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REPORT

TEST FOR MONITORING DIMENSIONAL CHANGES
OF GRAPHITE IN ROD CHANNEL 74 AT N-REACTOR

APRIL, 1965

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TEST FOR MONITORING DIMENSIONAL CHANGES
OF GRAPHITE IN ROD CHANNEL 74 AT N-REACTOR

By

B. A. Ryan

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TEST FOR MONITORING DIMENSIONAL CHANGES OF GRAPHITE IN ROD CHANNEL 74 AT N-REACTOR

INTRODUCTION

The irradiation-induced contraction of the graphite moderator at N-Reactor poses a potentially important structural problem. Irradiation tests are in progress in the General Electric Test Reactor (GETR)⁽¹⁾ to provide quantitative contraction rates on small samples of N-Reactor core material (TSX graphite). At this reactor the irradiation damage in graphite is accumulated rapidly because of the high fast-flux. But, because of differences in the flux distribution and intensity and limitations on the size and number of samples in the GETR experiment, complementary tests in N-Reactor were planned.

To complement the GETR experiment, graphite samples will be irradiated in Ball Channel 60 and Rod Channel 74 in the N-Reactor moderator core.⁽²⁾ Data from all these tests will help to relate radiation damage from the different neutron spectra at GETR and N-Reactor and to determine the uniformity of length changes in a large number of TSX graphite bars. Sections of moderator bars in the ball channel will be used to establish the size factor between small samples and large bars. On the basis of these results, it should be possible to perform a more exact analysis of the distortion of the N-Reactor graphite core. This report describes the geometries and measurements of samples used in experiments in Rod Channel 74 at N-Reactor. A similar report on the ball channel experiments was issued earlier.⁽³⁾

SUMMARY

Three hundred fifty-seven graphite samples have been fabricated, annealed, measured, and placed in seven carriers for irradiation in Rod Channel 74 at N-Reactor. Included in the test are

- 36 CSF and 38 TSX samples of the same size and shape as the ones used in the GETR experiments

- 180 samples to furnish information on the variability of length changes within ten different heats of TSX graphite
- 50 samples to furnish information on the variability of length changes across the width of one bar of TSX graphite
- 48 samples with diameters ranging from 1/8 to 1 1/4 in. to furnish data on the "sample-size" effect.

EXPERIMENTAL FACILITY

For purposes of graphite monitoring, empty rod Channel 74 provided a hole with a square cross section of 4 1/2 in. The dimensions of the sample carrier are limited to approximately 2 3/4 in. , however, because of an off-set at the intersection of the graphite reflector and the biological shield. The sample carrier and its dimensions are shown in Figures 1 and 2. The rod channel is located four reactor lattice units below and eight lattice units to the rear of the center of the reactor core. Entry is from the left side (near side) when viewed from the front of the reactor.

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FIGURE 1

Empty Sample Carrier

EXPERIMENTAL DESIGNS

Relative Damage by Neutron Fluxes in GETR and N-Reactor

Because the neutron-flux intensity in the GETR is significantly higher than in Hanford's production reactors, it is possible to generate expected lifetime radiation exposures in graphite test samples relatively quickly. However, the dissimilar neutron-flux spectra in the GETR and N-Reactor may introduce some inconsistency of radiation damage.

Note: All units are in inches.

FIGURE 2
Sketch of Sample Carrier

Furthermore, such experiments are limited to small samples; therefore, it is desirable to conduct correlative experiments with sections of large bars in N-Reactor.⁽³⁾ It is also desirable to irradiate graphite with the same sample geometry and taken from the same source as that used in the GETR experiments to furnish experimental verification of damage predicted from the GETR data. In the GETR experiments the TSX and CSF samples were quarter-round cylinders 3 7/8 in. long with a 7/16 in. shoulder at each end. To preclude any origin and geometry effects, a number of samples were fabricated from the same bars used in the GETR experiments; these were TSX graphite Bar 167 and CSF graphite Bar 142. Extraction positions of the samples, the numbering system and sample dimensions are shown in Figures 3 and 4 for Bars 167 and 142, respectively.

Uniformity of Length Changes in Several Bars of TSX Graphite

The core of the N-Reactor is composed of numerous bars of TSX graphite from many manufacturing heats (graphitizing furnace loads). The bars are 6 in. square in cross section and of various lengths up to 48 in.

To obtain radiation-induced length changes representative of the numerous bars in N-Reactor, experiments were designed with a total of 180 samples from ten bars selected at random, each from a different heat. By extracting the samples from the same area of each bar, extraneous effects were minimized.

Table I lists the heats and the corresponding Hanford identification of the ten bars of TSX graphite for this experiment.

An equal number of parallel and perpendicular samples were used. The samples were machined to 0.43 in. diam x 6 in. long. The additional length of 2 in. above the standard 4 in. long samples was necessary to include any surface effects of the larger 6 by 6 in. TSX material.

The extraction positions and the identification scheme for the samples are shown in Figure 5. In general the samples identified by the shaded areas were used in the experiment; in the perpendicular samples, however, some substitution was necessary because flow-line cracks in the graphite caused breakage during machining.

FIGURE 3

Extraction of Quarter-Round Samples
from TSX Bar 167

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TABLE I
IDENTIFICATION
OF REPRESENTATIVE BARS
FROM TEN TSX HEATS

Manufacturer's Heat	Hanford's Identification	Manufacturer's Heat	Hanford's Identification
104E	207	117D	213
105A	208	120C	214
114D	210	124C	215
115C	211	125E	216
116D	212	106B	217

FIGURE 5
Extraction of Samples
from Ten Heats of TSX Graphite

Cross-Sectional Uniformity in One Bar of TSX Graphite

During extrusion of the bars, before graphitization, coke particles in the matrix near the outside edges of the bars are forced into a preferred orientation; whereas, the coke particles in the middle of the bars are unaffected and remain randomly oriented.⁽⁴⁾ This induced-alignment of the particles near the edges is expected to cause unequal length changes across the bars during irradiation.

An experiment designed to examine the variation in radiation-induced length changes across a bar of TSX graphite (Bar 202) was included. A sample length of 6 in. was chosen so that both sides of the bar were included for the perpendicular samples; the standard diameter of 0.43 in. was used.

A diagram of the sampling pattern is shown in Figure 6. About half of the bar had been used during the construction of N-Reactor. Out of the remainder, a section 7 1/4 in. from the end was chosen for the samples. This section was divided into an equal number of parallel and perpendicular samples. In general, alternating samples from each group (e. g. , 1, 3, 5, and 201, 203, 205, etc.) were used in the experiment. Some substitution in the perpendicular group, however, was necessary to replace samples broken by flow-line cracks.

Effect of Sample-Size

There is some evidence that the extent of radiation-induced contraction in graphite may be influenced by the size of the test sample.⁽⁵⁾ Contraction in large graphite bars appears to be approximately twice that in small, 0.43 in. diam by 4 in. long samples. This "sample-size" effect may be due to anisotropy in the large bars.

Two other experiments are in progress at Hanford to provide additional information on the sample-size effect:

- The first experiment was designed for a wide range of sample sizes and shapes from four graphites (CSF, TSGBF, CSGBF, and TSX)⁽⁶⁾
- The second experiment was designed to furnish data for comparing conventional TSX test samples with large blocks 4 by 5 3/8 by 18 in. long. This last test is in progress at N-Reactor.⁽³⁾

FIGURE 6

Extraction of Samples from TSX Bar 202

Because of the potential significance of the sample-size effect, and, since the parameters which determine its magnitude are not fully defined, it was decided to include other samples of various sizes in the rod-channel experiments.

Sample diameters ranged from $1/8$ to $1\ 1/4$ in. and the nominal length was 3 in. To minimize any anisotropic effects, the samples were extracted from the core of Bar 205 as shown in Figure 7. Both ends of the bar were discarded, and alternating sections were used for parallel and perpendicular samples.

FIGURE 7
Extraction of Samples from Bar 205

Any bar-to-bar effects were avoided by removing all the samples from the same bar. To ensure enough data for a statistical treatment, the experiment was composed of four sets of parallel and four sets of perpendicular samples. Except for samples lost due to breakage, each set contained seven samples.

Samples in this series with diameters of 1/8, 3/4, 7/8, and 1 1/4 in. were machined with flat ends and measured at several locations with a hand micrometer. The measuring positions are shown in Figure 7. The other samples had slightly rounded ends and were measured on the Bausch and Lomb DR-25 optical gauge.

SAMPLE TREATMENT AND MEASUREMENT

Annealing

All samples prepared for experiments in Rod Channel 74 were annealed in a helium atmosphere at approximately 950 °C for 2 to 3 hr. The annealing was done before the length measurements.

Length Measurements

The length of the samples was determined with either a 5 to 6 in. Starrett hand micrometer or a Bausch and Lomb DR-25 optical gauge. Hand measurements at several positions were necessary on the large diameter samples in the sample-size experiment.

Weight Measurements

After annealing and measuring, the individual samples were weighed on an analytical balance. Thus, they can serve a dual function as oxidation monitors.

Retrieving Tool and Shipping Casks

The retrieving tool performed satisfactorily during mock-up trials.

Because it is inconvenient to position a heavy cask near the experimental facility, the shipping cask was constructed in two parts. One part,

a light-weight aluminum canister, will be used to transfer a single sample carrier from the facility and through the control-rod assembly room to the second heavy lead-filled cask.

The frequency of sample examination is expected to be on the order of 8 to 12 month intervals.

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