GENERAL ELECTRIC
Research Laboratory

REPORT NO: RL-686

STRESS-STRAIN PROPERTIES OF POLYTRIFLUOROCHLOROETHYLENE AS A FUNCTION OF TEMPERATURE

H. Tracy Hall

May 1952

CLASS 1

Available to anyone upon request

Published by
Research Laboratory Publications

SCHENECTADY, NEW YORK

Abstract: Stress-strain curves for crystalline and non-crystalline polytrifluorochloroethylene as a function of temperature are given for the temperature range from 25° to 190° C. Yield values and Young's modulus as a function of temperature have also been obtained.

STRESS-STRAIN PROPERTIES OF POLYTRIFLUOROCHLOROETHYLENE AS A FUNCTION OF TEMPERATURE

H. Tracy Hall

Polytrifluorochloroethylene is a partially crystalline polymer. Its physical properties may be modified by heat treatment. The least crystalline material is produced by heating the polymer near 250° C for a few minutes and then rapidly cooling to room temperature. Stress-strain curves for polymer treated in this manner are shown is Fig. 1.

A highly crystalline material is produced by heating the polymer to 250° C and allowing the polymer to cool to room temperature slowly over a period of about twelve hours. Stress-strain curves for polymer treated in this manner are shown in Fig. 2.

Young's modulus by stretching is obtained by multiplying the initial slopes in Figs. 1 and 2 by the length of the test specimen. This information is portrayed graphically in Fig. 3.

The maxima in the curves of Figs. 1 and 2 (called yield values) are shown in Fig. 4 as a function of temperature.

EXPERIMENTAL

Stress-strain curves were recorded automatically on an "Instron" machine. Rate of elongation was 0.2 inch per minute. The specimens were 0.125 inch wide, about 0.022 inch thick and 3.00 inches long between the grips. The thickness of each individual specimen was taken into account in the construction of Figs. 1 and 2. The sheets from which the specimens were cut were molded from polytrifluorochloroethylene manufactured by the Kellogg Company and designated as Kel-F 300, Lot 162-L. Temperature of the specimen was maintained by immersion in a silicone oil bath. The silicone oil does not swell or dissolve polytrifluorochloroethylene, and its presence should in no way affect the results.

DISCUSSION

From the graphs it is apparent that at a given temperature the tensile strength and yield value of the slow-cooled polymer are greater than for the quenched. Elongation curve break for quenched polymer in the temperature interval 25° to 175° C exceeds 300 percent. At 186° C, elongation at break for quenched polymer is about 50 percent. For slow-cooled polymer at 28° C, elongation at break is about 20 percent. In the temperature range 50° to 140° C, elongation before break exceeds 300 percent. From 160° to 200° C, elongation before break for slow-cooled polymer is less than 25 percent.

For slow-cooled polymer stretched at temperatures in the interval from 150° to 200° C, the specimen forms threads instead of necking down smoothly. This phenomenon is shown by the photograph in Fig. 5. For quenched polymer this phenomenon does not occur in any of the specimens stretched at 176° or lower, but does occur in the specimen stretched at 186° C.

The quenched polymer is very transparent and remains so on stretching throughout the temperature range 28° C through 90° C. The samples stretched in the temperature interval 120°-200°C have about the same cloudiness after stretching as they do before stretching.

The Young's modulus vs. temperature curve for quenched polymer is interesting because of the abrupt change in slope of the curve near 100° C. Young's modulus can be discussed in terms of "springs." From A to B (Fig. 4) something is the molecular architecture of the polymer corresponds to a spring that becomes weaker with increasing temperature. Extrapolation would indicate the disappearance of this spring at 98° C (substance becomes liquid-like). Near 95° C, however, the existence of a spring that is less dependent on temperature, but weaker, is revealed by the abrupt break in the curve. Extrapolation of the B to C portion of the curve to Young's modulus = 0 gives a temperature of about 220° C. Above this temperature the polymer would exhibit only viscous properties.

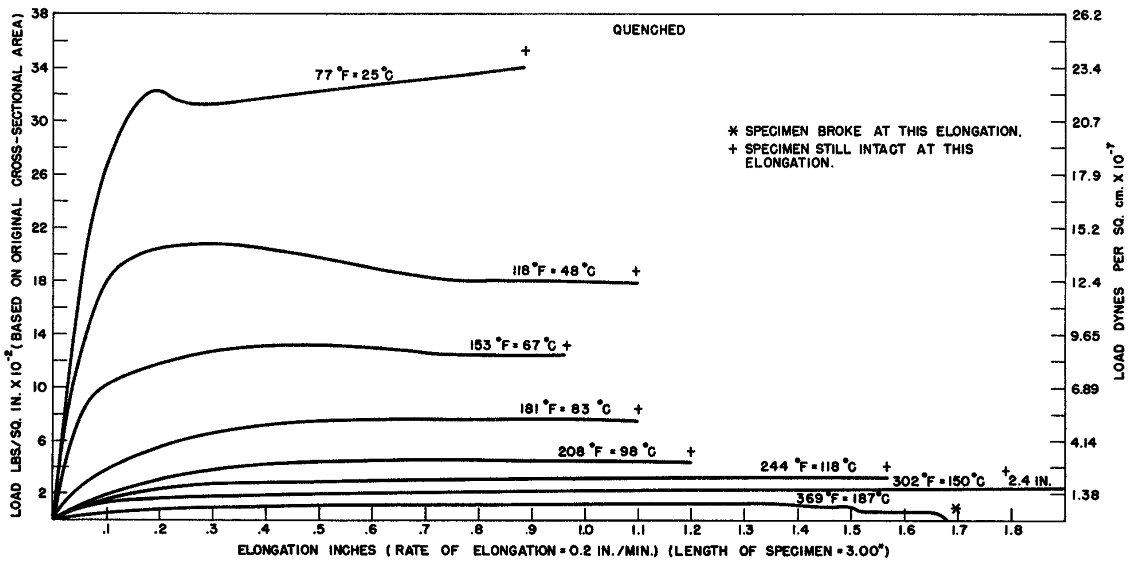

FIGURE 1 STRESS-STRAIN CURVES AT VARIOUS TEMPERATURES FOR QUENCHED POLYTRIFLUOROCHLOROETHYLENE.

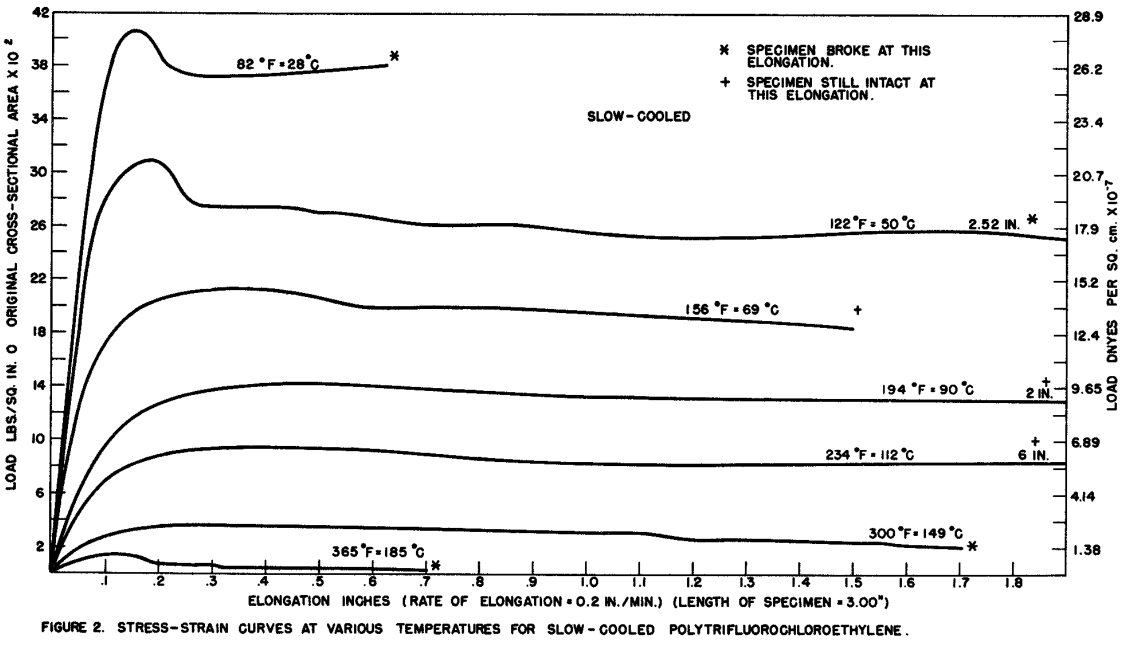

FIGURE 2. STRESS-STRAIN CURVES AT VARIOUS TEMPERATURES FOR SLOW-COOLED POLYTRIFLUOROCHLOROETHYLENE.

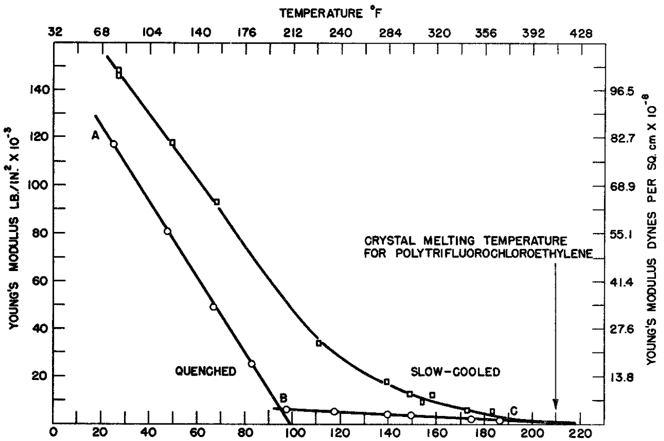

FIGURE 3. YOUNG'S MODULUS VS. TEMPERATURE FOR QUENCHED AND SLOW-COOLED POLYTRIFLUOROCHLOROETHYLENE.

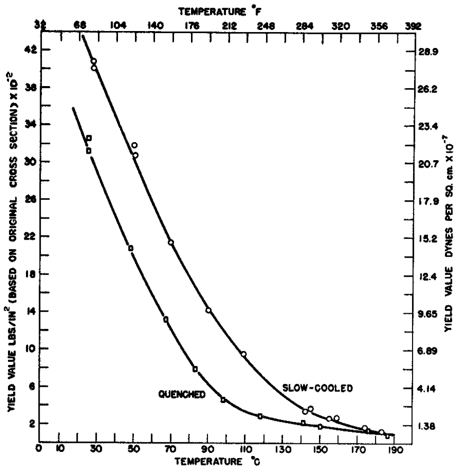

FIGURE 4. YIELD VALUE VS. TEMPERATURE FOR QUENCHED AND SLOW-COOLED POLYTRIFLUOROCHLOROETHYLENE.

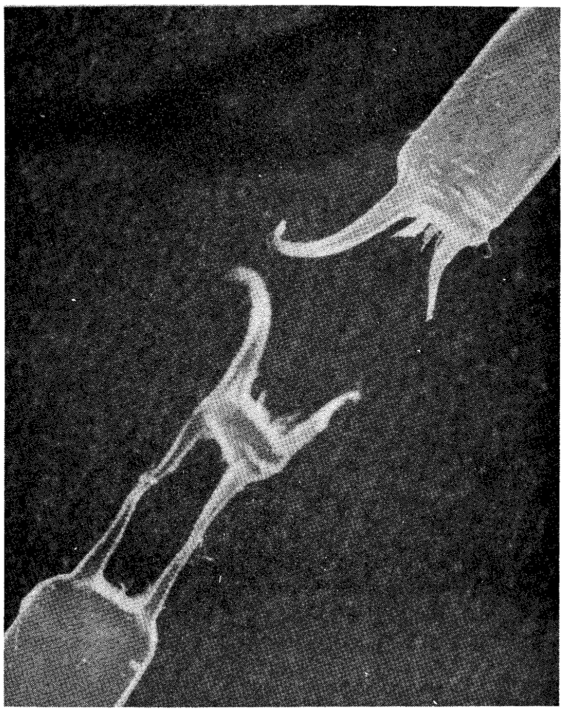

Fig. 5

DISTRIBUTION LIST

Additional copies of this report will be supplied to qualified persons upon application to:

Research Laboratory Publications
Room 2E3, The Knolls
Schenectady

- APPARATUS GROUP
  - Motor & Generator Division
    - Large Motor & Generator Department
      - Schenectady, N.Y.
        - A. C. Titus
  - Switchgear & Control Division
    - Switchgear Department
      - Philadelphia, Pa.
        - A. E. Anderson
        - D. D. Bergh
        - J. T. Clenny
        - T. J. Connor
    - Control Department
      - Schenectady, N.Y.
        - F. R. Quinn
  - Transformer & Allied Products Division
    - Transformer & Allied Products Department
      - Pittsfield, Mass.
        - S. E. Q. Ashley
        - R. G. Flowers
        - R. T. Foley
        - E. A. Kern
        - G. H. Porter
    - Locke Department
      - Baltimore, Md.
        - P. D. Horton
  - Turbine Division
    - Engineering Department
      - Schenectady, N.Y.
        - P. H. Knowlton
    - Schenectady Works Laboratory
      - Schenectady, N.Y.
        - E. J. Flynn
        - B. H. Kindt
        - W. L. Marshall
        - J. F. Quinlan
        - E. A. Reehl
        - C. D. Richardson
        - J. E. Scott
        - A. F. Zavist
    - Locomotive & Car Equipment Department
      - Erie, Pa.
        - J. A. Coffman
        - R. W. Finholt
- APPLIANCE & ELECTRONICS GROUP
  - Air Conditioning Division
    - Engineering Department
      - Bloomfield, N.J.
        - A. B. Hubbard
        - P. S. Kingsley
  - Electronics Division
    - Engineering Department

      - Syracuse, N.Y.
        - Electronic Park Library
        - R. N. Gillmor
        - J. R. Lampman
  - Major Appliance Division
    - Engineering Department
      - Bridgeport, Conn.
        - R. M. Lacy
        - C. F. Scott
    - Household Refrigerator Department
      - Erie, Pa.
        - J. T. Ferguson
        - W. L. Maucher
        - R. A. Sellers
  - Small Appliance Division
    - Telechron Department
      - Ashland, Mass.
        - A. E. Miner
- INDUSTRIAL PRODUCTS & LAMP GROUP
  - Chemical Division
    - Engineering Department
      - Pittsfield, mass.
        - E. F. Fiedler
        - P. A. Goodwin
        - B. W. Keith
        - G. R. Lucas
        - L. S. Moody
        - A. Pechukas
      - Anaheim, Calif.
        - H. C. Nelson, Jr.
    - Laminated & Insulating Products Department
      - Coshocton, Ohio
        - J. J. Pyle
    - Silicone Products Department
      - Waterford, N.Y.
        - R. O. Sauer (2)
  - Component Products Division
    - Fort Wayne Works Service Department
      - Fort Wayne, Ind.
        - C. M. Summers
        - F. C. Zimmer
  - Construction Materials Division
    - Engineering Department
      - Bridgeport, Conn.
        - I. C. Eaton
  - Lamp Division
    - Chemical Products Works
      - Cleveland, Ohio
        - Library
    - Lamp Development Laboratory
      - Cleveland, Ohio
        - Nela Park Library
  - Measurements & Industrial Products Division
    - Meter & Instrument Department
      - West Lynn, Mass.
        - H. R. Broadley
        - J. P. Leftin

      - M. Morse
      - T. O. Paine
  - River Works Service Department
    - Lynn, Mass.
      - A. E. Baker
      - R. Brissey
      - C. W. Hewlett
      - H. Kirtchik
      - F. S. Schultz
      - E. R. Booser
      - A. E. Durkin
      - C. K. Jones
      - R. H. Krieble
  - Carboloy Department
    - Detroit, Mich.
      - E. W. Goliebersuch
      - I. L. Wallace
  - Trumbull Electric Department
    - Plainville, Conn.
      - R. T. Casey
- DEFENSE PRODUCTS GROUP
  - Aeronautics & Ordnance Systems Division
    - Schenectady, N.Y.
      - R. W. Porter
- ENGINEERING SERVICES DIVISION
  - Technical & Engineering Administrative Services Department
    - Schenectady, N.Y.
      - John Horn
  - General Engineering Laboratory
    - Schenectady, N.Y.
      - J. Q. Adams
      - J. G. Cashell
      - C. W. Clapp
      - F. M. Clark
      - T. A. Rich
      - E. D. Cook
      - F. E. Crever
      - M. A. Edwards
      - R. B. Hook
  - Technical Data Center
    - Schenectady, N.Y.
      - B. R. Vrooman, 5-122
- LEGAL AND PATENT SERVICES DIVISION
    - Schenectady, N.Y.
      - P. A. Frank
- RESEARCH SERVICES DIVISION
  - Knolls Atomic Power Laboratory-Technical Department
    - Schenectady, N.Y.
      - Library
  - Research Laboratory
    - Schenectady, N.Y.
      - E. M. Boldebuck
      - W. E. Cass
      - D. E. Chambers
      - J. R. Elliott
      - J. W. Eustance
      - W. F. Gilliam
      - H. T. Hall (2)
      - R. W. Larson
      - Library
      - H. A. Liebhafsky
      - A. L. Marshall
      - R. L. Myers
      - A. J. Nerad
      - A. E. Newkirk
      - B. W. Nordlander
      - R. P. Price
      - M. M. Safford
      - A. E. Schubert
      - M. M. Sprung