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INSPECTION OF FUEL ELEMENT COMPONENTS AND FUEL
ELEMENTS FOR THE ARGONNE LOW POWER REACTOR

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TABLE OF CONTENTS

	<u>Page</u>
I. Introduction	3
II. Radiography	4
A. Core Blanks	4
B. Fuel Plates before Shearing	4
C. Fuel Elements after Bending	4
III. Ultrasonic Testing	5
A. Core Blanks	5
B. Cladding Stock	5
C. Bond Test	5
IV. Gamma Scintillation Counting	5
V. References	6

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I. INTRODUCTION

The Argonne Low Power Reactor (ALPR) is a direct-cycle boiling water reactor, using enriched uranium fuel and moderated and cooled by the natural circulation of light water. ALPR is designed to produce 3000 kilowatts of gross reactor heat. The core material is U-235 in the form of an alloy containing 80.5 w/o aluminum, 17.5 w/o uranium and 2 w/o nickel.

There were approximately 40 grams of U-235 per core blank. The cladding material was X8001 aluminum alloy. The core and clad were bonded by means of a silicon pressure-bonding technique.

The finished plates were 27.8 inches long, 4.6 inches wide and 0.120 inch thick. Details concerning the fabrication of the fuel and fuel components can be found in the following reports:

ANL-5950 - "Development and Production of Core Material for ALPR Fuel Elements," R. E. Macherey, R. L. Salley and W. R. Burt, Jr. (to be issued)

ANL-5965 - "Manufacture of Fuel Plates and Fuel Subassemblies for the Argonne Low Power Reactor," R. A. Noland, D. E. Walker, and M. M. Martin (to be issued)

Three nondestructive testing techniques were used in inspecting the ALPR fuel elements and fuel element components: radiography, ultrasonic transmission and gamma scintillation counting. Radiography was used to inspect the alloy cores, the rolled fuel elements before shearing and the fuel plates after bending. The ultrasonic transmission was used to inspect the alloy cores, the cladding stock and the finished fuel elements. Gamma scintillation counting was used to determine the U-235 content in the fuel element core blanks.

II. RADIOGRAPHY

A. Core Blanks

Radiographs were made of all ALPR fuel element core blanks, which had the following dimensions: length - 6.875 inches; width - 3.31 inches; thickness - 0.200 inch. The radiographs were made under the following conditions:

Kilovoltage	- 250
Source to film distance	- 48 inches
Exposure	- 550 milliamperes seconds
Film type	- Kodak AA

Six core blanks were radiographed in each 14 inch x 17 inch film. The cores were arranged on the film in the same order that they were punched out of the alloy sheet. Thus, if radiographs were laid out in order, they would make a record of the sheet. A penetrometer made from core alloy was used. A penetrometer sensitivity of 2 per cent was obtained. A total of 1150 cores were radiographed. One hundred thirty-two cores were rejected because of inhomogeneities in the alloy.

B. Fuel Plates before Shearing

Radiographs were made of all ALPR fuel elements after rolling and before shearing. The ends of two fuel elements were radiographed on each 14 inch x 17 inch film. Two radiographs were made per fuel plate. Radiographs were made under the following conditions:

Kilovoltage	- 70
Source to film distance	- 48 inches
Exposure	- 100 milliamperes seconds
Film type	- Ansco Super A

Sensitivity was of no primary concern in these radiographs because the radiographs were used only as a guide in the shearing operation.

C. Fuel Elements after Bending

Radiographs were made of all fuel elements after the bending operation. This was done to determine the amount of clad material remaining between the core and the bent portion of the fuel element. Radiographs were made under the following conditions:

Kilovoltage	- 95
Source to film distance	- 48 inches
Exposure	- 125 milliamperes seconds
Film type	- Ansco Super A

Three fuel elements were placed on each 14 inch x 17 inch film. The middle 17 inches of the fuel element was the only section radiographed. Sensitivity was of no primary concern in radiographing the 675 bent fuel elements. Twenty fuel elements were rejected for not having sufficient side clad.

III. ULTRASONIC TESTING

An ultrasonic transmission technique was used for inspecting the alloy core blanks, the aluminum cladding stock and the finished fuel elements. A frequency of 1 megacycle was used in testing all the specimens. Electro-sensitive paper recordings were made of all specimens. Details of the ultrasonic transmission technique and the scanning equipment are described in ANL-5653.⁽¹⁾

A. Core Blanks

Seven hundred twenty-six core blanks were inspected by the ultrasonic transmission technique. Ninety-two were rejected for various kinds of flaws.

B. Cladding Stock

A large percentage of the X8001 alloy cladding stock was inspected for laminations and other flaws. Considerable material was found unacceptable for reactor use by this technique.

C. Bond Test

A total of 675 ALPR fuel plates were ultrasonically tested for bond. Unbonded areas were found in 111 of the plates. Any unbonded area greater than 1/8 inch in diameter was rejected.

IV. GAMMA SCINTILLATION COUNTING

A gamma scintillation counting technique was used to determine the U-235 content of the ALPR core blanks. The details of this technique and its application to ALPR core blanks are described in detail in ANL-5944.⁽²⁾ The U-235 content could be determined to ± 0.1 gram in the core blanks.

V. REFERENCES

1. W. N. Beck and W. J. McGonnagle, "Development of Ultrasonic Techniques for Inspecting Experimental Boiling Water Reactor Cast Uranium Alloy Cores and Fuel Plates," ANL-5653 (December 1957).
2. W. J. McGonnagle and R. B. Perry, "Analysis of Fuel Element Core Blanks for Argonne Low Power Reactor by Gamma Counting," ANL-5944 (to be issued).