

REPORT DOCUMENTATION PAGE

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Please see
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12. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for public release; distribution unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

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MEMORANDUM FOR PR (In-House Publication)

FROM: PROI (TI) (STINFO)

06 March 2000

SUBJECT: Authorization for Release of Technical Information, Control Number: **AFRL-PR-ED-TP-2000-044**
Miller, Timothy C., Liu, C.T., "Pressure Effects and Fracture of a Rubbery Particulate Composite"

Society for Experimental Mechanics (SEM) IX Internat'l Congress (Statement A)
(Orlando, FL 5-8 Jun 00)(Deadline: 04 Jun 2000)

1. This request has been reviewed by the Foreign Disclosure Office for: a.) appropriateness of distribution statement, b.) military/national critical technology, c.) export controls or distribution restrictions, d.) appropriateness for release to a foreign nation, and e.) technical sensitivity and/or economic sensitivity.

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Comments: _____

APPROVED/APPROVED AS AMENDED/DISAPPROVED

ROBERT C. CORLEY (Date)
Senior Scientist (Propulsion)
Propulsion Directorate



The Effects of Pressure on Fracture of a Rubbery Particulate Composite

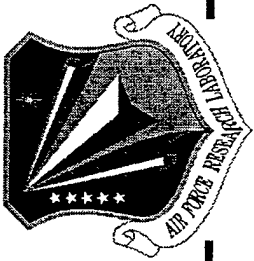
T. C. Miller and C. T. Liu

Air Force Research Laboratory
Edwards Air Force Base, California

SEM IX International Congress

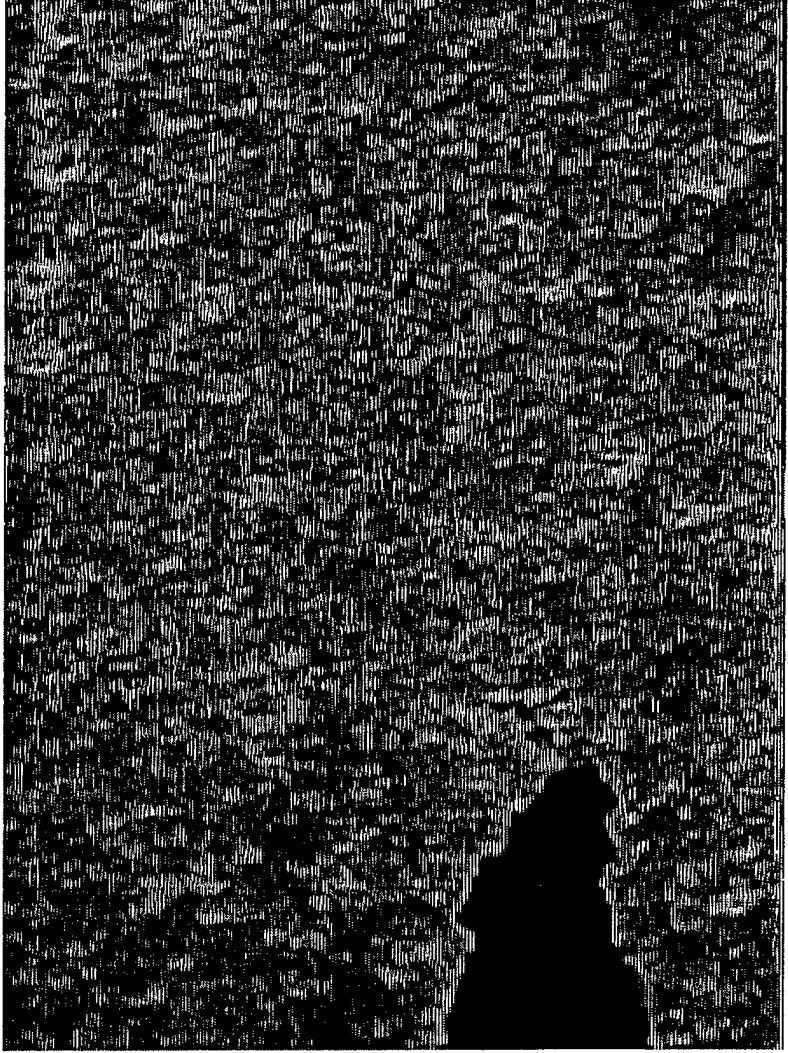
Orlando, Florida

June 5-8, 2000



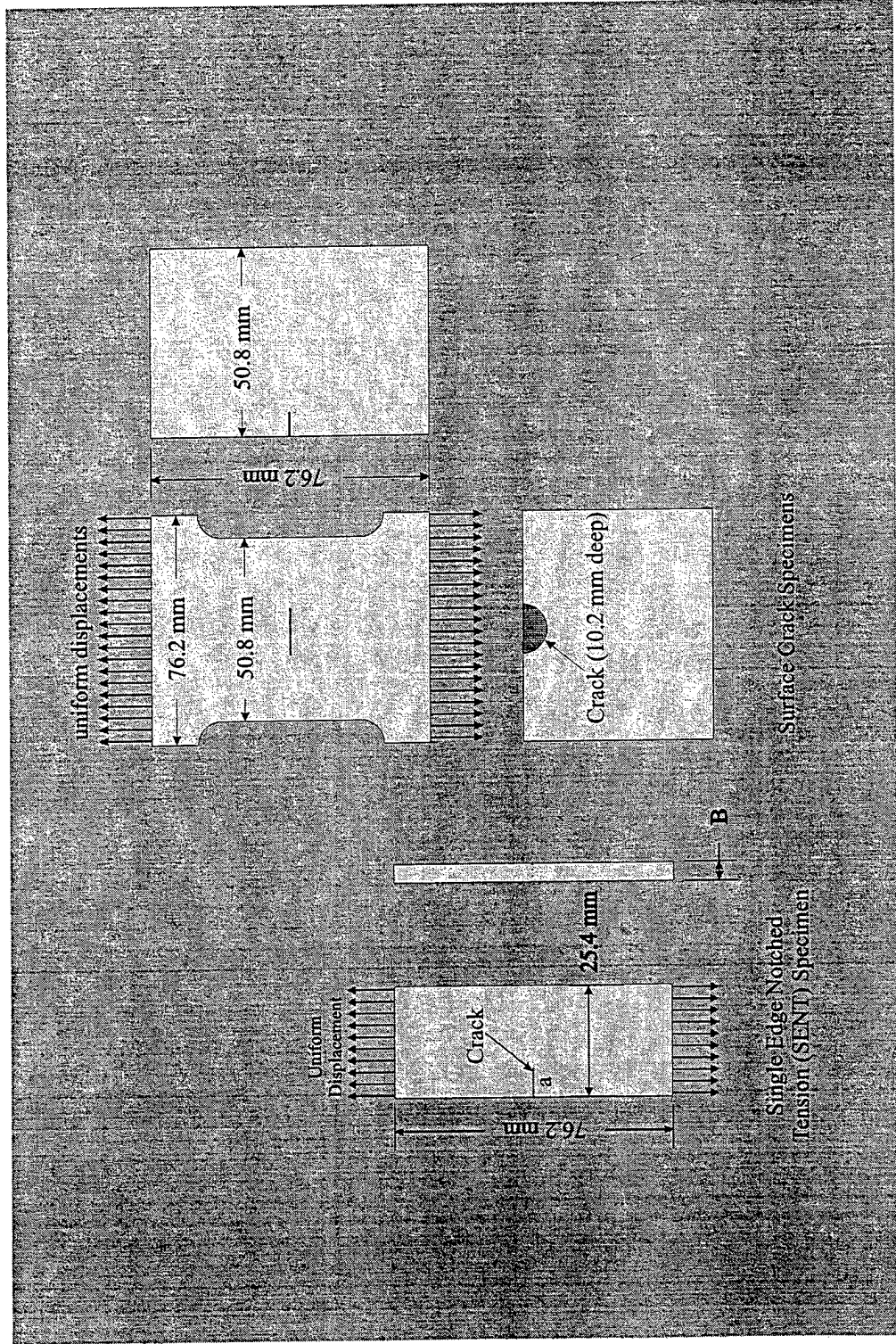
Introduction

- Need for studying effect of pressure
- Materials involved





Geometries Used in Testing





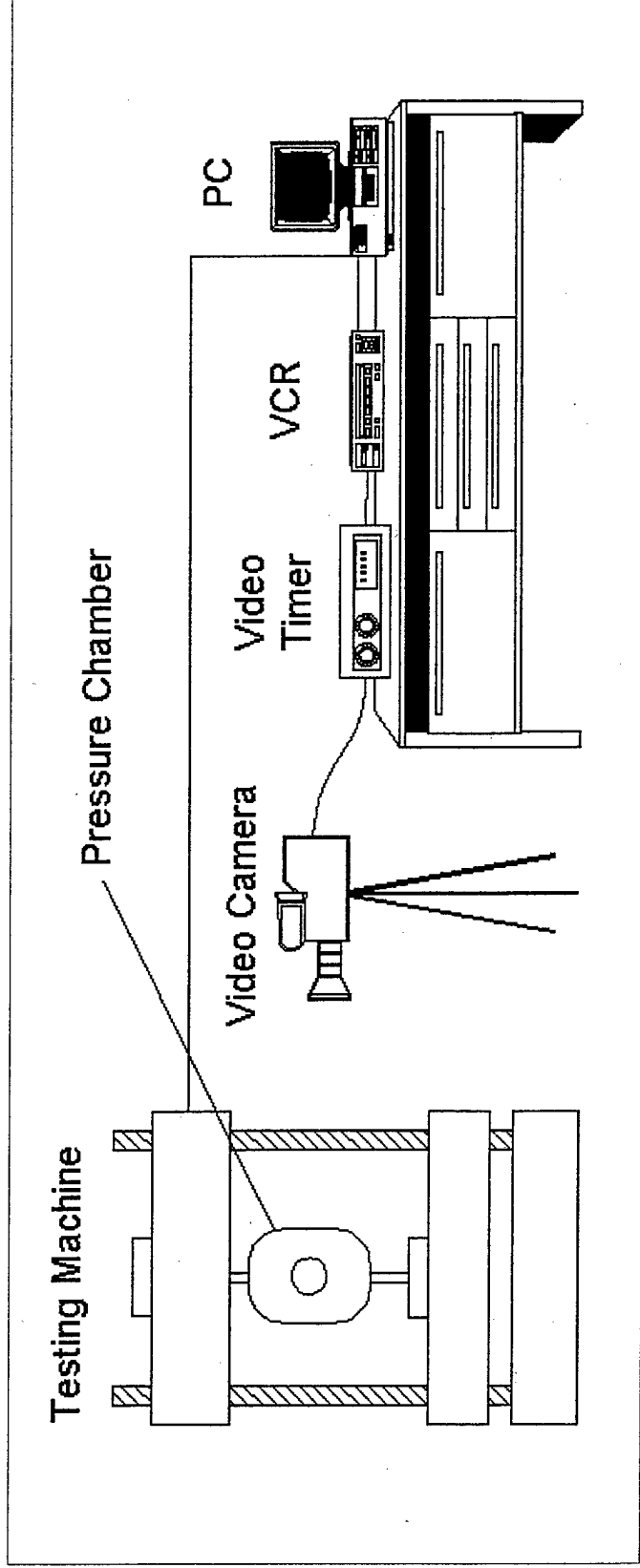
Test Matrix for Pressure Tested Specimens

Number of SENT specimens tested	B [mm]		2.54	7.62	12.70
	a_0 [mm]				
Number of surface crack specimens	5.08	3	3	3	3
	12.70	3	3	3	3
	38.10	3	3	3	3



Experimental Method

- Test pressure of 6894 kPa
- Constant strain rate of 0.067 mm/mm/min.
- Room temperature
- Both single edge notched tension (SENT) and surface cracked specimens were tested





Modeling Issues

- Displacement controlled boundary conditions
- Use of hybrid elements for incompressible materials
- Domain integral method $\Rightarrow J \Rightarrow K_{ii}$
- Geometric correction factor from K_{ii} / $[\sigma(\pi a)^{1/2}]$

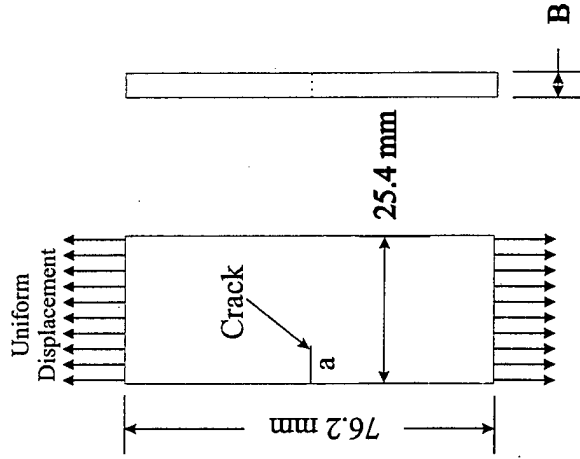


Geometric Correction Factors Used

SENT Geometry (a/w ratio varies)

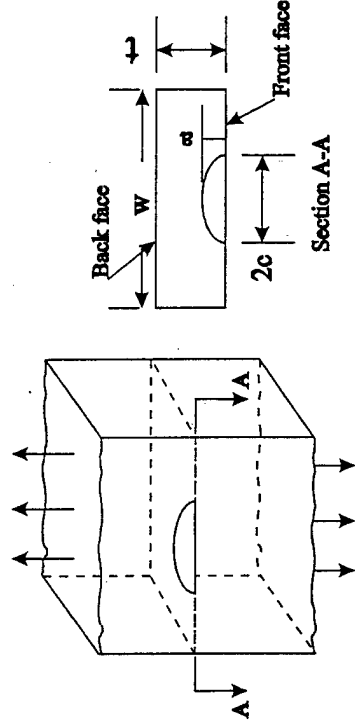
$$K_I = \sigma \sqrt{\pi a} f(a/w)$$

$$f(a/w) = 2.694 \left(\frac{a}{w}\right)^3 - 1.949 \left(\frac{a}{w}\right)^2 + 1.327 \left(\frac{a}{w}\right) + 1.008$$



Surface Crack Geometry (fixed crack geometry)

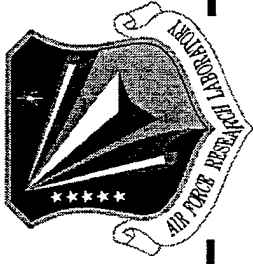
$$K_I = \sigma \sqrt{\pi a} (0.6720)$$





Results

- Determination of stress intensity factor at growth initiation
- Determination of subsequent crack growth rate
- Comparisons with ambient pressure data



The Process of Crack Growth Initiation

- Definition of initiation toughness: the *fracture initiation toughness* is defined as the stress intensity factor at the point in time at which the crack begins actual growth
- Prior to this point, significant blunting may occur
- Substantial crack growth can also occur
- Use of videotape images to determine onset of crack growth
- Determination of initiation toughness based on test machine data and correction factors

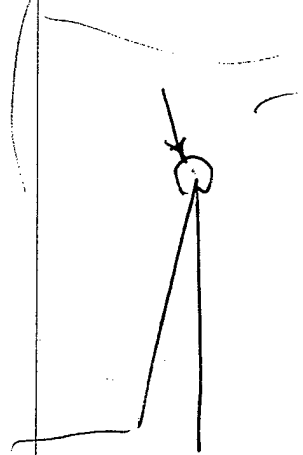


Determining Initiation Toughnesses

Initiation toughness is found using regression method

$$K_I = \sigma \sqrt{\pi a} f(a/w)$$

$$\sigma = \frac{K_I}{\sqrt{\pi a} f(a/w)}$$



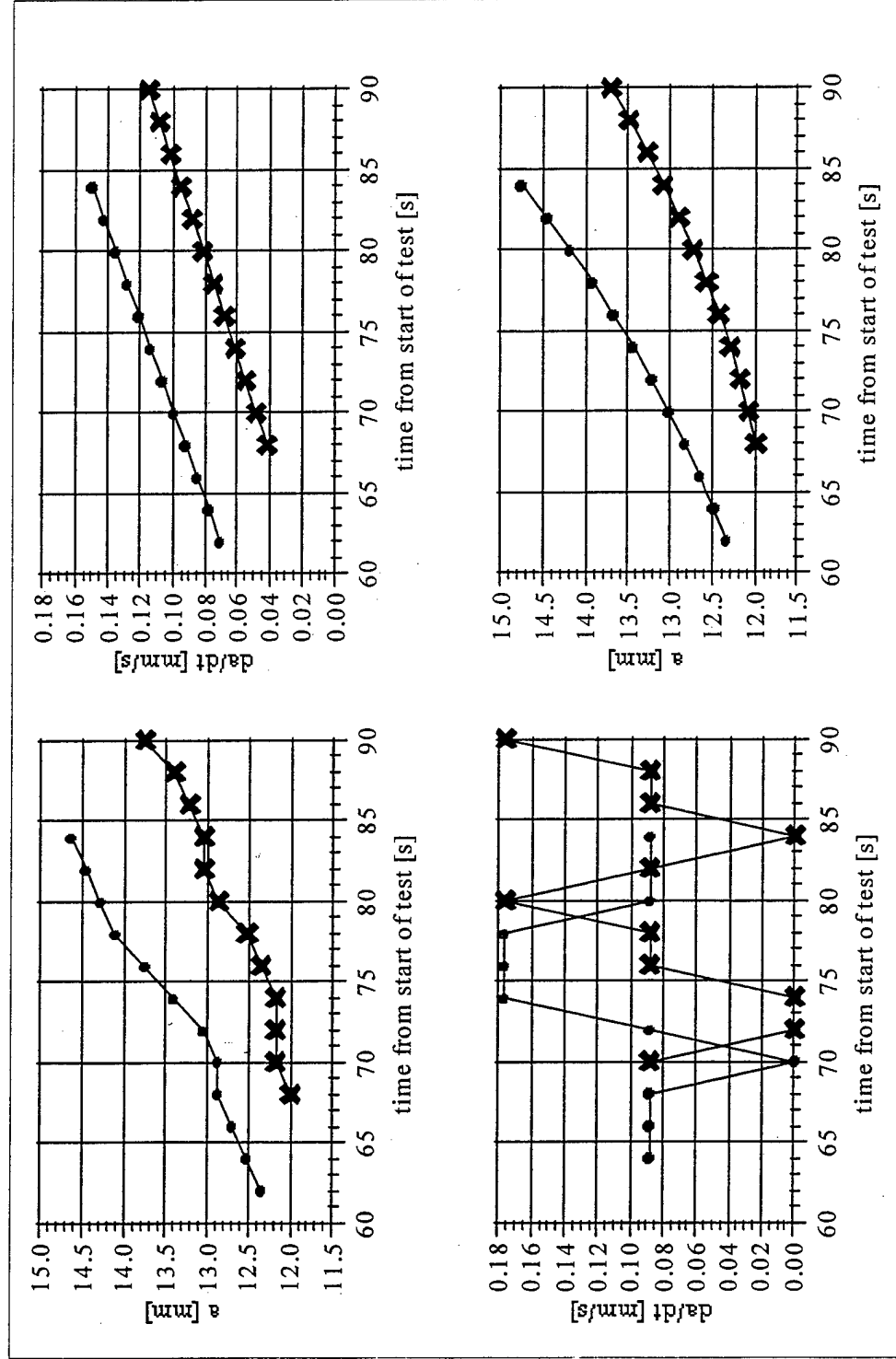


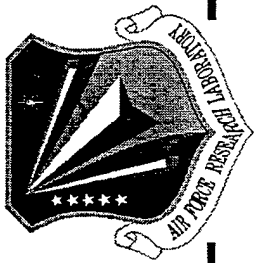
Complications in Determining Crack Growth Rates

Growth Rates

Secant method

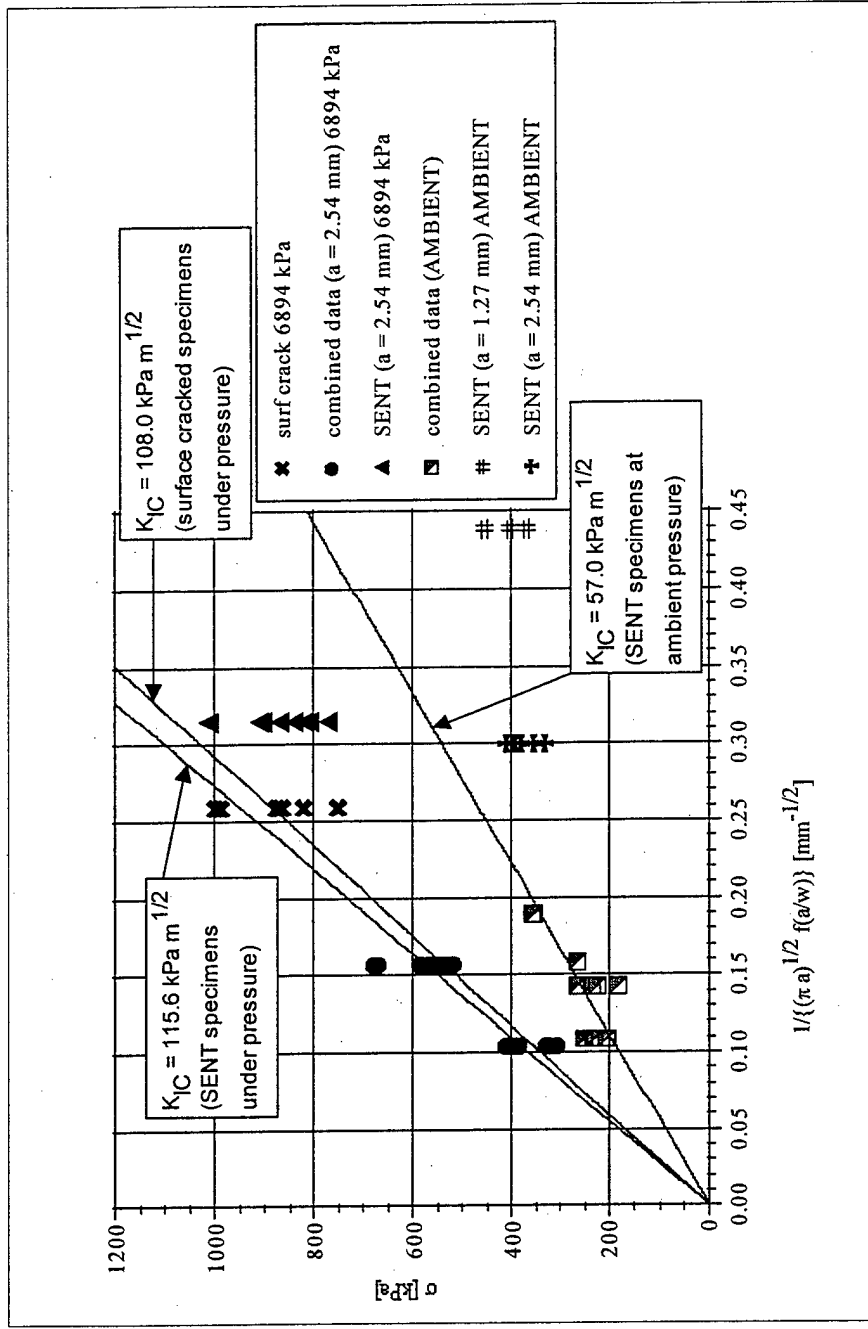
Polynomial method





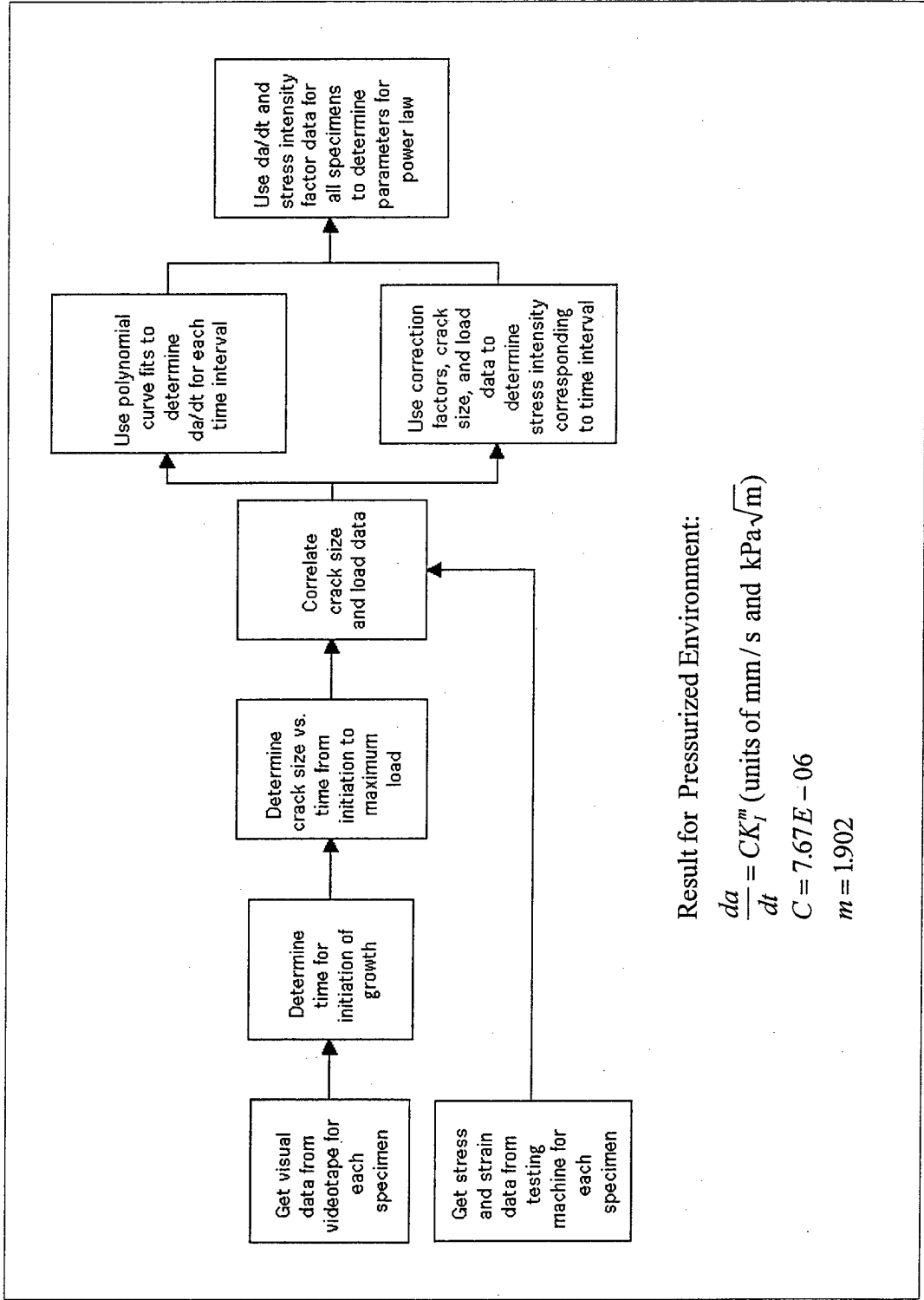
Initiation Toughness Results

- Results give approximate threshold crack size
- Effect of pressure is to elevate initiation toughness
- SENT and surface cracked specimens give similar results





Determining Crack Growth Rates



Result for Pressurized Environment:

$$\frac{da}{dt} = CK_I^m \text{ (units of mm/s and kPa}\sqrt{\text{m}})$$

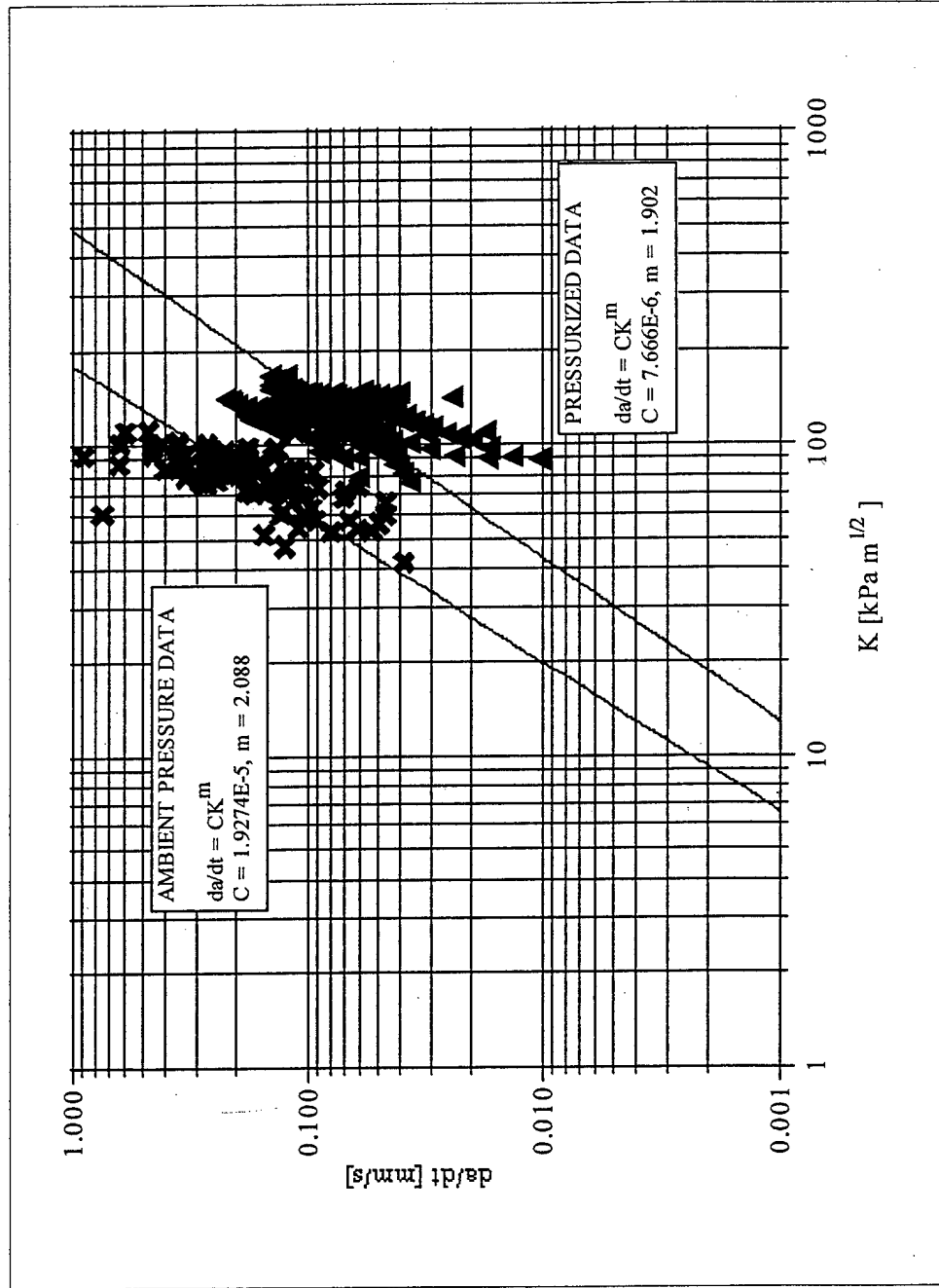
$$C = 7.67E - 06$$

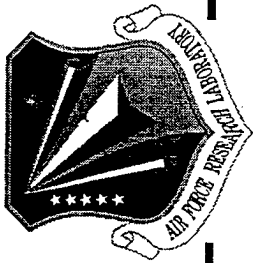
$$m = 1.902$$



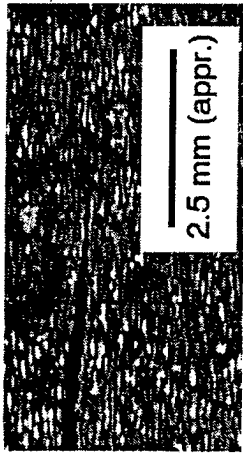
Crack Growth Results

Effect of pressure is to slow crack growth

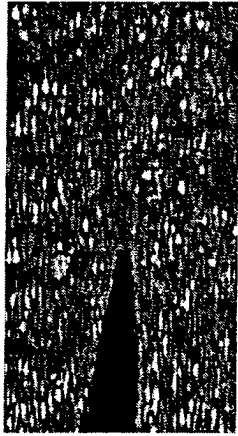




Crack Initiation and Growth in a Rubbery Particulate Composite



Crack just after loading begins



Continued loading



Continued loading with blunting



Close-up of crack at initiation of growth



Continued growth



Crack after extensive growth

Recommendations for Future Work

- Examination of short crack fracture phenomena
 - ▶ (Why do the short cracks behave differently?)
- Surface crack growth analysis
 - ▶ (Find a way to measure crack depth and width in pressurized environment)
- Link between microstructure and pressure effect
 - ▶ (Establish a connection between pressure effect and microstructural phenomena such as void nucleation, growth, and coalescence) ←