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Subject: Deflection of an Aluminum
Sheet into a Depression in
a Graphite Block

TEST REPORT

WESTINGHOUSE ASTRONUCLEAR LABORATORY

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ABSTRACT

A 6 x 6" sheet of 2219-T31 aluminum alloy was uniformly loaded while being supported by a similar size block of graphite with a diamond shaped cavity. The load was produced by a dry nitrogen gas pressure of 150 psig. Static tests were performed with the aluminum sheets at room and low temperatures ($\sim -320^{\circ}\text{F}$). A single dynamic test was also performed at room temperature.

INTRODUCTION

The presently proposed lateral support system for the NRX-A1 reactor consists of stainless steel leaf springs mounted in depressions in the graphite barrel of the core. A close-fitting, thin aluminum barrel will enclose the graphite barrel. Since pressure differentials of 150 psig. can exist across this aluminum barrel in the radial direction, the possibility of its deforming into the cavities in the graphite exists. Should these deformations be large, malfunction of the springs and hence, the lateral support system, would result.

DISCUSSION

The purpose of this test was to determine the amount of deflection which could occur into the graphite cavity with a .032" thick sheet of 2219-T31 aluminum alloy. The flat sheet specimen was used because of the ease it afforded in setting up the experiment. Actually, it was a more strenuous test in that the aluminum barrel is a continuous curved sheet and therefore will be subjected to tangential compressive stresses which will tend to reduce deflections into the cavity. The only tangential restraint offered to the test sheet was due to the clamping pressure and gasket-graphite friction. No attempt was made to measure this. Measurements were taken before, during and after loading. Figure 1 is a drawing indicating the location of the dial gages used to measure deflections during the course of testing. The figure also depicts the coordinate system used to perform the surface analysis after testing. The surface analysis provided an accurate description of the shape of the permanent deformation sustained by the plates during loading.

The uniform load was produced by dry nitrogen gas. Loading was in 10 psig. increments up to 150 psig. The maximum load was maintained for 10 minutes on each plate tested statically.

The tests were conducted at low temperatures by introducing liquid nitrogen through the top clamping plate down into the graphite cavity and onto the aluminum sheet. Figure 2 shows an exploded view of the test rig with the relative positions of the graphite cavity, aluminum sheet, center support and associated hardware. Pressure was introduced from the bottom of the fixture while deflections were measured from the top by means of dial gages. The dial gages were calibrated in the test rig at reduced temperatures and found to vary only about -2 mils. That is, under no load conditions with the base plate previously chilled, the dial indicator and its extension shaft underwent a maximum contraction of .002". For the low temperature tests the test sheet was allowed to chill before setting the dial indicators and proceeding with the pressurization. Temperatures could not be monitored by thermocouples due to the problem of

sealing the pressures. The plate was considered to be sufficiently chilled when the liquid nitrogen ceased to boil violently and began to accumulate in the graphite cavity. The liquid nitrogen was allowed to flow continuously during the course of testing in order to maintain the previously established level. The dial indicators were continually checked for possible sticking due to frosting. Figures 3, 4, and 5 are graphs indicating the deflections measured by the dial gages during the course of loading. Complete test conditions are indicated in each figure. The results of the surface analysis performed after testing on these sheets are shown in Figures 6, 7, and 8.

A single dynamic test was performed at room temperature on specimen "F". The load was cycled from 0 to 150 psig. continuously for a 10 minute period. The same sheet of aluminum was subjected to 5 straight periods of this dynamic testing. The frequency of pressurization was 40 cycles per minute. A total of about 2000 cycles was applied to the specimen. Maximum deflections were monitored during loading with dial indicators. Figure 9 gives the final surface analysis for this test.

Table I is a listing of the various tests performed. Temperatures, loads and deflections are also indicated.

Close examination revealed no cracking or chipping around the periphery of the cut-out in the graphite block.

TABLE I

LISTING OF TESTS PERFORMED ON
ALUMINUM SHEET OVER A CAVITY IN GRAPHITE

<u>Sheet</u>	<u>Type of Load</u>	<u>Max. Load</u>	<u>Frequency</u>	<u>Temperature</u>	<u>Maximum Deflection</u>	<u>Max. Set</u>
C	Static	150	-----	Room	.049	.005
D	Static	150	-----	Room	.048	.0055
E	Static	150	-----	Low	.037	.004
F	Dynamic	150	40 cpm	Room	.052	.006

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DRAWING OF PLATE INDICATING LOCATION OF DIAL GAGES,
COORDINATE MARKINGS USED FOR SURFACE ANALYZING, AND
IDENTIFYING CAVITY AREAS NO.-1 AND NO.-2. RELATIVE POSITION
OF GRAPHITE CAVITY AND CENTER SUPPORT BAR ARE ALSO SHOWN.

SCALE: 1"=1"

Figure 1 - Drawing of Cavity Outline, Coordinate System and Dial Gage Locations

TEST DEVICE FOR DEFLECTING ALUMINUM SHEET INTO A CAVITY WHILE UNDER PRESSURE

EXPLODED PICTORIAL VIEW

ASSEMBLY VIEW

Figure 2 - Test Rig Used for Deflection of Aluminum Sheets into Graphite Cavity

THE AMOUNT OF DEFLECTION OF ALUMINUM SHEET WHILE
BEING PRESSURIZED OVER A GRAPHITE CAVITY OF DIAMOND SHAPE

TEST CONDITIONS

Temperature - Room
Loading - Static

SPECIMEN

Material - No. 2219-T31 Aluminum
Thickness - .032"
Test Sheet - C

Figure 3 - Graph of Load vs Deflection

THE AMOUNT OF DEFLECTION OF ALUMINUM SHEET WHILE BEING PRESSURIZED OVER A GRAPHITE CAVITY OF DIAMOND SHAPE

TEST CONDITIONS

Temperature - Room
Loading - Static

SPECIMEN

Material - No. 2219-T31 Aluminum
Thickness - .032"
Test Sheet - D

Figure 4 - Graph of Load vs Deflection

THE AMOUNT OF DEFLECTION OF ALUMINUM SHEET WHILE BEING PRESSURIZED OVER A GRAPHITE CAVITY OF DIAMOND SHAPE

TEST CONDITIONS

Temperature - Low
Loading - Static

SPECIMEN

Material - No. 2219-31 Aluminum
Thickness - .032"
Test Sheet - E

Figure 5 - Graph of Load vs Deflection

DEFLECTION OF ALUMINUM SHEET
OVER GRAPHITE WITH A DIAMOND
SHAPED DEPRESSION

CONDITIONS

PRESSURE 150 PSI

TEMPERATURE Room

TIME AT PRESSURE 10-Min

TIME AT TEMPERATURE —

SCALE: $1\frac{1}{2}'' = 1''$

EACH VERTICAL
UNIT = .001"

TEST Plate-C

MATERIAL #2219 T31

DATE 4/20/23

Figure 6 - Surface Analysis of Permanent Set in Pressurized Aluminum Sheet

DEFLECTION OF ALUMINUM SHEET
OVER GRAPHITE WITH A DIAMOND
SHAPED DEPRESSION

CONDITIONS

PRESSURE 150 PSI
TEMPERATURE Room
TIME AT PRESSURE 10 Min.
TIME AT TEMPERATURE

SCALE: $1\frac{1}{2}'' = 1''$

EACH VERTICAL
UNIT = .001"

TEST Plate - D
MATERIAL #2219-T31
DATE 4/20/63

Figure 7 - Surface Analysis of Permanent Set in Pressurized Aluminum Sheet

DEFLECTION OF ALUMINUM SHEET
OVER GRAPHITE WITH A DIAMOND
SHAPED DEPRESSION

CONDITIONS

PRESSURE 150 PSI
TEMPERATURE LOW
TIME AT PRESSURE 10-min.
TIME AT TEMPERATURE 31.5 min.

SCALE: 1-1/2" = 1"

EACH VERTICAL
UNIT = .001"

TEST Plate-E
MATERIAL #2219-T31
DATE 4/23/63

Figure 8 - Surface Analysis of Permanent Set in Pressurized Aluminum Sheet

DEFLECTION OF ALUMINUM SHEET
OVER GRAPHITE WITH A DIAMOND
SHAPED DEPRESSION

Note:

40 cP/M
40 min @
Total 2000 cycles

CONDITIONS

PRESSURE 150 PSI
TEMPERATURE - Room
TIME AT PRESSURE See Note
TIME AT TEMPERATURE

SCALE: $1\frac{1}{2}'' = 1''$

EACH VERTICAL
UNIT = .001"

TEST Plate-F
MATERIAL # 2219-T31
DATE 4/22/63

Figure 9 - Surface Analysis of Permanent Set in Pressurized Aluminum Sheet