PRELIMINARY STEAM BYPASS LINE STRUCTURAL EVALUATION

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A catastrophic response to flow-generated noise was observed in the Fermi facility main steam relief valve dumplines during operation in 1985. As a result, this 30" diameter piping was redesigned to enhance its operational response characteristics. The material thickness was increased from 3/8" to 1", and support lugs were removed from the piping to reduce wall stresses and stress concentrations. In addition, flow orifice plates were installed downstream to mitigate the noise levels at high mass flow rates. The newly configured piping was thoroughly instrumented to provide immediate feedback on the operational response of the system.

Evaluation of the resulting data shows that, as predicted, the most severe structural response in the form of wall flutter occurred in the west line just downstream from the valve. Significant random vibration was observed at mass flow rates between 30 to 40 percent of the design limit. A fatigue life evaluation using a correlated fracture mechanics approach indicates that the system is not susceptible to structural degradation even in the most critical mode of operation.

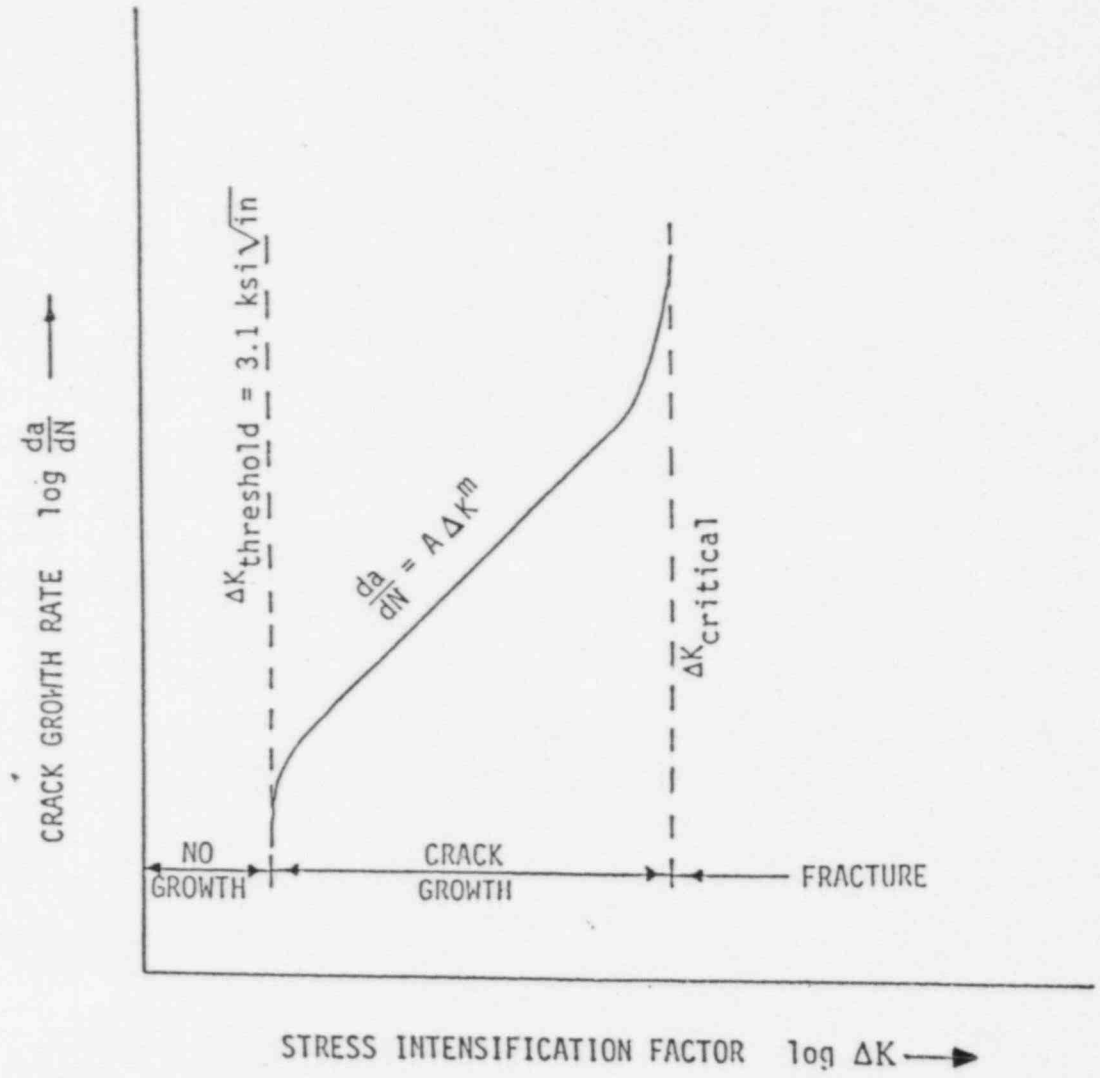
The wall flutter observed in the dumplines was noted to have random vibration characteristics. The fatigue life evaluation was based upon a detailed fracture mechanics analysis in which a maximal permissible weld flaw was assumed at the location of critical stress. Crack growth was evaluated in accordance with the relationship presented in Exhibit A.

As anticipated, data from the instrumentation revealed critical strains in the west line just downstream from the valve. Exhibit B indicates maximal half amplitude (0-P) microstrain recorded at this location as a function of mass flow rate. For the postulated weld flaws to grow, the strain (0-P) must exceed a 100 microstrain threshold level. These strains were noted only at 30 to 40 percent design mass flow rate levels. At other mass flow rates, crack growth is improbable.

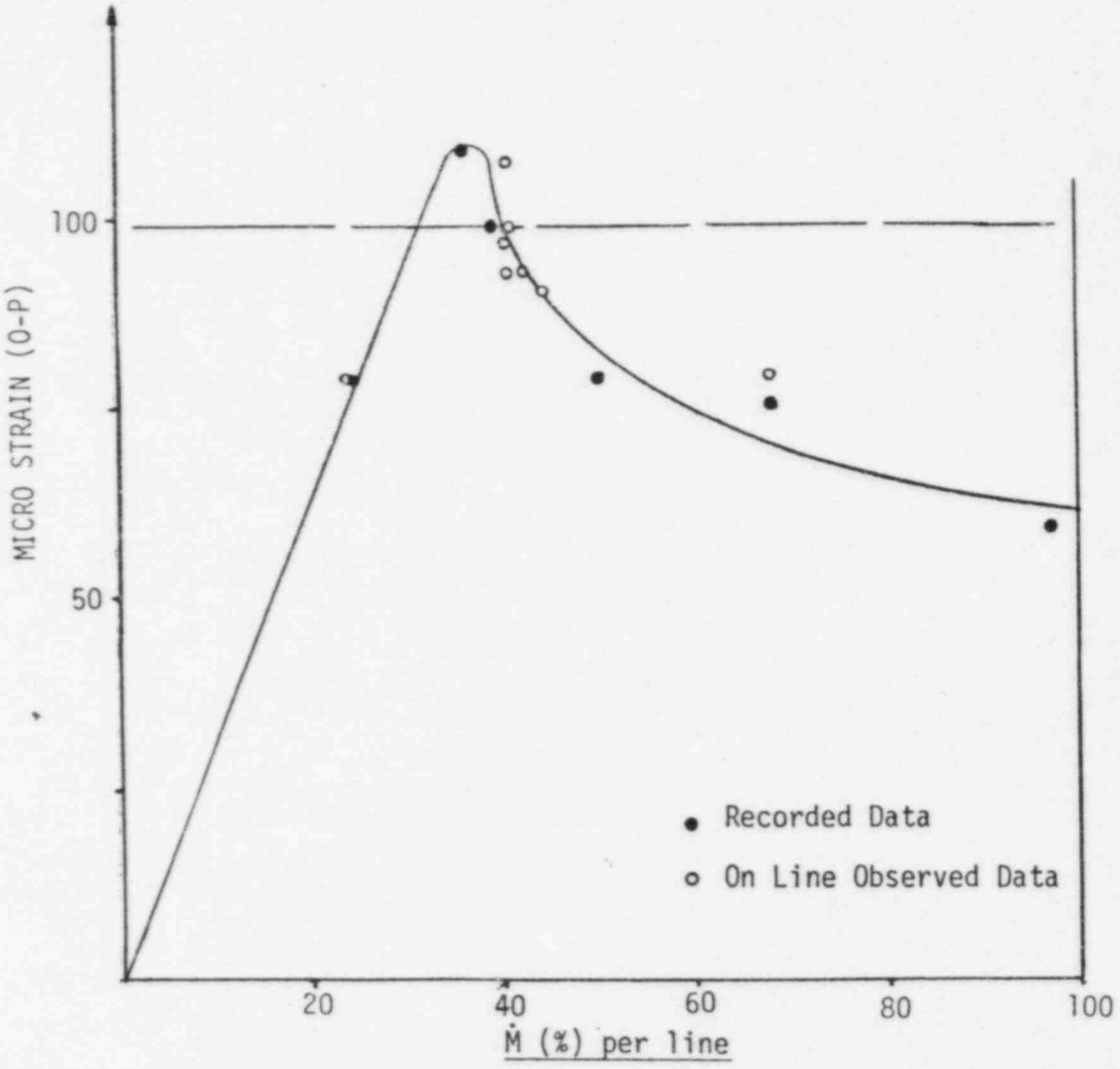
Statistical analysis of maximal and minimal peak strain values measured from expanded scale strain traces yielded a normal distribution for number of occurrences as a function of peak strains. The number of occurrences for alternating stresses is determined by the difference (maximal minus minimal distributions) as a Rayleigh distribution. The Rayleigh distribution of occurrences for alternating stress ranges at 36% mass flow rate determined for a one-second time interval is shown in Exhibit C. A minimal occurrence of detrimental stresses (i.e. $\Delta S > 5.85$ KSI) is observed from the Rayleigh distribution. These stress-occurrence value sets are then used to predict fatigue crack growth.

The life of the west dumpline in the most critical operating mode at 36% mass flow is estimated to be in excess of 130 days as shown in Exhibit D. This represents the total accumulated time in the critical mode, therefore, brief transitory periods through the critical operating mode range are not detrimental to the overall life of the pipe (this phenomenon is akin to the transition of a turbine through its critical speed during synchronization). Furthermore, radiography of the welds in the critical regions has indicated that flaws with the postulated size are not present. This means that the critical fatigue life prediction is extremely conservative and that structural degradation is improbable even in the worst-case operating situation. However, avoiding operation of the west dumpline between the 30 and 40 percent flow rates can do no harm.

Larger peak stress intensity ranges are probable at other locations in the line as a result of three-dimensional stress combination and stress concentration effects. Such stresses do not appear to be detrimental since significant material flaws are not observed in the parent material.



CRACK GROWTH AND FRACTURE PHENOMENA



ALTERNATING STRAIN VS. MASS FLOW RATE

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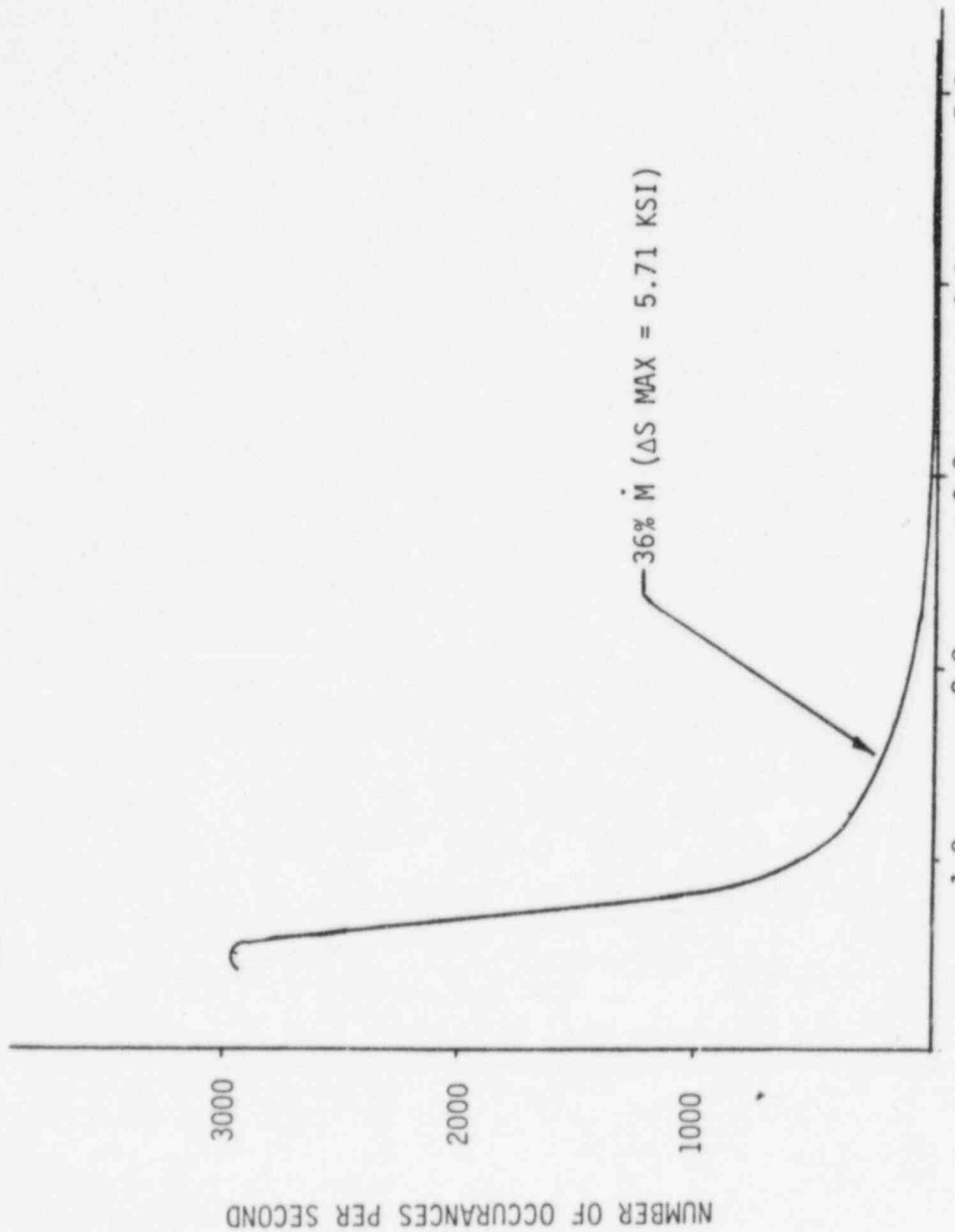
ENGINEERS



RAYLEIGH DISTRIBUTION OF ALTERNATING STRESSES

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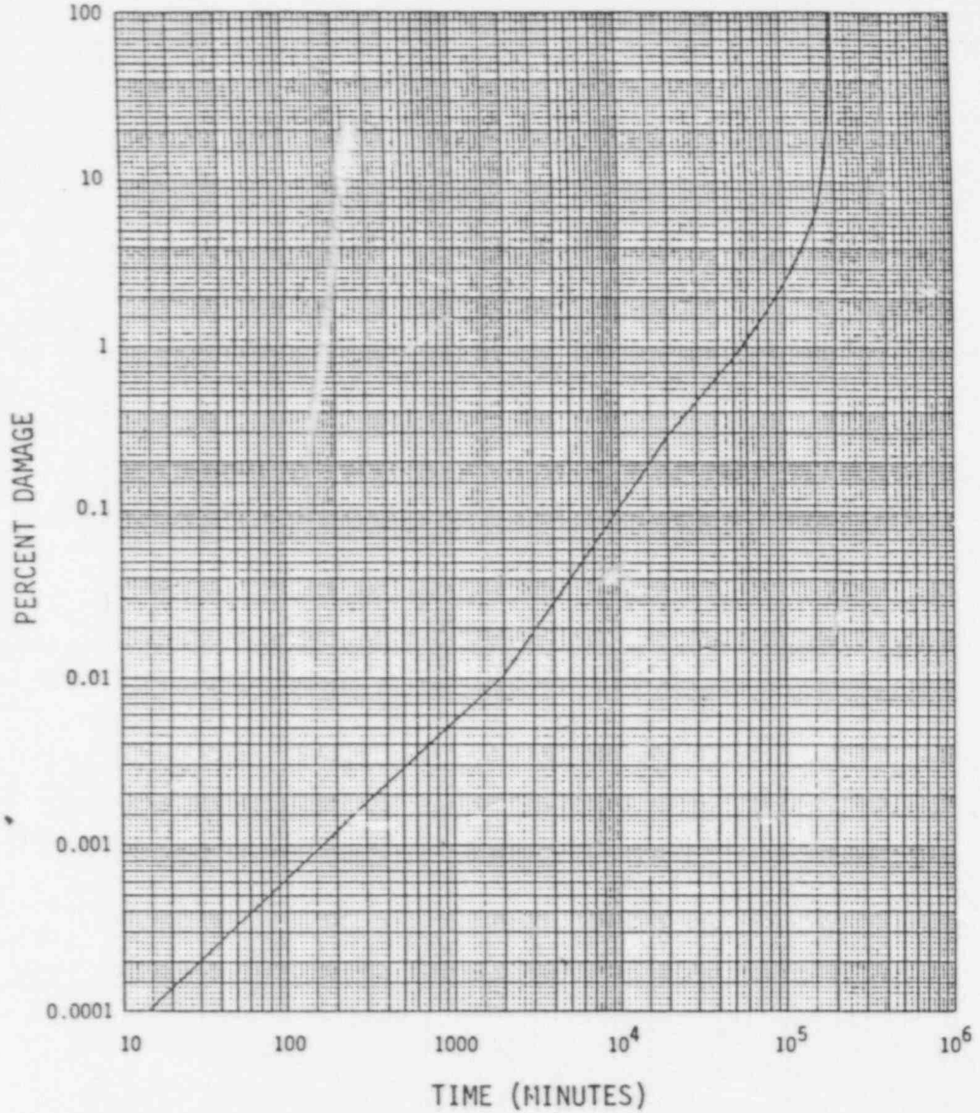

(1" WALL, FULL NOISE)

CALCULATED FATIGUE CRACK GROWTH

VERSUS TIME AT 36% MASS FLOW RATE