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Cryogenic Thermal Expansion
of Y-12 Graphite Fuel Elements

(Title Unclassified)

UNITED STATES
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LOS ALAMOS SCIENTIFIC LABORATORY
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Report written: March 1968

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Cryogenic Thermal Expansion
of Y-12 Graphite Fuel Elements

(Title Unclassified)

by

David T. Eash

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CRYOGENIC THERMAL EXPANSION OF Y-12 GRAPHITE FUEL ELEMENTS

by

David T. Eash

ABSTRACT

Thermal expansion measurements between 20°K and 300°K were made on segments of three uranium-loaded Y-12 uncoated graphite fuel elements. The thermal expansion of these fuel elements over this temperature range is represented by the equation:

$$\Delta L/L = -39.42 \times 10^{-5} + 1.10 \times 10^{-7} T + 6.47 \times 10^{-9} T^2 - 8.30 \times 10^{-12} T^3.$$

INTRODUCTION

As part of a program involving the cryogenic testing of Rover project materials, thermal expansion measurements were made on three specimens of uncoated Y-12 graphite fuel elements loaded with varying amounts of uranium.

PROCEDURE

The three specimens were 4-inch segments of hexagonal, 19-hole, uranium-loaded, uncoated, graphite fuel elements. The numerical designations of the elements were: 0-467-21154, 0-492-20667, and 0-504-20147. The loading composition varied from about 467 to 504 mg of uranium per cc of fuel element.

Each specimen was placed in a copper container connected by a flange to a thin-walled stainless steel tube of sufficient length to position the container at the bottom of the cryostat. Two quartz rods extended full length inside the tube so that one rested on top of the specimen, and the other on a copper base plate in contact with the bottom of the specimen. A Statham (strain-gauge type) transducer was fastened to the top of one quartz rod with its movable sensor resting on top of the other quartz rod. The

transducer remained at room temperature. The relative motion of the two quartz rods registered the thermal expansion of the specimen subject to a correction for 4 inches of quartz. A small apparatus correction was determined by replacing the specimen with a piece of quartz. The quartz correction was obtained from a literature compilation by Corruccini and Gniewek⁽¹⁾.

In practice, the specimen and container are rapidly cooled to the temperature of liquid hydrogen by filling the cryostat with liquid hydrogen. The hydrogen is exhausted by self-pressurization, and measurements of temperature and thermal expansion are then taken simultaneously on an X-Y recorder during warm-up. The initial rate of warm-up is about one degree per minute, with 24 hours being required for a complete run.

RESULTS AND DISCUSSION

The thermal expansion curves for the three specimens did not show any systematic differences attributable to the amount of loading in the fuel elements. Therefore, the three curves are presented in Fig. 1 as an average curve for the thermal expansion of fuel elements. Over the temperature range 20°K to 300°K this curve is represented by the equation:

$$(L_T - L_{300^\circ\text{K}})/L_{300^\circ\text{K}} = -39.42 \times 10^{-5} + 1.10 \times 10^{-7} T + 6.47 \times 10^{-9} T^2 - 8.30 \times 10^{-12} T^3$$

where: $L_{300^\circ\text{K}}$ = the length at 300°K

T = the absolute temperature in °K.

ACKNOWLEDGEMENTS

The author acknowledges the help received from T. S. Brooks in performing these measurements, and N-Division of LASL for supplying the ORNL-produced specimens.

REFERENCES

1. R. J. Corruccini and J. J. Gniewek, "Thermal Expansion of Technical Solids at Low Temperature, A Compilation From the Literature", NBS Monograph 29, 1960.

Fig. 1. The average thermal expansion curve for uncoated fuel elements over the temperature range 20°K to 300°K.

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