

Summary of SAE Keyhole project and results

SAE FD&E Semi-Annual Meeting

Dan Lingenfelser

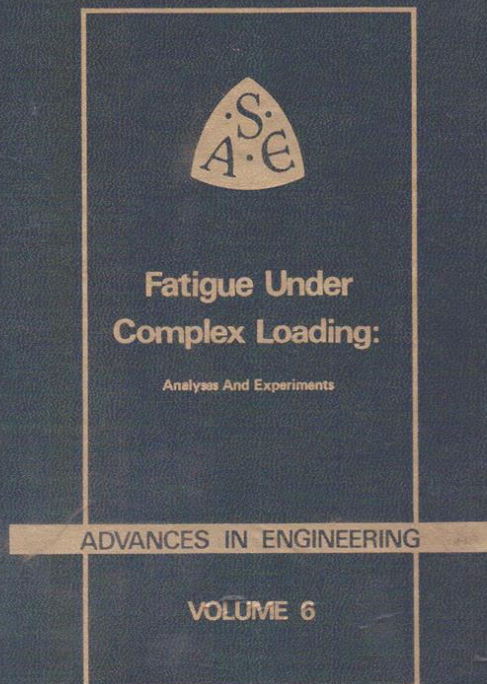
12 October 2016

October 12, 2016

SAE FD&E

- Overview of AE6
- Brief overview of Keyhole project
- Example demonstrating value of documentation
- Possible use of keyhole data for FDE total life project

October 12, 2016



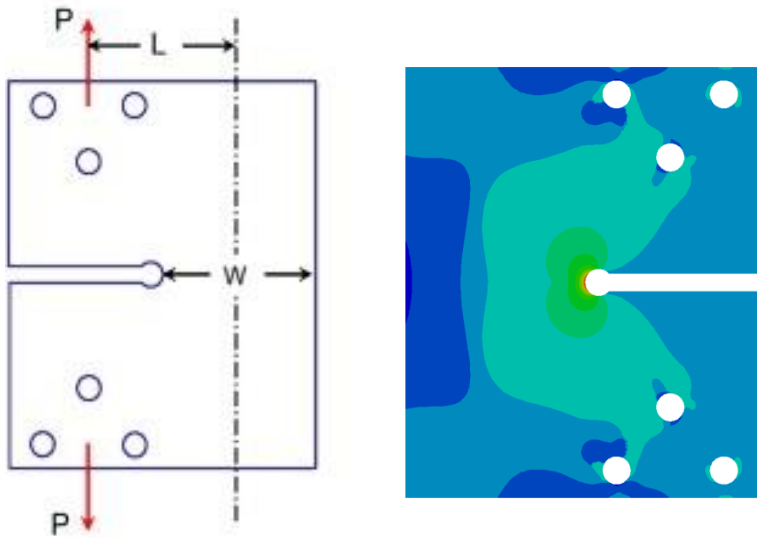
- Test program started in 1970
- Published in 1977
- Edited by R. M. Wetzel
- Summarizes SAE FDE “Keyhole” specimen project
- Not written as a book with chapters
- Collection of individually authored papers from project
- Documents project in detail
- Includes a summary discussion by H. O. Fuchs
- Still a valuable source of data
- Total life load history developed by concatenating these histories

Documented well enough that I
could pick up the book and
recreate life predictions

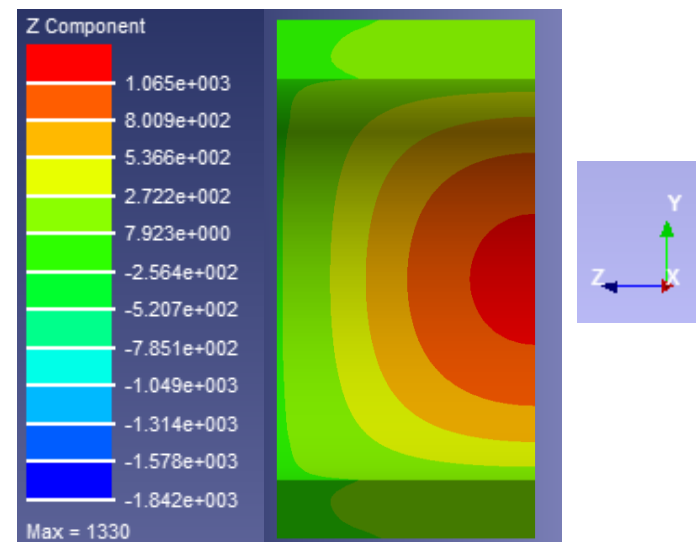
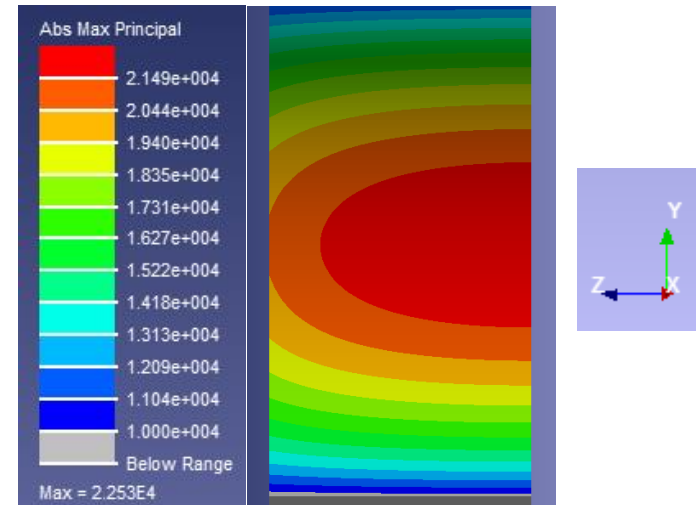
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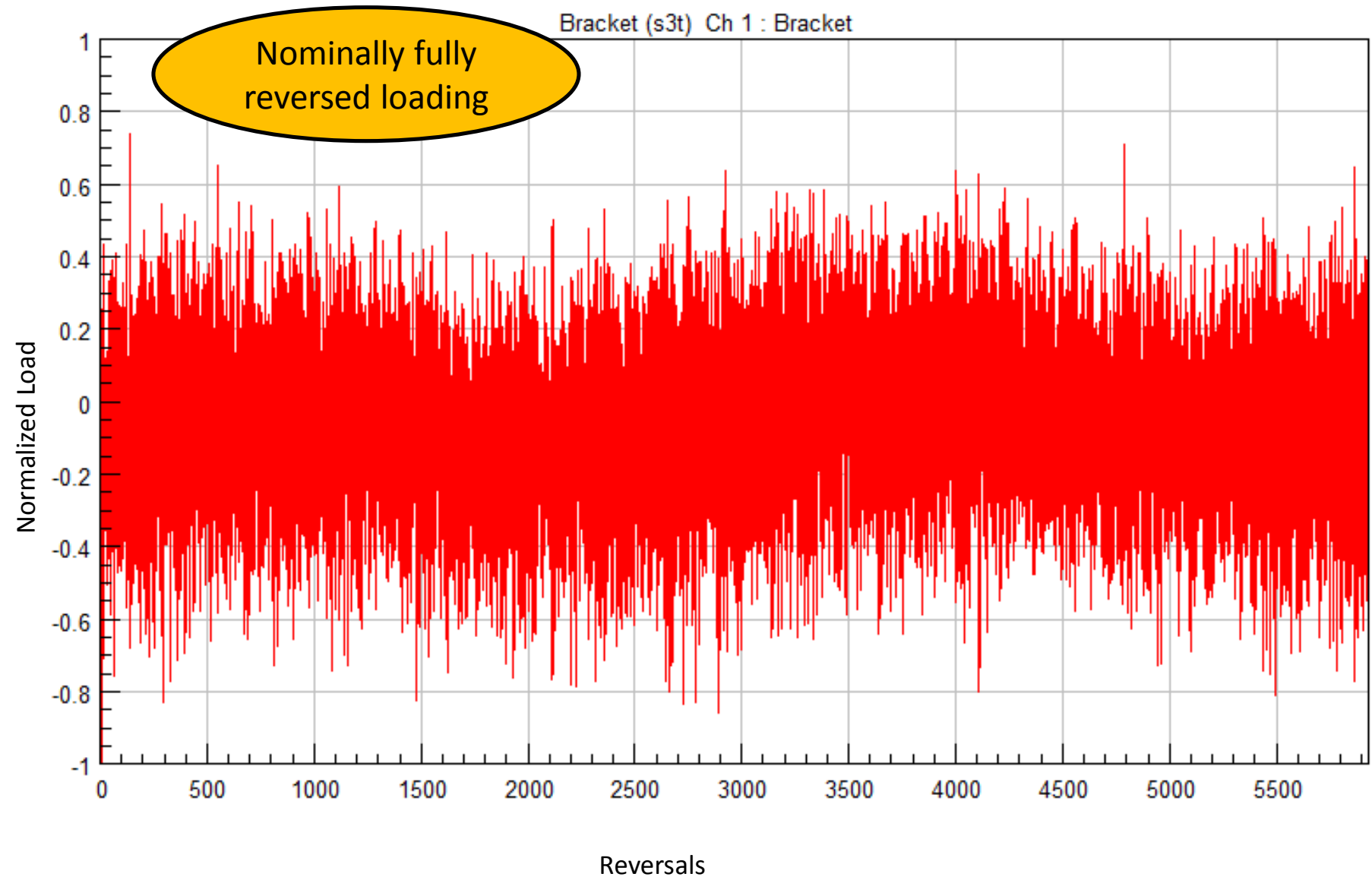
Keyhole specimen 0.375" thick



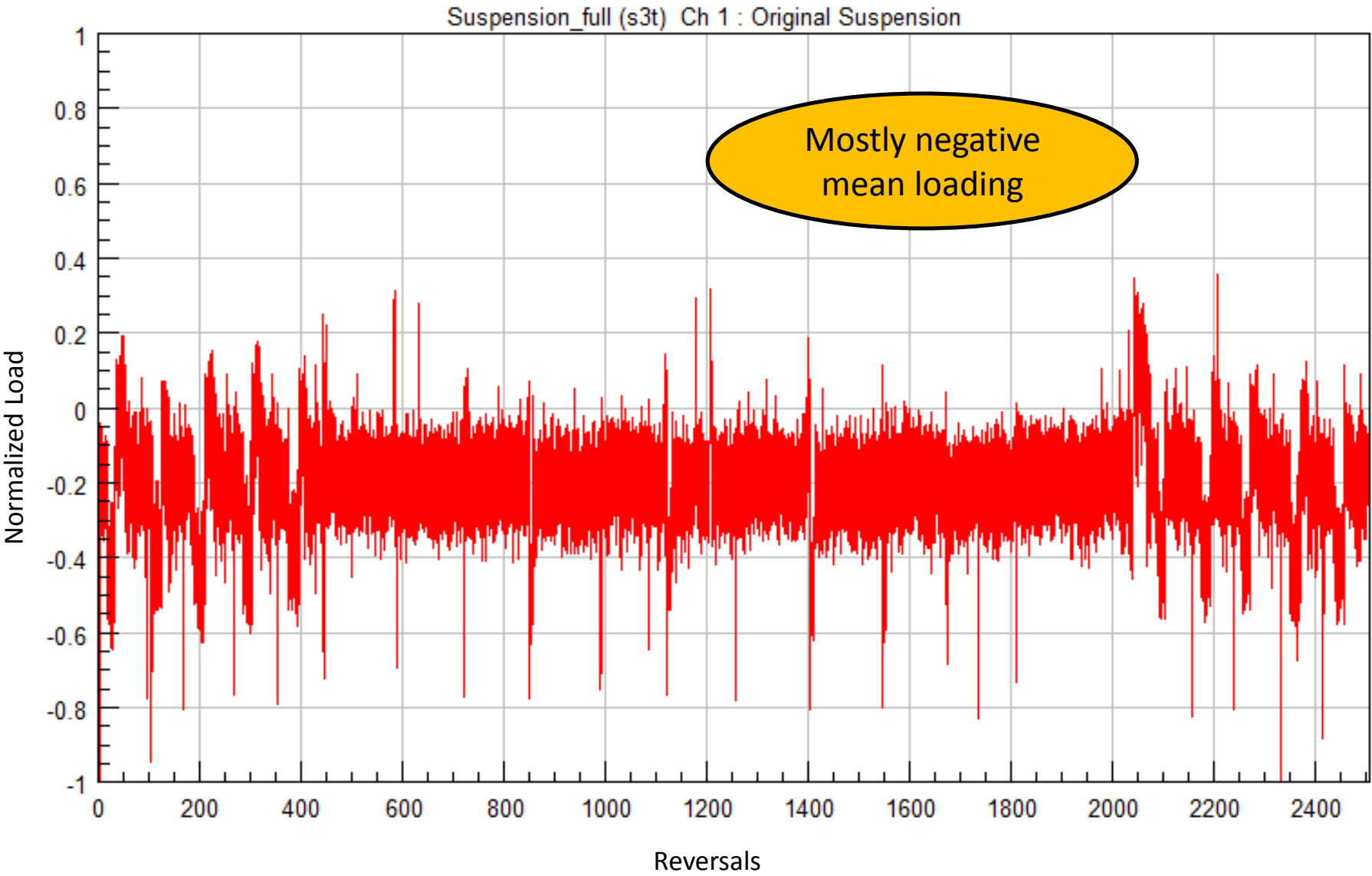
- Two materials
 - U.S. Steel's Man-Ten - Yield strength = 325 Mpa
 - Bethlehem Steel's RQC-100 -Yield strength = 770 MPa
- Limited biaxiality (proportional)
 - Max principal stress in center is 10% higher than on edge
 - Mean biaxiality ratio ~5%



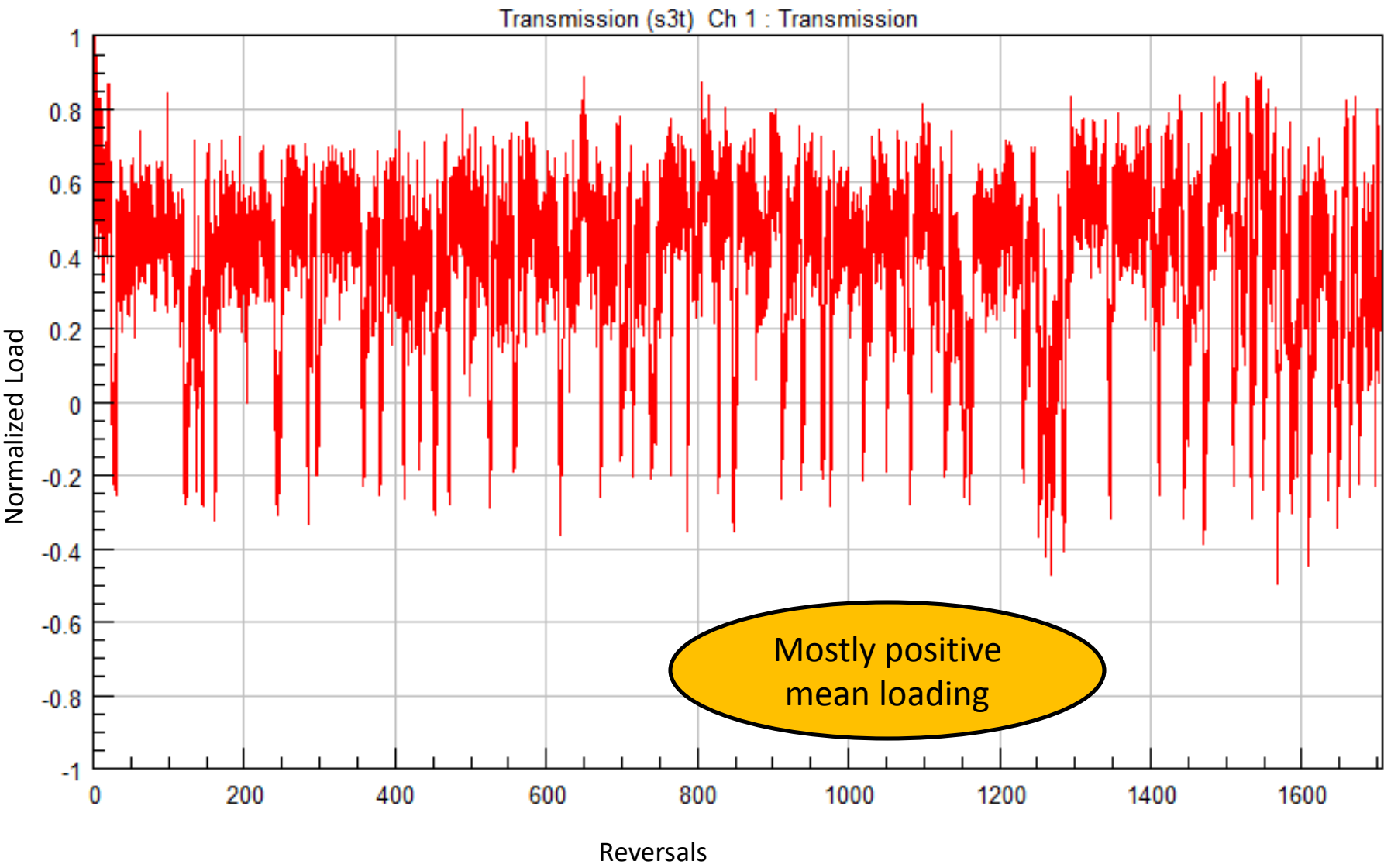
Normalized SAE Keyhole Project Bracket History



Normalized SAE Keyhole Project Suspension History



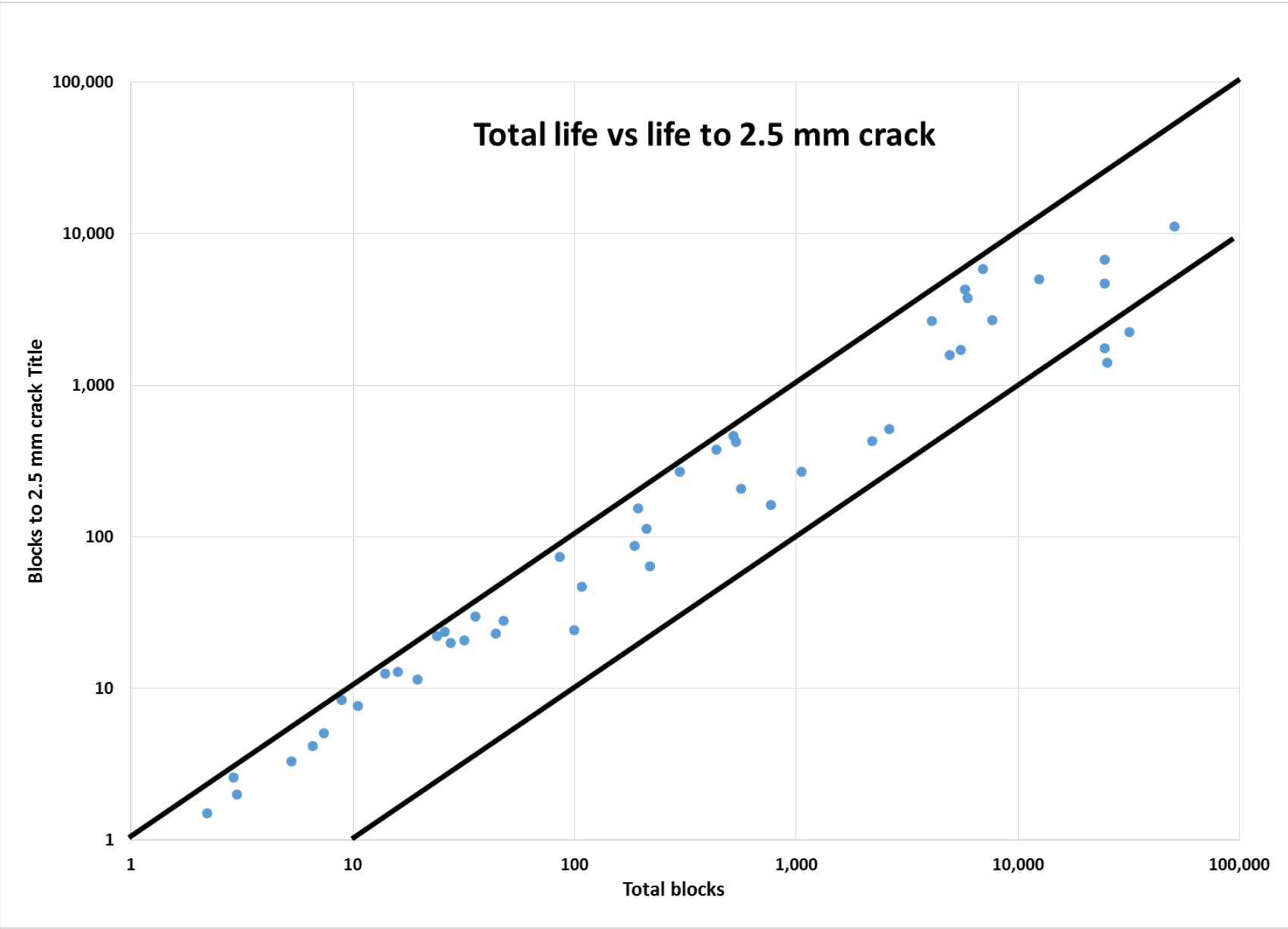
Normalized SAE Keyhole Project Transmission History



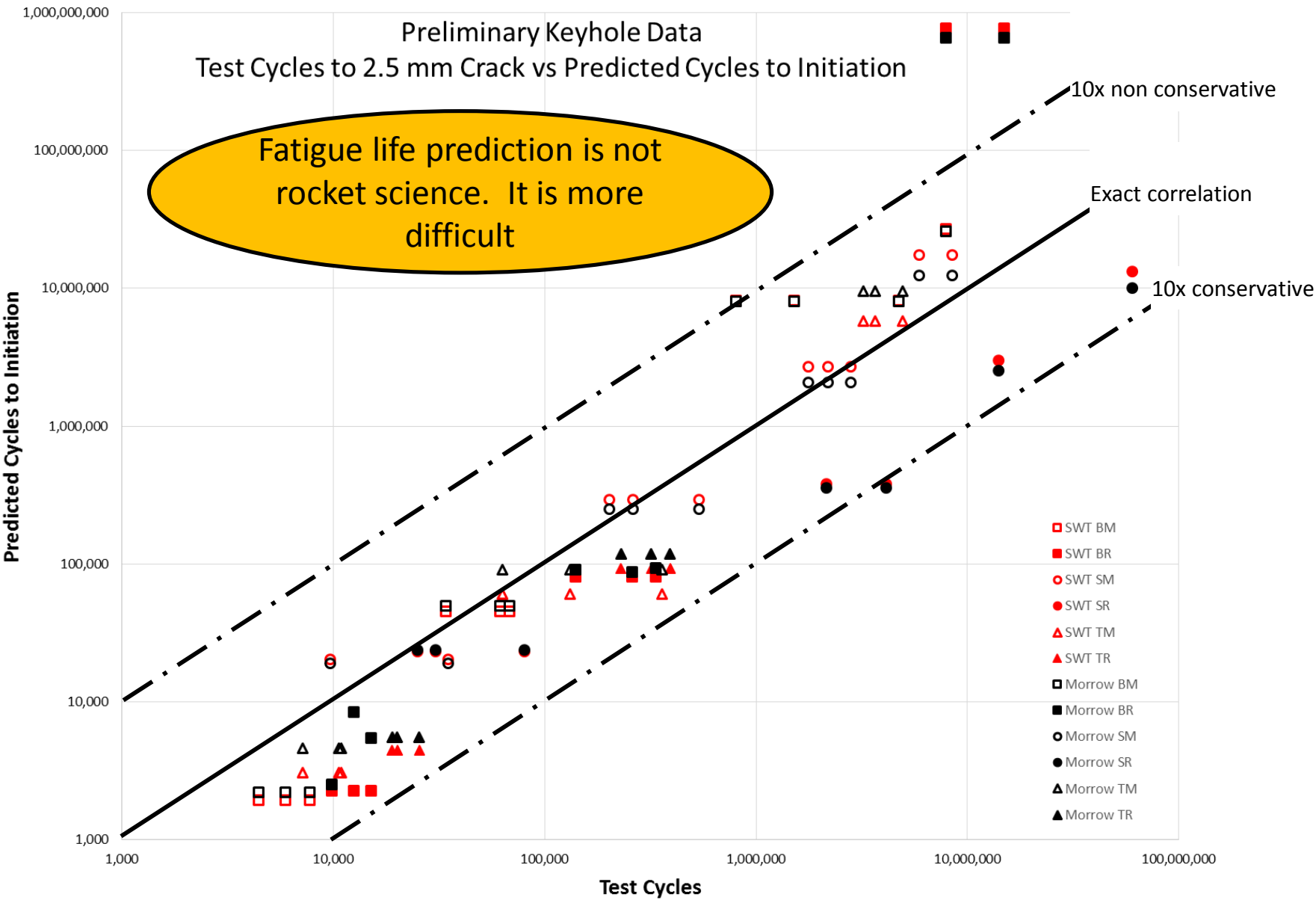
SAE AE6: Fatigue Under Complex Loading ... Test Results

Variable Amplitude Tests RQC-100						
Identification	Maximum Load		Load Range		Life to 2.5 mm crack	Total Life
	kN	lbs.	kN	lbs.	blocks	blocks
SR1-1	-71.2	-16,000	95.6	21,500	20	28
SR1-2	-71.2	-16,000	95.6	21,500	24	100
SR1-3	-71.2	-16,000	95.6	21,500	64	218
SR2-2	-40.0	-9,000	53.8	12,100	1,710	>5,535
SR3-2	-31.1	-7,000	41.8	9,400	11,200	51,124
SR4-1	-26.7	-6,000	35.9	8,060	48,000	>106,732
BR1-1	-71.2	-16,000	123.7	27,800	3.3	5.3
BR1-2	-71.2	-16,000	123.7	27,800	5.1	7.4
BR1-3	-71.2	-16,000	123.7	27,800	4.2	6.6
BR2-1	-35.6	-8,000	61.8	13,900	88	186
BR2-2	-35.6	-8,000	61.8	13,900	47	108
BR2-3	-35.6	-8,000	61.8	13,900	113	212
BR3-1	-15.6	-3,500	27.0	6,080	2,673	7,673
BR3-3	-15.6	-3,500	27.0	6,080	5,020	12,519
TR1-1	71.2	16,000	106.3	23,900	30	36
TR1-2	71.2	16,000	106.3	23,900	24	26
TR1-3	71.2	16,000	106.3	23,900	22	24
TR2-1	35.6	8,000	53.2	11,950	269	297
TR2-2	35.6	8,000	53.2	11,950	460	520
TR2-3	35.6	8,000	53.2	11,950	374	436

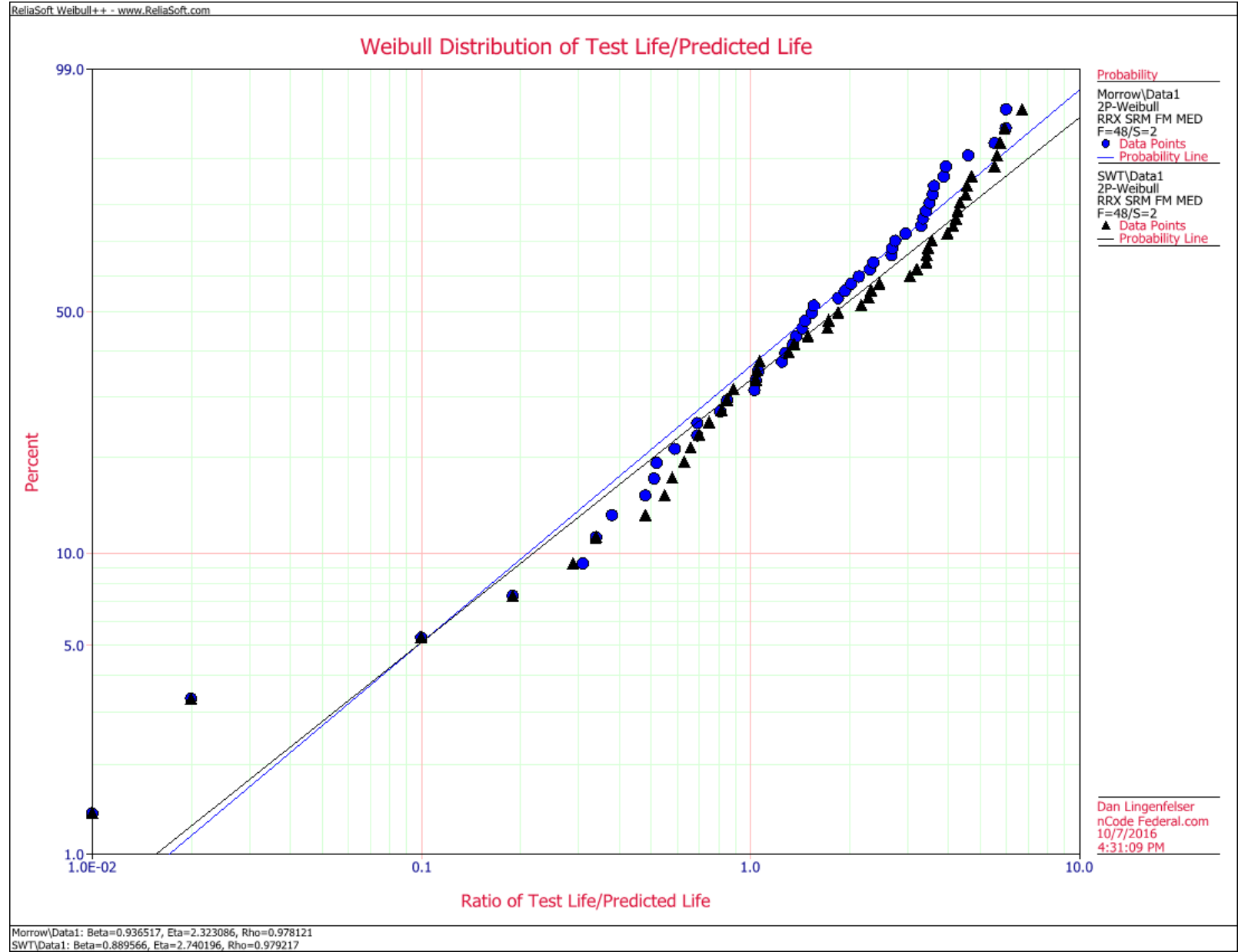
Variable Amplitude Tests MAN-TEN						
Identification	Maximum Load		Load Range		Life to 2.5 mm crack	Total Life
	kN	lbs.	kN	lbs.	blocks	blocks
SM1-1	-71.2	-16,000	95.6	21,500	8	11
SM1-3	-71.2	-16,000	95.6	21,500	28	48
SM2-1	-40.0	-9,000	53.8	12,100	430	2,200
SM2-2	-40.0	-9,000	53.8	12,100	208	565
SM2-3	-40.0	-9,000	53.8	12,100	162	767
SM3-1	-26.7	-6,000	35.9	8,060	1,750	24,608
SM3-2	-26.7	-6,000	35.9	8,060	2,240	31,884
SM3-3	-26.7	-6,000	35.9	8,060	1,410	>25,353
SM4-2	-20.0	-4,500	26.9	6,050	4,700	24,666
BM1-1	-71.2	-16,000	123.7	27,800	1.5	2.2
BM1-2	-71.2	-16,000	123.7	27,800	2.6	2.9
BM1-3	-71.2	-16,000	123.7	27,800	2.0	3.0
BM2-1	-35.6	-8,000	61.8	13,900	21	32
BM2-2	-35.6	-8,000	61.8	13,900	12	20
BM2-3	-35.6	-8,000	61.8	13,900	23	44
BM3-1	-15.6	-3,500	27.0	6,080	1,588	4,944
BM3-2	-15.6	-3,500	27.0	6,080	270	1,054
BM3-3	-15.6	-3,500	27.0	6,080	510	2,626
BM4-3	-13.3	-3,000	23.2	5,210	2,666	4,076
TM1-1	71.2	16,000	106.3	23,900	8	9
TM1-2	71.2	16,000	106.3	23,900	13	16
TM1-3	71.2	16,000	106.3	23,900	13	14
TM2-1	35.6	8,000	53.2	11,950	420	537
TM2-2	35.6	8,000	53.2	11,950	154	193
TM2-3	35.6	8,000	53.2	11,950	74	86
TM3-1	15.6	3,500	23.3	5,230	5,800	6,957
TM3-2	15.6	3,500	23.3	5,230	4,270	5,780
TM3-3	15.6	3,500	23.3	5,230	3,755	5,920



SAE AE6: Fatigue Under Complex Loading ... Summary of Test vs Predictions



SAE AE6: Fatigue Under Complex Loading ... Summary of Test vs Predictions



Summary

- Work was well documented
- Significant quantify of useful data
- Focus at the time was on initiation not crack growth
- May want to investigate the load life curves and life prediction
- Should investigate predicting life with total life methodology