DAEDALEAN ASSOCIATES, Inc.

THE APPLICATION OF THE INTERNAL FRICTION DAMPING (IFD) NONDESTRUCTIVE EVALUATION (NDE) TECHNIQUE FOR DETECTING IGSCC CRACK INITIATION IN BWR PIPING SYSTEMS

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SAFETY RESEARCH MEETING

U.S. NUCLEAR REGULATORY COMMISSION

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NRC PROGRAM MANAGER
DR. J. MUSCARA

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THE APPLICATION OF THE INTERNAL FRICTION DAMPING (IFD) NONDESTRUCTIVE EVALUATION (NDE) TECHNIQUE FOR DETECTING IGSCC CRACK INITIATION IN BWR PIPING SYSTEMS

This technical research and development program was initiated by the U. S. Nuclear Regulatory Commission under the auspices of the Reactor Safety Research Program with Dr. Joseph Muscara as the Program Manager.

The specific objective of the program is to determine the technical feasibility of applying the IFD-NDE technique to laboratory specimens for the purpose of detecting IGSCC in 304SS pipes. An ancillary objective is to determine the technical feasibility of applying the IFD-NDE technique to the feedwater line of an actual BWR. The purpose of the program is to demonstrate on laboratory pipe specimens that the IFD-NDE technique can detect IGSCC crack initiation. The data generated under the program is related to the specific damping capacity $\left(\frac{\Delta W}{W}\right)$ as a function of the overall load cycle history of the pipe up to and including thru-wall leakage.

Results of tests performed on three laboratory pipe specimens indicate that the IFD-NDE technique identified a typical increase in $\frac{\Delta W}{W}$ above the standard upper confidence limit in the range of 8 to 16 percent of the life of the pipe to thru-wall leakage.

Three pipe specimens (four inch diameter) of 304SS were stress cycled in a simulated bypass loop. Specific damping capacity values were obtained for pipes stressed at 136 percent, 140 percent and 150 percent of the yield stress of the pipe determined at 550°F. Base line values of specific damping capacity were 100×10^{-4} for the pipes tested. The upper confidence limit varied between 150×10^{-4} and 225×10^{-4} depending upon the number of data points taken. The number of load stress cycles to the point where the recorded $\frac{\Delta W}{W}$ value exceeded the upper confidence limit was obtained for each pipe specimen. This recorded load cycle number for the $\frac{\Delta W}{W}$ was compared to the total number of load cycles associated with the thru-wall crack. The ratio of these two cycles in the overall load cycle history of the pipe specimen was reported as "Percentage of ultimate life (thru-wall crack) wherein IFD-NDE determined crack initiation." Table 1 is a test matrix for the pipe sections tested.

The increase in the measured specific damping capacity that occurred in the 8 to 16 percent range of the load cycle history has been identified for all pipe specimens. The specific damping capacity versus the number of applied load cycles for the various four inch pipe specimens is presented in Figures 1 through 3. The point where the measured $\frac{\Delta W}{W}$ values exceed the upper confidence limits is identified by an arrow and the letters "NDE." The upper confidence limit is identified by the dashed line. The mean value of the measured $\frac{\Delta W}{W}$ values up to and including the point where the measured value exceeds the upper confidence limit is depicted by the solid black line. The data presented in Figures 1 through 3 was collected for the pipes for two transducer locations at the peak load. The specific test frequency is identified for each pipe test.

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TABLE 1 TEST MATRIX AND TEST PARAMETERS FOR LABORATORY PIPE SECTIONS

PIPE SPECIMEN	LOAD STRESS (% OF 550°F YEILD STRESS)	FAILURE PREDICTION BY IFD-NDE (LOAD CYCLE)	TOTAL LOAD CYCLES TO FAILURE	PERCENTAGE OF LIFE TO THRU-WALL LEAK WHEN IFD-NDE DETECTED CRACKING
1	137/140/150 NOTE 1	37	243	15
2	150	12	76	16
3	136	13	163	8

NOTE 1 STRESS LOADING CHANGED TO 140% OF YEILD AFTER CYCLE 33.
CHANGED TO 150% OF YEILD AFTER CYCLE 220

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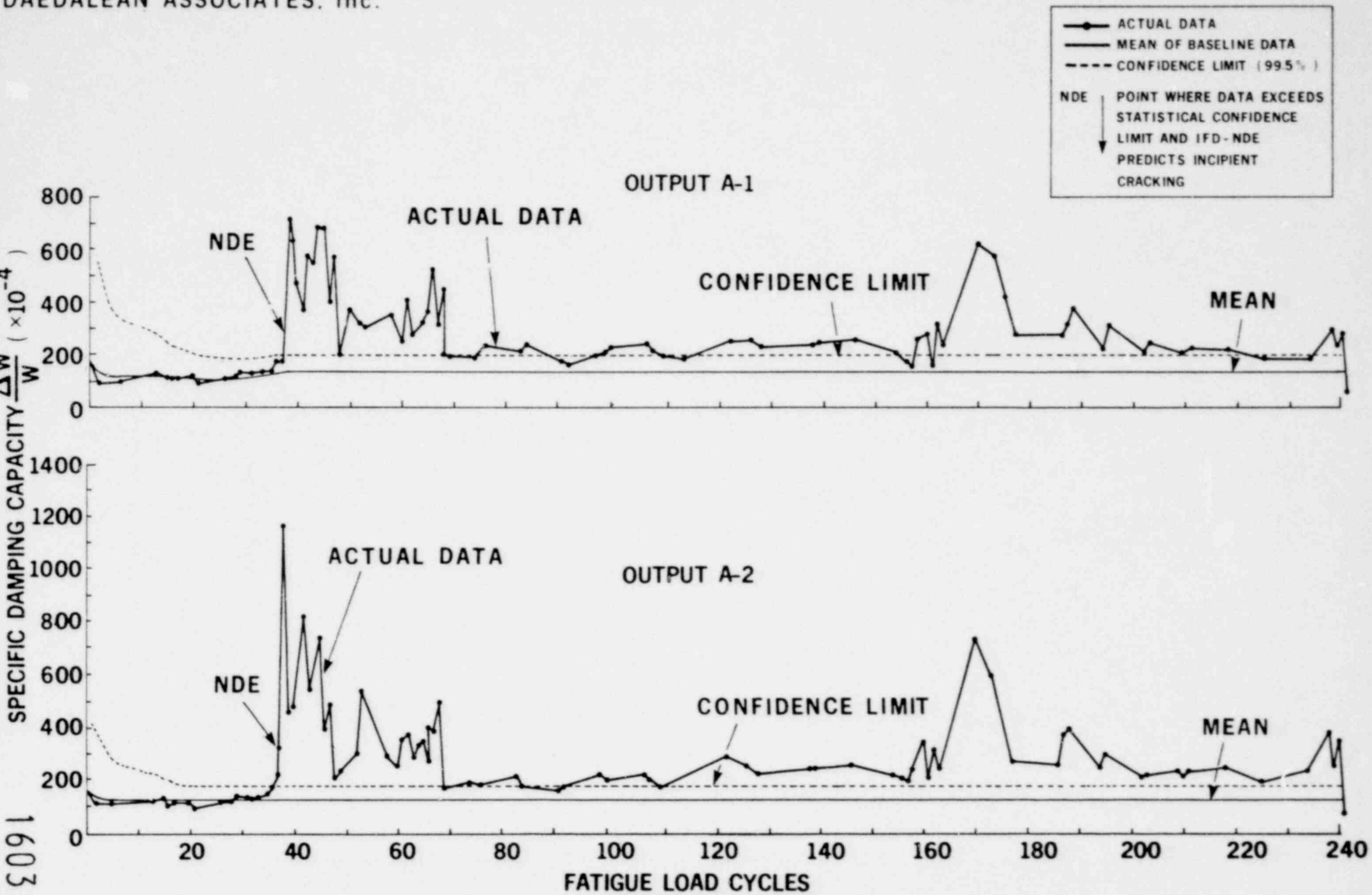

FIGURE 1 SPECIFIC DAMPING CAPACITY VERSUS FATIGUE LOAD CYCLES
FOR IGSCC PIPE #2 2300HZ RAMS AT MAXIMUM LOAD

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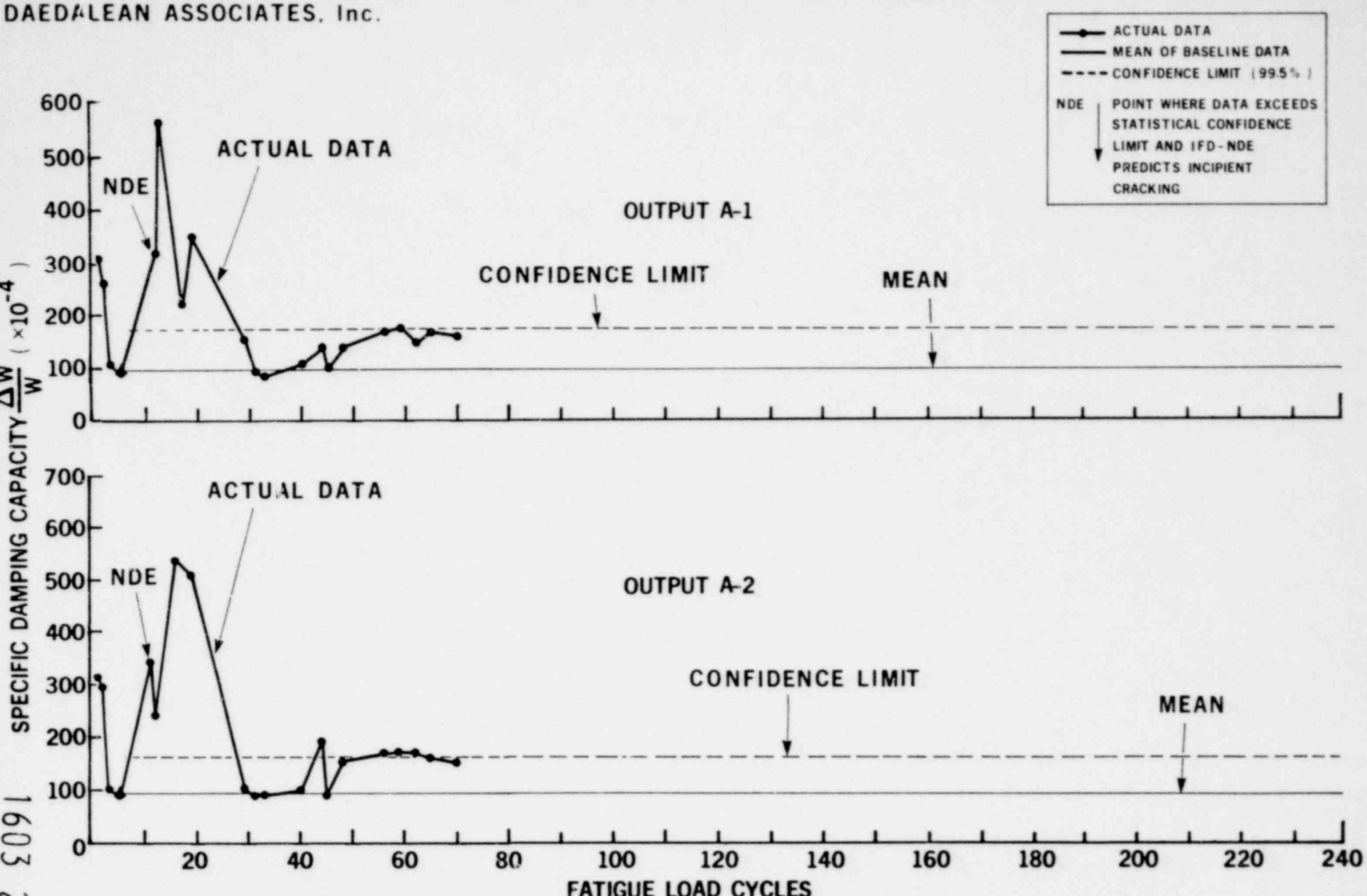

FIGURE 2 SPECIFIC DAMPING CAPACITY VERSUS FATIGUE LOAD CYCLES FOR IGSCC PIPE #3 2270HZ RAMS AT MAXIMUM LOAD

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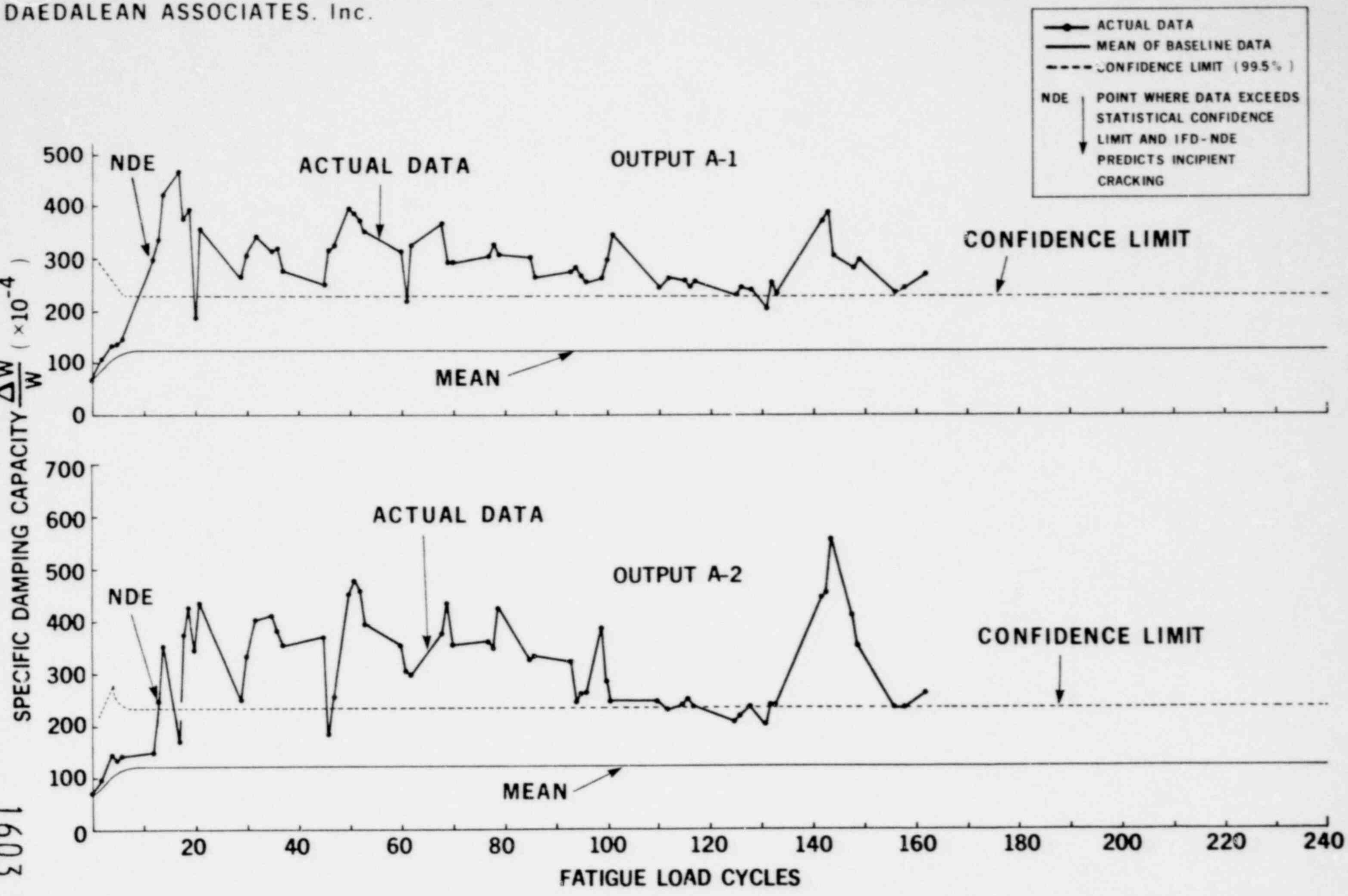

FIGURE 3 SPECIFIC DAMPING CAPACITY VERSUS FATIGUE LOAD CYCLES FOR IGSCC PIPE #4 2300HZ RAMS AT MAXIMUM LOAD

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