FINAL TEST SPECIFICATION

INCONEL-718 MATERIALS TEST, 37/W410

STEM SPECIMENS, 15/W202

STRESS RELAXATION SPECIMENS, 15/W101

Revision 2

Prepared by:

J. R. Coombe, Fellow Engineer
Materials Engineering & Specifications

R. P. Shogan, Engineer
Materials Engineering & Specifications

Approved by:

E. L. Layland, Manager
Materials Engineering & Specifications

D. E. Thomas, Engineering Manager
Systems and Technology

MASTER

INFORMATION CATEGORY

Authorized Classifier

10/22/68
Date

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.

UNCLASSIFIED

System: NERVA

Component: Inconel-718

Test: 37/W410

Date: October, 1968

Page 1 of 15

WANL-TME-1822, Revision 2

FINAL TEST SPECIFICATION
INCONEL-718 MATERIALS TEST, 37/W410
STEM SPECIMENS, 15/W202
STRESS RELAXATION SPECIMENS, 15/W101
Revision 2

I. EXPERIMENT IDENTIFICATION

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

NOTICE
This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Atomic Energy Commission, nor any of their employees, nor any of their contractors, subcontractors, or 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.

UNCLASSIFIED

DISTRIBUTION OF THIS DOCUMENT UNLIMITED

2 C

UNCLASSIFIED

RADIATION EFFECTS TESTING

System: NERVA

Component: Inconel-718

Test: 37/W410

Date: October, 1968

Page 2 of 15

WANL-TME-1822, Revision 2

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)

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 Stem I and II, 15/W202:

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

UNCLASSIFIED

UNCLASSIFIED

RADIATION EFFECTS TESTING

System: NERVA

Component: Inconel-718

Test: 37/W410

Date: October, 1968

Page 3 of 15

WANL-TME-1822, Revision 2

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 Group III specimens is to be determined at a gamma dose of 10^{12} ergs/gm-carbon for hydrogen pressures of 210 and 315 psig, (Stem 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. DRAWINGS

WANL'S DRAWING NUMBERS

DESCRIPTION

801C377

Round Tensile Specimens

979D482

Inconel-718 Lateral Support Spring

388D407

Tubular and Sealant Specimens

981D477

Tubular Specimen

UNCLASSIFIED

UNCLASSIFIED

RADIATION EFFECTS TESTING

System: NERVA

Component: Inconel-718

Test: 37/W410

Date: October, 1968

Page 4 of 15

IV. EQUIPMENT LIST

WANL-TME-1822, Revision 2

A. TO BE PROVIDED BY WANL

1. <u>Test Specimens</u>	<u>Irradiation</u>	<u>Control</u>	<u>Total</u>
Inconel-718 Specimens	141	29	170
Lateral Support Springs	7	7	14
Stem Tensile	18	8	26
Stem Sealant	6	4	10
2. Fixture for Measuring Elongation			
3. Grips and Pull Rods			
4. Cryogenic Temperature Control Coil			
5. Cryogenic Annealing Coil			

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
10. Device for Leak Testing Stem Sealant Specimens
11. Spring Constant Measuring Fixtures

UNCLASSIFIED

UNCLASSIFIED

RADIATION EFFECTS TESTING

System: NERVA

Component: Inconel-718

Test: 37/W410

Date: October, 1968

Page 5 of 15

WANL-TME-1822, Revision 2

V. TEST ENVIRONMENT

A. TEMPERATURE

1. IRRADIATION TEMPERATURE LN_2 (-320°F), Ambient, and 1200°R**

B. PRESSURE

Ambient

C. HUMIDITY

Not Applicable

D. VIBRATION

Not Applicable

E. 1. UNPERTURBED FAST NEUTRON FLUX

4.6×10^{12} and 2.3×10^{12} nv**

(E > 1.0 MeV)

2. UNPERTURBED THERMAL NEUTRON FLUX

2.3×10^{13} and 2.3×10^{12} nv**

F. UNPERTURBED INTEGRATED DOSE

1. Fast Neutron (E > 1.0 MeV)

1×10^{19} and 5×10^{18} nvt** 2.5×10^{18}

2. Thermal Neutron

5×10^{19} and 5×10^{18} nvt** 10^{17}

3. Gamma

10^{12} ergs/gm carbon**

G. FLUID ENVIRONMENT (During Irradiation)

LN_2

H. DURATION

600 Hours

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

** See Appendix A for environment conditions on each specimen.

UNCLASSIFIED

UNCLASSIFIED

RADIATION EFFECTS TESTING

System: NERVA

Component: Inconel-718

Test: 37/W410

Date: October, 1968

Page 6 of 15

WANL-TME-1822, Revision 2

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 $\pm 5\%$ of each other.

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

UNCLASSIFIED

UNCLASSIFIED

RADIATION EFFECTS TESTING

System: NERVA

Component: Inconel-718

Test: 37/W410

Date: October, 1968

Page 7 of 15

WANL-TME-1822, Revision 2

VIII. DOSIMETRY -(To be supplied by GD)

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

IX. DATA REQUIREMENTS

A. ACCURACY REQUIREMENTS

The neutron fluence for specimens with the same fluence requirement in any given group shall be within $\pm 5\%$. The ratio of high to low fluence shall be $10 \pm 10\%$ and $2 \pm 10\%$ for groups C-I and C-II, respectively. Variation in fluence between groups shall be $\pm 30\%$. The gamma dose for sealant specimens shall be within $\pm 10\%$.

The gamma dose of all specimens shall be reported to within $\pm 50\%$ to comply with the NERVA Trend Data Retrieval Program.

The Instron machine load shall be recorded within $\pm 0.5\%$.

All elongation measurements shall be made to $\pm 0.5\%$.

Reduction of area measurements shall be to $\pm 1\%$.

Room temperature shall be recorded to the nearest $^{\circ}\text{R}$.

The Instron machine grip temperatures shall be monitored with thermocouples, and they should be recorded to within $\pm 1^{\circ}\text{R}$. The specimen temperature shall be accurate to $\pm 5^{\circ}\text{R}$.

Annealing temperatures shall be accurate to $\pm 2^{\circ}\text{R}$ in the cryogenic

UNCLASSIFIED

UNCLASSIFIED

RADIATION EFFECTS TESTING

System: NERVA

Component: Inconel-718

Test: 37/WA10

Date: October, 1968

Page 8 of 15

WANL-TME-1822, Revision 2

range and to $\pm 5^{\circ}\text{R}$ at temperatures equal to or greater than room temperature.

The annealing times shall be accurate to $\pm 1\%$.

The temperature of the three Inconel 718 springs to be irradiated at 1200°R (See Appendix A, Group E-1) shall be accurate to within $\pm 10^{\circ}\text{R}$.

X. TEST DESCRIPTION

A total of 167 specimens will be irradiated in an 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 along with specimen numbers,

In addition for stem specimens, the following table describes the testing to be performed:

<u>Specimen</u>	<u>Quantity</u>	<u>Irradiation</u>	<u>Testing</u>	<u>Temperature ($^{\circ}\text{R}$)</u>
Stem Tens.	9	1×10^{19} nvt (thermal) in LN_2	Tensile at	1500 1750 2000
Stem Tens.	9	1×10^{19} nvt ($E > 1$ MeV) in LN_2	Tensile at	140 340 540

UNCLASSIFIED

UNCLASSIFIED

NERVA
PROGRAM

RADIATION EFFECTS TESTING

System: NERVA

Component: Inconel-718

Test: 37/W410

Date: October, 1968

Page 9 of 15

WANL-TME-1822, Revision 2

Stem 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

Specimen dimensions are approximated in the following table to demonstrate the space each specimen will occupy. The table also gives the drawing number(s) associated with each specimen for the exact dimensions. These drawings are Figures 1 through 5.

Approximate Dimensions (Inches)	Type of Inconel 718 Specimen				Sheet
	Bar Specimens	Springs	Tensile	Leak Test	
Length	3.60	5.0	7.15	5.2	3.6
Width	1.0	---	1.0	1.0	1.0
Thickness (or Diameter)	0.26	1.13	0.5	0.5	0.10" (heads)
Drawing Number(s)	801C377	979D482	981D477	981D477	799C877
		Fig. 3	388D407	388D407	

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

UNCLASSIFIED

UNCLASSIFIED

System: NERVA

NERVA
PROGRAM

RADIATION EFFECTS TESTING

Component: Inconel-718

Test: 37/W/L10

Date: October, 1968

Page 10 of 15

WANL-TME-1822, Revision 2

A. RECEIVING INSPECTION PROCEDURE

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.

UNCLASSIFIED

UNCLASSIFIED

NERVA
PROGRAM

RADIATION EFFECTS TESTING

System:	NERVA
Component:	Inconel-718
Test:	37/W410
Date:	October, 1968
Page	11 of 15

WANL-TME-1822, Revision 2

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

C. REACTOR INSTALLATION PROCEDURES

Upon initiation of LN₂ flow, all events affecting temperature of test specimens will be recorded.

D. IRRADIATION TEST PROCEDURE

There are no special requirements relating to reactor startup or shutdown procedures, except that the specimens irradiated must remain under LN₂ from the start of irradiation through the post-irradiation testing unless otherwise specified.

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. Specimens from CIII will be tested before CII.

The times to temperature in CIII will be determined and reported. The times referenced in CIII refer to times at temperature although this may be modified by WANL monitor depending on times taken to reach testing temperature. The specimens will be tested at 140°R.

UNCLASSIFIED

UNCLASSIFIED

NERVA
PROGRAM

RADIATION EFFECTS TESTING

System: NERVA

Component: Inconel-718

Test: 37/W410

Date: October, 1968

Page 12 of 15

WANL-TME-1822, Revision 2

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.

F. TENSILE TESTING (INSTRON MACHINE)

Each specimen shall be held at its planned test temperature for 15 minutes before starting the crosshead. This time is approximate and may be changed by the WANL monitor at the time of testing. The Instron machine crosshead speed shall be 0.05 inches/min. for specimens tested at temperatures between 140 and 740°R and 0.002 inches/minute for specimens tested at temperatures between 1250 and 2000°R. Alignment checks shall be made intermittently during tensile testing. This shall be accomplished with three strain gages mounted 120° apart around the circumference of the gage section of a dummy specimen. The WANL monitor will determine whether the alignment of the system is adequate.

G. METALLOGRAPHY

Macrographs with a magnification of 2 to 4 shall be taken of the fractured surface of specimens numbered 295, 313, 316, 318, 363, 364, 371, 386, 387, and 393. (See Appendix A for specimen numbering.)

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

Westinghouse Nuclear

UNCLASSIFIED

UNCLASSIFIED

RADIATION EFFECTS TESTING

System: NERVA

Component: Inconel-718

Test: 37/W410

Date: October, 1968

Page 13 of 15

WANL-TME-1822, Revision 2

Electron fractographs (having suggested magnification 6000) of the fractured surface and microphotographs (having magnification 100 and 500) of the polished longitudinal area including the fracture shall be taken of specimens numbered 291, 300, 387, and 393. WANL shall receive replicas of the electron fractographs.

H. DISPOSITION OF SPARE SPECIMENS

Spare specimens will be used to replace damaged specimens if there are any. If spares are not used to replace damaged specimens, they will be used for additional replication at the most stringent test temperature (140°R, or as determined by the WANL monitor).

I. INCONEL 718 LEAK TEST SPECIMENS

The 10 Inconel 718 leak test specimens shall be pressurized to 210 and 315 psig with room temperature hydrogen. The leakage rates shall be determined before and after irradiation.

J. INCONEL 718 SPRINGS (STRESS RELAXATION)

The free length and compressed length shall be measured for specimens irradiated at LN₂ before and after irradiation at LN₂ temperature.

The spring constants shall be measured at WANL before irradiation

UNCLASSIFIED

UNCLASSIFIED

RADIATION EFFECTS TESTING

System: NERVA

Component: Inconel-718

Test: 37/W410

Date: October, 1968

Page 14 of 15

WANL-TME-1822, Revision 2

and shall be measured at GD/FW after irradiation. These specimens and all others will be measured for the same properties at room temperature.

XI. HAZARDS

A. PERSONNEL

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

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.

UNCLASSIFIED

UNCLASSIFIED

NERVA
PROGRAM

RADIATION EFFECTS TESTING

System: NERVA

Component: Inconel-718

Test: 37/W410

Date: October, 1968

Page 15 of 15

WANL-TME-1822, Revision 2

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.

UNCLASSIFIED

APPENDIX A

The following pages give tabulation of all Inconel-718 specimens, the group number of each group, and the independent variables. Test order 313 through 426.

C-I Inconel-718 - Plain Tensile

Test Conditions

<u>Specimen No.</u>	<u>Grain Size</u>	<u>Heat Treatment</u>	<u>Fluence (Thermal) (nvt)</u>	<u>Test Temperature (°R)</u>	<u>Test Order</u>
364	<5	1750°F	0	1250	315
393			↓	1750	350
392			5 x 10 ¹⁸	1500	349
377			↓	2000	332
386			5 x 10 ¹⁹	1250	341
374				1500	328
387				1750	343
363				2000	313
379		↓	↓	1500	334
384		1950°F	0	2000	339
389			↓	1250	346
383			5 x 10 ¹⁸	1750	338
365			↓	1250	316
394			5 x 10 ¹⁹	1500	351
366				1750	318
372				2000	325
370	↓	↓	↓	1500	323
371	>7	1750°F	0	2000	324
390	↓	↓	↓	1250	347
			5 x 10 ¹⁸		

C-I Inconel-718 - Plain Tensile
(continued)

Test Conditions

<u>Specimen No.</u>	<u>Grain Size</u>	<u>Heat Treatment</u>	<u>Fluence (Thermal) (nvt)</u>	<u>Test Temperature (°R)</u>	<u>Test Order</u>
388	↓ >7	1750°F	5 x 10 ¹⁸	1750	345
381		↓	5 x 10 ¹⁹	1250	336
385			↓	1500	340
376				1750	331
378				2000	333
373		1950°F	0	1250	327
380		↓	↓	1750	335
367			5 x 10 ¹⁸	1500	320
369			↓	2000	322
368			5 x 10 ¹⁹	1250	321
382			↓	1500	337
391				1750	348
375				2000	330
478		1950°F	10 ¹⁷	2000	314
471		1750°F	"	1250	317
473		1750°F	"	1750	319
474		1750°F	"	2000	326
476		1950°F	"	1500	329
475		1950°F	"	1250	342
477	↓	1950°F	"	1750	344
472		1750°F	"	1550	352

C-1 Inconel - 718 - Plain Tensile

Spare Specimens

**Astronuclear
Laboratory**

WANI-TME-1822

Revision 2

October, 1968

<u>Specimen No.</u>	<u>Heat Treatment (°F)</u>	<u>Fluence (thermal)(nvt)</u>
479	1750	0
480	↓	10^{17}
481	↓	5×10^{18}
482	↓	5×10^{19}
483	1950	0
484	↓	10^{17}
485	↓	5×10^{18}
486	↓	5×10^{19}

C-1 Inconel-718

Sheet

<u>Specimen No.</u>	<u>Fluence (thermal)</u>	<u>Test Temperature (°R)</u>	<u>Test Order</u>
717	0	1250	430
718	↓	1500	432
719	↓	1750	441
720	↓	2000	434
721	10^{17}	1250	440
722	↓	1500	433
723	↓	1750	435
724	↓	2000	427
725	5×10^{18}	1250	442
726	↓	1500	439
727	↓	1750	428
728	↓	2000	436
729	5×10^{19}	1250	437
730	↓	1500	431
731	↓	1750	429
732	↓	2000	438
<u>Spares</u>			
733	10^{17}		
734	5×10^{18}		
735	5×10^{19}

Astronuclear
Laboratory

WANL-TME-1822

Revision 2

October, 1968

C-II Inconel-718 - Plain Tensile

Test Conditions

<u>Specimen No.</u>	<u>Grain Size</u>	<u>Heat Treatment</u>	<u>Fluence Fast (nvt)</u>	<u>Test Temperature (°R)</u>	<u>Test Order</u>
300	<5	1750°F	0	140	405
286			↓	540	393
309			5 x 10 ¹⁸	340	420
315			↓	740	407
291			10 ¹⁹	140	397
308				340	418
284				540	391
326				740	415
487				140	398
488				340	419
489				540	392
490				740	416
303		1950	0	340	425
321			↓	740	411
302			5 x 10 ¹⁸	140	406
280			↓	540	388
297			10 ¹⁹	140	402
310				340	421
288				540	394
324				740	413
491			2.5 x 10 ¹⁸	140	403
492			2.5 x 10 ¹⁸	340	422
493			2.5 x 10 ¹⁸	540	395
499			2.5 x 10 ¹⁸	740	414
313	>7	1750	0	340	424
318			↓	740	409
296			5 x 10 ¹⁸	140	401
279			↓	540	387
295			10 ¹⁹	140	400

C-II Inconel-718 - Plain Tensile
(Continued)

Test Conditions

<u>Specimen No.</u>	<u>Grain Size</u>	<u>Heat Treatment</u>	<u>Fluence Fast (nvt)</u>	<u>Test Temperature (°R)</u>	<u>Test Order</u>
305	>7	1750°F	10 ¹⁹	340	426
283	↓	↓	↓	540	390
316	↓	↓	↓	740	408
298	↓	1950°F	0	140	404
289	↓	↓	↓	540	396
307	↓	↓	5 x 10 ¹⁸	340	417
323	↓	↓	↓	740	412
293	↓	↓	10 ¹⁹	140	399
312	↓	↓	↓	340	423
281	↓	↓	↓	540	389
320	↓	↓	↓	740	410

Spare Specimens

<u>Specimen No.</u>	<u>Grain Size</u>	<u>Heat Treatment</u>	<u>Fluence Fast (nvt)</u>
494	<5	1750	0
495	↓	↓	2.5 x 10 ¹⁸
496	↓	↓	5 x 10 ¹⁸
497	↓	↓	10 ¹⁹
498	↓	↓	0
500	↓	1950°F	0
501	↓	1950°F	10 ¹⁹
502	↓	1750°F	10 ¹⁹
509	>7	1750°F	10 ¹⁹
510	>7	1750°F	10 ¹⁹

C-II Inconel-718 - Sheet Tensile

<u>Specimen No.</u>	<u>Fluence Fast (nvt)</u>	<u>Test Temperature</u>	<u>Test Order</u>
701	0	140	450
702	↓	340	452
703	↓	540	443
704	↓	740	456
705	2.5×10^{18}	140	449
706	↓	340	451
707	↓	540	446
708	↓	740	458
709	5×10^{18}	140	447
710	↓	340	453
711	↓	540	540
712	↓	740	457
713	1×10^{19}	140	448
714	↓	340	454
715	↓	540	444
716	↓	740	455
	<u>Spares</u>		
736	2.5×10^{18}		
737	5×10^{18}		
738	1×10^{19}		

C-III Inconel-718 - Plain Tensile - Annealing Study
(Fast Fluence = 1×10^{19} nvt)

Test Conditions

<u>Specimen No.</u>	<u>Grain Size</u>	<u>Heat Treatment</u>	<u>Annealing Temperature (°R)</u>	<u>Annealing Time (min.)</u>	<u>Test Order</u>
333	<5	1750°F	340	10	355
342			↓	100	367
328			↓	1000	381
347			540	10	356
351			↓	100	366
355			↓	1000	382
335			740	10	362
344			↓	100	369
332			↓	1000	378
358		1950°F	340	10	359
362			↓	100	375
361			↓	1000	380
334			540	10	353
340			↓	100	372
329			↓	1000	386
359			740	10	363
360			↓	100	374
348			↓	1000	383
338	>7	1750°F	340	10	361
343			↓	100	368
327			↓	1000	376

C-III Inconel-718 - Plain Tensile - Annealing Study
 (Fast Fluence = 1×10^{19} nvt)
 (Continued)

Test Conditions

<u>Specimen No.</u>	<u>Grain Size</u>	<u>Heat Treatment</u>	<u>Annealing Temperature (°R)</u>	<u>Annealing Time (min.)</u>	<u>Test Order</u>
346	7	1750°F	540	10	357
352		↓	↓	100	371
349				1000	379
337				10	364
341				100	365
350		1950°F	340	10	358
357		↓	↓	100	373
353				1000	377
336				10	360
339				100	370
331				1000	384
354				10	354
345		↓	↓	1000	385

E-I Inconel-718 - Spring Test

<u>Spring No.</u>	<u>Load (lb)</u>	<u>Temp. During Irradiation (°R)</u>	<u>Fluence (Fast) (n/cm²)</u>	<u>Test Order</u>
1	0	1200	0	459
2	↓	↓	5 x 10 ¹⁸	460
3	65	↓	0	461
4	↓	↓	5 x 10 ¹⁸	462
5	↓	540	0	465
6	↓	↓	5 x 10 ¹⁸	466
7	↓	140	0	469
8	↓	↓	5 x 10 ¹⁸	470
9	130	1200	0	463
10	↓	↓	5 x 10 ¹⁸	464
11	↓	540	0	467
12	↓	↓	5 x 10 ¹⁸	468
13	↓	140	0	471
14	↓	↓	5 x 10 ¹⁸	472

Inconel-718 Stem Specimens*

Irradiation in LN₂ (140°R)

<u>Group</u>	<u>Neutron Fluence (nvt)</u>		<u>Irradiated</u>	<u>Number of Unirradiated Control Specimens</u>
Stem I	1 x 10 ¹⁹	fast	9 (T1-9)	4 (T10-13)
Stem II	1 x 10 ¹⁹	thermal	9 (T14+22)	4 (T23-26)
Stem III (Sealant)	1 x 10 ¹²	ergs/gm	6	4

*Pulled last.

Astronuclear
Laboratory

WANL-TME-1822

Revision 2

October, 1968

GTR-20 TEST ORDER

INCONEL-718

<u>Specimen No.</u>	<u>Test Order</u>
363	313
478	314
364	315
365	316
471	317
366	318
473	319
367	320
368	321
369	322
370	323
371	324
372	325
474	326
373	327
374	328
476	329
375	330
376	331
377	332
378	333
379	334

GTR-20 TEST ORDER
(continued)

INCONEL-718

<u>Specimen No.</u>	<u>Test Order</u>
380	335
381	336
382	337
383	338
384	339
385	340
386	341
475	342
387	343
477	344
388	345
389	346
390	347
391	348
392	349
393	350
394	351
472	352
334	353
354	354
333	355

GTR-20 TEST ORDER
(continued)

INCONEL-718

<u>Specimen No.</u>	<u>Test Order</u>
347	356
346	357
350	358
358	359
336	360
338	361
335	362
359	363
337	364
341	365
351	366
342	367
343	368
344	369
339	370
352	371
340	372
357	373
360	374
362	375
327	376

GTR-20 TEST ORDER
(continued)
INCONEL-718

<u>Specimen No.</u>	<u>Test Order</u>
353	377
332	378
349	379
361	380
328	381
355	382
348	383
331	384
345	385
329	386
279	387
280	388
281	389
283	390
284	391
489	392
286	393
288	394
493	395
289	396
291	397

Astronuclear
Laboratory

WANL-TME-1822

Revision 2

October, 1968

GTR-20 TEST ORDER
(continued)

INCONEL-718

<u>Specimen No.</u>	<u>Test Order</u>
487	398
293	399
295	400
296	401
297	402
491	403
298	404
300	405
302	406
315	407
316	408
318	409
320	410
321	411
323	412
324	413
499	414
326	415
490	416
307	417
308	418

GTR-20 TEST ORDER
(continued)

INCONEL-718

<u>Specimen No.</u>	<u>Test Order</u>
488	419
309	420
310	421
492	422
312	423
313	424
303	425
305	426
724	427
727	428
731	429
717	430
730	431
718	432
722	433
720	434
723	435
728	436
729	437
732	438
726	439

GTR-20 TEST ORDER
(continued)

INCONEL-718

<u>Specimen No.</u>	<u>Test Order</u>
721	440
719	441
725	442
703	443
715	444
711	445
707	446
709	447
713	448
705	449
701	450
706	451
702	452
710	453
714	454
716	455
704	456
712	457
708	458

DESIGN DATA									WORKING CONDITIONS							
ITEM NO.	WIRE SIZE		O.D.		I.D. REF	FREE LENGTH	NO. OF COILS		IN DIA HOLE	ON DIA SHAFT	SOLID HEIGHT	DIRECTION OF COILS	RATE (REF) LBS/IN.	WORKING LOAD (2 CONDITIONS)		
	A	B	AS WOUND	GROUND			ACTIVE	TOTAL						LOAD LBS ± LBS	AT LENGTH	
1	.112 ±.001	.179 ±.001	687±005	672 ⁺⁰⁰⁵ ₋₀₀₀	.463	3.802 REF	15.4 REF	17.4 REF	-	-	3.120 REF	LEFT HAND	265.0	81.6 133.0	4.0 6.0	3.494 BASIC 3.300 BASIC

FIGURE 2 Inconel-718 Springs

612531-10B

FIGURE 3 Inconel-718 Springs on Fixture

FIGURE 4 Inconel-718 Tubular & Sealant Specimens

FIGURE 5 Inconel-718 Tubular Specimens