ACOUSTIC EMISSIONS DURING CORROSION FATIGUE CRACK GROWTH

by

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PROBLEM

- Crack Detection in Compressed Natural Gas (CNG) Cylinders
- Cylinders Used for Distribution of Industrial Gases
- Dimensions: 43 ft. Long x 22 in. OD x 0.536 in. Thick at 2640 psi
- Material: AISI 4130, Bainite, and 15B30
- Current Practice is to Use Hydrotest at 167 Percent of Operating Pressure Every 5 Years
- Hydrotest is Time Consuming as Cylinders Have to be Disassembled and Placed in a Water Jacket
- Industry is Looking for a Simple NDE Inservice Test for Testing Cylinders

PROGRAM APPROACH

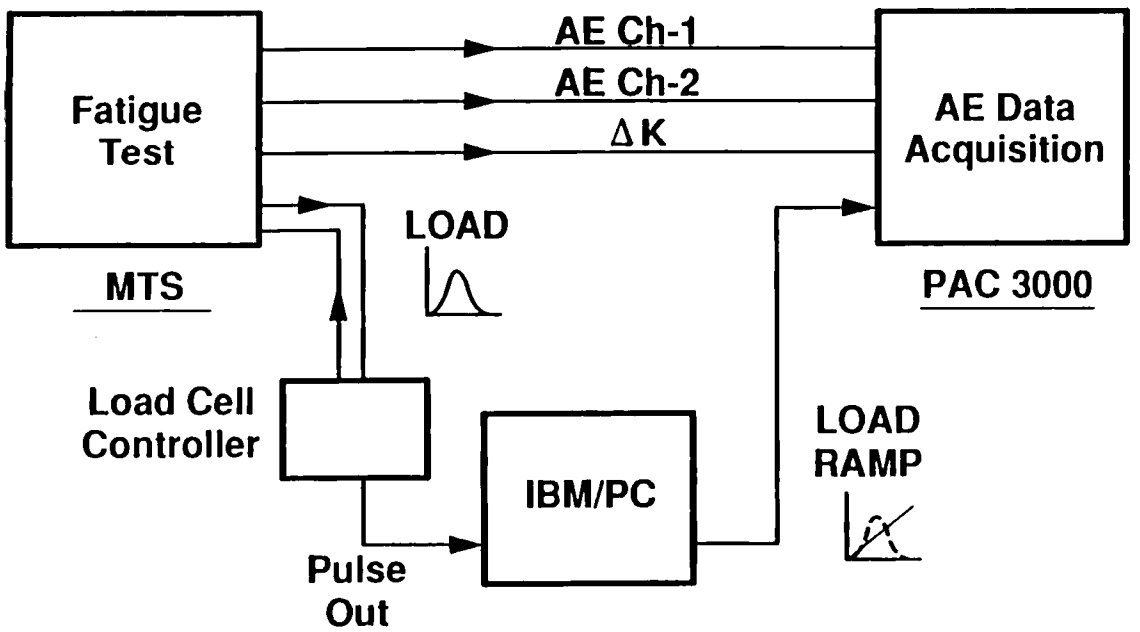
- **Perform Fatigue Tests**
  - Study Acoustic Emission During Crack Growth
  - Measure Crack Growth Properties

    i.e. $\frac{da}{dn} = C\Delta K^n$
- **Fracture Specimens in a Cyclic Load and Monitor AE**
- **Obtain AE Noise Data While Filling the Cylinders**
- **Perform Tests on Cracked Cylinders**
- **Combine Crack Growth Data and AE to Develop a Fracture Control Plan**

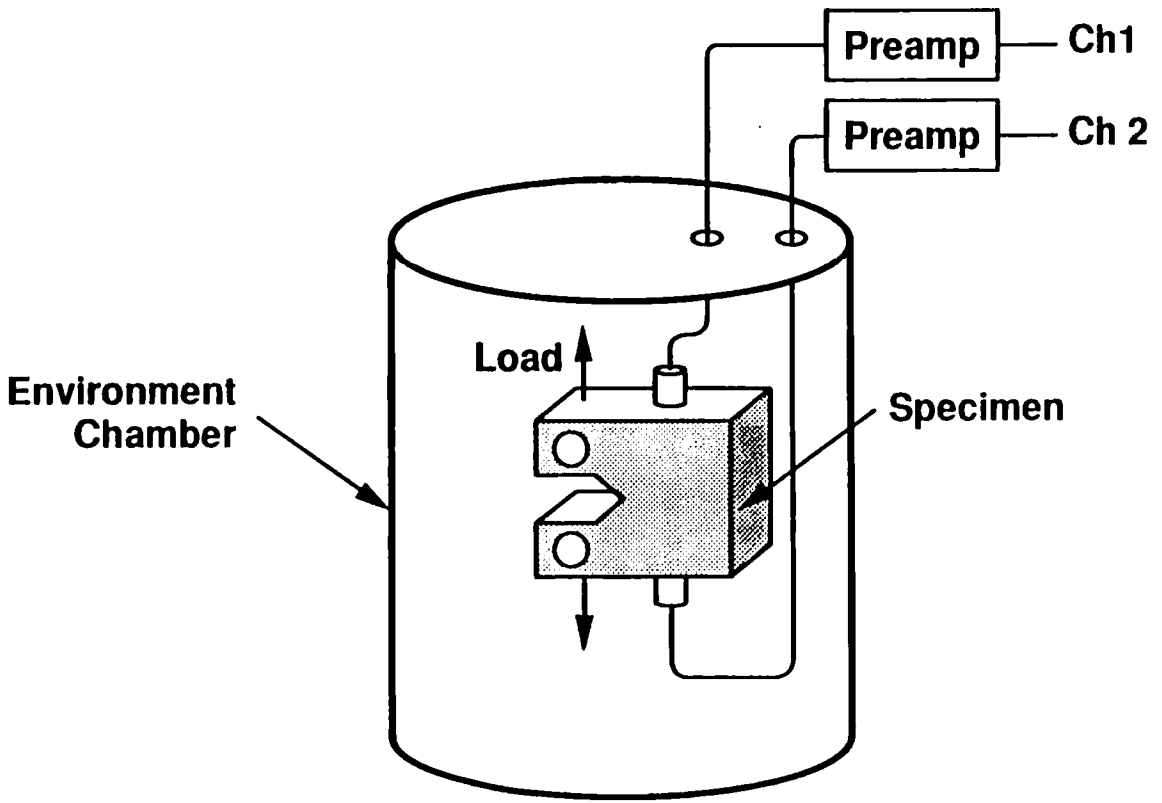
FATIGUE TESTS

- Source of AE
  - Crack Growth
  - Rubbing of Faces During Crack Closure or Opening
  - Growth of Plastic Zone
- Affect of Environment H_2S + CO_2
  Dry vs. Wet
- Affect of Materials: 4130, Bainite, and 15B30
- Affect of Loading Frequency and Load Ratio

AE TEST INSTRUMENTATION



AE TEST



AE DATA OUTPUT

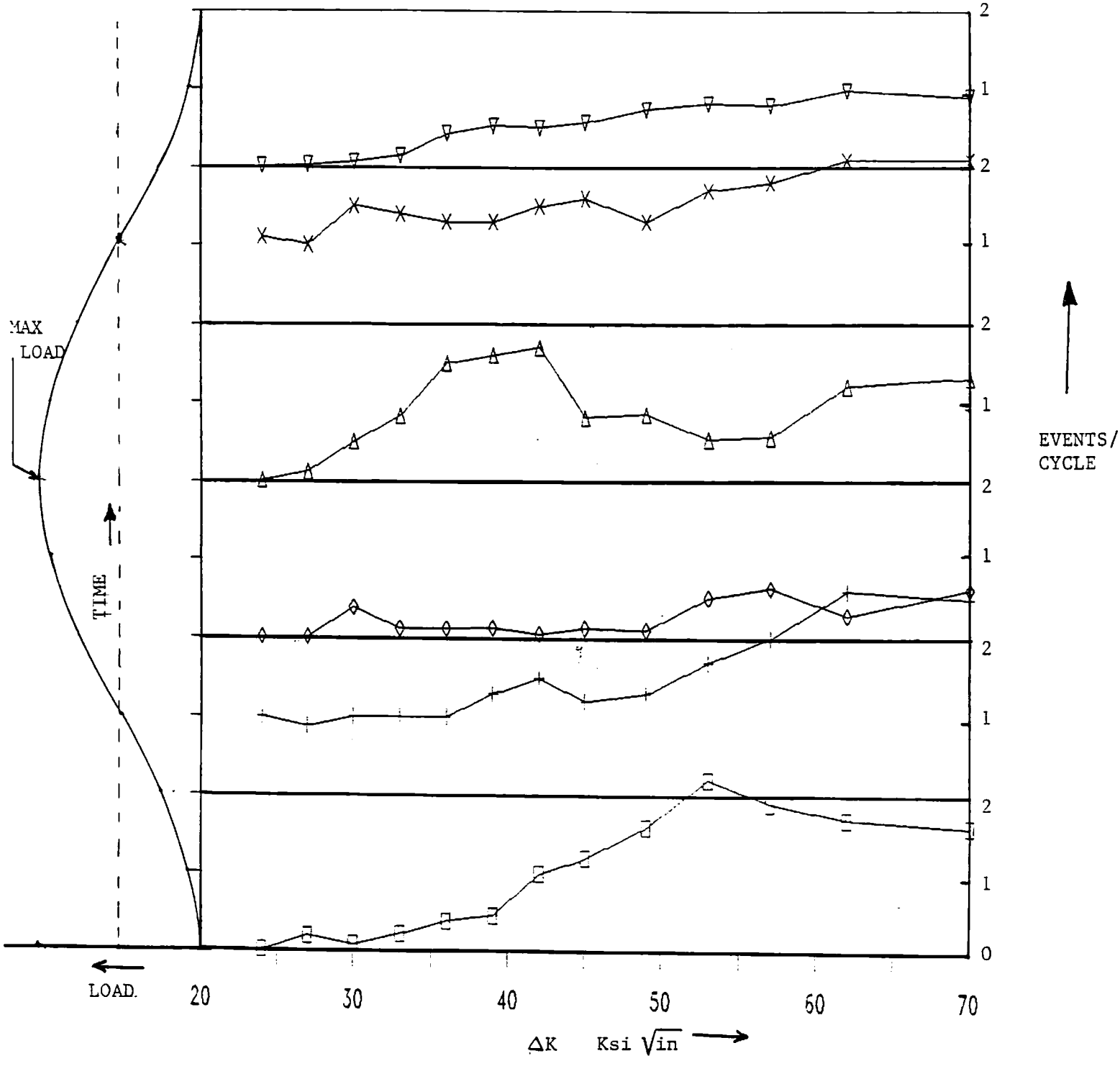
AE Parameters		Fracture Parameters
• Event Rate	VS.	Load Phase
• Amplitude		ΔK

TESTS CONDUCTED

Test No.	Material	Freq. (Hz)	Load Ratio	Environment
2	4130	1	0.1	CO_2 + H_2S
5	4130	1	0.1	CO_2 + H_2S + Water

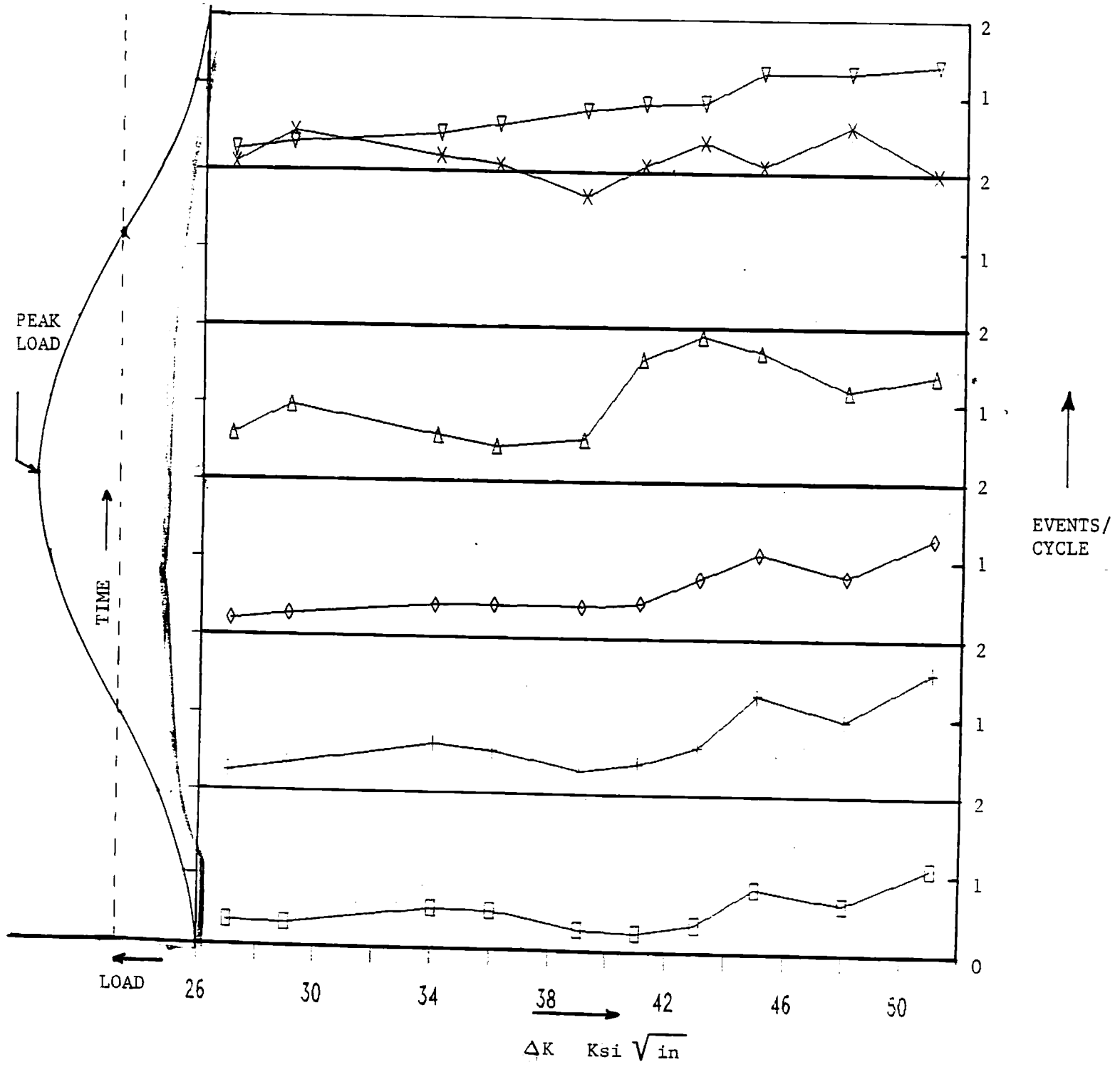
Acoustic Emission Rate from CT Sample

in H2S + CO2



Acoustic Emission Rate from CT Sample

in H2S + CO2 + H2O



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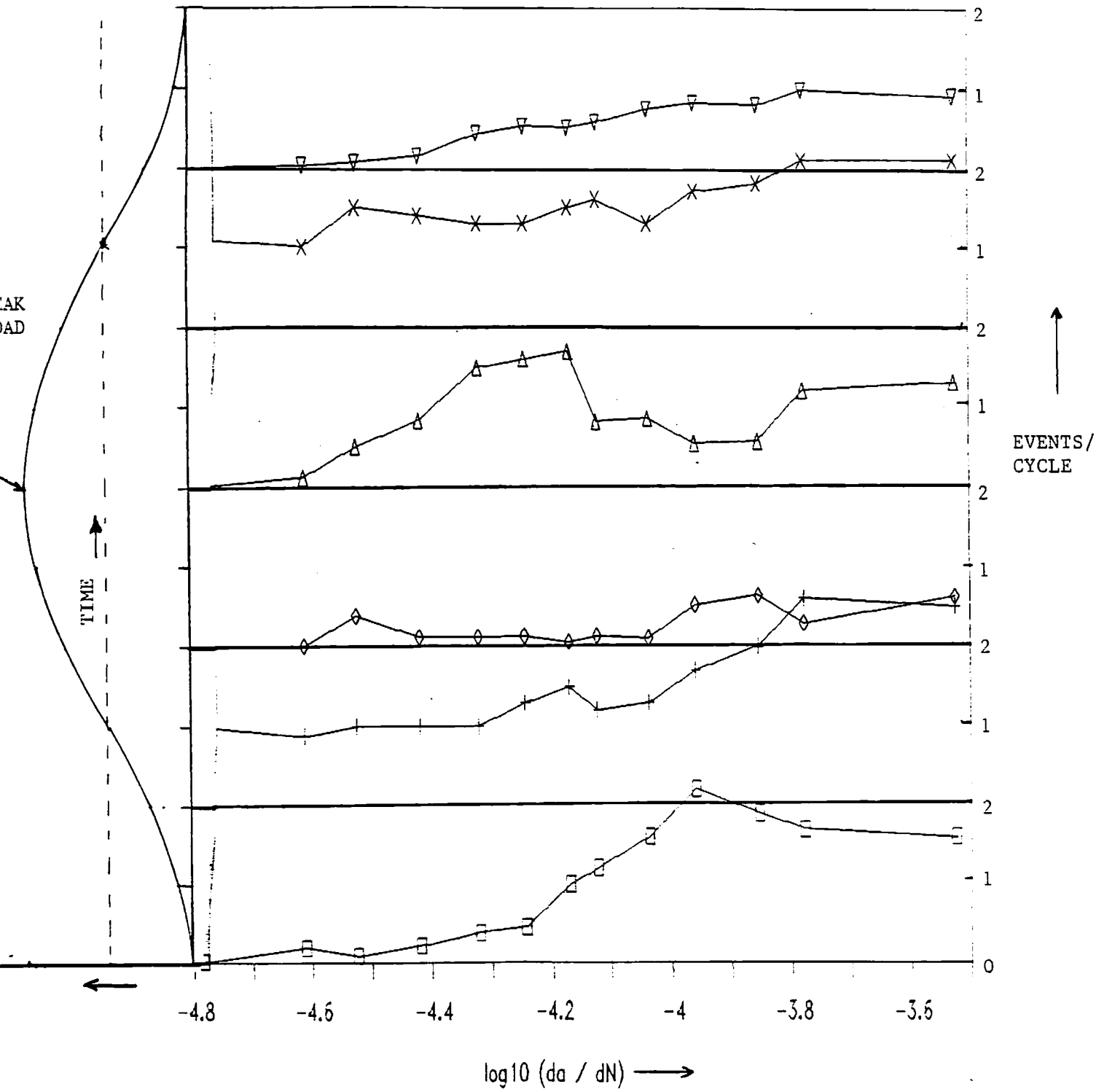

Acoustic Emission Rate from CT Sample

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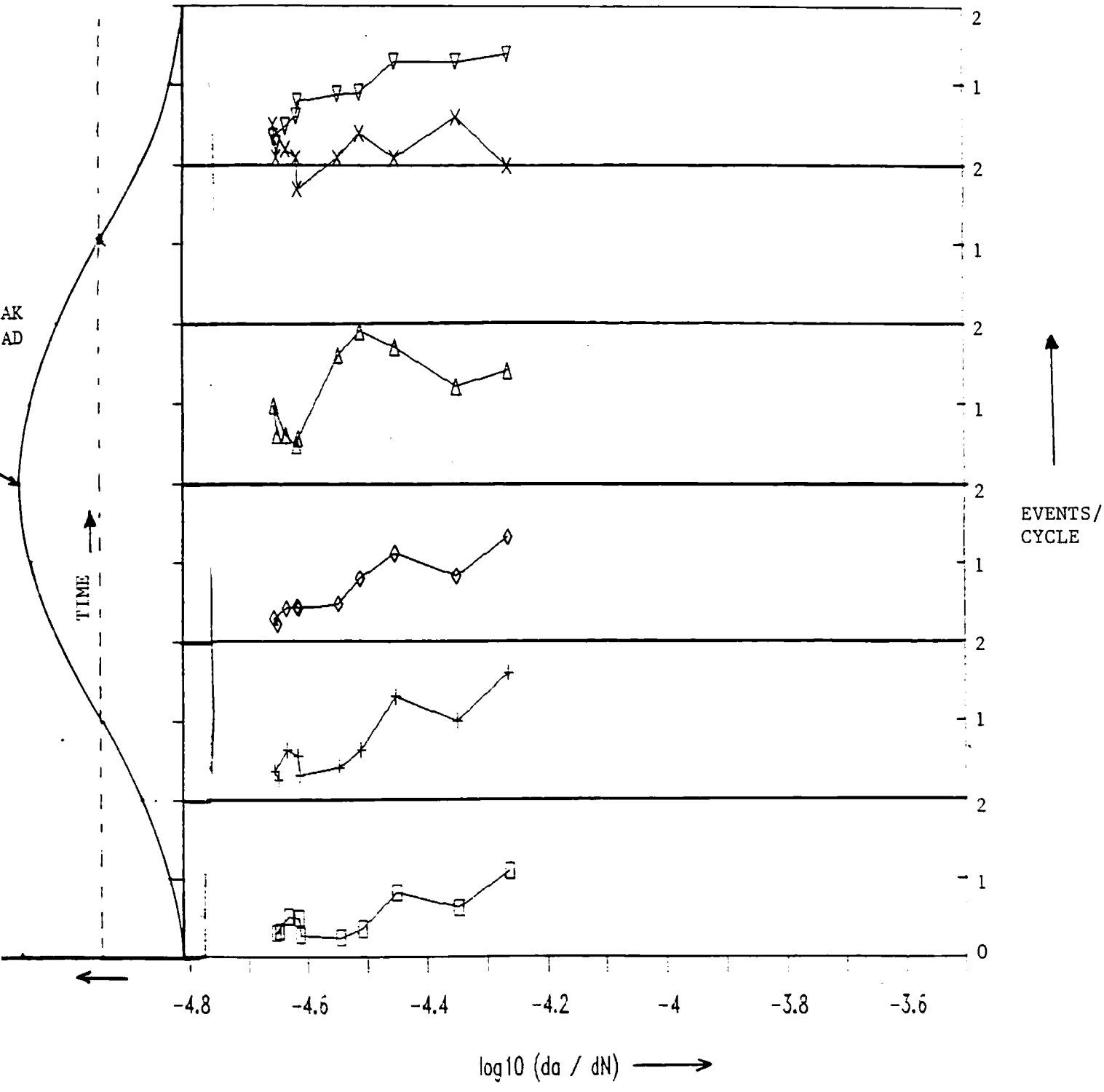
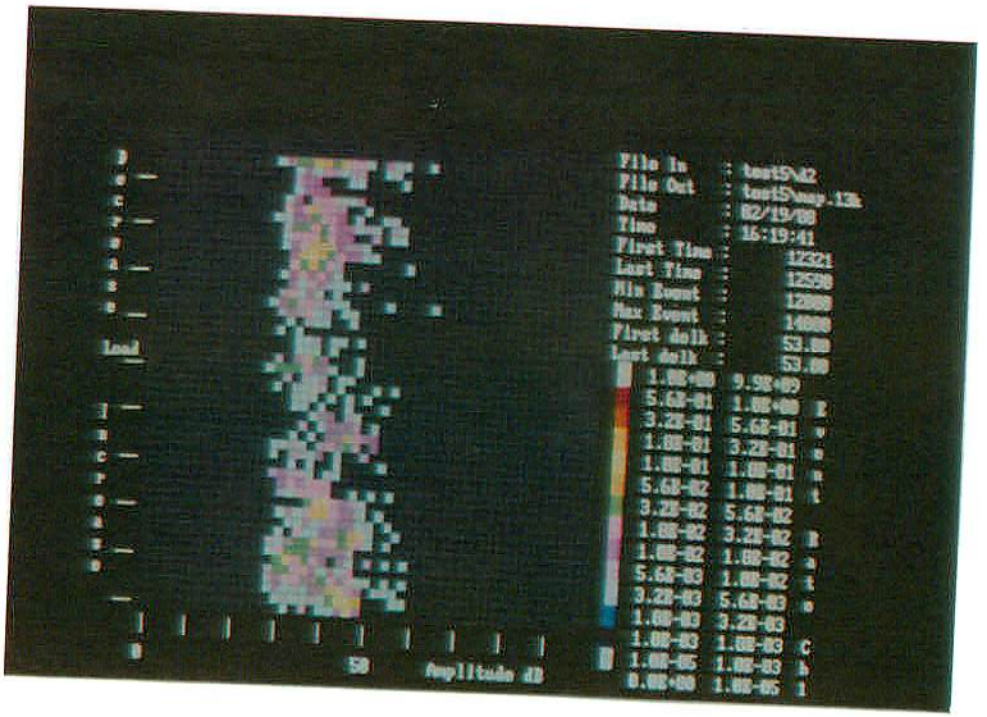


OBSERVATIONS

1. AE IS PRODUCED AT BOTH LOADING AND UNLOADING.
2. AE DURING UNLOADING IS MORE THAN DURING LOADING.
3. EVENT RATE INCREASES WITH ΔK DURING LOADING.
4. AMPLITUDE RANGE OF AE EVENTS DOES NOT VERY SIGNIFICANTLY WITH ΔK.
5. FOR THE SAME CRACK GROWTH RATE, AE RATE IS HIGHER FOR THE AQUEOUS TEST.
6. AE AT PEAK LOAD DOES NOT HAVE THE HIGHEST AMPLITUDE.

AE DURING FATIGUE TESTS

MOST OF THE AE IS LESS THAN 50 db



CONCLUSIONS

1. MOST OF THE ACOUSTIC EMISSION IS PRODUCED BY CRACK RUBBING.

2. AE FROM CRACK GROWTH CAN NOT BE SEPARATED BY USING AN AMPLITUDE THRESHOLD.

Presented at 33rd Acoustic Emission Working Group (AEWG) Meeting
on January 16-19, 1990 at the University of California at Berkeley.

ABSTRACT

"Acoustic Emission Testing in Natural Gas Vehicle Cylinders"
by John J. Hanley, Anmol S. Birring, Steve J. Hudak, Martin L. Bartlett

The feasibility of acoustic emission (AE) testing to inspect natural gas vehicle (NGV) cylinders for cracks is being evaluated. Presently, hydrostatic testing depressurizing the cylinders while they are still in the vehicles can quicken the inspection. Laboratory fatigue and fracture tests have been done to study the mechanisms that produce AE from cracks and to record characteristics of the AE signals. Background noise measurements were also obtained while filling and releasing gas from NGV cylinders. This was necessary in assessing the detectability of the AE signals above typical background noise. Some preliminary AE testing has begun on a hydraulically pressurized cylinder with a fatigue crack initiated from an EDM notch. A laboratory system capable of detecting and locating the source of the AE has been developed.

This project was funded by Gas Research Institute (GRI), Contract No. 5086-252-1440, managed by Ted A. Williams of GRI's Environment and Safety Division.