REPORT DOCUMENTATION PAGE

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing this collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing burden, to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondent should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.

1. REPORT DATE (DD-MM-YYYY) 2. REPORT TYPE 3. DATES COVERED (From - To) Technical Papers

4. TITLE AND SUBTITLE Please see attached

5a. CONTRACT NUMBER
5b. GRANT NUMBER
5c. PROGRAM ELEMENT NUMBER
5d. PROJECT NUMBER Q302
5e. TASK NUMBER M160
5f. WORK UNIT NUMBER 346120

6. AUTHOR(S)

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Air Force Research Laboratory (AFMC)
AFRL/PRS
5 Pollux Drive
Edwards AFB CA 93524-7048

8. PERFORMING ORGANIZATION REPORT

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Air Force Research Laboratory (AFMC)
AFRL/PRS
5 Pollux Drive
Edwards AFB CA 93524-7048

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S NUMBER(S) Please see attached

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:

a. REPORT b. ABSTRACT c. THIS PAGE
Unclassified Unclassified Unclassified

17. LIMITATION OF ABSTRACT

18. NUMBER OF PAGES 19a. NAME OF RESPONSIBLE PERSON
19b. TELEPHONE NUMBER
Unclassified
(661) 275-5015
Leilani Richardson

Standard Form 298 (Rev. 8-98) Prescribed by ANSI Std. 239.18
MEMORANDUM FOR PRS (In-House Publication)

FROM: PROI (STINFO)  

Miller, T.C., “Crack Growth Rates in a Propellant Under Various Conditions” (VuGraphs)

SEM Annual Conf. on Experimental Mechanics  
(Portland, OR, 4-6 June 2001) (Deadline: 16 May 2001)  

(Statement A)
PRESSURE EFFECTS AND SURFACE CRACKS IN A RUBBERY PARTICULATE COMPOSITE

04 Jun 01

T. C. Miller
Engineer
Propulsion Directorate
Air force research laboratory
Introduction

- Cracks develop during manufacturing, handling, and storage of rubbery particulate composites
- Previous tests used single edge notched tension (SENT) specimens. In this work, surface cracked specimens are compared with the previous results
- Results for ambient and pressurized test conditions are also compared
Rubbery Particulate Composite Experiences
Pressurization During Service Life

• Pressure affects fracture behavior by suppressing void nucleation, growth, and coalescence

• Both initiation of growth and subsequent growth rates are affected

• Applying ambient test data can result in overly conservative predictions
Experimental Procedure

- Specimen geometries and test matrix
- Test conditions
- Equipment
Specimen Geometries and Test Matrix

- Razor blade cutting devices used to form initial cracks
- Side cutouts needed for surface cracked specimens
- For SENT specimens, thickness and initial crack size were varied

<table>
<thead>
<tr>
<th>Number of SENT specimens tested</th>
<th>B [mm]</th>
<th>2.54</th>
<th>7.62</th>
<th>12.70</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.06</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>12.70</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>38.10</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

Number of surface cracked specimens tested: 6
Test Conditions

- Ambient temperature
- Ambient pressure and 6895 kpa pressure (nitrogen gas)
- Constant strain rate tests (0.067 mm/mm/min)
Equipment

- Testing machine
- Pressure test chamber
- Videotape equipment
Fixture Is Used to Apply Uniform Displacement Boundary Conditions
Analysis of Data

- Step 1: data acquisition
- Step 2: determining $da/dt$ and $K_i$
- Step 3: relating $da/dt$ and $K_i$
Analysis of Data
Step 1: Data Acquisition

- Use videotape to determine initiation of growth
- Use videotape to measure crack size vs. Time from initiation until maximum load
  - For surface cracks, depth could not be directly measured
- Use test machine data to determine loads at these same times
Analysis of Data
Step 2: Determining Da/dt and $K_i$

- Use load and geometric correction factors to determine $K_i$ at these same times
  - Geometric correction factors come from finite element analyses
  - For surface cracks, semicircular crack front is assumed throughout growth

- Use crack size vs. Time data to determine da/dt at these same times
  - Crack speed is nonuniform due to microstructural phenomena
  - Polynomial curve fits of a vs. T are used; derivatives give growth rate
Nonuniform Crack Growth

Introduction
Experimental Procedure
Analysis of Data
Results and Discussion
Summary and Conclusions
Analysis of Data
Step 3: Relating $\frac{da}{dt}$ and $K_l$

- $\frac{da}{dt}$ and $K_l$ can now be related for each test:

$$\frac{da}{dt} = CK_l^m$$
Results and Discussion

- Ambient vs. Pressurized test condition comparisons
- SENT and surface cracked specimen comparisons
Ambient Vs. Pressurized Conditions

- Pressure causes crack growth to slow
- Microstructural explanation
- Implication: ambient data may be overly conservative for pressurized service conditions
SENT and Surface Cracked Specimen Comparisons

- Similar growth rates found for both geometries
- Implication: SENT data can be used instead of testing with surface cracked specimens
Combination of All Data
Summary and Conclusions

- **Summary:** this work has investigated the effect of pressure on fracture behavior of a rubbery particulate composite, and has compared the results for two different crack geometries under pressure. Pressure delays the onset of crack growth and slows the subsequent growth rate. The results for the two specimen geometries tested under pressure (SENT and surface cracked specimens) show good agreement.

- **Conclusions:**
  - Pressure inhibits the start of crack growth and slows the subsequent crack growth
  - Pressurized test data should be used to test for pressurized service conditions
  - SENT specimens can be used rather than surface cracked specimens

*For the material and crack geometry considered in this study*.