Please see attached
MEMORANDUM FOR PRS (In-House Publication)

FROM: PROI (STINFO) 29 May 2001

Liu, C.T., “Investigating Cumulative Damage in a Highly Filled Polymeric Material (VuGraphs)”

2001 ASME Summer Meeting
(San Diego, CA, 27-29 June 01) (Deadline: 21 June 01)

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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APPROVED/APPROVED AS AMENDED/DISAPPROVED

PHILIP A. KESSEL Date
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Investigating Cumulative Damage in a Highly Filled Polymeric Material

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Objectives

- Investigate the Effects of Strain Rate and Cyclic Loading on Cumulative Damage in a Highly Filled Polymeric Material.

- Determine the Relationship between the NDE Damage Parameter and material Properties.
Specimen Geometry

- 5 in
- 3 in
- 0.375 in
- R = 0.5 in
- 0.375 in
Stress-Strain Curves as Functions of Strain Rate

\[ \varepsilon = 0.5 \text{ min}^{-1} \]
\[ \varepsilon = 0.05 \text{ min}^{-1} \]
\[ \varepsilon = 0.005 \text{ min}^{-1} \]
Relative Change in Acoustic Attenuation Versus Strain
(constant strain rate loading)

Delta Relative Attenuation, $\Delta \alpha$
$\text{dB/cm}$

- $\bullet \, \xi = 0.005 \text{ min}^{-1}$
- $\circ \, \xi = 0.05 \text{ min}^{-1}$
- $\triangle \, \xi = 0.5 \text{ min}^{-1}$
Damage Parameters Versus Log Time at Different Strain Rates

Damage Parameter, N(t)

Log Time, Time in Min.

- 0.02 in/mln
- 0.2 in/mln
- 2 in/mln
- 20 in/min
Damage Parameters Versus Time at Different Strain Rates

\[ N(t) = \left[ \int_0^t \sigma^\beta dT \right]^{1/\beta} \]

- \( \sigma \) is the stress
- \( t \) is time
- \( \beta \) is the strain rate

Graph showing the relationship between damage parameter \( N(t) \) and time in minutes for different strain rates:
- 0.02 in/min
- 0.2 in/min
- 2 in/min
- 20 in/min
Material Behavior is Initially Linear and Incompressible; Following Dewetting, Response is Nonlinear and Compressible
Relative Attenuation of Acoustic Energy Versus Volume Dilatation

(monotonic loading)

Log $Y = 1.385868 \times \log X + 0.274528$  $R = 0.992702$
Cycle Stress-Strain Behavior and Relative Change in Acoustic Attenuation Under Cycle Loading Condition

Cyclic Stress-Strain Curves

Relative Change in Acoustic Attenuation Versus Strain
Ratio of Hysteresis Energy to Total Energy Versus Total Energy at Different Strain Rates

- 10 in/min
- 1 in/min
- 0.1 in/min

\[ \frac{E_H}{E_T} \]

- Total Energy \( E_T \)
- Hysteresis Energy \( E_H \)

\[ E_T, \text{ in} - \text{lb} \over \text{in}^3 \]
Conclusions

- Strain rate has a large effect on damage intensity.
- Strain rate has no significant effect on the critical damage intensity.
- A good correlation exists between the NDE damage parameter and the material property.
- The cyclic stress-strain curves exhibit the typical stress softening phenomena.