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TORSION TESTING OF PLUTONIUM

By
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Introduction

To realize the maximum utilization of plutonium in its engineering applications it is necessary to determine and assemble appropriate mechanical property data. Of importance from a design standpoint are the shear properties of plutonium. It was decided to use the torsion test to determine the shear properties.

Experimental Procedure and ResultsMaterial

A total of five tubular torsion specimens were cast in vacuo in MgO coated graphite molds. The pouring temperature was 950° C and mold temperature was 300° C. Chemical analysis and density data are presented in Table I. The as cast and cold treated torsion specimens were machined to the design illustrated in Figure 1.

TABLE I

Chemical Analysis⁽¹⁾ and Density⁽²⁾
of Plutonium Torsion Specimens

Specimen	<u>Al</u>	<u>Ca</u>	<u>Cr</u>	<u>Cu</u>	<u>Fe</u>	<u>Mg</u>	<u>Mn</u>	<u>Ni</u>	<u>Si</u>	<u>C</u>	<u>Total</u>	<u>Density</u>
19-6-1B	3	5	5	5	171	10	20	1	2	160	382	19.45
19-10-8A,B,C	32	32	20	5	360	10	20	20	10	185	694	19.55

(1) ppm

(2) g/cc

MATERIAL-
FINISH $\sqrt{32}$ ALL SURFACES
 $\frac{1}{4}$ RADII SHOWN TO BE
TANGENT TO .375 D. SURFACE

FIGURE 1
Torsion Specimen Design

Testing Procedure

Since the scope of this work was rather limited it was not considered feasible to purchase a torsion testing machine and enclose it in a glove box. The availability of a torsion testing machine in another building made it necessary only to design a fixture that would allow plutonium to be tested with no contamination spread. Such a fixture was designed by H. L. Butts of the Construction Engineering and Utilities Operation, Figure 2. It consisted of two grips or holders enclosed by a plastic bag. The plutonium specimens are entered by attaching the plastic case with holders attached to a glove box. The specimens are put into the fixture from the glove box and then transported to the testing machine. There the specimens are tested to failure in torsion at room temperature.

Initially it was determined that the torsion testing apparatus was capable of modulus of rigidity determinations. However, during testing it was found that the angular rotation indicating device was faulty and not practical to repair. Consequently only ultimate shear strength data could be obtained.

All torsion specimens were tested at a speed of 0.01 RPM. Four specimens produced satisfactory results and one failed at a defect, Table II. A typical brittle helicoidal fracture was obtained in each test bar, Figure 3.

FIGURE 2

Torsion Fixture with Specimen Inserted at Left, Fixture Encased in Plastic at Right. Magnification 1/4X.

FIGURE 3

Typical Brittle Helicoidal Fracture Occurring In Plutonium, 1X.

TABLE IITorsion Properties of Plutonium

Specimen Number	Ultimate Shear Strength (psi)	Density (g/cc)	Total Impurity Content (ppm)
19-6-4B	46,400	19.56	382
19-10-8A	54,700	19.55	694
19-10-8B	53,700	19.55	694
19-10-8C	57,800	19.55	694
AVERAGE	53,200	—	—
Average Ultimate Tensile Strength }	50,900	19.53	520

Discussion

The ultimate shear strength data and helicoidal fracture obtained for plutonium indicate that its ultimate tensile strength is less than its ultimate shear strength. Thus, failure under torsional loading occurs by tensile separation along a plane making a 45 degree angle with the plane of maximum shear. This results in a helicoidal fracture surface which was observed in our tests.

It has been reported⁽¹⁾ that the ratio of the true shear strength to true tensile strength is in the range of 1.1 to 1.3 for brittle materials such as cast iron. Using a ratio of 1.2 and a value of 50,900 psi for the true ultimate tensile strength of plutonium, an estimate of 61,100 psi can be obtained for the true ultimate shear strength of plutonium.

(1) Davis, H. E., Troxell, G. E., and Wiskocil, C. T., "The Testing and Inspection of Engineering Materials," McGraw-Hill Book Co., 1948.

To establish an experimental value of the ultimate shear strength of plutonium it would be necessary to use a direct or transverse shear test.

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