UNCLASSIFIED

~~SECRET~~

C/S 113

HW-25412

AEC RESEARCH AND DEVELOPMENT REPORT

RESTRICTED DATA

This document contains restricted data as defined in the Atomic Energy Act of 1954. Its transmittal or the disclosure of its contents in any manner to unauthorized person is prohibited.

This document contains Secret-Restricted Data relating to civilian applications of atomic energy.

Photostat Charge \$ 1.70 for
Access Permittees

Available from
Technical Information Service Extension
P. O. Box 1001, Oak Ridge, Tennessee

LEGAL NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

A. Makes any warranty or representation, express or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or

B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission to the extent that such employee or contractor prepares, handles or distributes, or provides access to, any information pursuant to his employment or contract with the Commission.

W. L. Schalliel
Head, Pile Fuels
PILE TECHNOLOGY UNIT
ENGINEERING DEPARTMENT

IRRADIATION OF 63S ALUMINUM SAMPLES

by

P. D. Wright
Metal Quality, Pile Fuels
PILE TECHNOLOGY UNIT

CLASSIFICATION CANCELLED

DATE 5/5/60

For The Atomic Energy Commission

H. F. Canale
Chief, Declassification Branch *ael*

This document is
in the
or
an

This document is
PUBLICLY RELEASABLE

Larry E. Wilbur
Authorizing Official
Date: 06/02/2004

~~SECRET~~

UNCLASSIFIED

173 8638

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

~~SECRET~~

UNCLASSIFIED

-2-

HW-25412

TO: W. L. Schalliol
Head, Pile Fuels
PILE TECHNOLOGY UNIT
ENGINEERING DEPARTMENT

Introduction

In considering any candidate metal as a pile structural material, consideration must be given to the possibility of damage to the metal as a result of irradiation. Gross radiation effects may be determined by a short term irradiation of specimens of the metal. To this end, samples of 63S Aluminum, in various heat-treated conditions, were prepared and irradiated in a water-cooled "B" test hole in 105F for approximately three months. This irradiation was conducted as Production Test #105-531-SR.¹

Summary

This report contains a compilation of the data obtained from testing and observing samples of 63S Aluminum irradiated for approximately three months. Tensile data shows a slight, general increase in strength during pile exposure with a slight decrease in elongation. It is uncertain whether this increase in strength is a result of irradiation, exposure to slightly elevated temperatures or a combination of the two effects. Metallographic examination shows no apparent damage to the microstructure of the aluminum. As a result of these tests, it has been determined that there is no damage in the 63S Aluminum samples caused by irradiation.

Details

Three specimens, two tensile and one metallographic, of each of the following heat treated conditions were prepared and canned in 2S aluminum jackets; solution heat treated only, solution heat treated and precipitation hardened, and solution heat treated, precipitation hardened and overaged at 180°C (350°F) for 100 hours. Tensile specimens of the same heat treated conditions were prepared for use as unirradiated comparisons. Before canning, the metallographic specimens were photographed to show the micro-structure before irradiation.

The samples to be irradiated were charged into F pile on March 12, 1952 and were discharged June 5, 1952 one week short of the specified three months irradiation. They were immediately transferred to the Radio-metallurgy Building in 100-B Area for de-canning and examination. The tensile specimens were transported to the 300 Area for testing. Comparison samples of

173 302

1 Production Test No. 105-531-Sr, Irradiation of 63S Aluminum Samples, M. W. Hulin, February 12, 1952, HW-23531.

~~SECRET~~

UNCLASSIFIED

unirradiated 63S Aluminum were also tested. Samples of both the 63S Aluminum specimens and the 2S Aluminum jacket were taken for decay studies.

Results

1. Mechanical Properties

Table I contains the tensile properties resulting from tests of the 63S Aluminum both irradiated and unirradiated. There was no significant change in the yield strength, ultimate strength, elongation or hardness of the precipitation hardened and precipitation hardened and overaged specimens. Unfortunately, the two specimens of irradiated, solution heat treated 63S Aluminum were loaded erratically causing the yield strengths determined by these tests to be unreliable. These yield strengths, though unreliable, indicate a significant increase, while the ultimate strengths show an average increase of 7800 psi. This increase in ultimate strength places the irradiated, solution heat treated samples in the strength class of precipitation hardened 63S Aluminum. As can be seen, this increase in strength appears to have been accomplished with little or no change in elongation. The exact cause of the apparent precipitation hardening of the solution heat treated samples is not known. The age hardening character of 63S Aluminum leads to precipitation of Mg_2Si on standing even at room temperature. Since this test exposed the samples to temperatures slightly above room temperature, some or all of the precipitation may have resulted from aging. However, there is a probability that some of the precipitation may have been caused by the irradiation. In succeeding irradiation tests closer control on non-irradiated specimens will be attempted in order to determine the exact cause of the increase in strength of the solution heat treated specimens.

Since 63S Aluminum is a candidate process tube and can metal, a comparison of the 63S Aluminum properties reported in Table I can be made to the properties of 2S Aluminum given in Table II. The values listed in Table II are handbook⁽²⁾ values for unirradiated 2S Al and values obtained by JL Klein⁽³⁾ for irradiated Hanford process tubing. This is the only data available on irradiated 2S Aluminum and since the methods of testing differ only a qualitative comparison may be made.

2. Metallographic Studies

The photographs included in this report tend to be misleading. Care must be taken when evaluating the photographs of the irradiated material that the poor quality of the photographs is interpreted as roughness in the surface of the specimen rather than any inherent flaws in the metal. Difficulties encountered in handling the irradiated specimens cause this roughness. Whereas, the unirradiated specimens were polished

(2) Alcoa Aluminum and Its Alloys, Aluminum Company of America, 1950.

(3) MIT 1067, J. L. Klein, Effects of Irradiation on a Hanford 2S Aluminum Water Cooling Tube, May 7, 1951.

Secret

113 303

SECRET

on lap wheels by hand to as fine a polished surface as possible, the irradiated materials were merely lapped flat on a "Lapmaster", electropolished, anodized and photographed. This process leaves much to be desired as concerns the surface of the specimens. All photographs included in this report are of material anodized in fluoro-boric acid and photographed at 100X.

Figures I and II are photographs of the solution heat-treated 63S Aluminum sample. As can be seen in Figure I of the unirradiated specimen, enough time had elapsed between heat-treating and photographing to allow some degree of precipitation to take place. The photograph also shows the large grained character of the metal, probably caused by working at too high a temperature. This fact would explain the high elongation determined in the tensile tests. Figure II, of the irradiated material, shows no increase in grain size and a general overall precipitation of Mg_2Si in the 63S Aluminum. Because of the room temperature aging characteristics of the material, the exact cause of the precipitation of this material is unknown.

Photographs of the solution heat treated and precipitation hardened 63S Aluminum samples are shown in Figures III and IV. Figure III, the unirradiated specimen, shows a general overall precipitation of the Mg_2Si within the grains plus some precipitation at the grain boundaries. Again, the large grain size of the material is noted. Figure IV, the irradiated sample shows very little, if any, change in the character of the metal after these months exposure in the pile. The quality of this photograph is especially poor and therefore comparison to the unirradiated specimen is extremely difficult.

The photographs of the solution heat treated, precipitation hardened and overaged material are shown in Figures V and VI. The unirradiated specimen, Figure V, shows a large grained structure with a fine precipitation of Mg_2Si interspersed throughout the material and at the grain boundaries. Figure VI, the irradiated specimen, exhibits the same overall characteristics with perhaps some slight agglomeration of the fine precipitate into large particles in the matrix.

From close study of the metallographic specimens used in this test, one may conclude that there is no apparent grain growth caused by irradiation. It is also apparent that there is no damaging effect to the microstructure of 63S Aluminum in any of the three heat treated conditions tested. In succeeding irradiation tests of 63S Aluminum better polishing techniques of irradiated specimens should be sought.

3. Decay Studies

Samples of both the 63S Aluminum specimens and the 2S Aluminum jackets were run simultaneously for decay comparison. Both Beta and Gamma activity were checked. The calculated half-lives as determined from decay data collected from the sixth to the twentieth day after discharge from the pile are listed below:

Beta Activity

T-1/2 2S
30.3 days

T-1/2 63S
23.0 days

113 304

SECRET

DECLASSIFIED

~~SECRET~~

~~SECURITY INFORMATION~~

-5-

HW-25412

Gamma Activity

32.1 days

28.1 days

Comparison of the counting rates of the two Aluminums both at the beginning and at the end of the counting period show that the 2S Aluminum has a counting rate per unit weight, much higher than the 63S Aluminum. Therefore, it may be concluded that, from a radiation standpoint, the handling of irradiated 63S Aluminum presents no problems not encountered in the handling of irradiated 2S Aluminum.

4. Additional Work Being Done

In order to determine possible crystallographic changes, x-ray diffraction studies of both irradiated and unirradiated 63S Aluminum will be run. This work will be done by WV Cummings Jr. of the Metallurgy Sub-Unit of Applied Research in the near future and results of these studies will be reported by Mr. Cummings.

Conclusions

Short term irradiations are used to evaluate gross effects of radiation upon materials. From this three month test it may be concluded that there is no damage to 63S Aluminum caused by irradiation. Many phases of this test proved inconclusive. Should further tests be initiated, the following steps should be taken towards making the data obtained more conclusive:

1. The number of samples should be substantially increased so that if some specimens give unreliable data there will be enough others to offset this data.
2. Closer control of unirradiated samples should be attempted to determine the exact cause of the precipitation hardening phenomenon found present in the solution heat treated specimens.
3. A better polishing technique for the irradiated samples should be sought.

It is felt that if these goals are attained much more conclusive data will be obtained from this type of test in the future.

Acknowledgements

The writer wishes to thank the personnel of the Applied Research Unit for their assistance. Members of the metallurgy sub-unit prepared the Metallographic specimens and performed the tensile tests and members of the Radio-Chemistry sub-unit obtained the decay data.

P.D. Wright

P. D. Wright, Metal Quality
Pile Technology Unit
ENGINEERING DEPARTMENT

PDW/bf

173 206

SECRET

DECLASSIFIED

SECRET

HW-25412

MECHANICAL PROPERTIES OF 63S A1 BEFORE AND AFTER IRRADIATION

<u>UNIRRADIATED</u>					<u>IRRADIATED</u>				
Sample	Ultimate Strength psi	Yield Strength psi	Elongation % in 1 inch	Hardness ** R-15T	Sample	Ultimate Strength psi	Yield Strength psi	Elongation % in 1 inch	Hardness ** R-15T
1A	25,900	11,900	32.8	----	1A	33,900	*20,400	34.4	70.0
1B	23,200	10,000	28.1	59.0	1B	31,600	19,200	28.1	----
2A	32,700	28,200	23.4	77.0	2A	35,500	29,000	21.9	75.0
2B	33,700	28,400	23.4		2B	32,600	27,200	18.8	
3A	35,000	34,300	15.6	74.0	3A	35,700	33,400	12.5	75.0
3B	34,100	32,500	17.2		3B	36,000	34,200	15.6	

* Due to faulty loading of specimens these values of yield strength are not reliable.

** Hardness values obtained on metallographic specimens.

Key:

- (1) Solution heat-treated only.
- (2) Solution heat-treated and precipitation hardened.
- (3) Solution heat-treated precipitation hardened and overaged 100 hours at 180°C (350°F)

SECRET

SECRET

7

H-25412

TABLE II

TYPICAL PROPERTIES OF 2S A1

Material	Tensile Strength psi	Yield Strength psi	Elongation % in 2 in.
2S-C	13,000	5,000	35
2S-H12	15,000	13,000	12
2S-H14	17,000	14,000	9
2S-H16	20,000	17,000	6
2S-H18	24,000	21,000	5

PROPERTIES OF IRRADIATED HANFORD PROCESS TUBES (2S-H14)*

Position of Mat'l	Tensile Strength psi	Yield Strength psi	Elongation % in 1 in.
2S-H14			
Out of Active Zone	22,400	20,100	6
In Active Zone	28,300	24,400	6

* Data from MIT 1067. J. L. Klein, Effects of Irradiation on a Hanford 2S Aluminum Water Cooling Tube, May 7, 1952.

Fig. 1 Unirradiated 63S Aluminum

Fig. II Irradiated 63S Aluminum
Heat Treatment - Solution heat treated only. Fluoroboric Anodize - 173 208
100 X - Polarized light.

Fig. III Unirradiated 63S Aluminum

Fig. IV. Irradiated Aluminum

Heat Treatment - Solution heat treated and precipitation hardened. Fluoro-boric Anodize - 100 X - Polarized light.

173 009

SECRET

DECLASSIFIED

~~SECRET~~

UNCLASSIFIED

21-10

HW-25412

Fig. V Unirradiated 63S Aluminum

Fig. VI Irradiated 63S Aluminum 173 1010

~~SECRET~~

Heat Treatment - Solution heat treated, precipitation hardened and overaged for 100 hours at 180°C. Fluoroboric anodize + 100 X - Polarized light.