REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

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 this 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. Respondents 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)*
03-01-2004

2. REPORT TYPE
Technical Paper (View Graph)

3. DATES COVERED *(From - To)*

4. TITLE AND SUBTITLE

Monitoring Micro-Structural Evolution and Crack Formation in a Solid Propellant under Incremental Strain Condition – Using Digital Radiograph X-Ray Techniques

5a. CONTRACT NUMBER
F04611-99-C-0025

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

C. T. Liu, Lee M. Klynn, Jay D. Thompson

5d. PROJECT NUMBER
2302

5e. TASK NUMBER
0378

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

ERC Incorporated
555 Sparkman Drive
Huntsville, AL 35816-0000

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Air Force Research Laboratory (AFMC)
AFRL/PRSB
4 Draco Drive
Edwards AFB CA 93524-7160

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S NUMBER(S)
AFRL-PR-ED-VG-2004-049

12. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for public release; distribution unlimited.

13. SUPPLEMENTARY NOTES
JANNAF Nondestructive Evaluation Subcommittee Meeting (NDES)
New Orleans, LA, 29 Mar – 02 Apr 2004

14. ABSTRACT

20040503 189

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
					Linda Talon
a. REPORT	b. ABSTRACT	c. THIS PAGE	A	10	19b. TELEPHONE NUMBER *(include area code)*
Unclassified	Unclassified	Unclassified			(661) 275-5865

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. 239.18

Monitoring Micro-Structural Evolution and Crack Formation in a Solid Propellant under Incremental Strain Condition-Using Digital Radiograph X-Ray Techniques

C. T. Liu
AFRL/PRSM
10 E. Saturn Blvd.
Edwards AFB CA 93524-7680

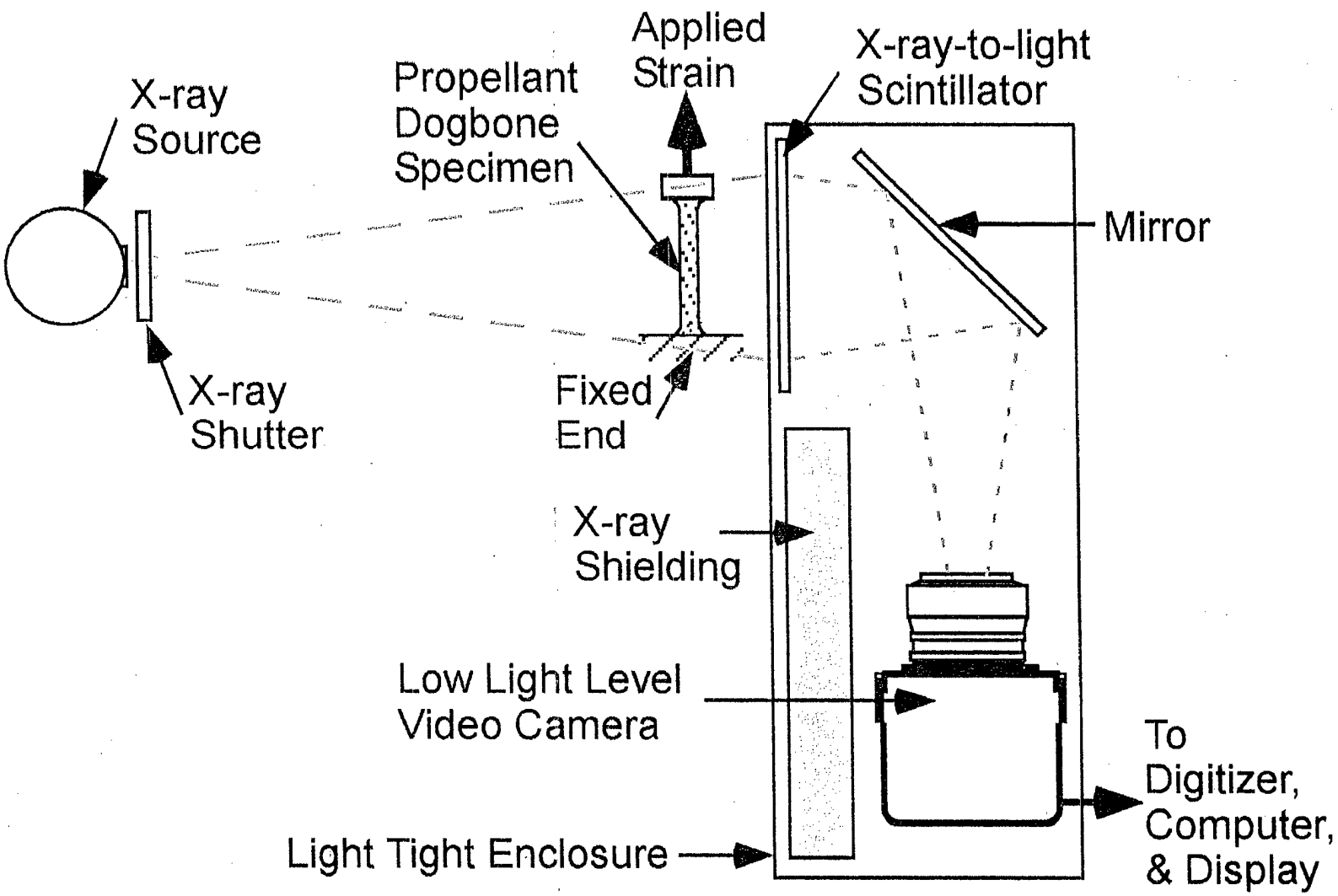
Lee M. Klynn & Jay D. Thompson
Lockheed Martin
Advanced Technology Center
3251 Hanover St.
Palo Alto, CA 91356

Distribution A:
Approved for Public Release; distribution unlimited

Objective

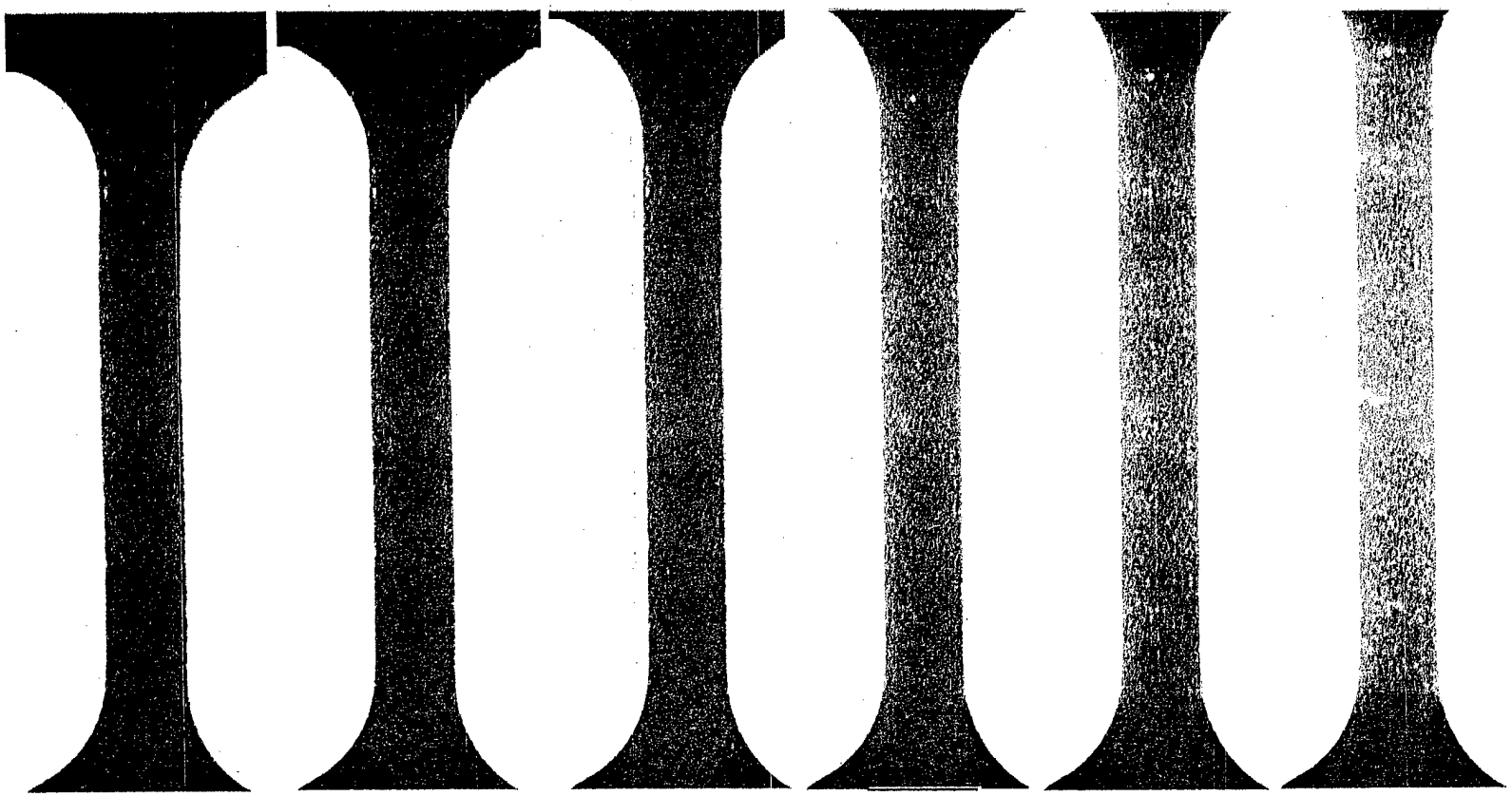
- Monitor Micro-Structure Evolution, Damage process, and Crack Formation in a Solid Propellant.

Testing Setup



Approved for Public Release; distribution unlimited

X-Ray Images at Different Amounts of Stretch



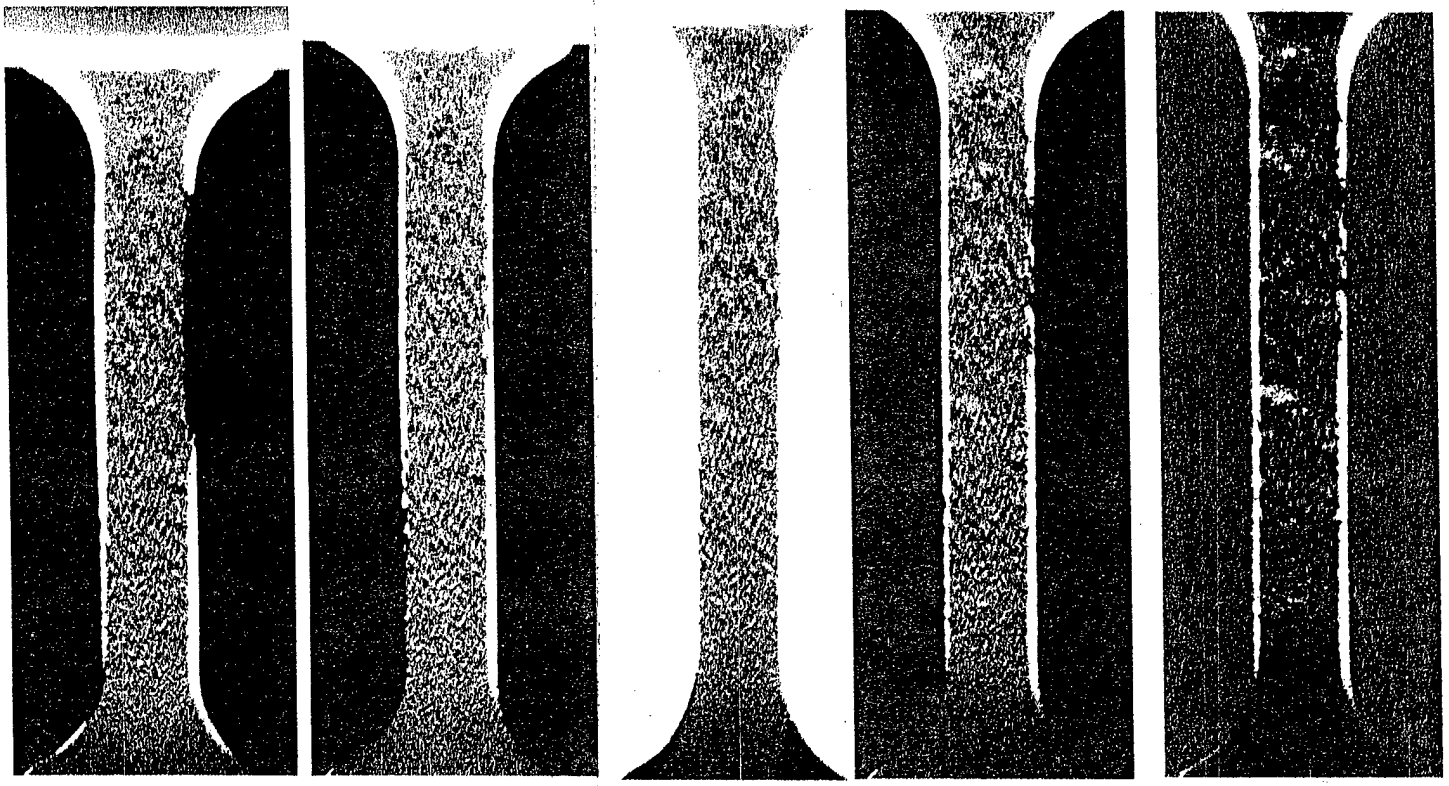
0.0" stretch | 0.1" stretch | 0.2" stretch | 0.3" stretch | 0.4" stretch | 0.5" stretch

Uniaxial_sample3_comp.jpg

Test Sample #3

Approved for Public Release; distribution unlimited

Difference X-Ray Images of the Change from One Stretch to the Next



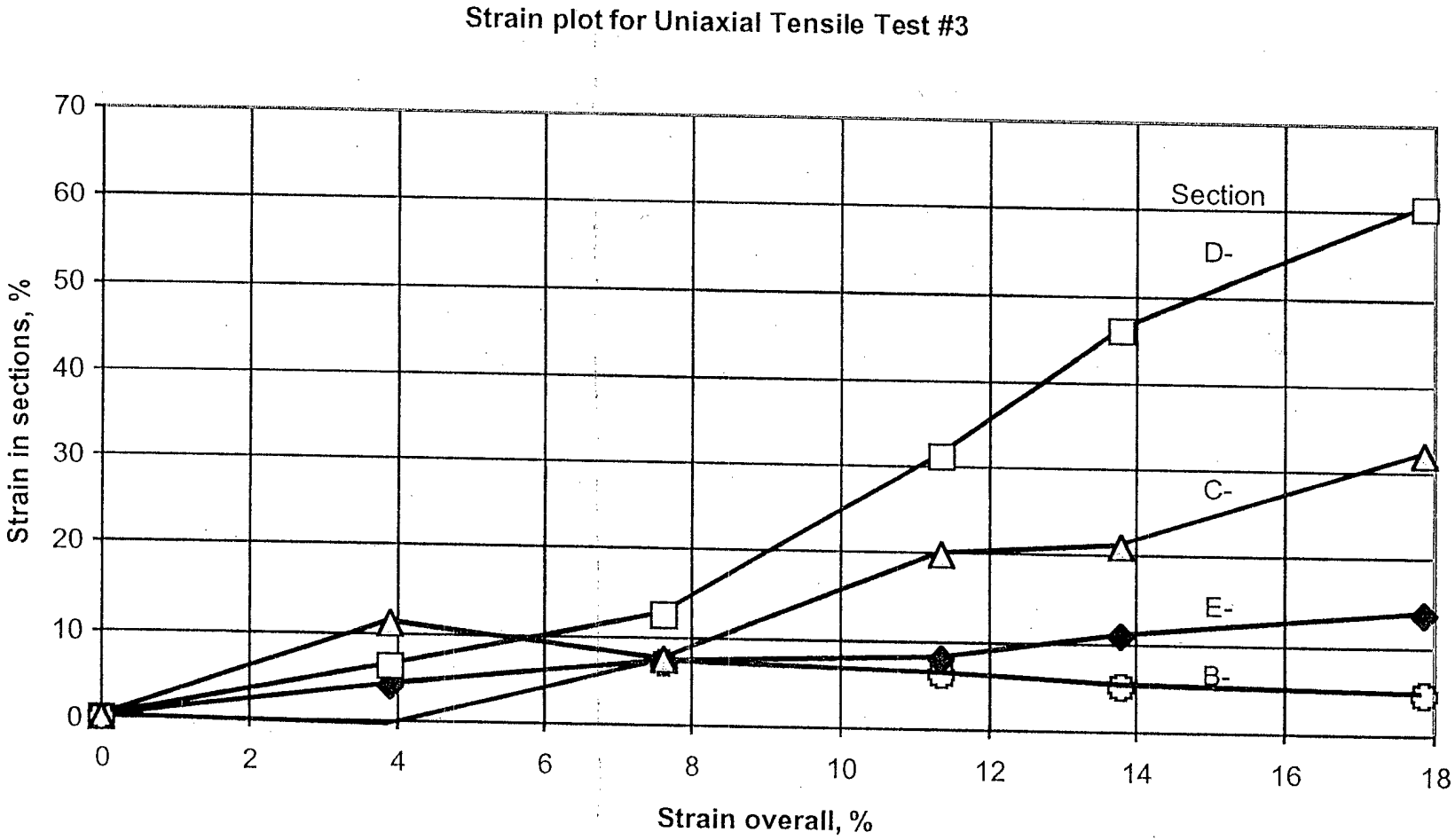
0.1 - 0.0 | 0.2 - 0.1 | 0.3 - 0.2 | 0.4 - 0.3 | 0.5 - 0.4

Sample3_diff_comp.jpg

Difference images for Sample #3

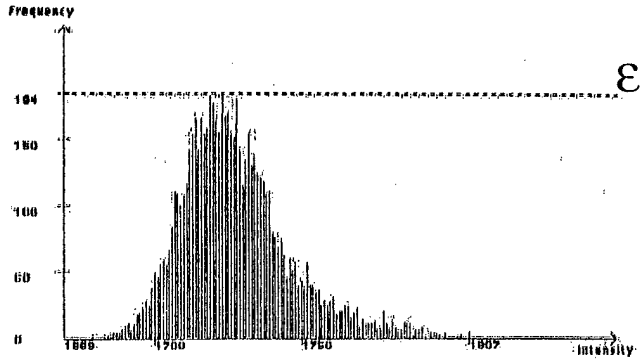
Approved for Public Release; distribution unlimited

Section Strain as a Function of Applied Strain

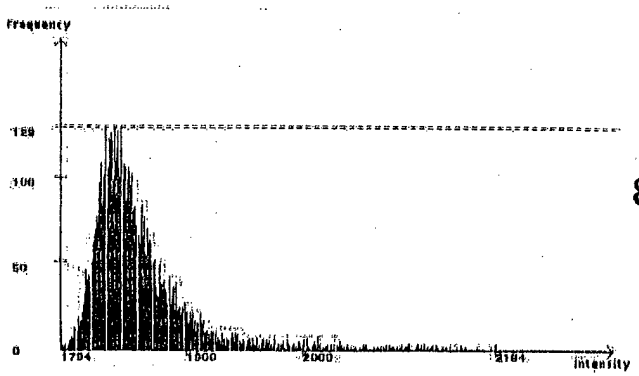


Approved for Public Release; distribution unlimited

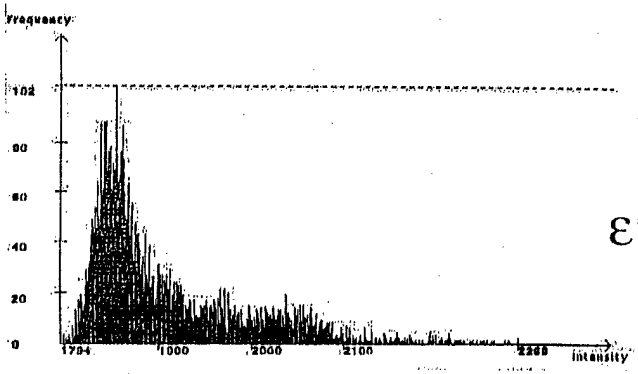
Histogram of X-Ray Intensity as Function of the Applied Strain at the Crack Location



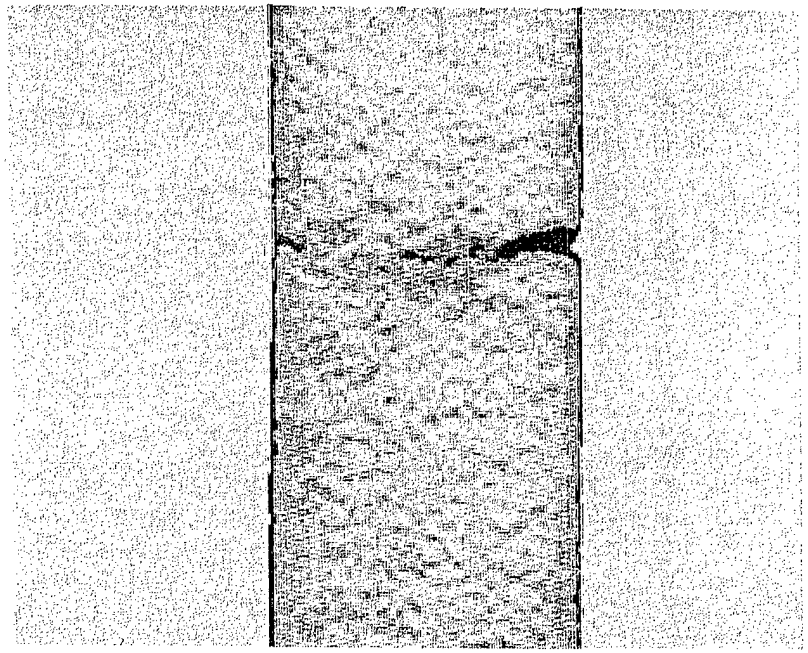
ε = 0%



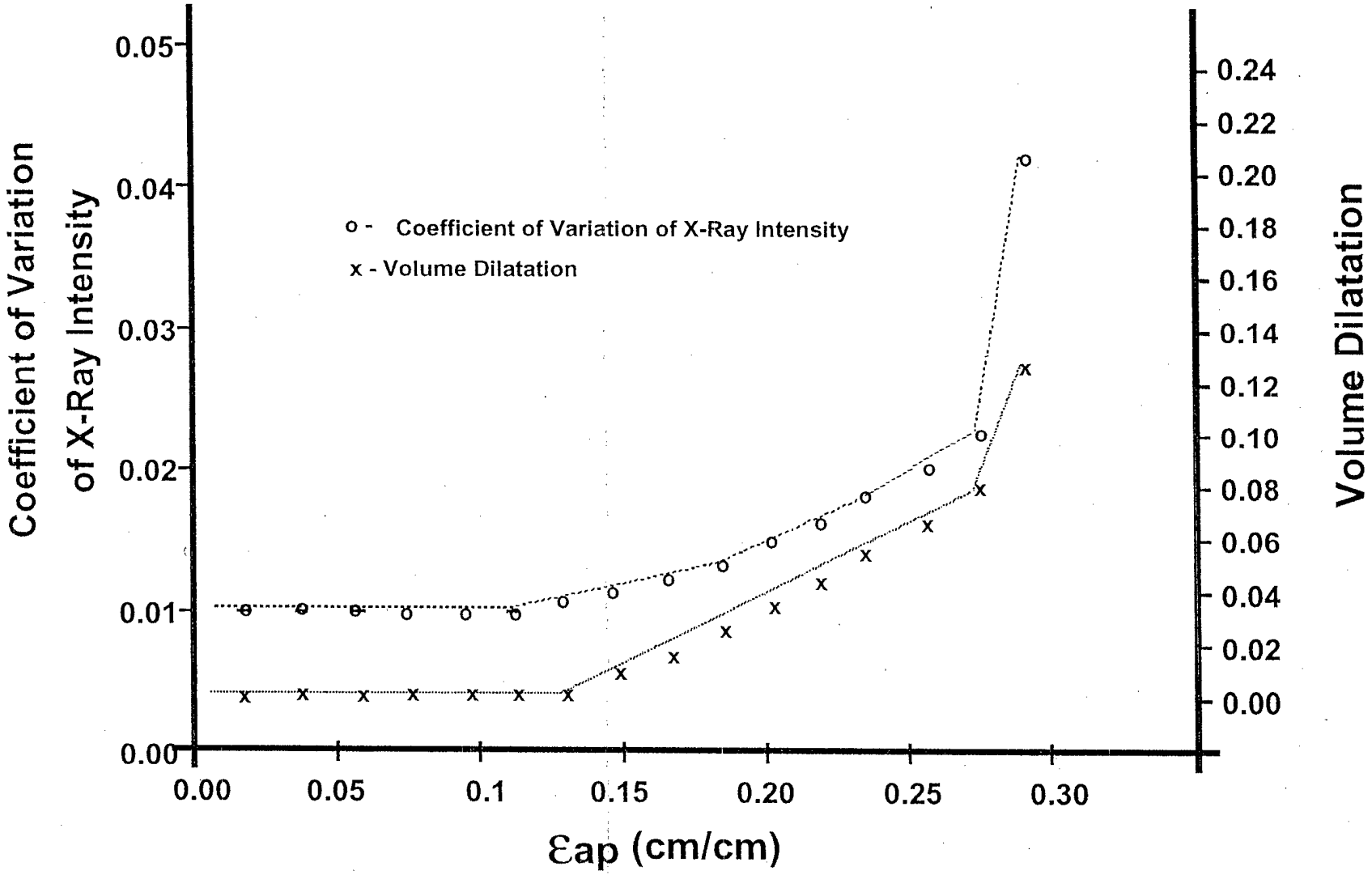
ε = 27%



ε = 29%

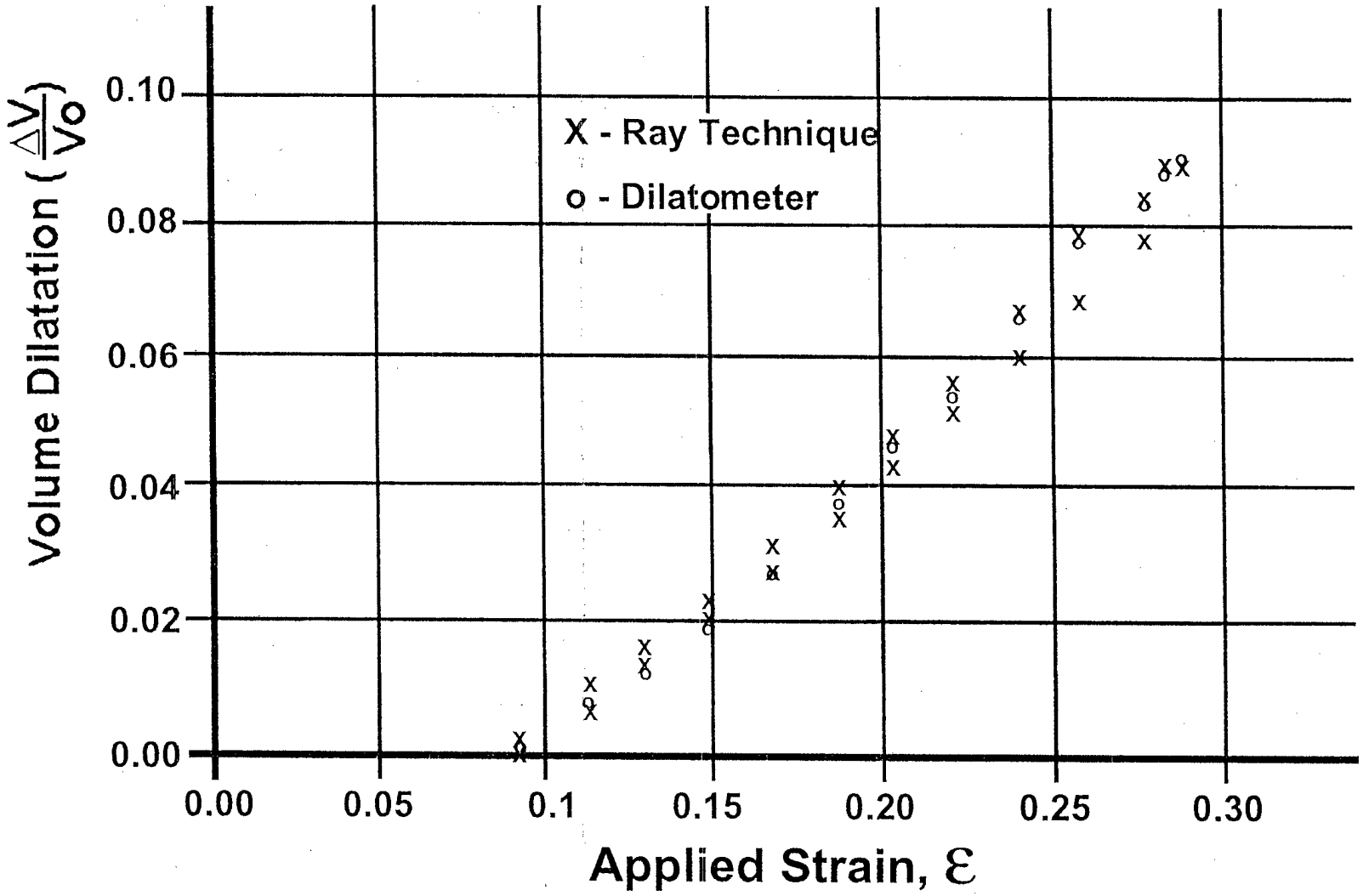


Coefficient of Variation of X-Ray Intensity and Volume Dilatation as Functions of Applied Strain



Approved for Public Release; distribution unlimited

Volume Dilatation as a Function of Applied Strain



Approved for Public Release; distribution unlimited

Conclusions

- The degree of inhomogeneity of material's micro-structure and number of non-propagating cracks increase as the applied strain is increased.
- The rate of x-ray intensity increases very fast prior to the formation of a crack.
- At high applied strain levels, the strain distributions are highly non-uniform.
- A good correlation exists between the dilatations measured by x-ray technique and dilatometer.
- X-ray technique is a promising method to monitor micro-structure change and crack formation in solid propellants.

Approved for Public Release; distribution unlimited