| 3            | 264.2           | -1.6           | 1.097        |
| 4            | 287.0           | 1.2            | 1.106        |
| 5            | 155.3           | -31.7          | 2.290        |
| 6            | 167.6           | -10.5          | 2.606        |
| 7            | 167.8           | -5.9           | 1.266        |
| 8            | 287.1           | 4.5            | 1.466        |

## UNLOADING:

| strn<br>chan | SLOPE<br>ms/kip | INTER<br>mstrn | STAND<br>DEV |
|--------------|-----------------|----------------|--------------|
| 1            | 303.1           | 9.4            | 0.921        |
| 2            | 211.1           | -17.3          | 0.854        |
| 3            | 265.3           | -5.6           | 0.993        |
| 4            | 286.7           | 6.5            | 1.082        |
| 5            | 156.9           | -15.9          | 1.084        |
| 6            | 162.7           | 26.7           | 1.078        |
| 7            | 168.2           | 1.2            | 0.887        |
| 8            | 284.0           | 13.2           | 0.996        |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs3-9  
 Current Flight Hours = 55041.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn<br>chan | SLOPE<br>ms/kip | INTER<br>mstrn | STAND<br>DEV |
|--------------|-----------------|----------------|--------------|
| 1            | 300.7           | 18.5           | 1.407        |
| 2            | 211.1           | -21.1          | 1.328        |
| 3            | 264.6           | -12.3          | 1.224        |
| 4            | 286.7           | 0.5            | 1.194        |
| 5            | 154.1           | -3.7           | 1.251        |
| 6            | 165.8           | 6.8            | 1.266        |
| 7            | 168.6           | 7.4            | 1.132        |
| 8            | 288.1           | 1.7            | 1.334        |

## UNLOADING:

| strn<br>chan | SLOPE<br>ms/kip | INTER<br>mstrn | STAND<br>DEV |
|--------------|-----------------|----------------|--------------|
| 1            | 302.5           | 3.3            | 1.159        |
| 2            | 210.7           | -10.4          | 0.913        |
| 3            | 264.9           | -13.9          | 1.137        |
| 4            | 286.0           | 7.1            | 1.182        |
| 5            | 155.5           | 10.7           | 1.205        |
| 6            | 161.9           | 41.8           | 1.117        |
| 7            | 168.4           | 16.7           | 0.927        |
| 8            | 283.9           | 13.5           | 1.243        |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs3-10  
 Current Flight Hours = 66046.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 300.4  | 15.0  | 1.808 |
| 2    | 211.4  | -21.5 | 1.319 |
| 3    | 263.9  | -14.1 | 1.213 |
| 4    | 287.5  | 1.4   | 1.271 |
| 5    | 153.8  | 5.8   | 1.224 |
| 6    | 165.7  | 18.7  | 1.184 |
| 7    | 168.5  | 9.7   | 1.096 |
| 8    | 288.3  | 0.2   | 1.378 |

## UNLOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 301.2  | 2.3   | 1.234 |
| 2    | 210.9  | -10.0 | 0.939 |
| 3    | 264.0  | -17.3 | 1.196 |
| 4    | 286.0  | 9.7   | 1.232 |
| 5    | 154.4  | 25.7  | 1.309 |
| 6    | 161.6  | 56.0  | 1.202 |
| 7    | 169.0  | 18.9  | 0.965 |
| 8    | 283.6  | 11.9  | 1.339 |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs3-11  
 Current Flight Hours = 77047.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 300.7  | 21.9  | 1.668 |
| 2    | 212.2  | -27.8 | 1.493 |
| 3    | 263.9  | -9.7  | 1.143 |
| 4    | 287.0  | 4.0   | 1.122 |
| 5    | 155.1  | -24.1 | 2.369 |
| 6    | 168.2  | 7.6   | 2.698 |
| 7    | 168.4  | 1.3   | 1.644 |
| 8    | 286.7  | 11.6  | 1.663 |

## UNLOADING:

| strn | SLOPE  | INTER | STAND |
|------|--------|-------|-------|
| chan | ms/kip | mstrn | DEV   |
| 1    | 302.2  | 5.8   | 1.099 |
| 2    | 212.0  | -16.5 | 0.883 |
| 3    | 263.4  | -11.8 | 1.034 |
| 4    | 285.9  | 10.8  | 1.151 |
| 5    | 155.8  | -7.2  | 0.951 |
| 6    | 162.6  | 46.5  | 1.190 |
| 7    | 169.5  | 7.3   | 0.964 |
| 8    | 284.6  | 17.0  | 1.163 |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs3-13  
 Current Flight Hours = 99052.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn<br>chan | SLOPE<br>ms/kip | INTER<br>mstrn | STAND<br>DEV |
|--------------|-----------------|----------------|--------------|
| 1            | 299.2           | 16.1           | 1.579        |
| 2            | 212.2           | -22.5          | 1.324        |
| 3            | 261.6           | -15.7          | 1.259        |
| 4            | 287.3           | 6.2            | 1.299        |
| 5            | 152.0           | 2.4            | 1.113        |
| 6            | 165.6           | 25.8           | 1.203        |
| 7            | 169.4           | 7.9            | 1.350        |
| 8            | 288.6           | 7.4            | 1.368        |

## UNLOADING:

| strn<br>chan | SLOPE<br>ms/kip | INTER<br>mstrn | STAND<br>DEV |
|--------------|-----------------|----------------|--------------|
| 1            | 300.6           | 1.8            | 1.301        |
| 2            | 211.8           | -9.3           | 0.939        |
| 3            | 262.7           | -21.3          | 1.207        |
| 4            | 286.9           | 12.5           | 1.272        |
| 5            | 153.3           | 16.7           | 1.242        |
| 6            | 161.6           | 62.3           | 1.122        |
| 7            | 170.8           | 15.9           | 0.932        |
| 8            | 284.7           | 17.7           | 1.336        |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs3-14  
 Current Flight Hours = 109997.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn<br>chan | SLOPE<br>ms/kip | INTER<br>mstrn | STAND<br>DEV |
|--------------|-----------------|----------------|--------------|
| 1            | 299.0           | 18.8           | 1.373        |
| 2            | 212.1           | -21.2          | 1.365        |
| 3            | 261.5           | -17.2          | 1.091        |
| 4            | 288.2           | 9.2            | 1.146        |
| 5            | 151.4           | -3.1           | 1.189        |
| 6            | 166.4           | 29.0           | 1.174        |
| 7            | 169.9           | 0.8            | 1.953        |
| 8            | 288.0           | 9.5            | 1.182        |

## UNLOADING:

| strn<br>chan | SLOPE<br>ms/kip | INTER<br>mstrn | STAND<br>DEV |
|--------------|-----------------|----------------|--------------|
| 1            | 301.0           | 2.2            | 1.245        |
| 2            | 212.5           | -10.2          | 0.928        |
| 3            | 261.0           | -21.1          | 1.145        |
| 4            | 288.6           | 15.1           | 1.195        |
| 5            | 152.9           | 13.2           | 1.179        |
| 6            | 164.3           | 55.5           | 1.521        |
| 7            | 172.7           | 10.1           | 1.058        |
| 8            | 285.7           | 19.2           | 1.407        |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs3-14  
 Current Flight Hours = 109997.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

| LOADING: |        |       |       | UNLOADING: |        |       |       |
|----------|--------|-------|-------|------------|--------|-------|-------|
| strn     | SLOPE  | INTER | STAND | strn       | SLOPE  | INTER | STAND |
| chan     | ms/kip | mstrn | DEV   | chan       | ms/kip | mstrn | DEV   |
| 1        | 299.0  | 18.8  | 1.373 | 1          | 301.0  | 2.2   | 1.245 |
| 2        | 212.1  | -21.2 | 1.365 | 2          | 212.5  | -10.2 | 0.928 |
| 3        | 261.5  | -17.2 | 1.091 | 3          | 261.0  | -21.1 | 1.145 |
| 4        | 288.2  | 9.2   | 1.146 | 4          | 288.6  | 15.1  | 1.195 |
| 5        | 151.4  | -3.1  | 1.189 | 5          | 152.9  | 13.2  | 1.179 |
| 6        | 166.4  | 29.0  | 1.174 | 6          | 164.3  | 55.5  | 1.521 |
| 7        | 169.9  | 0.8   | 1.953 | 7          | 172.7  | 10.1  | 1.058 |
| 8        | 288.0  | 9.5   | 1.182 | 8          | 285.7  | 19.2  | 1.407 |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs3-15  
 Current Flight Hours = 121020.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

| LOADING: |        |       |       | UNLOADING: |        |       |       |
|----------|--------|-------|-------|------------|--------|-------|-------|
| strn     | SLOPE  | INTER | STAND | strn       | SLOPE  | INTER | STAND |
| chan     | ms/kip | mstrn | DEV   | chan       | ms/kip | mstrn | DEV   |
| 1        | 299.0  | 15.1  | 1.601 | 1          | 299.4  | 0.0   | 1.261 |
| 2        | 214.5  | -24.4 | 1.533 | 2          | 213.8  | -9.3  | 0.936 |
| 3        | 258.0  | -25.1 | 1.272 | 3          | 257.4  | -33.9 | 1.112 |
| 4        | 290.5  | 10.7  | 1.421 | 4          | 289.4  | 22.0  | 1.263 |
| 5        | 150.1  | -12.5 | 1.819 | 5          | 151.5  | 0.4   | 1.307 |
| 6        | 167.4  | 26.6  | 2.150 | 6          | 162.2  | 65.9  | 1.228 |
| 7        | 172.0  | 0.1   | 1.580 | 7          | 174.3  | 7.3   | 0.915 |
| 8        | 290.4  | 10.5  | 1.500 | 8          | 286.7  | 20.7  | 1.357 |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs3-16  
 Current Flight Hours = 132075.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn<br>chan | SLOPE<br>ms/kip | INTER<br>mstrn | STAND<br>DEV |
|--------------|-----------------|----------------|--------------|
| 1            | 296.7           | 19.4           | 1.943        |
| 2            | 214.8           | -22.3          | 1.759        |
| 3            | 252.7           | -24.5          | 1.558        |
| 4            | 292.6           | 13.5           | 1.366        |
| 5            | 147.8           | -17.1          | 2.666        |
| 6            | 170.3           | 29.1           | 3.286        |
| 7            | 171.6           | 8.0            | 2.203        |
| 8            | 289.5           | 17.9           | 1.785        |

## UNLOADING:

| strn<br>chan | SLOPE<br>ms/kip | INTER<br>mstrn | STAND<br>DEV |
|--------------|-----------------|----------------|--------------|
| 1            | 298.8           | 0.0            | 1.210        |
| 2            | 214.9           | -7.5           | 0.983        |
| 3            | 253.9           | -42.9          | 1.178        |
| 4            | 292.5           | 24.9           | 1.192        |
| 5            | 147.7           | -0.9           | 1.155        |
| 6            | 164.4           | 70.2           | 1.333        |
| 7            | 176.3           | 12.3           | 1.084        |
| 8            | 288.5           | 23.3           | 1.416        |

# STRAIN LOAD/UNLOAD ANALYZER

File Prefix = cs3-17  
 Current Flight Hours = 142663.0  
 Number of Files = 3 with 6 junk lines each  
 Number of Strain Gages = 8

-----> FILE = averages of all 3 files

## LOADING:

| strn<br>chan | SLOPE<br>ms/kip | INTER<br>mstrn | STAND<br>DEV |
|--------------|-----------------|----------------|--------------|
| 1            | 291.3           | 18.8           | 2.203        |
| 2            | 221.5           | -20.9          | 2.318        |
| 3            | 231.2           | -62.9          | 3.743        |
| 4            | 304.0           | 37.1           | 2.456        |
| 5            | 126.8           | -101.2         | 1.182        |
| 6            | 170.5           | 24.0           | 3.135        |
| 7            | 179.4           | -12.9          | 2.075        |
| 8            | 296.9           | 26.3           | 1.658        |

## UNLOADING:

| strn<br>chan | SLOPE<br>ms/kip | INTER<br>mstrn | STAND<br>DEV |
|--------------|-----------------|----------------|--------------|
| 1            | 292.2           | -2.2           | 1.271        |
| 2            | 221.8           | -2.0           | 1.154        |
| 3            | 230.2           | -104.8         | 2.103        |
| 4            | 305.1           | 61.4           | 1.493        |
| 5            | 126.5           | -108.6         | 1.011        |
| 6            | 164.7           | 64.2           | 1.327        |
| 7            | 179.0           | 1.3            | 0.952        |
| 8            | 295.0           | 33.6           | 1.304        |

## **APPENDIX G3**

### **Crack Growth Analysis Data Files**

|                                                 | Page |
|-------------------------------------------------|------|
| • NASGRO Batch File for Simple Coupon Analysis  | G3-1 |
| • Spectrum File for Simple Coupon Analysis      | G3-2 |
| • NASGRO Batch File for Complex Coupon Analysis | G3-3 |
| • Spectrum File for Complex Coupon Analysis     | G3-4 |

# NASGRO Batch File for Simple Coupon Analysis

```

simple.out  Output file name
          1      1=US units; 2=SI units

d
FCL W1, Test Spectrum (Tension), M6                      (Title)
tc      Crack Model Type
3      Crack Model Number
      1.0000000000000000      Width
      0.1250000000000000      Thickness
      0.1900000000000000      Hole diameter
      0.3500000000000000      Hole center to edge
u      U = user defined; S = Standard NDE
      5.000000000000000E-002      Initial a
      C=change; RTN=continue; S=start over
          1      Num of materials

3
2014-T6511 SwRI da/dN data
Mod of McMaster Fit (M6, w/o closure: alpha=5.845, S/So=1.0)
      74.00000000000000      UTS, Matl      1
      65.00000000000000      Yield Str, matl      1
      27.00000000000000      KIC matl      1
      27.00000000000000      KIC, matl      1
      1.0000000000000000      Ak - matl      1
      1.0000000000000000      Bk - matl      1

w
      2.000000000000000E-009      C
      3.7000000000000000      n
      0.5000000000000000      p
      1.0000000000000000      q
      2.7000000000000000      DKo
      0.7000000000000000      Rcl
      5.8450000000000000      alpha
      1.0000000000000000      Smax/SIGo

N      No saving matl file in batch run
      C=change; RTN=continue; S=start over
Single Block Schedule for W1 Coupon Test (Simple)          (Heading)
n      Flag for indentifying steps
      100000      No. times to apply sched
          1      No. distinct blocks

n      Yes or No
          73      No. steps - blk      1
          2      Schedule option
TENSION      Block Name
      C=change; RTN=continue
n      Yes or No
          0      Schedule option
      C=change, RTN=continue, S=start over
      1.0600000000000000      SF(      1,      1)
      0.000000000000000E+000      SF(      2,      1)
      C=change, RTN=continue, S=start over
n      Ref Load Factor AREF( 1)
          1      SBlk Case
          1      No. of times to apply
          0      SBlk Case
      C=change, RTN=continue, S=start over
      C=change; RTN=continue; S=start over
          1      Print opt. - Sched interval
          1      Print opt. - Block interval
          0      Print opt. - Indiv step intr
      C=change; RTN=continue; S=start over
          3      Plot option
      C=change; RTN=continue; S=start over
          3      Plot Device No.
          0      Termination option

```

## Spectrum File for Simple Coupon Analysis

0/

# NASGRO Batch File for Complex Coupon Analysis

```

CXlt.out          Output file name
                  1      1=US units; 2=SI units

d
FCL W1, Complex Test, Spectrum = W1COUP, M6                (Title)
tc      Crack Model Type
3      Crack Model Number
      1.4340000000000000      Width
      0.1250000000000000      Thickness
      0.1590000000000000      Hole diameter
      0.3750000000000000      Hole center to edge
u      U = user defined; S = Standard NDE
      6.800000000000000E-002      Initial a
      C=change; RTN=continue; S=start over
      1      Num of materials

3
2014-T6511 SwRI da/dN data
Mod of McMaster Fit (M6, w/o closure: alpha=5.845, S/So=1.0)
      74.00000000000000      UTS, Matl      1
      65.00000000000000      Yield Str, matl      1
      27.00000000000000      KIC, matl      1
      27.00000000000000      KIC, matl      1
      1.0000000000000000      Ak - matl      1
      1.0000000000000000      Bk - matl      1
w
      2.000000000000000E-009      C
      3.7000000000000000      n
      0.5000000000000000      P
      1.0000000000000000      q
      2.7000000000000000      DKO
      0.7000000000000000      Rcl
      5.8450000000000000      alpha
      1.0000000000000000      Smax/SIGo
N      No saving matl file in batch run
      C=change; RTN=continue; S=start over
Single Block Schedule for W1 Coupon Test (Simple)          (Heading)
n Flag for indentifying steps
      100000      No. times to apply sched
      1      No. distinct blocks
n      Yes or No
      73      No. steps - blk      1
      2      Schedule option
W1COUP      Block Name
      C=change; RTN=continue
n      Yes or No
      0      Schedule option
      C=change; RTN=continue; S=start over
      1.0000000000000000      SF(      1,      1)
      1.000000000000000E+000      SF(      2,      1)
      C=change; RTN=continue; S=start over
n      Ref Load Factor AREF( 1)
      1      SBlk Case
      1      No. of times to apply
      0      SBlk Case
      C=change; RTN=continue; S=start over
      C=change; RTN=continue; S=start over
      1      Print opt. - Sched interval
      1      Print opt. - Block interval
      0      Print opt. - Indiv step intr
      C=change; RTN=continue; S=start over
      3      Plot option
      C=change; RTN=continue; S=start over
      3      Plot Device No.
      0      Termination option

```

# Spectrum File for Complex Coupon Analysis

71COUP Single Block Spectrum (550 hrs) for W1 Coupons

|            |         |         |          |          |        |        |        |        |
|------------|---------|---------|----------|----------|--------|--------|--------|--------|
| 190.00000  | -2.1140 | -3.9260 | -15.6520 | -29.0680 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 9.00000    | -1.8120 | -4.2280 | -13.4160 | -31.3040 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1.00000    | -1.3892 | -4.4092 | -12.0744 | -32.6456 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 957.00000  | 1.1040  | 2.2080  | 8.1960   | 16.3920  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 114.00000  | 0.7360  | 2.5760  | 5.4640   | 19.1240  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 57.00000   | 0.5520  | 2.7600  | 4.0980   | 20.4900  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 11.00000   | 0.1840  | 3.1280  | 1.3660   | 23.2220  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2.00000    | -0.1840 | 3.4960  | -1.3660  | 25.9540  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1.00000    | -0.5520 | 3.8640  | -4.0980  | 28.6860  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1.00000    | 0.4600  | 2.8520  | 3.4150   | 21.1730  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 28.00000   | 1.3900  | 1.4039  | 10.2800  | 10.3828  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 44.00000   | 1.1259  | 1.4734  | 8.3268   | 10.8968  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 22.00000   | 0.8618  | 1.5568  | 6.3736   | 11.5136  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 6.00000    | 0.5977  | 1.6402  | 4.3176   | 12.1304  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1.00000    | -0.5738 | -3.7750 | -4.2484  | -27.9500 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 190.00000  | -2.1140 | -3.9260 | -15.6520 | -29.0680 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 9.00000    | -1.8120 | -4.2280 | -13.4160 | -31.3040 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1.00000    | -1.3892 | -4.4092 | -12.0744 | -32.6456 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1914.00000 | 1.1040  | 2.2080  | 8.2080   | 16.4160  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 229.00000  | 0.7360  | 2.5760  | 5.4720   | 19.1520  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 114.00000  | 0.5520  | 2.7600  | 4.1040   | 20.5200  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 23.00000   | 0.1840  | 3.1280  | 1.3680   | 23.2560  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 4.00000    | -0.1840 | 3.4960  | -1.3680  | 25.9920  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1.00000    | -0.5520 | 3.8640  | -4.1040  | 28.7280  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1.00000    | -1.2328 | 4.5448  | -9.1522  | 33.7402  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 28.00000   | 1.3900  | 1.4039  | 10.2800  | 10.3828  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 44.00000   | 1.1259  | 1.4734  | 8.3268   | 10.8968  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 22.00000   | 0.8618  | 1.5568  | 6.3736   | 11.5136  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 6.00000    | 0.5977  | 1.6402  | 4.3176   | 12.1304  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 190.00000  | -2.1140 | -3.9260 | -15.6520 | -29.0680 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 9.00000    | -1.8120 | -4.2280 | -13.4160 | -31.3040 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1.00000    | -1.3892 | -4.4092 | -12.0744 | -32.6456 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1914.00000 | 1.1040  | 2.2080  | 8.2080   | 16.4160  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 229.00000  | 0.7360  | 2.5760  | 5.4720   | 19.1520  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 114.00000  | 0.5520  | 2.7600  | 4.1040   | 20.5200  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 23.00000   | 0.1840  | 3.1280  | 1.3680   | 23.2560  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 4.00000    | -0.1840 | 3.4960  | -1.3680  | 25.9920  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1.00000    | -0.5520 | 3.8640  | -4.1040  | 28.7280  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 28.00000   | 1.3900  | 1.4039  | 10.2800  | 10.3828  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 44.00000   | 1.1259  | 1.4734  | 8.3268   | 10.8968  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 22.00000   | 0.8618  | 1.5568  | 6.3736   | 11.5136  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 6.00000    | 0.5977  | 1.6402  | 4.3176   | 12.1304  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1.00000    | 0.4600  | 2.8520  | 3.4150   | 21.1730  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 190.00000  | -2.1140 | -3.9260 | -15.6520 | -29.0680 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 9.00000    | -1.8120 | -4.2280 | -13.4160 | -31.3040 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1.00000    | -1.3892 | -4.4092 | -12.0744 | -32.6456 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1914.00000 | 1.1040  | 2.2080  | 8.2080   | 16.4160  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 229.00000  | 0.7360  | 2.5760  | 5.4720   | 19.1520  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 114.00000  | 0.5520  | 2.7600  | 4.1040   | 20.5200  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 23.00000   | 0.1840  | 3.1280  | 1.3680   | 23.2560  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 4.00000    | -0.1840 | 3.4960  | -1.3680  | 25.9920  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1.00000    | -0.5520 | 3.8640  | -4.1040  | 28.7280  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 28.00000   | 1.3900  | 1.4039  | 10.2800  | 10.3828  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 44.00000   | 1.1259  | 1.4734  | 8.3268   | 10.8968  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 22.00000   | 0.8618  | 1.5568  | 6.3736   | 11.5136  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 6.00000    | 0.5977  | 1.6402  | 4.3176   | 12.1304  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 190.00000  | -2.1140 | -3.9260 | -15.6520 | -29.0680 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 9.00000    | -1.8120 | -4.2280 | -13.4160 | -31.3040 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1.00000    | -1.3892 | -4.4092 | -12.0744 | -32.6456 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 3829.00000 | 1.1040  | 2.2080  | 8.1960   | 16.3920  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 457.00000  | 0.7360  | 2.5760  | 5.4640   | 19.1240  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 229.00000  | 0.5520  | 2.7600  | 4.0980   | 20.4900  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 46.00000   | 0.1840  | 3.1280  | 1.3660   | 23.2220  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 8.00000    | -0.1840 | 3.4960  | -1.3660  | 25.9540  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2.00000    | -0.5520 | 3.8640  | -4.0980  | 28.6860  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1.00000    | -0.9200 | 4.2320  | -6.8300  | 31.4180  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1.00000    | 0.4600  | 2.8520  | 3.4150   | 21.1730  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 28.00000   | 1.3900  | 1.4039  | 10.2800  | 10.3828  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 44.00000   | 1.1259  | 1.4734  | 8.3268   | 10.8968  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 22.00000   | 0.8618  | 1.5568  | 6.3736   | 11.5136  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 6.00000    | 0.5977  | 1.6402  | 4.3176   | 12.1304  | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1.00000    | -0.5738 | -3.7750 | -4.2484  | -27.9500 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

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