FINAL TEST SPECIFICATION
INCONEL-718 MATERIALS TEST, 37/W410
TUBULAR SPECIMENS, 15/W202
STRESS RELAXATION SPECIMENS, 15/W101

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RADIATION EFFECTS TESTING

System: NERVA

Component: Inconel-718

Test: 37/W410

Date: July, 1968

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FINAL TEST SPECIFICATION
INCONEL-718 MATERIALS TEST, 37/W410
TUBULAR SPECIMENS, 15/W202
STRESS RELAXATION SPECIMENS, 15/W101

I. EXPERIMENT IDENTIFICATION

A. EXPERIMENT DESIGN	37/W410, WANL-TME-1817
B. SPONSOR	WANL
C. TEST FACILITY	GD/FW (GTR-20)
D. TEST DATE	August, 1968

II. PURPOSE OF EXPERIMENT

Following are objectives for 37/W410:

To determine for Group C-I:

1. 0.2% tensile yield strength
2. ultimate tensile strength
3. elongation and reduction of area

As a function of:

1. test temperature between 1250 and 2000°R
2. thermal neutron fluence between 0 and 5×10^{19} nvt
3. grain size from 5 to 7 ASTM units
4. heat treatment at 1750 vs. heat treatment at 1950°F

To determine for Groups C-II, C-III, and C-IV

1. 0.2% tensile yield strength
2. ultimate tensile strength
3. elongation and reduction of area

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As a function of:

1. test temperature between 140 and 740°R
2. fast neutron fluence between 0 and 1×10^{19} nvt
3. grain size from 5 to 7 ASTM units
4. heat treatment at 1750 vs. that at 1950°F
5. annealing temperatures between 340 and 740°R (at a fast neutron fluence of 1×10^{19} nvt)
6. annealing times between 10 and 1000 minutes (at a fast neutron fluence of 1×10^{19} nvt)
7. notched vs. unnotched specimens

To determine for Group E-I, 15/W101:

1. stress relaxation in lateral support springs

As a function of:

1. irradiation temperature between 140 and 1200°R
2. fast neutron fluence between 0 and 5×10^{18} nvt
3. spring load between 0 and 130 lbs.

To determine for Tubular I and II, 15/W202:

1. 0.2% tensile yield strength
2. ultimate tensile strength
3. elongation and reduction of area

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As a function of test temperature from 140 to 2000°R at a thermal neutron fluence of 1×10^{19} nvt and a fast neutron fluence of 1×10^{19} nvt.

The sealing effectiveness of RTV-891 silicone cement used in the cemented end caps of these specimens is to be determined at a gamma dose of 10^{12} ergs/gm-carbon for hydrogen pressures of 210 and 315 psig, (Tubular III).

The effects of irradiating 7 identical specimens in LN_2 (140°R) to 1×10^{19} nvt and test them all at the same (worst) temperature, which will probably be 140°R, (C-V). There will be at least seven specimens of Inconel-718 bar material coarse grain size, 1750°F solution anneal, 10^{19} nvt, tested at 140°R with no intervening warm-up. The distribution of these specimens identified as specimen numbers 291, 489, 490, 494, 497, 498, and 502 will also be treated to a separate statistical analysis.

III. DRAWINGSWANL'S DRAWING NUMBERSDESCRIPTION

801C377

Round Tensile Specimens

979D482

Inconel-718 Lateral Support Spring

388D407

Tubular and Sealant Specimens

981D477

Tubular Specimen

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IV. EQUIPMENT LIST

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A. TO BE PROVIDED BY WANL

<u>1. Test Specimens</u>	<u>Irradiation</u>	<u>Control</u>	<u>Total</u>
Inconel-718 Bar Specimens	120	36	156
Lateral Support Springs	7	7	14
Tubular Tensile	18	8	26
Tubular Sealant	6	4	10

2. Fixture for Measuring Elongation

3. Grips and Pull Rods

B. TO BE PROVIDED BY TESTING AGENCY (GENERAL DYNAMICS/FORT WORTH)

1. Test Racks and Dewar for Holding Specimens During Irradiation
2. Instron Floor Model, Minimum Capacity 20,000 Pounds
3. Storage Dewar for Maintaining LN₂ Temperature
4. Instrumentation for Recording all Data
5. Transfer Devices to Transfer Specimens Under LN₂
6. Annealing Furnace (2000°R)
7. Furnace for High Temperature Testing Compatible with Instron Machine (2000°R)
8. Tensile testing cryostat
9. Thermocouple Recorders

V. TEST ENVIRONMENT

A. TEMPERATURE

1. IRRADIATION TEMPERATURE LN₂ (-320°F), Ambient, and 1200°R*

B. PRESSURE

Ambient

C. HUMIDITY

Not Applicable

D. VIBRATION

Not Applicable

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* See Appendix A of the Experiment Design (WANL-TME-1817) for environment conditions on each specimen.

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- E. 1. UNPERTURBED FAST NEUTRON FLUX 4.6×10^{13} and 2.3×10^{13} nv*
(E > 1.0 MeV)
2. UNPERTURBED THERMAL NEUTRON FLUX 2.3×10^{14} and 2.3×10^{13} nv*
- F. UNPERTURBED INTEGRATED DOSE
1. Fast Neutron (E > 1.0 MeV) 1×10^{19} and 5×10^{18} nvt*
2. Thermal Neutron 5×10^{19} and 5×10^{18} nvt*
3. Gamma 10^{12} ergs/gm carbon*
- G. FLUID ENVIRONMENT (During Irradiation) LN₂
- H. DURATION 600 Hours

VI. ANALYTICAL

A. PREDICTED PERTURBED FLUXES

Any perturbation of neutron flux by specimens, etc. on other specimens shall be estimated and taken into account, so that specimens will receive the specified fluence within $\pm 5\%$.

B. ACTIVATION LEVELS

1. Not Applicable

VII. FACILITY REQUIREMENTS

- A. ELECTRICAL 110 Volts - 60 Cycles
- B. PNEUMATIC Not Applicable
- C. HYDRAULIC Not Applicable
- D. SPECIAL FLUIDS LN₂ for Irradiation - LN₂ for Testing

* See Appendix A of the Experiment Design (WANL-TME-1817)
for environment conditions on each specimen.

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VIII. DOSIMETRY - (To be supplied by GD)

Thermal and fast neutron dosimetry at the front and rear of each experiment.

IX. DATA REQUIREMENTS

The data requirements are indicated in detail in WANL-TME-1817.

X. TEST DESCRIPTION

A total of 146 specimens will be irradiated in a LN_2 environment. In addition three of the lateral support springs shall be irradiated at 1200°R, and two shall be irradiated at room temperature. A description of the post-irradiation test conditions is itemized in Appendix A of the Experiment Design (WANL-TME-1817) along with specimen numbers, which are the same as the testing order. In addition for tubular specimens, the following table describes the testing to be performed.

<u>Specimen</u>	<u>Quantity</u>	<u>Irradiation</u>	<u>Testing</u>	<u>Temperature (°R)</u>
Tubular Tens.	9	1×10^{19} nvt (thermal) in LN_2	Tensile at	1500 1750 2000
Tubular Tens.	9	1×10^{19} nvt ($E > 1$ MeV) in LN_2	Tensile at	140 340 540
Tubular Tens.	8	(None)	Tensile at	140 540 1750 2000
Sealant	6	1×10^{12} ergs/gram carbon in LN_2	Leak	RT Hydrogen* at 210 & 315 psig
Sealant	4	(None)	Leak	RT Hydrogen* at 210 & 315 psig

* A substitute gas may be used if approval is given by WANL.

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RADIATION EFFECTS DATA BOOK

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A. RECEIVING INSPECTION PROCEDURE

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Upon receipt of specimens from WANL, all specimens will be visually inspected by GD/FW for possible damage due to handling and the results of this inspection recorded.

B. PRE-IRRADIATION CHECKOUT

Pre-irradiation checks will include (1) the measurement and recording of pre-test dimensions on all specimens by WANL and (2) identification of all specimens to be used in either the control or irradiation tests by WANL.

The identification symbols assigned to each specimen, which are scribed on each end, together with a description of the material will be entered in a permanent log book, along with the recorded location of specimens and dosimetry as in the test fixture by GD/FW. The location of specimens to be loaded into the dewars, designed by GD/FW and WANL, is given in the Experiment Design (WANL-TME-1817).

Detailed procedures including operating check lists shall be prepared by General Dynamics and approved by WANL.

C. REACTOR INSTALLATION PROCEDURES

Upon initiation of LN_2 flow, all events affecting temperature of test specimens will be recorded.

D. IRRADIATION TEST PROCEDURE

The reactor shall be operated for 600 hours at 10 megawatts. There are no special requirements relating to reactor startup or shutdown procedures, except that the specimens irradiated must remain under LN_2 from the start of irradiation through the post-irradiation testing unless otherwise specified.

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E. POST-IRRADIATION

The control specimens will be exposed to the same temperature environment including thermal cycling as the irradiated specimens.

The specimens shall be maintained at LN₂ temperature throughout the complete program through post-irradiation testing and not allowed to warm up above the test temperature, except those specifically warmed up. Procedures similar to those employed in GTR-16 will be required for the transfer of test specimens from the test dewar to the cryostat used in conjunction with the tests. GD/FW will concur with WANL on the use of load ranges for specific tests and materials.

1. Tensile Tests - Upon completion of tensile tests, the specimens will be fitted together and bench elongation data will be obtained with WANL fixture.* Area of reduction measurements using the photographic technique and/or micrometers will also be made. The tensile testing, alignment checks, and required metallography are described in the Experiment Design (WANL-TME-1817).

XI. HAZARDS

A. PERSONNEL

No foreseeable hazard other than handling irradiated material for testing at high temperature.

* Length between shoulders on each side of specimen shall be reported.

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B. FACILITY

No foreseeable hazards other than those connected with usual reactor operation.

XII. DATA REDUCTION

Data to be included in the report shall include ultimate and 0.2% offset yield tensile strength, relaxation in lateral support spring, leak rate in sealant test, the Instron chart elongation, the plastic elongation at maximum stress, the total plastic elongation obtained with bench measurement, and reduction of area using photography methods and/or micrometer measurements. Data shall be based on actual WANL reported gage length. Original or legible reproduced copies of all load-deflection curves, temperature recording curves, and raw data tabulations are to be made available to WANL as soon after testing as possible.

XIII. DISPOSITION OF SPECIMENS AND HARDWARE

Disposition of irradiated test specimens and/or equipment will be handled in accordance with current AEC regulations. The test specimens will be returned to WANL if specified. Obtain approval from WANL prior to disposition of any material or equipment.

XIV. SHIPPING AND RECEIVING INSTRUCTIONS

Specimens to be shipped to Mr. J. W. Allen at General Dynamics, Fort Worth, Texas.

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