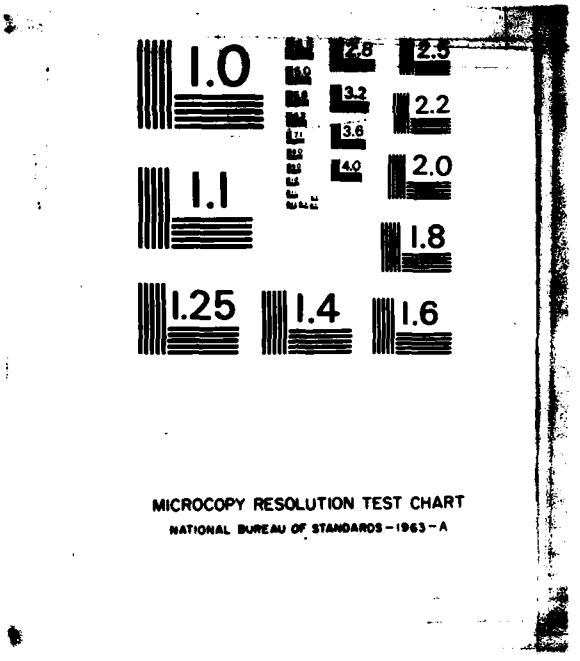
AD-A139 950 PREDICTION OF CREEP AND CREEP RELAXATION OF AL 2618 UNDER VARIABLE MULTIAXIAL STRESSES(U) BROWN UNIV PROVIDENCE RI W N FINDLEY MAR 84 ARO-17741.8-EG 1/1

UNCLASSIFIED DAAG29-81-K-0138 F/G 11/6 NL



Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
ARO 17741.8-EG	AD-A139950	

TITLE (and Subtitle)

Prediction of Creep and Creep Relaxation of AL 2618 Under Variable Multiaxial Stresses

5. TYPE OF REPORT & PERIOD COVERED
10 Aug 81 - 10 Feb 84
Final Report

6. PERFORMING ORG. REPORT NUMBER

AUTHOR(s)

William N. Findley

8. CONTRACT OR GRANT NUMBER(s)

DAAG29-81-K-0138

PERFORMING ORGANIZATION NAME AND ADDRESS

Brown Univ

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

N/A

CONTROLLING OFFICE NAME AND ADDRESS

U. S. Army Research Office
Post Office Box 12211
Research Triangle Park, NC 27709

12. REPORT DATE
Mar 1984

13. NUMBER OF PAGES
6p

MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)

15. SECURITY CLASS. (of this report)
Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

The view, opinions, and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Aluminum Alloy
Multiaxial Stress
Stress (aluminum)
Creep Relaxation
Creep Recovery
Strain Hardening

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report presents the results of studies of stress relaxation experiments in tension at low stresses; aging creep test; compression creep tests; non-proportional loading and unloading at low stresses; prediction from a viscous-viscoelastic model of the multiple-step non-proportional loading experiments at low stresses; the possibility of an upper limit to the recoverable strain, and the possible applicability of other theories to prediction of creep under complex stress histories.

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ARO 17741.8-EG

Final Report

on

"Prediction of Creep and Creep Relaxation of AL 2618
Under Variable Multiaxial Stresses"

BROWN UNIVERSITY, PROVIDENCE, R.I. 02912

August 10, 1981 through February 10, 1984

DAAG29-81-K-0138

by

William N. Findley

Statement of the Problem Studied

Information available for developing constitutive equations for use in design in critical applications involving variable stress states is limited largely to uniaxial states of stress. This is insufficient information. In addition to the experimental results and analysis previously reported on 2618 aluminum alloy, the following problems were proposed to be studied: stress relaxation experiments in tension at low stresses; aging creep test; compression creep tests; non-proportional loading and unloading at low stresses; prediction from a viscous-viscoelastic model of the multiple-step non-proportional loading experiments at low stresses; investigation of the possibility of an upper limit to the recoverable strain; and investigation of the possible applicability of other theories to prediction of creep under complex stress histories.

Summary of Important Results

A set of creep experiments on 2618-T61 aluminum were performed at several combinations of tension and torsion, and compression at various stresses and at 200°C. Major loading steps were of 48h duration. Data were represented by a viscous-viscoelastic model. Time dependence was represented by a power function of time with different exponents for recoverable and nonrecoverable components.

Experiments showed: that aging was negligible within the testing period of 312h; that there was symmetry between tension and compression; and there was no true creep limit so a homogeneous function of maximum shear stress was developed to represent the full range of stress dependence.

Multistep creep tests were performed using both proportional and non-proportional loading to evaluate hardening theory and viscoelastic behavior. A viscoelastic type component of strain was necessary to describe the observed behavior on removal of stress, partial reduction of stress or reloading.

A synergistic effect resulting from adding torsion (for example) during creep recovery was not predicted by any theory considered. The behavior is evidently due to the combined effect of internal stresses and applied stresses.

Isotropic strain hardening generally yields better prediction of creep under complex stress history than kinematic hardening.

Stress Relaxation experiments are essentially variable stress creep tests and showed similar behavior characteristics under changing complex straining as found in creep tests. A strain hardening theory was better than kinematic hardening for stress relaxation.

Creep experiments at constant stress under variable temperature were performed using both step temperature changes and linearly increasing and decreasing temperature. It was found that the creep behavior under variable temperature was well described by using a temperature compensated time proposed by Sherby and Dorn.

Publications and Technical Reports

Technical Reports:

No. 1 "48 Hour Multiaxial Creep and Recovery of 2618 Aluminum Alloy at 200°C," by Jow-Lian Ding and William N. Findley.

No. 2 "Multiaxial Creep of 2618 Aluminum Under Proportional Loading Steps," by Jow-Lian Ding and William N. Findley.

No. 3 "Creep and Creep Recovery of 2618-T61 Aluminum Under Variable Temperature," by U. W. Cho and W. N. Findley.

Publications:

"48 Hour Multiaxial Creep and Recovery of 2618 Aluminum at 200°C," by J. L. Ding and W. N. Findley, to be published in Journal of Applied Mechanics.

"Multiaxial Creep of 2618 Aluminum Under Proportional Loading Steps," by J. L. Ding and W. N. Findley, to be published in Journal of Applied Mechanics.

"Creep and Creep Recovery of 2618-T61 Aluminum Under Variable Temperature," U. by W. Cho and W. N. Findley, to be published in Journal of Applied Mechanics.

Submitted for Publication:

"Nonproportional Loading Steps in Multiaxial Creep of 2618 Aluminum," by J. L. Ding and W. N. Findley.

"Creep Experiments Under Nonproportional Loadings with Stress Reversals for 2618 Aluminum," by J. L. Ding and W. N. Findley.

"Theory and Comparison with Creep Experiments Under Nonproportional and Reversed Stressing," by J. L. Ding and W. N. Findley.

"Simultaneous and Mixed Stress Relaxation in Tension and Creep in Torsion of 2618 Aluminum," by J. L. Ding and W. N. Findley.

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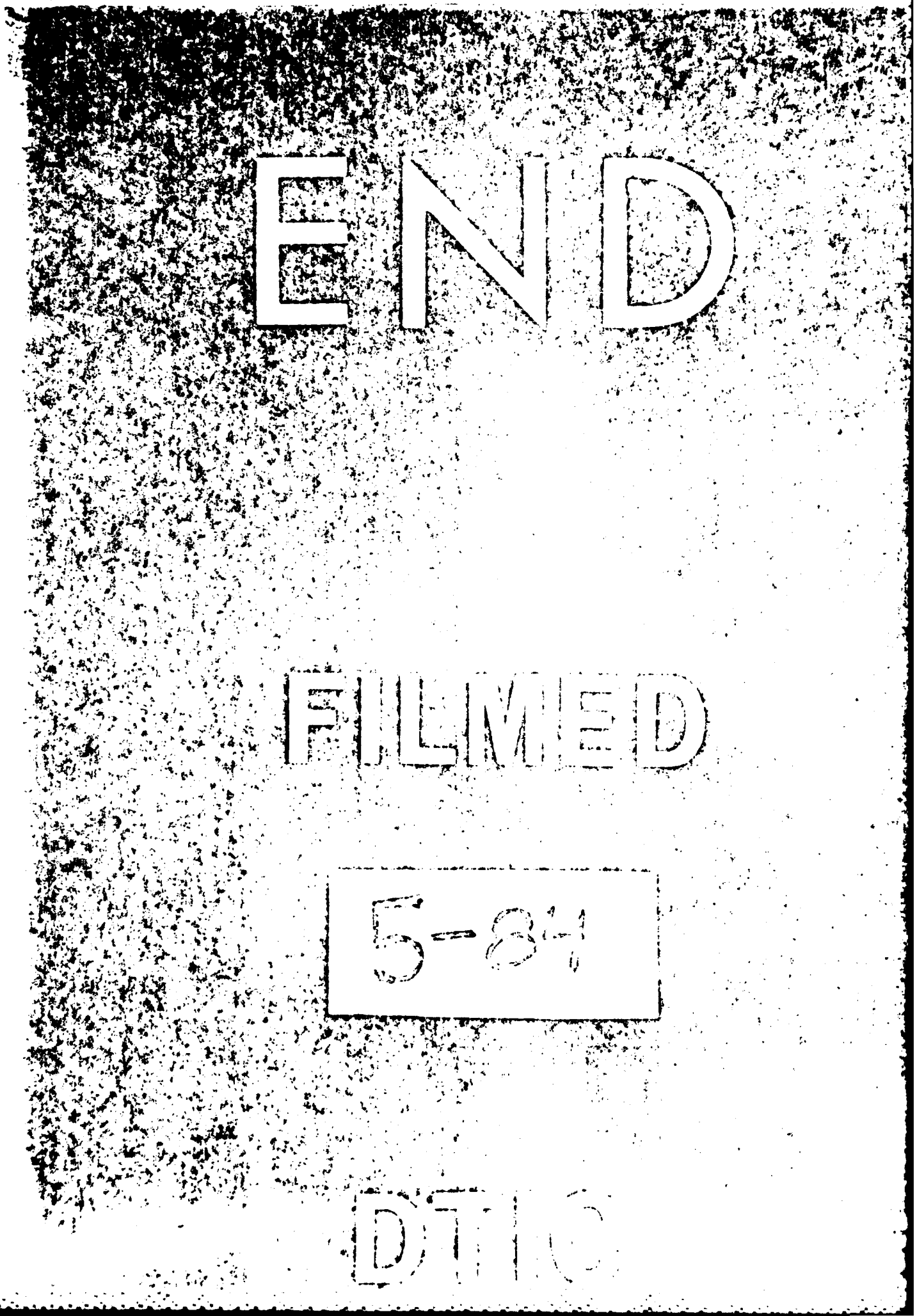
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