REPORT 2275

MATERIALS PROPERTIES DATA BOOK

REVISION OF 15 JULY 1970

VOLUME 2
FERROUS ALLOYS

30 AUGUST 1970

CONTRACT SNP-1

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.

PUBLISHED BY
ANSC

CLASSIFICATION CATEGORY

UNCLASSIFIED

CW Frank 30 AUG 1970
CLASSIFYING OFFICER DATE

IN COOPERATION WITH

AEROJET NUCLEAR SYSTEMS COMPANY

A DIVISION OF AEROJET - GENERAL

DISTRIBUTION

AGC--2275
Vol. 2

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.

PAGE BLANK

DATE	15 JULY 1970
-------------	--------------

SUPERSEDES	15 MAR 1970
-------------------	-------------

FOREWORD

This Data Book was prepared in partial fulfillment of Contract SNP-1 of the Space Nuclear Propulsion Office, a joint office of the National Aeronautics and Space Administration and the Atomic Energy Commission, with the Aerojet Nuclear Systems Company. Guidance of the work was the responsibility of the Cleveland Extension of SNPO.

Sheets based either wholly or in part on technical contributions by the Westinghouse Astro-nuclear Laboratory are identified by WANL's insignia.

Contributions of data from persons or organizations are solicited, and if included in the Data Book, proper acknowledgment will be made. Communications relevant to such contributions or for related matters should be addressed to the Manager, Materials and Processes Section, Aerojet Nuclear Systems Company, Sacramento, California, under whose supervision the work is being accomplished.

DATE 15 MAR 1970

SUPERSEDES 30 SEPT 1969

AUTHORIZATION FOR USE

This Materials Properties Data Book has been previously established, and continues in effect, as the basic design criterion for materials usage within the NERVA Program, subject to interpretation or extrapolation by the Aerojet Nuclear Systems Company, Materials and Processes Section.

Submitted:

C. W. Funk, Manager
Materials and Processes Section

Approved:

C. K. Leeper
Vice President and
Technical Director
Aerojet Nuclear Systems Company

I. L. Odgers, Manager
Engineering Department

DATE 15 JULY 1970

SUPERSEDES 15 MAR 1970

VOLUME 1
VOLUME 1
INTRODUCTION

<u>A. GENERAL</u>		<u>Page</u>	<u>B. LIST OF REFERENCES</u>		<u>Page</u>
		3			21
1.	Organization	4	Reference Presentation		22
2.	Data Presentation	6	1970		23
			1969		25
a.	Adjustment of Data	6	1968		27
			1967		29
b.	Identification of Primary Strength Properties	6	1966		32
			1965		36
			1964		41
c.	Categories of Primary Strength Properties	7	1963		46
			1962		50
			1961		54
d.	Design Properties	8	1960		56
			1959		59
e.	Statistical Analysis of Material Test Data	9	1958		61
			1957		62
			1956		63
f.	Symbology	10	1955		64
			1954		65
3.	Bearing Properties	12	1953		66
			1952		66
4.	Modulus of Elasticity	12	1951		67
			1950		67
5.	Thermal Emissivity and Emittance	13	1949		68
			1948		68
6.	Goodman Diagrams	14	1947		69
			1946		69
7.	Appendices	15	1939		70
			1938		70
8.	Data Sources	15			

DATE 15 JULY 1970

SUPERSEDES 15 MAR 1970

See Pages 4 and 5 of Introduction for Numerical Code

VOLUME 1
VOLUME 1
MATERIALS DATA
I. LIGHT METAL ALLOYS

	<u>Code</u>	<u>Page</u>
<u>Aluminum Alloys</u>	I-A	41
356	I-A-01	43
A356	I-A-02	51
2014	I-A-20	57
2024	I-A-24	61
2219	I-A-26	71
5083	I-A-52	79
5454	I-A-54	81
5456	I-A-56	83
6061	I-A-61	Vol. 1, Page 301
7039	I-A-74	97
7075	I-A-75	107
7079	I-A-77	119
7178	I-A-78	125
<u>Titanium Alloys</u>	I-B	127
Ti-5Al-2.5 Sn (A-110 AT)	I-B-10	129
Ti-5Al-2.5 Sn (A-110 AT)-ELI	I-B-11	Vol. 1, Page 471
Ti-6Al-4V (C-120 AV)	I-B-30	149
Ti-6Al-4V (C-120 AV)-ELI	I-B-31	163

DATE	15 JULY 1970
SUPERSEDES	30 SEPT 1969

See Pages 4 and 5 of Introduction for Numerical Code

VOLUME 1-A
VOLUME 1-A
MATERIALS DATA
II. NICKEL-BASE ALLOYS

	<u>Code</u>	<u>Page</u>
<u>Solution-Hardening Alloys</u>	II-A	169
Hastelloy C	II-A-13	171
Hastelloy N (INOR-8)	II-A-14	181
AISI 680 (Hastelloy X)	II-A-15	189
Inconel 625	II-A-17	197
<u>Precipitation-Hardening Alloys</u>	II-B	207
AISI 683 Rene' 41	II-B-10	209
AISI 684 Udimet 500	II-B-11	211*
AISI 685 Waspaloy	II-B-12	213
AISI 687 Udimet 700	II-B-14	215
AISI 688 Inconel X-750	II-B-15	217
Alloy 718	II-B-17	223
Udimet 630	II-B-28	231*
<u>Dispersion-Hardening Alloys</u>	II-C	235
TD Nickel	II-C-10	237

III. REFRACTORY METALS AND ALLOYS

	<u>Code</u>	<u>Page</u>
<u>Molybdenum and Molybdenum Alloys</u>	III-A	243
Molybdenum	III-A-10	245
TZM Molybdenum	III-A-11	257
<u>Tantalum and Tantalum Alloys</u>	III-B	263
Tantalum	III-B-10	265
<u>Tungsten and Tungsten Alloys</u>	III-C	273
Tungsten	III-C-10	275
Tungsten-25 Rhenium	III-C-20	283

IV. OTHER NONFERROUS METALS AND ALLOYS

	<u>Code</u>	<u>Page</u>
<u>Cobalt Alloys</u>	IV-A	289
AISI 670 Cobalt Alloy (Haynes 25)	IV-A-11	291
<u>Copper Alloys</u>	IV-B	303
Oxygen-Free, High-Conductivity	IV-B-10	305
<u>Zirconium Alloys</u>	IV-C	313

*To be published

DATE	30 SEPT 1969
SUPERSEDES	30 JUNE 1968

See Pages 4 and 5 of Introduction for Numerical Code

VOLUME 2
VOLUME 2
MATERIALS DATA
V. FERROUS ALLOYS

	<u>Code</u>	<u>Page</u>
<u>Carbon and Low-Alloy Steels</u>	V-A	315
AISI 1025	V-A-10	317
AISI 4340	V-A-43	319
<u>Austenitic Stainless Steels</u>	V-B	321
AISI 301	V-B-01	323
AISI 303	V-B-03	341
AISI 304	V-B-04	349
AISI 310	V-B-10	361
AISI 316	V-B-16	371
AISI 321	V-B-21	379
AISI 347	V-B-47 Vol. 2, Page 261	
<u>Martensitic Stainless Steels</u>	V-C	401
AISI 440C (also, AISI 617)	V-C-29	403
<u>Precipitation-Hardening</u>	V-D	407
<u>Stainless</u>		
AISI 630 (17-4 PH)	V-D-10	409
AISI 631 (17-7 PH)	V-D-11	411
AISI 632 (PH-15-7 Mo)	V-D-12	421
AISI 633 (AM 350)	V-D-13	425
<u>Iron-Nickel-Chromium Alloys</u>	V-E	429
AISI 660 (A-286)	V-E-10	431
AISI 664 (D-979)	V-E-14	445
Incoloy 800	V-E-16	454-A
Ni-SPAN-C902	V-E-20	455
<u>Bolt Materials</u>	V-F	463

DATE	30 SEPT 1969
SUPERSEDES	30 JUNE 1968

See Pages 4 and 5 of Introduction for Numerical Code

VOLUME 3
VOLUME 3
MATERIALS DATA
VI. NUCLEAR MATERIALS

	<u>Code</u>	<u>Page</u>
<u>Nuclear Fuel Materials</u>	VI-A	465
NERVA Fueled Elements	VI-A-10	467
NERVA Non-Fueled Elements	VI-A-11	471
<u>Neutron Control Materials</u>	VI-B	475
AISI 304 + Gd	VI-B-11	477
Lithium Hydride	VI-B-13	481
<u>Moderator Materials</u>	VI-C	485
Beryllium (S-200 grade)	VI-C-12	Vol. 3, Page 41
Beryllium (1-400 grade)	VI-C-14	495

VII. GRAPHITES

	<u>Code</u>	<u>Page</u>
<u>Structural Graphites</u>	VII-A	499
Graphitite G	VII-A-10	501
MHLM (H4LM)	VII-A-11	509
P-03	VII-A-12	515
ATJ	VII-A-13	521
ZTA	VII-A-14	527
Carb-I-Tex 500	VII-A-15	529
Carb-I-Tex 700	VII-A-16	532-A
Carb-I-Tex 715	VII-A-17	532-E
TS-699	VII-A-18	533
<u>High-Expansion</u>	VII-B	534-A
<u>Structural Graphites</u>		
L-56	VII-B-10	535
EP-192	VII-B011	537
EP-192C	VII-B-12	539
EP-192C-H	VII-B-13	540-A
SX-5	VII-B-14	540-C
<u>Pyrolytic Graphite</u>	VII-C	541
Pyrolytic graphite	VII-C-10	543
Pyrolytic graphite foil (Pyrofoil)	VII-C-20	548
<u>Other Graphites</u>	VII-D	549

DATE 30 SEPT 1969

SUPERSEDES 30 JUNE 1968

See Pages 4 and 5 of Introduction for Numerical Code

VOLUME 3
VOLUME 3
MATERIALS DATA
VIII. REFRACTORY CERAMICS

	<u>Code</u>	<u>Page</u>
<u>Oxides</u>	VIII-A	551
Beryllium oxide	VIII-A-10	553
Magnesium oxide	VIII-A-11	561
Thorium oxide	VIII-A-12	567
Zirconium oxide	VIII-A-13	575
<u>Carbides</u>	VIII-B	583
Boron carbide	VIII-B-10	585
Tantalum carbide	VIII-B-11	589
<u>Nitrides</u>	VIII-C	593
Boron nitride	VIII-C-10	595

IX. ADHESIVES

	<u>Code</u>	<u>Page</u>
<u>Epoxies</u>	IX-A	601
Epon 929 (Ep.)	IX-A-10	603
Epon 934 (Ep.)	IX-A-11	607
FM 1000 (Ep. -Nylon)	IX-A-12	609
HT 424 (Ep. -Phen.)	IX-A-13	611
Aerobond 430 (Ep. -Phen.)	IX-A-14	615
C-7 (Ep. -Resin)	IX-A-15	619
Epoxy-Patch 0151 (Ep. -Resin)	IX-A-16	621
Epy-150 (Ep. -Resin)	IX-A-17	623
Epy-400 (Ep. -Resin)	IX-A-18	625
<u>Phenolics</u>	IX-B	631
Metlbond 402 (Phen. -Nit.)	IX-B-10	633
FM-47 (Vinyl-Phen.)	IX-B-11	637
<u>Polyurethanes</u>	IX-C	641
Apco 1202	IX-C-10	643*
<u>Silicones</u>	IX-D	651
Silastic 140 (Silicone)	IX-D-10	653
RTV 891 (Silicone)	IX-D-11	655
<u>Ceramics (Cements)</u>	IX-E	
National Carbon No. 14	IX-E-10	663
DW-30	IX-E-11	665
P-514	IX-E-12	667

*To be published

DATE 30 SEPT 1969

SUPERSEDES 30 JUNE 1968

See Pages 4 and 5 of Introduction for Numerical Code

VOLUME 3
VOLUME 3
MATERIALS DATA
X. PLASTICS

	<u>Code</u>	<u>Page</u>
Armalon	X-A-10	673
Teflon	X-A-11	677
SP-3	X-A-12	687
Kapton (H-Film)	X-A-13	689

APPENDICES
A. PLASTIC BENDING MODULUS

	<u>Page</u>
Foreword and Nomenclature	703
1 Basic Relationships	704
2 Ultimate Bending Strength	705
3 Yield Bending Strength	707
4 General Stress Level	708
5 Example	710

**B. EFFECTS OF RADIATION ON STRUCTURAL
MATERIALS** *

*To be published

DATE 1 MAY 1966
SUPERSEDES

**STRESS VS STRAIN
AS FUNCTION OF
TEMPERATURE**

DATE 15 SEPT 1967
SUPERSEDES 1 MAY 1966

**IMPACT STRENGTH
ROCKWELL HARDNESS**

DATE 15 SEPT 1967

SUPERSEDES

ELONGATION
(AFTER IRRADIATION)

DESIGN VALUES 80% OF AVERAGE
SEE INTRODUCTION PAGE 3

EFFECTS OF IRRADIATION ON ELONGATION OF
AIISI TYPE 301 STAINLESS STEEL

UNLESS OTHERWISE NOTED
E > 1.0 MEV

FORM AND CONDITION	GAGE LENGTH (IN)	TEMPERATURES (°F)			PRE- IRRADIATION CONTROL VALUES	POST-IRRADIATION VALUES DOSAGES GIVEN AS INTEGRATED NEUTRON FLUX (NVT) IN TERMS OF NEUTRONS/CM ²										NO OF IRRADIATION SPECIMENS	REFERENCE	COMMENTS
		IRRADIATION	POST IRRADIATION ANNEAL	POST- IRRADIATION TEST		10 ¹⁵		10 ¹⁶		10 ¹⁷		10 ¹⁸		10 ¹⁹				
						ELONG - %	DOSAGE	ELONG	DOSAGE	ELONG /	DOSAGE	ELONG /	DOSAGE	ELONG /	DOSAGE			
SHEET (LONG)	1.75 (a)	320		320	16.5					16	5 x 10 ¹⁷					3	NP 66.3	
SHEET (LONG)	1.75 (a)	320	80	320	16.5					16	5 x 10 ¹⁷					3	NP 66.3	
SHEET (LONG)	1.75 (a)	320	80	80	15.5					14	5 x 10 ¹⁷					3	NP 66.3	
FULL HARD MATERIAL																		
(a) REDUCED SECTION 1/4 IN. WIDE BY 1/16 IN.																		

DATE 15 SEPT 1967
SUPERSEDES 1 MAY 1966

MODULUS OF ELASTICITY

MODULUS OF RIGIDITY

DATE 15 SEPT 1967
SUPERSEDES 1 MAY 1966

THERMAL EXPANSION VALUES ARE FROM
ROOM TEMPERATURE TO INDICATED TEMP.

**THERMAL EXPANSION
SPECIFIC HEAT**

MEAN COEFFICIENT-LINEAR THERMAL EXPANSION
 10^{-6} IN./IN.-°F

BTU/LB-°F
SPECIFIC HEAT

THERMAL CONDUCTIVITY

THERMAL CONDUCTIVITY
BTU-FT/HR-FT²-°F

TEMPERATURES IN 100° F

DATE 15 SEPT 1967
SUPERSEDES 1 MAY 1966

**POISSON'S RATIO
DENSITY**

DATE 15 SEPT 1967
SUPERSEDES 1 MAY 1966

**IMPACT STRENGTH
ROCKWELL HARDNESS**

DATE 15 SEPT 1967
SUPERSEDES

**ELONGATION
(AFTER IRRADIATION)**

DESIGN VALUES 80 OF AVERAGE
SEE INTRODUCTION PAGE 3

EFFECTS OF IRRADIATION ON ELONGATION OF
AISI TYPE 303S₈ STAINLESS STEEL

UNLESS OTHERWISE NOTED
E > 1.0 MEV

FORM AND CONDITION	GAGE LENGTH (IN)	TEMPERATURES (°F)			PRE- IRRADIATION CONTROL VALUES	POST-IRRADIATION VALUES DOSAGES GIVEN AS INTEGRATED NEUTRON FLUX (NVT) IN TERMS OF NEUTRONS/CM ²										NO OF IRRADIATION SPECIMENS	REFERENCE	COMMENTS
		IRRADIATION	POST IRRADIATION ANNEAL	POST IRRADIATION TEST		10 ¹⁵		10 ¹⁶		10 ¹⁷		10 ¹⁸		10 ¹⁹				
						ELONG	DOSAGE	ELONG	DOSAGE	ELONG	DOSAGE	ELONG /	DOSAGE	ELONG	DOSAGE			
BAR (LONG)	ANNEALED MATERIAL	320		320	36					27.5	6.5 x 10 ¹⁷					3	NP 66 3	
BAR (LONG)		320	80	320	36					31.0	6.5 x 10 ¹⁷					3	NP 66 3	
BAR (LONG)		320		0	25					21.0	6.5 x 10 ¹⁷					3	NP 66 3	

DATE 1 MAY 1966
SUPERSEDES

MODULUS OF ELASTICITY

MODULUS OF RIGIDITY

DATE 15 SEPT 1967
SUPERSEDES 1 MAY 1966

THERMAL EXPANSION VALUES ARE FROM
ROOM TEMPERATURE TO INDICATED TEMP.

**THERMAL EXPANSION
SPECIFIC HEAT**

MEAN COEFFICIENT-LINEAR THERMAL EXPANSION
 10^{-6} IN./IN.-°F

0.16

0.12

0.08

0.04

0

BTU/LB-°F
SPECIFIC HEAT

THERMAL CONDUCTIVITY
BTU-FT/HR-FT²-°F

THERMAL CONDUCTIVITY

TEMPERATURES IN 100° F

DATE 15 SEPT 1967

SUPERSEDES 1 MAY 1966

POISSON'S RATIO

ELECTRICAL RESISTIVITY

DATE 1 MAY 1966
SUPERSEDES

**STRESS VS STRAIN
AS FUNCTION OF
TEMPERATURE**

DATE 15 SEPT 1967
SUPERSEDES 1 MAY 1966

**IMPACT STRENGTH
ROCKWELL HARDNESS**

DATE 15 SEPT 1967

SUPERSEDES

**ELONGATION
(AFTER IRRADIATION)**

DESIGN VALUES - 80% OF AVERAGE
SEE INTRODUCTION, PAGE 3

EFFECTS OF IRRADIATION ON ELONGATION OF
AISI TYPE 304 STAINLESS STEEL

UNLESS OTHERWISE NOTED
E > 0.5 MEV

FORM AND CONDITION	GAGE LENGTH (IN.)	TEMPERATURES (°F)			PRE- IRRADIATION CONTROL VALUES	POST-IRRADIATION VALUES DOSAGES GIVEN AS INTEGRATED NEUTRON FLUX (NVT) IN TERMS OF NEUTRONS/CM ²										NO OF IRRADIATION SPECIMENS	REFERENCE	COMMENTS
		IRRADIATION	POST- IRRADIATION ANNEAL	POST- IRRADIATION TEST		10 ¹⁵		10 ¹⁶		10 ¹⁷		10 ¹⁸		10 ¹⁹				
						ELONG - γ	DOSAGE	ELONG - γ	DOSAGE	ELONG - γ	DOSAGE	ELONG - γ	DOSAGE	ELONG - γ	DOSAGE			
1 2-IN ROUND	0.5 (a)	430		-430	27.5					27.0	1 x 10 ¹⁷					3	NP-66-35 NP-63-3	E > 0.33 MEV
		-423	80	-423	30.0					31.0	2 x 10 ¹⁷							
ANNEALED MATERIAL																		
(a) REDUCED SECTION 1/8-IN DIA																		

DATE 15 SEPT 1967
SUPERSEDES 1 MAY 1966

MODULUS OF ELASTICITY

MODULUS OF RIGIDITY

DATE 15 SEPT 1967

SUPERSEDES 1 MAY 1966

THERMAL EXPANSION VALUES ARE FROM
ROOM TEMPERATURE TO INDICATED TEMP.

**THERMAL EXPANSION
SPECIFIC HEAT**

MEAN COEFFICIENT-LINEAR THERMAL EXPANSION
 10^{-6} IN./IN.-°F

THERMAL CONDUCTIVITY

THERMAL CONDUCTIVITY
BTU-FT/HR-FT²-°F

TEMPERATURES IN 100° F

DATE 15 SEPT 1967
SUPERSEDES 1 MAY 1966

POISSON'S RATIO

ELECTRICAL RESISTIVITY

MATERIALS DATA BOOK

AISS 347
STAINLESS STEEL

V-B-47

1

DATE 30 SEPT 1969

SUPERSEDES 1 MAY 1966

BASIC DATA
A. GENERAL

AISS 347 IS AN AUSTENITIC STABILIZED STAINLESS STEEL OF THE CHROMIUM-NICKEL SERIES NOT HARDENABLE THROUGH HEAT TREATMENT IT IS DESIGNED FOR USAGE REQUIRING INTERMITTENT HEATING AND COOLING TO BETWEEN 800 AND 1650 F. IT RESISTS OXIDATION TO 1700 F AND INTERGRANULAR CORROSION TO 2150 F. ANNEALING IS NOT USUALLY REQUIRED FOR CORROSION RESISTANCE, EXCEPT TO RELIEVE STRAINS FROM SEVERE FORMING OPERATIONS. IT CAN BE USED IN THE AS WELDED CONDITION IN CORROSIVE APPLICATIONS.

COLUMBIUM IS ADDED FOR STABILIZATION BECAUSE TANTALUM IS USUALLY IN COMBINATION AND SIMILAR CHEMICALLY, THE STABILIZING ELEMENT CONTENT IS SPECIFIED AS THE TOTAL OF COLUMBIUM AND TANTALUM, FOR NUCLEAR APPLICATIONS, TANTALUM CAN BE LIMITED TO 0.1% MAXIMUM AND THE ALLOY IS THEN DESIGNATED AS AISS 348. A FREE-MACHINING VARIETY CONTAINING SELENIUM IS ALSO AVAILABLE.

THIS MATERIAL IS AVAILABLE IN ALL WROUGHT FORMS AND AS CASTINGS.

DATA IN SECTION E ARE FOR ANNEALED MATERIAL UNLESS OTHERWISE STATED.

B. COMMERCIAL DESIGNATIONS

WROUGHT AISS 347 COLUMBIUM-STABILIZED
 CAST CF-8C 347C

C. FORMS, SPECIFICATIONS, SUPPLIERS

FORMS AND CONDITIONS	SPECIFICATIONS
SHEET, STRIP, PLATE	MIL-S-6721, TYPE Cb-Ta QQ-S-766, AMS 5512
TUBING, SEAMLESS	MIL-T-8606 COMP G-347 AMS 5571 AND 5558
TUBING, WELDED	MIL-T-6737 COMP G-347 AMS 5575 AND 5558
BAR, FORGING	QQ-S-763, CLASS 8 AMS 5646
WIRE, WELDING	MIL-R-5031, COMP 3 AMS 5680
ELECTRODE, COATED WELDING	MIL-E-6844 CLASS 5 AMS 5681

SUPPLIERS ALLEGHENY-LUDLUM STEEL CO
 CRUCIBLE STEEL COMPANY
 REPUBLIC STEEL COMPANY
 U S STEEL COMPANY

D. CHEMICAL COMPOSITION (%)

ELEMENT	C	Mn	Si	P	S	Cr	Ni	Mo	Cu	Ci
MAXIMUM	0.08	2.0	1.0	0.05	0.030	19.0	13.0	0.50	0.50	1.50
MINIMUM	-	-	-	-	-	17.0	9.0	-	-	10x

SOURCE REF 64-8 ETC BALANCE Fe

E. ROOM TEMPERATURE PROPERTIES

(AVERAGE UNLESS OTHERWISE NOTED)

1. MECHANICAL PROPERTIES

ULTIMATE TENSILE STRENGTH	F _{TU}	KSI
FORGINGS (80% OF AVE)	68	
SHEET (80% OF AVE)	72	
BAR (80% OF AVE)	69	

TENSILE YIELD STRENGTH	F _{TY}	KSI
FORGINGS (80% OF AVE)	32	
SHEET (80% OF AVE)	31	
BAR (80% OF AVE)	30	

COMP. YIELD STRENGTH	F _{CY}	KSI
SHEET	54	

ULTIMATE SHEAR STRENGTH	F _{SU}	KSI
SHEET	76	

ULTIMATE BEARING STRENGTH	F _{BRU}	KSI
e/D 1.5 (SHEET)	157	
e/D 2.0	—	

BEARING YIELD STRENGTH	F _{BRV}	KSI
e/D 1.5 (SHEET)	82	
e/D 2.0	—	

ELONGATION	e	%
FORGING (80% OF AVE.)	45	
SHEET (80% OF AVE)	40	
BAR (80% OF AVE)	45	

REDUCTION OF AREA	RA	%
FORGINGS (80% OF AVE)	56	
BAR (80% OF AVE)	56	

MODULUS OF ELASTICITY	E	10 ⁶ PSI
	29.3	

COMP. MODULUS OF ELASTICITY	E _c	10 ⁶ PSI
-----------------------------	----------------	---------------------

MODULUS OF RIGIDITY	G	10 ⁶ PSI
	11.4	

HARDNESS (ANNEALED)	MAX.
---------------------	------

BAR & PLATE,	228 BRINELL
SHEET & STRIP	90 R _B

2. PHYSICAL PROPERTIES

DENSITY	ρ
LB/IN ³ AT 81 F	0.2854
g/cc AT 81 F	7.899

SPECIFIC HEAT	C	BTU/LB. °F
AT 81 F	0.108	

THERMAL CONDUCTIVITY	k	BTU - FT HR - FT ² - °F
AT 81 F	8.55	

MEAN COEFF. LINEAR THERMAL EXPANSION	α	10 ⁻⁶ IN IN - °F
81 - 212 F	9.24	

ELECTRICAL RESISTIVITY	R	MICROHM - IN
(REF 63-21)	28.5	

MAGNETIC PROPERTIES

NON MAGNETIC IN THE ANNEALED CONDITION BECOMES SLIGHTLY MAGNETIC WHEN SEVERELY COLD WORKED, AS SHOWN IN THE FOLLOWING TABLE.

MAGNETIC PERMEABILITY		
REDUCTION	H = 50	H = 200
%		
0	1.0037	1.0044
13.5	1.0074	1.0088
40.0	1.062	1.088
60.0	1.245	1.445
90.0	1.97	4.12

F. THERMOPHYSICAL EFFECTS

MELTING RANGE
2550 - 2650 F

PHASE CHANGES

SUBJECT TO CARBIDE PRECIPITATION AFTER HEATING ABOVE 2150 F, FOLLOWED BY HEATING AT ABOUT 1200 F (SEE SECTION G).

EMISSION (SEE PAGE 13 OF INTRODUCTION)

HEMISPHERICAL TOTAL	0.125 ± 0.04
NORMAL TOTAL	0.10 ± 0.04

F. THERMOPHYSICAL EFFECTS (CONTINUED)**THERMAL CONDUCTIVITY VS. TEMPERATURE**

TEMPERATURE (°F)	k (BTU - FT HR - FT ² - °F)
-423	1.05
-280	5.26
-180	6.42
-100	7.28
80	8.55
260	9.54
440	10.37
620	11.10
800	11.85
980	12.66
1160	13.41
1340	14.22
1520	14.97
1700	15.78
1880	16.53
2060	17.38
2240	18.09
2420	18.90

G. CHEMICAL PROPERTIES

GENERAL CORROSION RESISTANCE OF THIS STEEL IS SIMILAR TO THAT OF TYPE 302, BUT IT HAS A GREATER TENDENCY TO PITTING CORROSION AND ATTACK IN STREAKS. THIS GRADE SUFFERS FROM PROLONGED HEATING IN THE RANGE OF 800 - 1600 F IN SEVERE CORROSIVE SERVICE.

THERE IS NO INTERGRANULAR CORROSION IN THIS STEEL, UNLESS IT IS HEATED TO ABOVE 2150 F. AT THIS TEMPERATURE COLUMBIUM CARBIDES GO INTO SOLID SOLUTION, AND SUBSEQUENT RAPID COOLING, FOLLOWED BY HEATING TO 1200 F, WILL CAUSE PRECIPITATION, REDUCING THE RESISTANCE TO INTERGRANULAR ATTACK. A STABILIZING ANNEAL WILL RESTORE THE CORROSION RESISTANCE.

STRESS CRACKING MAY OCCUR IN WATER CONTAINING SMALL AMOUNTS OF CHLORIDES.

PASSIVATING WILL IMPROVE THE CORROSION RESISTANCE.

OXIDATION RESISTANCE IS GOOD UP TO 1700 F FOR CONTINUING SERVICE AND 1600 F FOR INTERMITTENT SERVICE.

H. NUCLEAR PROPERTIES

THERMAL NEUTRON CROSS-SECTION IS 2.72 BARNS AT A MINIMUM CONTENT OF NICKEL, CHROMIUM, AND MANGANESE, AND 2.96 BARNS AT MAXIMUM CONTENT OF THESE ELEMENTS.

AUSTENITIC STAINLESS STEELS RETAIN THEIR HIGH IMPACT STRENGTH AFTER IRRADIATION IN CONTRAST TO FERRITIC STEELS WHICH MAY BECOME EMBRITTLED.

MATERIALS DATA BOOK

**AISI 347
STAINLESS STEEL**
**V-B-47
2**
DATE 30 SEPT 1969

SUPERSEDES 1 MAY 1966

BASIC DATA
I NOMENCLATURE
J SERVICE LIMITS

423 TO 1600 F (SEE BELOW)

CONTINUOUS SERVICE 1600 F

INTERMITTENT SERVICE 1450 F

SAFE RESISTANCE TO OXIDATION IN AIR OF ABOUT 1600 F

K PROCESSING
SURFACE TREATMENT

SCALE MAY BE REMOVED BY A SOLUTION OF 10-15% NITRIC ACID PLUS 0.5 TO 3% OF HYDROFLUORIC ACID AT 120-140 F FOR 20-30 MINUTES. SCALE REMOVAL IS EASIER WHEN PARTS HAVE BEEN HEATED IN AIR.

THE USE OF CHLORINATED HYDROCARBONS SUCH AS TRICHLOROETHYLENE SHOULD BE AVOIDED SINCE THEY MAY CONTINUE TO STRESS CORROSION CRACKING.

REMOVE ALL SURFACE CONTAMINANTS BEFORE ANNEALING.

THERMAL TREATMENT
ANNEALING

WROUGHT PRODUCTS 1800-2000 F (1800-1900 F PREFERRED) 1 HOUR PER INCH OF THICKNESS. 2 HOURS MINIMUM FOR PLATE. FURNACE COOL OR AIR COOL.

VARIATIONS IN ANNEALING TEMPERATURE WITHIN THE RECOMMENDED RANGE HAVE LITTLE EFFECT ON TENSILE PROPERTIES OF THIS ALLOY.

CASTINGS

1950-2050 F 30 MINUTES AT TEMPERATURE. QUENCH OR AIR COOL.

STABILIZATION FOR SERVICE

AT 800-1500 F HEAT TO 1500-1650 F. HOLD ONE HOUR PER INCH OF THICKNESS. 2 HOURS MINIMUM FOR PLATE.

STRESS RELIEF

AFTER FABRICATION 1300 F FOR TIMES NOT EXCEEDING 1 OR 2 HOURS.

ALLOY CAN BE HARDENED ONLY BY COLD WORKING.

K PROCESSING (CONTINUED)
FORMING

FORMABILITY IS GOOD. A STRESS RELIEF OR ANNEALING IS RECOMMENDED AFTER FABRICATION.

HOT WORKING STARTING RANGE 2100-2300 F.

HOT WORKING FINISH TEMPERATURE MINIMUM 1700 F.

COLD WORKING MAY BE USED TO ACHIEVE HIGHER HARDNESS AND STRENGTH WITH BETTER MACHINING CHARACTERISTICS THAN ARE OBTAINABLE IN THE ANNEALED CONDITION AS ILLUSTRATED IN THIS SKETCH.

THE EFFECT OF ROLLING CONDITIONS ON TS, YS, AND ϵ OF TYPE 347 IS SHOWN BELOW.

K PROCESSING (CONTINUED)
JOINING

FUSION WELDING OF THIS ALLOY IS MORE DIFFICULT THAN THAT OF OTHER 18-8 GRADES. POSTWELD ANNEALING IS NOT REQUIRED ALTHOUGH A STRESS RELIEF IS RECOMMENDED. TYPES 347 OR 349 FILLERS ARE USED.

FOR PARENT METAL WELDED TO ITSELF, SELECT ONE OF THE FOLLOWING WELD RODS:

AISI 347/MIL R 5031 CL 5A

AISI 349/MIL R 5031 CL 6

ER 349/ASTM A 371 CL ER349

MACHINING

USE SAME PRECAUTION AS FOR TYPE 302.

L GOODMAN DIAGRAM

M REFERENCES

69.3	66.37	63.3	60.2
69.4	66.70	63.21	58.2
68.12	65.1	63.22	56.8
67.6	65.71	63.33	54.7
67.7	65.89	63.56	52.1
67.44	65.99	63.61	49.3
66.3	65.100	62.84	47.1
66.35	64.8	61.3	
	63.1	61.20

MATERIALS DATA BOOK

AISI 347
STAINLESS STEEL

V-B-47
3

DATE 30 SEPT 1969
SUPERSEDES

TENSILE STRENGTHS

MATERIALS DATA BOOK

**AISI 347
STAINLESS STEEL**

**V-B-47
3B**

TEMPERATURES IN 100°F

MATERIALS DATA BOOK

**AISI 347
STAINLESS STEEL**

V-B-47

4

DATE 30 SEPT 1969
SUPERSEDES

**STRENGTHS
COMPRESSIVE, SHEAR,
BEARING, FLEXURAL**

MATERIALS DATA BOOK

AISI 347
STAINLESS STEEL

V-B-47
5

DATE 30 SEPT 1969
SUPERSEDES 1 MAY 1966

FATIGUE STRENGTH

MATERIALS DATA BOOK

AISI 347
STAINLESS STEEL

V-B-47
6

DATE 30 SEPT 1969
SUPERSEDES

STRESS TO RUPTURE
AND CREEP
AS FUNCTION OF TEMPERATURE

MATERIALS DATA BOOK

AISI 347
STAINLESS STEEL

V-B-47
7

DATE	30 SEPT 1969
SUPERSEDES	1 MAY 1966

STRESS TO RUPTURE
AND CREEP
AS FUNCTION OF TIME

MATERIALS DATA BOOK

**AISI 347
STAINLESS STEEL**

**V-B-47
6A**

DATE 30 SEPT 1969
SUPERSEDES

**STRESS TO RUPTURE
AND CREEP
AS FUNCTION OF TEMPERATURE**

MATERIALS DATA BOOK

AISI 347
STAINLESS STEEL

V-B-47
7A

DATE 30 SEPT 1969
SUPERSEDES 1 MAY 1966

STRESS TO RUPTURE
AND CREEP
AS FUNCTION OF TIME

MATERIALS DATA BOOK

**AISI 347
STAINLESS STEEL**

**V-B-47
6B**

DATE 30 SEPT 1969
SUPERSEDES

**STRESS TO RUPTURE
AND CREEP
AS FUNCTION OF TIME**

MATERIALS DATA BOOK

AISI 347
STAINLESS STEEL

V-B-47
7B

DATE 30 SEPT 1969
SUPERSEDES

STRESS TO RUPTURE
AND CREEP
AS FUNCTION OF TIME

MATERIALS DATA BOOK

AISI 347
STAINLESS STEEL

V-B-47

DATE 30 SEPT 1969
SUPERSEDES

THIS PAGE LEFT BLANK FOR PRINTING PURPOSES

MATERIALS DATA BOOK

AISI 347
STAINLESS STEEL

V-B-47
8

DATE 30 SEPT 1969
SUPERSEDES 1 MAY 1966

STRESS VS STRAIN
AS FUNCTION OF TEMPERATURE

MATERIALS DATA BOOK

**AISI 347
STAINLESS STEEL**

**V-B-47
8A
(UPPER)**

DATE	30 SEPT 1969
SUPERSEDES	1 MAY 1966

**STRESS VS STRAIN
AS FUNCTION OF TEMPERATURE**

MATERIALS DATA BOOK

**SAI 347
STAINLESS STEEL**
**V-B-47
8A
(LOWER)**
DATE 30 SEPT 1969

SUPERSEDES 1 MAY 1966

 MATCH LINE FOR CONTINUATION OF
DRAWING ON UPPER HALF OF SHEET

**STRESS VS STRAIN
AS FUNCTION OF TEMPERATURE**

MATERIALS DATA BOOK

**AINI 347
STAINLESS STEEL**

**V-B-47
9**

DATE 30 SEPT 1969
SUPERSEDES 1 MAY 1966

**IMPACT STRENGTH
HARDNESS**

MATERIALS DATA BOOK

AISI 347
STAINLESS STEEL

V-B-47
10

DATE 30 SEPT 1969
SUPERSEDES 15 SEPT 1967

REDUCTION OF AREA
ELONGATION

MATERIALS DATA BOOK

**AISI 347
STAINLESS STEEL**

**V-B-47
10A**

DATE 30 SEPT 1969
SUPERSEDES 15 SEPT 1967

**REDUCTION OF AREA
ELONGATION**

MATERIALS DATA BOOK

**AISI 347
STAINLESS STEEL**
**V-B-47
10B**
DATE 30 SEPT 1969

SUPERSEDES 15 SEPT 1967

**ELONGATION
(AFTER IRRADIATION)**
**DESIGN VALUES,
80 % OF AVERAGE**

SEE INTRODUCTION PAGE 3

EFFECTS OF IRRADIATION ON ELONGATION OF

AISI TYPE 347 STAINLESS STEEL
 UNLESS OTHERWISE NOTED
 $E \geq 1.0$ MEV (CRYOGENIC TESTS)
 $E \leq 0.48$ EV (ELEVATED TEMP TESTS)

FORM AND CONDITION	GAGE LENGTH (IN.)	TEMPERATURES (°F)			PRE- IRRADIATION CONTROL VALUES	POST-IRRADIATION VALUES DOSAGES GIVEN AS INTEGRATED NEUTRON FLUX (NVT) IN TERMS OF NEUTRONS/CM ²										NO OF IRRADIATION SPECIMENS	REFERENCE	COMMENTS
		IRRADIATION	POST- IRRADIATION ANNEAL	POST- IRRADIATION TEST		10 ¹⁵		10 ¹⁶		10 ¹⁷		10 ¹⁸		10 ¹⁹				
						ELONG -	DOSAGE	ELONG -	DOSAGE	ELONG -	DOSAGE	ELONG -	DOSAGE	ELONG -	DOSAGE			
LONG (a) (a) (a)	2 0 (c)	-423		-423	32			33	5 x 10 ¹⁶						4	67-6	308 FILLER E > 0.33 MEV	
	2 0 (c)	423		-423	21.5			24	5 x 10 ¹⁶						4	67-6		
	2 0 (c)	-423	80	-423	32					36.5					4	67-6		
CAST (a)		423		423	6.5			8	5 x 10 ¹⁶						4	67-6		
1 4-IN PL (a)	2 0	-423		423	21					21	4 x 10 ¹⁷				4	67-6		
1 4-IN PL (a)	2 0	-423		423	17.5					16	4 x 10 ¹⁷				4	67-6		
1 2 IN RD (a)	0 5 (d)	-430		430	33					29.5					3	67-6	E > 0.5 MEV	
1 4 IN PL (a)	2 0	320		320	25					26.5	4 x 10 ¹⁷				4			
1 4 IN PL	2 0	320		320	21.5					22.5	4 x 10 ¹⁷				4			
FORGING (b)	1 0 (e)	70-140	730 (g)	730	26							29	4 x 10 ¹⁸		3	66-3	6 PPM BORON	
FORGING (b)	1 0 (e)	70-140	780 (g)	780	20							21.5	4 x 10 ¹⁸		3	66-3 63-3		
FORGING (b)	1 0 (e)	70-140	1040 (i)	1040	30.5							29	4 x 10 ¹⁸		3	66-3	6 PPM BORON	
FORGING (b)	1 0 (e)	70-140	1040 (g)	1040	17.5							21.5	4 x 10 ¹⁸		3	66-3		
SHEET (b)	2 0 (f)	70-140	1040 (a)	1040	24							22.5	4 x 10 ¹⁸		3	67-7 67-7	7 PPM BORON 0.015-IN SH	
SHEET (b)	2 0 (f)	70-140	1290 (u)	1290	31					29.5	6 x 10 ¹⁷	26.5	4 x 10 ¹⁷	26.5	3	66-35		
SHEET (b)	2 0 (f)	70-140	1540 (u)	1540	54.5					50.5	6 x 10 ¹⁷	40.0	4 x 10 ¹⁷	27	3	67-7 67-7		
<p>(a) ANNEALED MATERIAL</p> <p>HEATED AT 1300°F AND COOLED SLOWLY TO SIMULATE BRAZE CYCLE AFTER 2150°F SOLUTION TREATMENT</p> <p>(c) REDUCED SECTION 3.8 IN x 1.8-IN</p> <p>(d) REDUCED SECTION 1.8-IN DIA</p> <p>(e) REDUCED SECTION 1.4 IN DIA</p> <p>(f) REDUCED SECTION 1.2-IN x 1.64 IN</p> <p>(i) SPECIMENS HELD AT TEST TEMP 30-MIN BEFORE INITIATING TEST STRAIN RATE 0.002 IN IN MIN TO FRACTURE IN ALL ELEVATED TEMP TESTS</p> <p>WELDED</p>

MATERIALS DATA BOOK

**AISI 347
STAINLESS STEEL**

**V-B-47
11**

DATE	30 SEPT 1969
SUPERSEDES	15 SEPT 1967

**MODULUS OF ELASTICITY
MODULUS OF RIGIDITY**

MATERIALS DATA BOOK

AISI 347
STAINLESS STEEL

V-B-47
12

DATE	30 SEPT 1969
SUPERSEDES	15 SEPT 1967

VALUES OF MEAN COEFFICIENT ARE FROM
ROOM TEMPERATURE TO INDICATED TEMPERATURES

THERMAL EXPANSION

MATERIALS DATA BOOK

AISI 347
STAINLESS STEEL

V-B-47
13

DATE 30 SEPT 1969
SUPERSEDES 15 SEPT 1967

THERMAL CONDUCTIVITY
SPECIFIC HEAT

MATERIALS DATA BOOK

**AISI 347
STAINLESS STEEL**
**V-B-47
14**

DATE 30 SEPT 1969

SUPERSEDES

**THERMAL DIFFUSIVITY
EMISSION**

MATERIALS DATA BOOK

AISI 347
STAINLESS STEEL

V-B-47
15

DATE 30 SEPT 1969
SUPERSEDES 15 SEPT 1967

DENSITY
POISSON'S RATIO

MATERIALS DATA BOOK

AISI 347
STAINLESS STEEL

V-B-47
16

DATE 30 SEPT 1969
SUPERSEDES 15 SEPT 1967

ELECTRICAL RESISTIVITY

DATE 15 SEPT 1967
SUPERSEDES 1 MAY 1966

IMPACT STRENGTH
ROCKWELL HARDNESS

DATE	15 SEPT 1967
SUPERSEDES	

ELONGATION (AFTER IRRADIATION)
--

DESIGN VALUES - 80% OF AVERAGE
SEE INTRODUCTION, PAGE 3

EFFECTS OF IRRADIATION ON ELONGATION OF
AISI TYPE 440-C STAINLESS STEEL

FORM AND CONDITION	GAGE LENGTH (IN.)	TEMPERATURES (°F)			PRE- IRRADIATION CONTROL VALUES	POST-IRRADIATION VALUES DOSAGES GIVEN AS INTEGRATED NEUTRON FLUX (NVT) IN TERMS OF NEUTRONS/CM ²										NO. OF IRRADIATION SPECIMENS	REFERENCE	COMMENTS
		IRRADIATION	POST- IRRADIATION ANNEAL	POST- IRRADIATION TEST		10 ¹⁵		10 ¹⁶		10 ¹⁷		10 ¹⁸		10 ¹⁹				
						ELONG. - %	DOSAGE	ELONG. - %	DOSAGE	ELONG. - %	DOSAGE	ELONG. - %	DOSAGE	ELONG. - %	DOSAGE			
1/2-IN. ROUND	0.5 (a)	-430		-430	NIL					NIL	1 x 10 ¹⁷					3	NP-66-35	E > 0.5 MEV
(a) REDUCED SECTION 1/8-IN. DIA. NOTE CONTROL F _{TU} AT -423° F - 260 KSI IRRADIATED F _{TU} AT -423° F - 219 KSI																		

DATE 15 SEPT 1967

SUPERSEDES 1 MAY 1966

THERMAL EXPANSION VALUES ARE FROM
ROOM TEMPERATURE TO INDICATED TEMP.

**THERMAL EXPANSION
SPECIFIC HEAT**

MEAN COEFFICIENT-LINEAR THERMAL EXPANSION
 10^{-6} IN./IN.-°F

0.16

0.12

0.08

0.04

0

BTU/LB-°F
SPECIFIC HEAT

THERMAL CONDUCTIVITY

THERMAL CONDUCTIVITY
BTU-FT/HR-FT²-°F

TEMPERATURES IN 100° F

DATE 15 SEPT 1967

SUPERSEDES 1 MAY 1966

MODULUS OF ELASTICITY

MODULUS OF RIGIDITY

DATE 15 SEPT 1967
SUPERSEDES 1 MAY 1966

THERMAL EXPANSION VALUES ARE FROM
ROOM TEMPERATURE TO INDICATED TEMP.

**THERMAL EXPANSION
SPECIFIC HEAT**

DATE 15 SEPT 1967
SUPERSEDES

**POISSON'S RATIO
DENSITY**

ELECTRICAL RESISTIVITY

DATE 15 SEPT 1967

SUPERSEDES

**ELONGATION
(AFTER IRRADIATION)**

DESIGN VALUES 80% OF AVERAGE

SEE INTRODUCTION PAGE 3

EFFECTS OF IRRADIATION ON ELONGATION OF
AM-350 STAINLESS STEEL

UNLESS OTHERWISE NOTED
E > 1.0 MEV

FORM AND CONDITION	GAGE LENGTH (IN)	TEMPERATURES (°F)			PRE- IRRADIATION CONTROL VALUES	POST IRRADIATION VALUES DOSAGES GIVEN AS INTEGRATED NEUTRON FLUX (NVT) IN TERMS OF NEUTRONS/CM ²										NO OF IRRADIATION SPECIMENS	REFERENCE	COMMENTS
		IRRADIATION	POST IRRADIATION ANNEAL	POST- IRRADIATION TEST		10 ¹⁶		10 ¹⁷		10 ¹⁸		10 ¹⁹		10 ²⁰				
						ELONG /	DOSAGE	ELONG	DOSAGE	ELONG /	DOSAGE	ELONG - /	DOSAGE	ELONG /	DOSAGE			
1 2 IN ROUND	0 5 (a)	430		430	9 0			5 8								5	NP 66 35	E > 0 5 MEV
UNKNOWN		120		80	13 5							10 0	6 x 10 ¹⁹				NP 61 41	
UNKNOWN		190		80	18 5							13 5	1 2 x 10 ¹⁹	12 0	1 5 x 10 ²⁰		NP 58 13	
(a) REDUCED SECTION 1/8 IN DIA																		

(a) REDUCED SECTION 1/8 IN. DIA

DATE 15 SEPT 1967
SUPERSEDES 1 MAY 1966

THERMAL EXPANSION VALUES ARE FROM
ROOM TEMPERATURE TO INDICATED TEMP.

**THERMAL EXPANSION
SPECIFIC HEAT**

MEAN COEFFICIENT-LINEAR THERMAL EXPANSION
 10^{-6} IN./IN.-°F

BTU/LB-°F
SPECIFIC HEAT

THERMAL CONDUCTIVITY

THERMAL CONDUCTIVITY
BTU-Ft/HR-Ft²-°F

TEMPERATURES IN 100° F

DATE 15 SEPT 1967
SUPERSEDES 1 MAY 1966

IMPACT STRENGTH
ROCKWELL HARDNESS

O Q OIL QUENCH
A C AIR COOLED
C D COLD DRAWN

REDUCTION OF AREA
ELONGATION

DATE	15 SEPT 1967
SUPERSEDES	

ELONGATION (AFTER IRRADIATION)

DESIGN VALUES 80% OF AVERAGE
SEE INTRODUCTION PAGE 3

EFFECTS OF IRRADIATION ON ELONGATION OF
A-286 STAINLESS STEEL

FORM AND CONDITION	GAGE LENGTH (IN)	TEMPERATURES (°F)			PRE IRRADIATION CONTROL VALUES	POST-IRRADIATION VALUES DOSAGES GIVEN AS INTEGRATED NEUTRON FLUX (NVT) IN TERMS OF NEUTRONS/CM ²										NO OF IRRADIATION SPECIMENS	REFERENCE	COMMENTS
		IRRADIATION	POST IRRADIATION ANNEAL	POST IRRADIATION TEST		10 ¹⁵		10 ¹⁶		10 ¹⁷		10 ¹⁸		10 ¹⁹				
						ELONG	DOSAGE	ELONG	DOSAGE	ELONG	DOSAGE	ELONG	DOSAGE	ELONG	DOSAGE			
1 4 IN PLATE		423		423	30 5			32	5 x 10 ¹⁶							4	NP 66 3	E > 1 0 MEV
1 2 IN ROUND	0 5 (a)	430		430	28 0					27 0	1 x 10 ¹⁷					3	NP 66 35	E > 0 5 MEV
1/2 N ROUND	0 5 (b)	430		430	25 5					25 0	1 x 10 ¹⁷					3	NP 66 35	E > 0 5 MEV
FORGING	1 0	423		423	21 0					15 0	4 x 10 ¹⁷					4	NP 67 7	E > 1 0 MEV
FORGING *	1 0	320		320	26 0					26 0	4 x 10 ¹⁷					4	NP 67 7	E > 1 0 MEV
(a) IN ACCORDANCE WITH SPECIFICATION AMS 5735 AIR MELTED SOLUTION TREATED AT 1800° F AND AGED REDUCED SECTION 0 125 IN DIA																		
(b) IN ACCORDANCE WITH SPECIFICATION AMS 5737 CON VAC REMELT SOLUTION TREATED AT 1650° F AND AGED REDUCED SECTION 0 125 IN DIA																		
* (PANCAKE)																		

DATE 15 SEPT 1967

SUPERSEDES 1 MAY 1966

MODULUS OF ELASTICITY

MODULUS OF RIGIDITY

TEMPERATURES IN 100° F

DATE 15 SEPT 1967

SUPERSEDES 1 MAY 1966

THERMAL EXPANSION VALUES ARE FROM
ROOM TEMPERATURE TO INDICATED TEMP.

THERMAL EXPANSION
SPECIFIC HEAT

MEAN COEFFICIENT-LINEAR THERMAL EXPANSION
 10^{-6} IN./IN.-°F

0.16

0.12

BTU/LB-°F
SPECIFIC HEAT

0.08

0.04

0

THERMAL CONDUCTIVITY

THERMAL CONDUCTIVITY
BTU-FT/HR-FT²-°F

TEMPERATURES IN 100° F

DATE 15 SEPT 1967
SUPERSEDES 1 MAY 1966

POISSON'S RATIO

ELECTRICAL RESISTIVITY

DATE 15 SEPT 1967

SUPERSEDES

BASIC DATA

A. GENERAL

INCOLOY ALLOY 800 AN AUSTENITIC SOLID SOLUTION ALLOY PROVIDES GOOD STRENGTH AND RESISTANCE TO OXIDATION AND CARBURIZATION AT ELEVATED TEMPERATURES

IT IS STABLY AUSTENITIC AND HAS DUCTILITY WITH RESISTANCE TO SCALING AND GENERAL CORROSION AND TO STRESS-CORROSION CRACKING

IT IS READILY FABRICATED AND WELDED BY STANDARD COMMERCIAL PROCEDURES

INCOLOY ALLOY 800 IS USED IN THE INDUSTRIAL HEATING, PETROCHEMICAL AND PROCESS FIELDS

THE VALUES IN SECTION E ARE AVERAGE VALUES EXCEPT F_{TU} , F_{TY} , RA AND e WHICH ARE DESIGN VALUES, AND SPECIFICATION MINIMA

B. COMMERCIAL DESIGNATIONS

INCOLOY ALLOY 800

C. AVAILABLE FORMS, SPECIFICATIONS, SUPPLIERS

FORMS & CONDITIONS	SPECIFICATIONS
SEAMLESS PIPE AND TUBE (BY 1/16-IN FROM 1/4-IN TO 1-IN)	ASME SB-407 ASTM B-407
ROD & BAR (0.5 TO 20-IN DIA x 24 FT MAX)	ASME SB-408 ASTM B-408
PLATE, SHEET & STRIP (MAX 60 x 144-IN & TO 4-IN THICK)	ASME SB-409 ASTM B-409
SEAMLESS CONDENSER & HEAT-EXCHANGER TUBES	ASME SB-163 ASTM B-163

SUPPLIERS

HUNTINGTON ALLOY PRODUCTS DIV
INTERNATIONAL NICKEL CO INC

D. CHEMICAL COMPOSITION (%)

ELEMENT *	N	Cr	C	Mn	S	P	Cu	Al	Ti
MAXIMUM	35.0	23.0	0.10	1.50	0.015	0.005	0.75	0.60	0.60
MINIMUM	30.0	19.0	—	—	—	—	—	0.15	0.15

SOURCE NP-65 68 * BAL Fe (NOMINAL, 46.0)

E. ROOM TEMPERATURE PROPERTIES
(AVERAGE UNLESS OTHERWISE NOTED)

I. MECHANICAL PROPERTIES **

<u>C D PIPE, TUBE</u>			<u>SHEET & STRIP</u>	<u>H R</u>
<u>SOL C D ALL OTHER</u>			<u>H R PLATE</u>	<u>PLATE</u>
<u>ANN C D TEMPER</u>			<u>ANN</u>	<u>A R</u>
<u>TENSILE</u>	<u>ULTIMATE</u>	<u>STRENGTH</u>	<u>F_{TU}</u>	<u>KSI</u>
70	75	70	75	80

70 75 70 75 80

TENSILE	YIELD	STRENGTH	F_{TY}	KSI
---------	-------	----------	----------	-----

25 30 25 30 35

COMP	YIELD	STRENGTH	F_{CY}	KSI
------	-------	----------	----------	-----

--- -- -- 41.6 ---

ULTIMATE	SHEAR	STRENGTH	F_{SU}	KSI
----------	-------	----------	----------	-----

SHEAR	YIELD	STRENGTH	F_{SY}	KSI
-------	-------	----------	----------	-----

ULTIMATE	BEARING	STRENGTH	F_{BRU}	KSI
----------	---------	----------	-----------	-----

e/D 1.5
e/D 2.0

BEARING	YIELD	STRENGTH	F_{BRY}	KSI
---------	-------	----------	-----------	-----

e/D 1.5
e/D 2.0

ELONGATION	e	%
------------	-----	---

30 30 30 30 25

REDUCTION	OF AREA	RA	%
-----------	---------	----	---

HARDNESS	ROCKWELL
----------	----------

COMP	MODULUS	OF ELASTICITY	E_C	10^6 PSI
------	---------	---------------	-------	------------

PLASTIC	BENDING	MODULUS	(SEE APPENDIX A)
---------	---------	---------	------------------

** SEE SECTION I PAGE 2, FOR NOMENCLATURE

I. MECHANICAL PROPERTIES (CONTINUED)

MODULUS	OF ELASTICITY	E	10^6 PSI
---------	---------------	---	------------

75° F 28.50

MODULUS	OF RIGIDITY	G	10^6 PSI
---------	-------------	---	------------

75° F 10.64

POISSON'S	RATIO
-----------	-------

75° F 0.339

2. PHYSICAL PROPERTIES

DENSITY	ρ
---------	--------

LB/IN³ 0.290
g/cc 8.02

SPECIFIC	HEAT	C	BTU/LB-°F
----------	------	---	-----------

(32 - 212° F CALCULATED) 0.12

THERMAL	CONDUCTIVITY	k	$\frac{BTU-FT}{HR-FT^2-°F}$
---------	--------------	---	-----------------------------

70° F 6.7

MEAN	COEFF	OF	LINEAR	THERMAL	EXPAN	α	$\frac{10^{-6} IN}{IN-°F}$
------	-------	----	--------	---------	-------	----------	----------------------------

70 TO 200° F 7.9

ELECTRICAL	RESISTIVITY	R	MICROHM-IN
------------	-------------	---	------------

70° F 38.6

MAGNETIC	PERMEABILITY
----------	--------------

HOT-ROLLED } (70° F H 200) 1.0137
ANNEALED } 1.0092

CURIE	TEMPERATURE
-------	-------------

ANNEALED MATERIAL -175° F

F. THERMOPHYSICAL EFFECTS

MELTING	RANGE
---------	-------

2475 - 2525° F

F. THERMOPHYSICAL EFFECTS (CONTINUED)

PHASE CHANGES

BETWEEN 1000 - 2000° F, METAL CARBIDE PRESUMABLY CHROMIUM CARBIDE, IS PRECIPITATED THEREFORE, THE ALLOY CAN BE MADE SUSCEPTIBLE TO INTERGRANULAR ATTACK BY SENSITIZATION IN THE 1000 - 1400° F TEMPERATURE RANGE

SENSITIZATION SHOULD BE AVOIDED IF THE MATERIAL IS TO BE PICKLED OR EXPOSED TO VERY AGGRESSIVE ENVIRONMENTS

BECAUSE OF ITS STABLY AUSTENITIC STRUCTURE, IT DOES NOT FORM THE BRITTLE SIGMA PHASE EVEN AFTER LONG PERIODS OF USE IN THE CRITICAL TEMPERATURE RANGE OF 1200 - 1600° F

THERMAL CONDUCTIVITY VS TEMPERATURE

TEMPERATURE °F	k $\left(\frac{BTU-FT}{HR-FT^2-°F} \right)$
-250	4.6
-200	4.9
-100	5.6
0	6.3
70	6.7
100	6.9
200	7.4
400	8.6
600	9.6
800	10.6
1000	11.6
1200	12.7
1400	13.8
1600	15
1800	17.8

G. CHEMICAL PROPERTIES

CORROSION RESISTANCE (SEE PHASE CHANGES, SEC F)

OXIDATION - DUE TO THE HIGH NICKEL AND CHROMIUM CONTENT, IT HAS EXCELLENT RESISTANCE TO OXIDATION AND SCALING AT HIGH TEMPERATURES SCALING RESISTANCE BECOMES A SIGNIFICANT FACTOR AT 1800° F

BECAUSE OF THE IRON CONTENT, IT IS RESISTANT TO GREEN ROT, OR INTERNAL OXIDATION.

CARBURIZATION - INCOLOY ALLOY 800 HAS VERY GOOD RESISTANCE TO CARBURIZATION, AND IS WIDELY USED UNDER CARBURIZING CONDITIONS

STRESS-CORROSION CRACKING

AN IMPORTANT PROPERTY OF THIS ALLOY IS ITS RELATIVE FREEDOM FROM STRESS-CORROSION CRACKING ITS RESISTANCE IS SO SUPERIOR THAT IT IS USED TO REPLACE MATERIALS THAT HAVE FAILED IN SERVICE FROM STRESS-CORROSION CRACKING

DATE 15 SEPT 1967

SUPERSEDES
BASIC DATA
H NUCLEAR PROPERTIES

NEUTRON EXPOSURES TO 4×10^{20} NVT ($E > 1$ MEV AT 700 TO 800° F DO NOT AFFECT THE ROOM TEMPERATURE TENSILE PROPERTIES OF INCOLOY 800 WHEN TESTED AT 1100° F IRRADIATED TENSILE SPECIMENS SHOWED NO CHANGE IN 0.2% YIELD STRENGTH BUT A DROP IN ULTIMATE TENSILE STRENGTH AND ELONGATION. MINIMUM ELONGATION VALUES RECORDED WERE 23.

I NOMENCLATURE

ANN	ANNEALED
AR	AS ROLLED
CD	COLD DRAWN
CR	COLD ROLLED
HF	HOT FINISHED
HR	HOT ROLLED
WQ	WATER QUENCHED
SOL ANN	SOLUTION ANNEALED

MILL ANNEALED GRADE I SEE K THERMAL TREATMENT

SOLUTION ANNEALED GRADE II SEE K THERMAL TREATMENT

J SERVICE LIMITS

CARBURIZING 1550-1750° F (USUAL SERVICE TEMPERATURE)

GASES 2000° F AIR
 650° F CHLORINE
 800° F HYDROGEN CHLORIDE
 2300° F HYDROGEN

LIQUID SODIUM, POTASSIUM, SODIUM POTASSIUM (STATIC)
 1600° F

STEAM 1800° F

K PROCESSING
SURFACE TREATMENT
CLEANING

ELECTROLYTIC AND NON ELECTROLYTIC MOLTEN SALT DE-SCALING AND DILUTE ACID NEUTRALIZING

HF HNO₃ ACID PICKLE

CAUSTIC SODA CLEANING AND DILUTE ACID NEUTRALIZING

EMULSION DETERGENT OR VAPOR DEGREASE AND DILUTE ACID NEUTRALIZING

ULTRASONIC

FOLLOW ALL ACID TREATMENTS WITH WATER RINSE

THERMAL TREATMENT
HEATING

TEMPERATURE AND FURNACE ATMOSPHERE MUST BE CAREFULLY CONTROLLED WHEN HEATING THIS ALLOY. FURNACE ATMOSPHERES SHOULD BE SLIGHTLY REDUCING WITH ABOUT 2% CARBON MONOXIDE.

ANNEALING

ANNEAL IN BOX OR MUFFLE FURNACES WITH PREPARED REDUCING ATMOSPHERES SUCH AS BY CRACKING SULFUR FREE NATURAL GAS.

MILL ANNEALING 1700° F HOLD 70 MIN. A.C. (GRADE I) WITH COLD WORKING YIELDS FAIRLY WIDE RANGE OF STRENGTH AND HARDNESS. RATE OF COOLING AFTER ANNEALING HAS NO EFFECT ON HARDNESS.

SOLUTION ANNEALING (GRADE II) HEAT TO 2050-2100° F FOR 1 TO 2 HOURS. W.Q.

HARDENING

THIS ALLOY CAN BE HARDENED ONLY BY COLD WORKING.

STRESS RELIEF

STRESS RELIEF IS VIRTUALLY COMPLETE WHEN THE MATERIAL IS HEATED AT 1600° F FOR 1 TO 2 HOURS.

K PROCESSING (CONTINUED)
JOINING

WROUGHT OR EXTRUDED MATERIAL EITHER MILL ANNEALED OR AS EXTRUDED CAN BE WELDED TO ITSELF OR TO OTHER WROUGHT ALLOYS BY THE METAL ARC PROCESS.

TO PREVENT WELD SLAG ON THE INTERIOR OF TUBING USE THE TIG PROCESS WITH INCONEL FILLER METAL 82.

FORMING

THIS ALLOY IS READILY FABRICATED BOTH BY HOT AND COLD WORKING.

FORGING OPERATIONS START AT 2200° F. HEAVY FORGING IS DONE DOWN TO 1850° F. LIGHT WORKING CAN BE DONE DOWN TO 1600° F. DO NOT FORGE BETWEEN 1600° F AND 1200° F.

K PROCESSING (CONTINUED)
MACHINABILITY

THIS ALLOY IS READILY MACHINED BY STANDARD PROCEDURES.

TURNING SHOULD BE DONE WITH CISC GRADE C-2 CEMENTED CARBIDE TOOLS.

SOLUTION ANNEALED MATERIAL CAN BE TURNED WITH LONGER TOOL LIFE THAN CAN MILL ANNEALED MATERIAL.

L REFERENCES

NP 65 68
 NP 64 60

DATE 15 SEPT 1967

SUPERSEDES

TENSILE STRENGTHS

DATE 15 SEPT 1967**SUPERSEDES**

THIS SHEET LEFT BLANK FOR PRINTING PURPOSES

DATE 15 SEPT 1967

SUPERSEDES

TENSILE STRENGTHS

DATE 15 SEPT 1967
SUPERSEDES

FATIGUE STRENGTH

DATE 15 SEPT 1967

SUPERSEDES

FATIGUE STRENGTH

DATE 15 SEPT 1967
SUPERSEDES

**STRESS TO RUPTURE
AND CREEP
TEMPERATURE**

DATE 15 SEPT 1967
SUPERSEDES

STRESS TO RUPTURE AND CREEP TIME

DATE 15 SEPT 1967
SUPERSEDES

**STRESS TO RUPTURE
AND CREEP
TEMPERATURE**

DATE 15 SEPT 1967
SUPERSEDES

**STRESS TO RUPTURE
AND CREEP
TIME**

DATE 15 SEPT 1967
SUPERSEDES

IMPACT STRENGTH

ROCKWELL HARDNESS

DATE 15 SEPT 1967

SUPERSEDES

REDUCTION OF AREA
ELONGATION

DATE 15 SEPT 1967

SUPERSEDES

MODULUS OF ELASTICITY

MODULUS OF RIGIDITY

DATE 15 SEPT 1967

SUPERSEDES

THERMAL EXPANSION VALUES ARE FROM
ROOM TEMPERATURE TO INDICATED TEMP.

**THERMAL EXPANSION
SPECIFIC HEAT**

MEAN COEFFICIENT-LINEAR THERMAL EXPANSION
 10^{-6} IN./IN.-°F

BTU/LB-°F
SPECIFIC HEAT

THERMAL CONDUCTIVITY
BTU-FT/HR-FT²-°F

TEMPERATURES IN 100° F

DATE 15 SEPT 1967
SUPERSEDES

POISSON'S RATIO

POISSON'S RATIO

ELECTRICAL RESISTIVITY

ELECTRICAL RESISTIVITY
MICROHM-IN