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MECHANICAL PROPERTIES OF IRRADIATED
PLAIN CARBON AND ALLOY STEELS

A Compilation of the Data in the Literature

by

Richard E. Schreiber

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ABSTRACT

Changes in the mechanical properties of plain carbon and alloy steels that are caused by fast neutron irradiation are presented in graphic form. These data were abstracted from classified and unclassified reports published since 1948 by USAEC, AECL, and AERE. Data are included for the following steels: A-105-55T, A-106, A-200-55T-T22 (Croloy), A-201, A-242, A-301-B, A-302-B, AISI-C-1013, AISI-C-1065, SA-70, SA-193, 4, SA-212, SA-285, SA-336, SAE-1018, SAE-1020, SAE-1042, SAE-1045, SAE-1095, SAE-1113, SAE-1141, SAE-4130, SAE-4340. The mechanical properties for which data are reported include hardness, yield strength, tensile strength, total and uniform elongation, reduction of area, fatigue strength, notch factor, creep, impact energy, and transition temperature.

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MECHANICAL PROPERTIES OF IRRADIATED PLAIN CARBON AND ALLOY STEELS

A Compilation of the Data in the Literature

INTRODUCTION AND SUMMARY

Information on the effects of fast neutron irradiation on the mechanical properties of structural materials is widely dispersed and duplicated in the literature. This report summarizes the information that was obtained from a search of the classified and unclassified literature published since 1948. The subject matter in this report has been limited to the plain carbon and alloy steels of potential use in nuclear reactors. The data are presented graphically as functions of exposure to neutrons with energies greater than 1 Mev. Where the effects of other variables, such as temperature of irradiation, temperature of test, specimen size, or initial cold work were reported, this information is included on the charts or the associated data sheet. The purpose of this report is to provide irradiation data in a form that is convenient to the designer and to indicate areas of knowledge that are incomplete or which contain inconsistent information.

DISCUSSION

This report is a compilation of the data that are available in the literature on the effect of fast neutron irradiation on the mechanical properties of a variety of plain carbon and alloy steels. The literature data have been converted to consistent scales or terms for compilation in this report; for example, all hardness data have been converted to the Rockwell scale. Some test conditions cannot be interpreted in a standard way because the variables are not independent or their effects are unknown. The following sections discuss various test conditions to show why results of various experiments did not always agree as closely as would be expected if test conditions had been identical.

DIFFERENCES BETWEEN IN-PILE TESTS AND PRE- AND POSTIRRADIATION TESTS

The study of the effect of fast neutrons on dynamic phenomena, such as creep and fatigue, yields results that can be interpreted with confidence if the tests are performed in a radiation field. Because the relationship between cumulative strain and cumulative radiation damage is not known, it is not possible to interpret results where the material was first irradiated and then the dynamic test was performed outside the pile. In addition, dynamic tests at high fluxes for short times may not yield the same dynamic properties as tests conducted at low fluxes for long times, even though the exposures are the same. Such phenomena as hardness, yield strength, and impact energy are not thought to be sensitive to flux level alone but rather to total exposure only, because these tests do not involve straining the material during irradiation.

COUPLED EFFECT OF RADIATION AND TEMPERATURE

Fast neutrons act primarily in two ways on structural materials. First, they introduce lattice vacancies and interstitials, which act as point defects. These defects harden the material. Second, they disrupt the lattice with cascade collisions. A single collision by a fast neutron can cause hundreds or even thousands of atoms to be dislodged from their positions in the lattice. The atoms quickly return to equilibrium positions in the lattice and thus anneal the material locally. Annealing, of course, removes lattice defects. This action is called a displacement spike. Eventually a balance is reached between the introduction and removal of lattice defects. The mechanical properties of the material at this balance point depend on the temperature of irradiation. Temperature affects the mobility of vacancies and interstitials, causing them to cancel or anneal one another if the temperature is high, or to restrict their motion if the temperature is low. It can be seen from the data that generally the higher the temperature of irradiation, the less the static properties are changed.

EFFECT OF SPECIMEN SIZE

The space available in reactors for irradiation of materials is limited, so small specimens are often used. For example, two groups of impact specimens have been used: subsize Izod and Charpy V-notch. A typical Izod specimen is a round bar 0.204 inch in diameter, with a 45° circumferential groove with a bottom radius of 0.005 inch, a 15-20 micro-inch finish in groove, and a root diameter of 0.164 inch. The standard Charpy V-notch specimen is a square bar 2.165 x 0.394 x 0.394 inches notched on one side only, 45°, with bottom radius of 0.010 inch, and bar thickness at root of groove of 0.315 inch. Figure 38 illustrates the effect of impact specimen size; the Charpy specimen is 3 to 4 times as strong as the Izod specimen. Where known, the size of the specimen is indicated in the data presented in this report.

EFFECTS OF FLUX SPECTRUM

Theoretical studies by F. Seitz* have shown that neutrons with energies as low as a few hundred electron volts are capable of disrupting the crystal lattice. For this reason, correlation of properties with exposure to neutrons with energies greater than 1 Mev, as is done in the report, may be invalid when data from thermal and fast reactors are compared, or even when data are compared from thermal reactors whose fast spectra differ appreciably. The variation of fast neutron spectra with position in any given reactor must also be considered. For example, a spectrum variation exists between a position within a tubular fuel element such as the Canadian "transformer rod" and positions

*Seitz, F. "On the Disordering of Solids by Action of Fast Massive Particles". Disc. Faraday Soc. 5, pp. 271-282 (1949).

within or between fuel slugs or fuel elements where a specimen is surrounded by several inches of moderator and coolant. Neutron flux close to fuel has a higher proportion of fission neutrons than does flux in positions surrounded mainly by moderator. In recent years it has become conventional to report exposures only in terms of neutrons with energies greater than 1 Mev, since it is believed that these neutrons produce most of the worst radiation damage. To date, the flux spectrum has not been investigated extensively with regard to its effect on the mechanical properties of structural materials.

COMPOSITION OF THE STAINLESS STEEL ALLOYS

The table on the following page lists the composition of the materials for which data are included in this report.

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COMPOSITION OF PLAIN CARBON AND ALLOY STEELS

<u>Type Steel</u>	<u>C, %</u>	<u>Mn, %</u>	<u>P, %</u>	<u>S, %</u>	<u>Si, %</u>	<u>Cr, %</u>	<u>Mo, %</u>	<u>Ni, %</u>	<u>Cu, %</u>
A-200-55T Grade T-22 (Croloy) (a)	0.10	0.45	0.018	-	-	2.18	-	-	-
A-301-B (b)	0.21	0.65 max	0.040 max	0.050 max	0.15-0.30	0.80-1.15	0.45-0.65	-	-
A-105-58T (c)	0.35 max	0.90 max	0.050 max	0.050 max	0.35 max	-	-	-	-
SA-212-B (b)	0.31	0.90	0.40	0.050 max	0.15-0.30	-	-	-	-
SA-285-57T (c)	0.35 max	0.80	0.05	0.050	-	-	-	-	-
AISI-C-1065 (d)	0.60-0.70	0.60-0.90	0.04 max	0.05 max	-	-	-	-	-
AISI-C-1013 (b)	0.11-0.16	0.50-0.80	0.04 max	0.05 max	-	-	-	-	-
SAE-1045 (b)	0.43-0.50	0.60-0.90	0.04 max	0.05 max	-	-	-	-	-
SAE-1020 (b)	0.18-0.23	0.30-0.60	0.04 max	0.05 max	-	-	-	-	-
SAE-1141 (d)	0.37-0.45	1.35-1.65	0.04 max	0.08-0.13	-	-	-	-	-
SAE-1113 (b)	0.10-0.16	1.0-1.3	0.04 max	0.24-0.33	-	-	-	-	-
SAE-1095 (b)	0.90-1.03	0.30-0.50	0.04 max	0.05 max	-	-	-	-	-
SAE-1042 (d)	0.40-0.47	0.60-0.90	0.04 max	0.05 max	-	-	-	-	-
SAE-1018 (b)	0.15-0.20	0.60-0.90	0.04 max	0.05 max	-	-	-	-	-
A-242-55 (c)	0.22 max	1.25 max	-	0.05 max	-	-	-	-	-
A-201-B (b)	0.24 max	0.80 max	0.04 max	0.05 max	0.15-0.30	-	-	-	-
SA-193,4 (e)	-	-	-	-	-	-	-	-	-
SA-70 (f)	0.21	0.4	0.04 max	0.04 max	-	-	-	-	-
A-106-B (b)	0.27 max	0.35-1.00	0.040 max	0.050 max	0.12 min	-	-	-	-
SAE-4130 (b)	0.28-33	0.4-0.6	0.040 max	0.040 max	0.20-0.35	0.80-1.10	0.15-0.25	-	-
SAE-4340 (b)	0.38-0.43	0.60-0.80	0.04 max	0.04 max	0.20-0.35	0.70-0.90	0.20-0.30	1.65-2.00	-
SAE-336 (g)	0.19	0.65	0.011	0.014	0.26	0.40	0.64	0.79	0.12

(a) ORNL-2829, p. 211.

(b) Hoyt, S. L. "Metal Properties". American Society of Mechanical Engineers.
ASME Handbook. New York: McGraw-Hill, 433 pp. (1954).

(c) ASTM Standards. Part I. Philadelphia: American Society for Testing Materials,
1594 pp. (1958).

(d) Steel's Specifications Handbook. Penton Building, Cleveland 13, Ohio,
405 pp. (1953).

(e) Several grades available; reference (ANL-4792) did not specify which grade.

(f) AERE-M/TN-54.

(g) ASTM STP No. 286.

FIG. 1 IMPACT ENERGY OF A-105-55T

FIG. 2 TRANSITION TEMPERATURE OF A-105-55T

IMPACT ENERGY OF A-105-55T

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Specimen Size</u>	<u>Preirradiation Conditions, etc.</u>
1	ORNL-2829 (Fig. 177, p. 213)	199	Standard Charpy V-notch	Forged at 1200°F

TRANSITION TEMPERATURE OF A-105-55T

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Specimen Size</u>	<u>Preirradiation Conditions, etc.</u>
1	ORNL-2829 (Fig. 177, p. 213)	199	Standard Charpy V-notch	Forged at 1200°F

FIG. 3 YIELD STRENGTH OF A-106

YIELD STRENGTH OF A-106

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Testing Temp., °C</u>	<u>Preirradiation Conditions, etc.</u>
1	ORNL-2561 (p. 263)	80	Room	Fine grain, 0.24% C
2	ORNL-2561 (p. 263)	305-360	Room	Fine grain, 0.24% C
3	ORNL-2561 (p. 263)	405-415	Room	Fine grain, 0.24% C
4	ORNL-2561 (p. 263)	80	Room	Coarse grain, 0.24% C
5	ORNL-2561 (p. 263)	305-360	Room	Coarse grain, 0.24% C
6	ORNL-2561 (p. 263)	405-415	Room	Coarse grain, 0.24% C
7	TID-7515 (Vol. II, p. 60)	93	Room	ASTM grain size #7, normalized from 1700°F, strain rate 0.05 min ⁻¹
8	TID-7515 (Vol. II, p. 60)	300	Room	ASTM grain size #7, normalized from 1700°F, strain rate 0.05 min ⁻¹
9	TID-7515 (Vol. II, p. 60)	93	Room	ASTM grain size #2, normalized from 1700°F, strain rate 0.05 min ⁻¹
10	TID-7515 (Vol. II, p. 60)	300	Room	ASTM grain size #2, normalized from 1700°F, strain rate 0.05 min ⁻¹

FIG. 4 TENSILE STRENGTH OF A-106

TENSILE STRENGTH OF A-106

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Testing Temp., °C</u>	<u>Preirradiation Conditions, etc.</u>
1	ORNL-2561 (p. 263)	80	Room	Fine grain, 0.24% C
2	ORNL-2561 (p. 263)	305-360	Room	Fine grain, 0.24% C
3	ORNL-2561 (p. 263)	405-415	Room	Fine grain, 0.24% C
4	ORNL-2561 (p. 263)	80	Room	Coarse grain, 0.24% C
5	ORNL-2561 (p. 263)	305-360	Room	Coarse grain, 0.24% C
6	ORNL-2561 (p. 263)	405-415	Room	Coarse grain, 0.24% C
7	TID-7515 (Vol. II, p. 60)	93	Room	ASTM grain size #7, normalized from 1700°F, strain rate 0.05 min ⁻¹
8	TID-7515 (Vol. II, p. 60)	300	Room	ASTM grain size #7, normalized from 1700°F, strain rate 0.05 min ⁻¹
9	TID-7515 (Vol. II, p. 60)	93	Room	ASTM grain size #2, normalized from 1700°F, strain rate 0.05 min ⁻¹
10	TID-7515 (Vol. II, p. 60)	300	Room	ASTM grain size #2, normalized from 1700°F, strain rate 0.05 min ⁻¹

FIG. 5 ELONGATION OF A-106

ELONGATION OF A-106

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Testing Temp., °C</u>	<u>Preirradiation Conditions, etc.</u>
1	ORNL-2561 (p. 263)	80	Room	Fine grain, 0.24% C
2	ORNL-2561 (p. 263)	305-360	Room	Fine grain, 0.24% C
3	ORNL-2561 (p. 263)	405-415	Room	Fine grain, 0.24% C
4	ORNL-2561 (p. 263)	80	Room	Coarse grain, 0.24% C
5	ORNL-2561 (p. 263)	305-360	Room	Coarse grain, 0.24% C
6	ORNL-2561 (p. 263)	405-415	Room	Coarse grain, 0.24% C
7	TID-7515 (Vol. II, p. 60)	93	Room	ASTM grain size #7, normalized from 1700°F, strain rate 0.05 min ⁻¹
8	TID-7515 (Vol. II, p. 60)	300	Room	ASTM grain size #7, normalized from 1700°F, strain rate 0.05 min ⁻¹
9	TID-7515 (Vol. II, p. 60)	93	Room	ASTM grain size #2, normalized from 1700°F, strain rate 0.05 min ⁻¹
10	TID-7515 (Vol. II, p. 60)	300	Room	ASTM grain size #2, normalized from 1700°F, strain rate 0.05 min ⁻¹

FIG. 6 REDUCTION OF AREA OF A-106

FIG. 7 IMPACT ENERGY OF A-106

FIG. 8 TRANSITION TEMPERATURE OF A-106

REDUCTION OF AREA OF A-106

Data Points	Reference	Irradiation Temp., °C	Testing Temp., °C	Preirradiation Conditions, etc.
1	TID-7515 (Vol. II, p. 50)	93	Room	ASTM grain size #7, normalized from 1700°F, strain rate 0.05 min ⁻¹
2	TID-7515 (Vol. II, p. 50)	300	Room	ASTM grain size #7, normalized from 1700°F, strain rate 0.05 min ⁻¹
3	TID-7515 (Vol. II, p. 50)	93	Room	ASTM grain size # 2, normalized from 1700°F, strain rate 0.05 min ⁻¹
4	TID-7515 (Vol. II, p. 50)	300	Room	ASTM grain size #2, normalized from 1700°F, strain rate 0.05 min ⁻¹

IMPACT ENERGY OF A-106

Data Points	Reference	Irradiation Temp., °C	Specimen Size	Preirradiation Conditions, etc.
1	ORNL-CF-56-11-1 (p. 22)	<93	0.2" x 0.2", grooves 0.060" deep, 45°, root radius 0.005"	ASTM grain size #2, normalized from 1700°F
2	ORNL-CF-56-11-1 (p. 22)	315	0.2" x 0.2", grooves 0.060" deep, 45°, root radius 0.005"	ASTM grain size #2, normalized from 1700°F
3	ORNL-CF-56-11-1 (p. 23)	<93	0.2" x 0.2", grooves 0.060" deep, 45°, root radius 0.005"	ASTM grain size #7, normalized from 1700°F
4	ORNL-CF-56-11-1 (p. 23)	315	0.2" x 0.2", grooves 0.060" deep, 45°, root radius 0.005"	ASTM grain size #7, normalized from 1700°F

TRANSITION TEMPERATURE OF A-106

Data Points	Reference	Irradiation Temp., °C	Specimen Size	Preirradiation Conditions, etc.
1	ORNL-CF-56-11-1 (p. 22)	<93	0.2" x 0.2", grooves 0.060" deep, 45°, root radius 0.005"	ASTM grain size #2, normalized from 1700°F
2	ORNL-CF-56-11-1 (p. 22)	315	0.2" x 0.2", grooves 0.060" deep, 45°, root radius 0.005"	ASTM grain size #2, normalized from 1700°F
3	ORNL-CF-56-11-1 (p. 23)	<93	0.2" x 0.2", grooves 0.060" deep, 45°, root radius 0.005"	ASTM grain size #7, normalized from 1700°F
4	ORNL-CF-56-11-1 (p. 23)	315	0.2" x 0.2", grooves 0.060" deep, 45°, root radius 0.005"	ASTM grain size #7, normalized from 1700°F

FIG. 9 IMPACT ENERGY OF A-200-55T-T22 (CROLOY)

FIG. 10 TRANSITION TEMPERATURE OF A-200-55T-T22 (CROLOY)

IMPACT ENERGY OF A-200-55T-T22 (CROLOY)

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Specimen Size</u>	<u>Preirradiation Conditions, etc.</u>
1	ORNL-2829 (Fig. 172, p. 209)	80	Standard Charpy V-notch	-
2	ORNL-2829 (Fig. 172, p. 209)	135	Standard Charpy V-notch	-

TRANSITION TEMPERATURE OF A-200-55T-T22 (CROLOY)

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Specimen Size</u>	<u>Preirradiation Conditions, etc.</u>
1	ORNL-2829 (Fig. 172, p. 209)	80	Standard Charpy V-notch	-
2	ORNL-2829 (Fig. 172, p. 209)	135	Standard Charpy V-notch	-

FIG. 11 YIELD STRENGTH OF A-201

FIG. 12 TENSILE STRENGTH OF A-201

FIG. 13 ELONGATION OF A-201

YIELD STRENGTH OF A-201

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Testing Temp., °C</u>	<u>Preirradiation Conditions, etc.</u>
1	AECU-3566	~150	Room-315	Sheet tensile specimens irradiated in helium atmosphere. Specimens were 1/16" thick, 0.70" wide, 3" long. Gauge length was 1/2". Material initially cold rolled and annealed.

TENSILE STRENGTH OF A-201

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Testing Temp., °C</u>	<u>Preirradiation Conditions, etc.</u>
1	AECU-3566	~150	Room-315	Sheet tensile specimens irradiated in helium atmosphere. Specimens were 1/16" thick, 0.70" wide, 3" long. Gauge length was 1/2". Material initially cold rolled and annealed.

ELONGATION OF A-201

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Testing Temp., °C</u>	<u>Preirradiation Conditions, etc.</u>
1	AECU-3566	~150	Room-315	Sheet tensile specimens irradiated in helium atmosphere. Specimens were 1/16" thick, 0.70" wide, 3" long. Gauge length was 1/2". Material initially cold rolled and annealed.

FIG. 14 IMPACT ENERGY OF A-201

FIG. 15 TRANSITION TEMPERATURE OF A-201

IMPACT ENERGY OF A-201

Data Points	Reference	Irradiation Temp., °C	Specimen Size	Preirradiation Conditions, etc.
1	UK/C6/108	-68	3/16" dia, 50-mil groove one side, 90°, 1 to 2-mil root radius, notch every 11/16"	Hot rolled, subsize Izod
2	ASTM STP No. 286	302	Standard Charpy V-notch	6" plate, irradiated at BNL
3	ASTM STP No. 286	302	Standard Charpy V-notch	2" plate, irradiated at BNL
4	ASTM STP No. 286	93	Standard Charpy V-notch	6" plate, irradiated at LITR
5	ASTM STP No. 286	93	Standard Charpy V-notch	2" plate, irradiated at LITR

In the reference for point 1, a comparison was made between subsize Izod and Charpy V-notch specimens of cold material. The effect of specimen size was shown by an increase from 7.5 ft-lbs to 110 ft-lbs maximum impact energy in going from the subsize Izod to the Charpy V-notch design.

TRANSITION TEMPERATURE OF A-201

Data Points	Reference	Irradiation Temp., °C	Specimen Size	Preirradiation Conditions, etc.
1	UK/C6/108	-68	3/16" dia, 50-mil groove one side, 90°, 1 to 2-mil root radius, notch every 11/16"	Hot rolled, subsize Izod
2	ASTM STP No. 286	302	Standard Charpy V-notch	6" plate, irradiated at BNL
3	ASTM STP No. 286	302	Standard Charpy V-notch	2" plate, irradiated at BNL
4	ASTM STP No. 286	93	Standard Charpy V-notch	6" plate, irradiated at LITR
5	ASTM STP No. 286	93	Standard Charpy V-notch	2" plate, irradiated at LITR

In the reference for point 1, a comparison was made between subsize Izod and Charpy V-notch specimens of cold material. The effect of specimen size was shown by an increase from -60°C to +5°C transition temperature in going from the subsize Izod to the Charpy V-notch design.

FIG. 16 IMPACT ENERGY OF A-242

FIG. 17 TRANSITION TEMPERATURE OF A-242

IMPACT ENERGY OF A-242

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Specimen Size</u>	<u>Preirradiation Conditions, etc.</u>
1	AERE-M/TN-54 (p. 38, item 6)	<95	0.2" x 0.2" x 1.10" between notches, notch 0.060" deep with 0.005" root radius	Normalized from 1700°F, subsize Izod

TRANSITION TEMPERATURE OF A-242

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Specimen Size</u>	<u>Preirradiation Conditions, etc.</u>
1	AERE-M/TN-54 (p. 38, item 6)	<95	0.2" x 0.2" x 1.10" between notches, notch 0.050" deep with 0.005" root radius	Normalized from 1700°F, subsize Izod

FIG. 18 IMPACT ENERGY OF A-301-B

FIG. 19 TRANSITION TEMPERATURE OF A-301-B

IMPACT ENERGY OF A-301-B

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Specimen Size</u>	<u>Preirradiation Conditions, etc.</u>
1	ORNL-2829 (Fig. 171, p. 209)	80	Standard Charpy V-notch	-
2	ORNL-2829 (Fig. 171, p. 209)	132	Standard Charpy V-notch	-
3	ORNL-2829 (Fig. 171, p. 209)	165	Standard Charpy V-notch	-

TRANSITION TEMPERATURE OF A-301-B

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Specimen Size</u>	<u>Preirradiation Conditions, etc.</u>
1	ORNL-2829 (Fig. 171, p. 209)	80	Standard Charpy V-notch	-
2	ORNL-2829 (Fig. 171, p. 209)	132	Standard Charpy V-notch	-
3	ORNL-2829 (Fig. 171, p. 209)	165	Standard Charpy V-notch	-

FIG. 20 ELONGATION OF A-302-B

FIG. 21 REDUCTION OF AREA OF A-302-B

ELONGATION OF A-302-B

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Testing Temp., °C</u>	<u>Preirradiation Conditions, etc.</u>
1	KAPL-1416 (p. 36)	260	60-70	Normalized and tempered, unirradiated specimens held at 260°C for 20 days
2	KAPL-1416 (p. 36)	370	60-70	Normalized and tempered, unirradiated specimens held at 370°C for 20 days

REDUCTION OF AREA OF A-302-B

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Testing Temp., °C</u>	<u>Preirradiation Conditions, etc.</u>
1	KAPL-1416 (p. 36)	260	60-70	Normalized and tempered, unirradiated specimens held at 260°C for 20 days
2	KAPL-1416 (p. 36)	370	60-70	Normalized and tempered, unirradiated specimens held at 370°C for 20 days

FIG. 22 IMPACT ENERGY OF A-302-B

IMPACT ENERGY OF A-302-B

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Specimen Size</u>	<u>Preirradiation Conditions, etc.</u>
1	KAPL-1416 (Figs. KS6330 and 6331)	260	Standard Charpy V-notch	Unirradiated specimens held at 260°C for 20 days
2	KAPL-1416 (Figs. KS6330 and 6331)	370	Standard Charpy V-notch	Unirradiated specimens held at 370°C for 20 days
3	ASTM STP No. 286	302	Standard Charpy V-notch	4" weld irradiated at BNL
4	ASTM STP No. 286	302	Standard Charpy V-notch	4" plate irradiated at BNL
5	ASTM STP No. 286	302	Standard Charpy V-notch	4" weld irradiated at LITR
6	ASTM STP No. 286	302	Standard Charpy V-notch	5-1/2" weld irradiated at LITR
7	ASTM STP No. 286	93	Standard Charpy V-notch	5-1/2" weld irradiated at LITR
8	ASTM STP No. 286	93	Standard Charpy V-notch	4" plate irradiated at LITR
9	ASTM STP No. 286	315	Standard Charpy V-notch	4" plate irradiated at MTR
10	ASTM STP No. 286	260	Standard Charpy V-notch	4" plate irradiated at MTR

Most of the curves of impact energy vs temperature do not show a maximum of zero slope. The maximum impact energy plotted here is just the highest point on the curve in the reference document.

FIG. 23 TRANSITION TEMPERATURE OF A-302-B

TRANSITION TEMPERATURE OF A-302-B

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Specimen Size</u>	<u>Preirradiation Conditions, etc.</u>
1	KAPL-1416 (Figs. KS6330 and KS6331)	260	Standard Charpy V-notch	Normalized and tempered, unirradiated specimens held at 260°C for 20 days
2	KAPL-1416 (Figs. KS6332 and KS6333)	370	Standard Charpy V-notch	Normalized and tempered, unirradiated specimens held at 370°C for 20 days
3	ASTM STP No. 286	302	Standard Charpy V-notch	4" weld irradiated at BNL
4	ASTM STP No. 286	302	Standard Charpy V-notch	4" plate irradiated at BNL
5	ASTM STP No. 286	302	Standard Charpy V-notch	4" weld irradiated at LITR
6	ASTM STP No. 286	302	Standard Charpy V-notch	5-1/2" weld irradiated at LITR
7	ASTM STP No. 286	93	Standard Charpy V-notch	5-1/2" weld irradiated at LITR
8	ASTM STP No. 286	93	Standard Charpy V-notch	4" plate irradiated at LITR
9	ASTM STP No. 286	315	Standard Charpy V-notch	4" plate irradiated at MTR
10	ASTM STP No. 286	260	Standard Charpy V-notch	4" plate irradiated at MTR

Some of the curves of impact energy vs temperature given in the reference of points 3-10 showed a "saddle". The transition temperature was taken at the steepest part of the curve above the saddle before and after irradiation.

FIG. 24 IMPACT ENERGY OF AISI-C-1013

FIG. 25 TRANSITION TEMPERATURE OF AISI-C-1013

IMPACT ENERGY OF AISI-C-1013

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Specimen Size</u>	<u>Preirradiation Conditions, etc.</u>
1	AERE-M/TN-54 (p. 38, item 12)	<95	0.2" x 0.2", 1.10" between notches, notch 0.060" deep with 0.005" root radius	Hot rolled

TRANSITION TEMPERATURE OF AISI-C-1013

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Specimen size</u>	<u>Preirradiation Conditions, etc.</u>
1	AERE-M/TN-54 (p. 38, item 12)	<95	0.2" x 0.2", 1.10" between notches, notch 0.060" deep with 0.005" root radius	Hot rolled

FIG. 26 IMPACT ENERGY OF AISI-C-1065

FIG. 27 TRANSITION TEMPERATURE OF AISI-C-1065

IMPACT ENERGY OF AISI-C-1065

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Specimen Size</u>	<u>Preirradiation Conditions, etc.</u>
1	AERE-M/TN-54	<95	0.2" x 0.2", 1.10" between notches, notch 0.060" deep with 0.005" root radius	Hot rolled

TRANSITION TEMPERATURE OF AISI-C-1065

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Specimen Size</u>	<u>Preirradiation Conditions, etc.</u>
1	AERE-M/TN-54	<95	0.2" x 0.2", 1.10" between notches, notch 0.060" deep with 0.005" root radius	Hot rolled

FIG. 28 IMPACT ENERGY OF SA-70

FIG. 29 TRANSITION TEMPERATURE OF SA-70

IMPACT ENERGY OF SA-70

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Specimen Size</u>	<u>Preirradiation Conditions, etc.</u>
1	AERE-M/TN-54 (p. 38, items 1, 2, 3)	50	0.204" dia, 0.164" dia at root of notch, 0.005" root radius, notch 1" apart	No heat treatment

TRANSITION TEMPERATURE OF SA-70

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Specimen Size</u>	<u>Preirradiation Conditions, etc.</u>
1	AERE-M/TN-54 (p. 38, items 1, 2, 3)	50	0.204" dia, 0.164" dia at root of notch, 0.005" root radius, notch 1" apart	No heat treatment

FIG. 30 TENSILE STRENGTH OF SA-193,4

FIG. 31 ELONGATION OF SA-193,4

FIG. 32 CREEP OF SA-193,4

TENSILE STRENGTH OF SA-193, 4

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Testing Temp., °C</u>	<u>Preirradiation Conditions, etc.</u>
1	NARF-54-1T (Vol. I, p. 74)	20-60	Room	Hot rolled

ELONGATION OF SA-193, 4

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Testing Temp., °C</u>	<u>Preirradiation Conditions, etc.</u>
1	NARF-54-1T (Vol. I, p. 74)	20-60	Room	Hot rolled

CREEP OF SA-193, 4

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Flux, n/cm²sec</u>	<u>Stress, psi</u>	<u>Preirradiation Conditions, etc.</u>
1	ANL-4792 (p. 31, table III, item in group A)	20-60	$>10^{12}$	15,000 ^(a)	Spring loaded, in tension, .032" diameter, 1.5" gauge length
2	ANL-4792 (p. 31, table III, item in group C)	232-260	$>10^{12}$	15,000 ^(a)	Spring loaded, in tension, .032" diameter, 1.5" gauge length

(a) It is not known whether or not the stress in the spring relaxed during irradiation.

FIG. 33 HARDNESS OF SA-212

FIG. 34 YIELD STRENGTH OF SA-212

HARDNESS OF SA-212

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Testing Temp., °C</u>	<u>Preirradiation Conditions, etc.</u>
1	ANL-4508	66	Room	-
2	ANL-4508	66	Room	-
3	ANL-4504	66	Room	-
4	WAPD-T-206	<95	Room	-
5	ANL-4583	<95	Room	Stress relieved at 1100°F after welding

YIELD STRENGTH OF SA-212

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Testing Temp., °C</u>	<u>Preirradiation Conditions, etc.</u>
1	ORNL-2561	80 ^(a) 295-415 ^(b)	Room	0.2% C
2	ANL-4792	20-60	Room	-
3	AERE-M/TN-54	<95	Room	ASTM A212B
4	ANL-4508	66	Room	-
5	ANL-4504	66	Room	-

(a) Upper curve

(b) Lower curve

FIG. 35 TENSILE STRENGTH OF SA-212

FIG. 36 ELONGATION OF SA-212

TENSILE STRENGTH OF SA-212

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Testing Temp., °C</u>	<u>Preirradiation Conditions, etc.</u>
1	ORNL-2561	80 ^(a) 295-415 ^(b)	Room	0.2% C
2	ANL-4792	20-60	Room	Notched
3	ANL-4792	20-60	Room	Unnotched
4	AERE-M/TN-54	<95	Room	ASTM 212B

(a) Upper curve

(b) Lower curve

ELONGATION OF SA-212

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Testing Temp., °C</u>	<u>Preirradiation Conditions, etc.</u>
1	ORNL-2561	80 ^(a) 295-415 ^(b)	Room	0.2% C
2	AERE-M/TN-54	<95	Room	ASTM A212B
3	ANL-4792	20-60	Room	1" gauge

(a) Upper curve

(b) Lower curve

FIG. 37 REDUCTION OF AREA OF SA-212

FIG. 38 FATIGUE STRENGTH OF SA-212

REDUCTION OF AREA OF SA-212

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Testing Temp., °C</u>	<u>Preirradiation Conditions, etc.</u>
1	TID-7515 (Vol. II, p. 60)	<95	Room	ASTM A212B normalized from 1700°F
2	TID-7515 (Vol. II, p. 60)	300	Room	ASTM A212B normalized from 1700°F

FATIGUE STRENGTH OF SA-212

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Testing Temp., °C</u>	<u>Preirradiation Conditions, etc.</u>
1	AERE M/TN-54	20-60	Room	The tests on irradiated material were run after rather than during exposure.
2	AERE M/TN-54	20-60	Room	The tests on irradiated material were run after rather than during exposure.

FIG. 39 IMPACT ENERGY OF SA-212

IMPACT ENERGY OF SA-212

Data Points	Reference	Irradiation Temp., °C	Specimen Size	Preirradiation Conditions, etc.
1	ORNL-CF-56-11-1 (p. 19)	<95	0.2" x 0.2", notch 0.060" deep, 45°, root radius 0.005"	Subsize Izod, hot rolled
2	TID-7515 (Vol. II, p. 77)	<195	0.2" x 0.2", notch 0.060" deep, 45°, root radius 0.005"	Subsize Izod, normalized from 1900°F
3	ORNL-2561 (p. 258)	80	2.165" x 0.394" x 0.394", 0.315" thickness at root of 45° notch, 0.010" radius at root	Charpy V-notch, hot rolled
4	ORNL-2561 (p. 258)	300	2.165" x 0.394" x 0.394", 0.315" thickness at root of 45° notch, 0.010" radius at root	Charpy V-notch, hot rolled
5	ORNL-2561 (p. 258)	80	2.165" x 0.394" x 0.394", 0.315" thickness at root of 45° notch, 0.010" radius at root	Charpy V-notch, normalized
6	ORNL-2561 (p. 258)	300	2.165" x 0.394" x 0.394", 0.315" thickness at root of 45° notch, 0.010" radius at root	Charpy V-notch, normalized
7	ORNL-2561 (p. 258)	80-300	2.165" x 0.394" x 0.394", 0.315" thickness at root of 45° notch, 0.010" radius at root	Charpy V-notch, normalized and stress relieved
8	ORNL-CF-56-11-1 (p. 24)	<200	0.2" x 0.2", notch 0.060" deep, 45°, root radius 0.005"	Subsize Izod
9	ORNL-CF-56-11-1 (p. 24)	<315	0.2" x 0.2", notch 0.060" deep, 45°, root radius 0.005"	Subsize Izod
10	ANL-4825 (p. 18)	<60	0.204" dia, 0.164" root dia, 0.005" root radius, notch 1" apart	Subsize Izod, parent metal
11	ANL-4825 (p. 18)	<60	0.204" dia, 0.164" root dia, 0.005" root radius, notch 1" apart	Subsize Izod, parent metal, heat affected zone
12	WAPD-T-206	<100	0.2" x 0.2", 0.050" deep notch	Modified Izod
13	ORNL-2829 (fig. 167, p. 208)	80	Standard Charpy V-notch	Hot rolled
14	ORNL-2829 (fig. 167, p. 208)	132	Standard Charpy V-notch	Hot rolled
15	ORNL-2829 (fig. 167, p. 208)	165	Standard Charpy V-notch	Hot rolled
16	ORNL-2829 (fig. 168, p. 208)	80	Standard Charpy V-notch	Normalized from 1700°F
17	ORNL-2829 (fig. 168, p. 208)	132	Standard Charpy V-notch	Normalized from 1700°F
18	ORNL-2829 (fig. 168, p. 208)	165	Standard Charpy V-notch	Normalized from 1700°F
19	ORNL-2829 (fig. 176, p. 212)	199	Standard Charpy V-notch	Stress relieved, Charpy
20	ASTM STP No. 286	302	Standard Charpy V-notch	6-1/2" weld, irradiated at BNL
21	ASTM STP No. 286	302	Standard Charpy V-notch	6-1/2" plate, irradiated at BNL
22	ASTM STP No. 286	302	Standard Charpy V-notch	6-1/2" weld, irradiated at LITR
23	ASTM STP No. 286	93	Standard Charpy V-notch	6-1/2" weld, irradiated at LITR
24	ASTM STP No. 286	93	Standard Charpy V-notch	6-1/2" plate, irradiated at LITR
25	ASTM STP No. 286	177	Standard Charpy V-notch	6-1/2" weld, irradiated at MTR
26	ASTM STP No. 286	93	Standard Charpy V-notch	6-1/2" weld, irradiated at MTR

FIG. 40 TRANSITION TEMPERATURE OF SA-212

TRANSITION TEMPERATURE OF SA-212

Data Points	Reference	Irradiation Temp., °C	Specimen Size	Preirradiation Conditions, etc.
1	ORNL-CF-56-11-1 (p. 19)	<95	0.2" x 0.2", notch 0.050" deep, 45°, root radius 0.005"	Subsize Izod, hot rolled
2	TID-7515 (Vol. II, p. 77)	<195	0.2" x 0.2", notch 0.050" deep, 45°, root radius 0.005"	Subsize Izod, normalized from 1900°F
3	ORNL-2561 (p. 258)	80	2.165" x 0.394" x 0.394", 0.315" thickness at root of 45° notch, 0.010" radius at root	Charpy V-notch, hot rolled
4	ORNL-2561 (p. 258)	300	2.165" x 0.394" x 0.394", 0.315" thickness at root of 45° notch, 0.010" radius at root	Charpy V-notch, hot rolled
5	ORNL-2561 (p. 258)	80	2.165" x 0.394" x 0.394", 0.315" thickness at root of 45° notch, 0.010" radius at root	Charpy V-notch, normalized
6	ORNL-2561 (p. 258)	300	2.165" x 0.394" x 0.394", 0.315" thickness at root of 45° notch, 0.010" radius at root	Charpy V-notch, normalized
7	ORNL-2561 (p. 258)	80-300	2.165" x 0.394" x 0.394", 0.315" thickness at root of 45° notch, 0.010" radius at root	Charpy V-notch, normalized and stress relieved
8	ORNL-CF-56-11-1 (p. 24)	<200	0.2" x 0.2", notch 0.050" deep, 45°, root radius 0.005"	Subsize Izod
9	ORNL-CF-56-11-1 (p. 24)	<315	0.2" x 0.2", notch 0.050" deep, 45°, root radius 0.005"	Subsize Izod
10	ANL-4825 (p. 18)	<50	0.204" dia, 0.164" root dia, 0.005" root radius, notch 1" apart	Subsize Izod, parent metal
11	ANL-4825 (p. 18)	<50	0.204" dia, 0.164" root dia, 0.005" root radius, notch 1" apart	Subsize Izod, parent metal, heat affected zone
12	WAPD-T-206	<100	0.2" x 0.2", 0.050" deep notch	Modified Izod
13	ORNL-2829 (fig. 167, p. 208)	80	Standard Charpy V-notch	Hot rolled
14	ORNL-2829 (fig. 167, p. 208)	132	Standard Charpy V-notch	Hot rolled
15	ORNL-2829 (fig. 167, p. 208)	165	Standard Charpy V-notch	Hot rolled
16	ORNL-2829 (fig. 168, p. 208)	80	Standard Charpy V-notch	Normalized from 1700°F
17	ORNL-2829 (fig. 168, p. 208)	132	Standard Charpy V-notch	Normalized from 1700°F
18	ORNL-2829 (fig. 168, p. 208)	165	Standard Charpy V-notch	Normalized from 1700°F
19	ORNL-2829 (fig. 176, p. 212)	199	Standard Charpy V-notch	Stress relieved, Charpy
20	ASTM STP No. 286	302	Standard Charpy V-notch	6-1/2" weld, irradiated at BNL
21	ASTM STP No. 286	302	Standard Charpy V-notch	6-1/2" plate, irradiated at BNL
22	ASTM STP No. 286	302	Standard Charpy V-notch	6-1/2" weld, irradiated at LITR
23	ASTM STP No. 286	93	Standard Charpy V-notch	6-1/2" weld, irradiated at LITR
24	ASTM STP No. 286	93	Standard Charpy V-notch	6-1/2" plate, irradiated at LITR
25	ASTM STP No. 286	177	Standard Charpy V-notch	6-1/2" weld, irradiated at MTR
26	ASTM STP No. 286	93	Standard Charpy V-notch	6-1/2" weld, irradiated at MTR

FIG. 41 CREEP OF SA-212

FIG. 42 TENSILE STRENGTH OF SA-285

FIG. 43 ELONGATION OF SA-285

CREEP OF SA-212

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Flux, n/cm²sec</u>	<u>Stress, psi</u>	<u>Preirradiation Conditions, etc.</u>
1	ANL-4792	20-60	$>10^{12}$	15,000 ^(a)	0.032" diameter rods spring loaded in tension and irradiated. Gauge length = 1.5"

(a) It is not known whether this stress relaxed during irradiation.

TENSILE STRENGTH OF SA-285

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Testing Temp., °C</u>	<u>Preirradiation Conditions, etc.</u>
1	NARF-54-1T (Vol. I, p. 74)	20-60	Room	Hot rolled

ELONGATION OF SA-285

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Testing Temp., °C</u>	<u>Preirradiation Conditions, etc.</u>
1	NARF-54-1T (Vol. I, p. 74)	20-60	Room	Hot rolled

FIG. 44 IMPACT ENERGY OF SA-285

IMPACT ENERGY OF SA-285

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Specimen Size</u>	<u>Preirradiation Conditions, etc.</u>
1	AERE-M/TN-54 (p. 38, item 7)	<95	0.2" x 0.2", 45°, 0.060" deep, 0.005" root radius	Hot rolled, Izod, ASTM grain size #7
2	ORNL-2561 (p. 259)	80	2.165" x 0.394" x 0.394", 0.315" root thickness, 45° notch, 0.010" root radius	Hot rolled
3	ORNL-2561 (p. 259)	80	2.165" x 0.394" x 0.394", 0.315" root thickness, 45° notch, 0.010" root radius	Normalized
4	ORNL-2829 (Fig. 169, p. 208)	80	Standard Charpy V-notch	Grade A, hot rolled
5	ORNL-2829 (Fig. 169, p. 208)	132	Standard Charpy V-notch	Grade A, hot rolled
6	ORNL-2829 (Fig. 169, p. 208)	165	Standard Charpy V-notch	Grade A, hot rolled
7	ORNL-2829 (Fig. 170, p. 208)	80	Standard Charpy V-notch	Grade A, norma- lized from 1700°F
8	ORNL-2829 (Fig. 170, p. 208)	132	Standard Charpy V-notch	Grade A, norma- lized from 1700°F
9	ORNL-2829 (Fig. 170, p. 208)	165	Standard Charpy V-notch	Grade A, norma- lized from 1700°F

FIG. 45 TRANSITION TEMPERATURE OF SA-285

TRANSITION TEMPERATURE OF SA-285

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Specimen Size</u>	<u>Preirradiation Conditions, etc.</u>
1	AERE-M/TN-54 (p. 38, item 7)	<95	0.2" x 0.2", 45°, 0.060" deep, 0.005" root radius	Hot rolled, Izod, ASTM grain size #7
2	ORNL-2561 (p. 259)	80	2.165" x 0.394" x 0.394", 0.315" root thickness, 45° notch, 0.010" root radius	Hot rolled
3	ORNL-2561 (p. 259)	80	2.165" x 0.394" x 0.394", 0.315" root thickness, 45° notch, 0.010" root radius	Normalized
4	ORNL-2829 (Fig. 169, p. 208)	80	Standard Charpy V-notch	Grade A, hot rolled
5	ORNL-2829 (Fig. 169, p. 208)	132	Standard Charpy V-notch	Grade A, hot rolled
6	ORNL-2829 (Fig. 169, p. 208)	165	Standard Charpy V-notch	Grade A, hot rolled
7	ORNL-2829 (Fig. 170, p. 208)	80	Standard Charpy V-notch	Grade A, norma- lized from 1700°F
8	ORNL-2829 (Fig. 170, p. 208)	132	Standard Charpy V-notch	Grade A, norma- lized from 1700°F
9	ORNL-2829 (Fig. 170, p. 208)	165	Standard Charpy V-notch	Grade A, norma- lized from 1700°F

FIG. 46 CREEP OF SA-285

FIG. 47 IMPACT ENERGY OF SA-336

FIG. 48 TRANSITION TEMPERATURE OF SA-336

CREEP OF SA-285

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Flux, n/cm²sec</u>	<u>Stress, psi</u>	<u>Conditions, etc.</u>
1	ANL-4792 (p. 31)	20-60	$>10^{12}$	15,000 ^(a)	Spring loaded, in tension, 0.032" dia, 1.5" gauge length

(a) It is not known whether or not the stress in the spring relaxed during irradiation.

IMPACT ENERGY OF SA-336

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Specimen Size</u>	<u>Preirradiation Conditions, etc.</u>
1	ASTM STP No. 286	302	Standard Charpy V-notch	11" x 4" forging, irradiated at BNL
2	ASTM STP No. 286	302	Standard Charpy V-notch	11" x 4" forging, irradiated at LITR
3	ASTM STP No. 286	93	Standard Charpy V-notch	11" x 4" forging, irradiated at LITR
4	ASTM STP No. 286	93	Standard Charpy V-notch	11" x 4" forging, irradiated at MTR

TRANSITION TEMPERATURE OF SA-336

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Specimen Size</u>	<u>Preirradiation Conditions, etc.</u>
1	ASTM STP No. 286	302	Standard Charpy V-notch	11" x 4" forging, irradiated at BNL
2	ASTM STP No. 286	302	Standard Charpy V-notch	11" x 4" forging, irradiated at LITR
3	ASTM STP No. 286	93	Standard Charpy V-notch	11" x 4" forging, irradiated at LITR
4	ASTM STP No. 286	93	Standard Charpy V-notch	11" x 4" forging, irradiated at MTR

FIG. 49 HARDNESS OF SAE-1018

FIG. 50 YIELD STRENGTH OF SAE-1020

FIG. 51 TENSILE STRENGTH OF SAE-1020

HARDNESS OF SAE-1018

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Testing Temp., °C</u>	<u>Preirradiation Conditions, etc.</u>
1	AERE-M/TN-54 (p. 5)	230-260	Room	Annealed
2	AERE-M/TN-54 (p. 5)	230-260	Room	Hardened
3	AERE-M/TN-54 (p. 5)	21-60	Room	Annealed
4	AERE-M/TN-54 (p. 5)	21-60	Room	Hardened

YIELD STRENGTH OF SAE-1020

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Testing Temp., °C</u>	<u>Preirradiation Conditions, etc.</u>
1	NAA-SR-2570	315	Room	Hot rolled. Irradiation was done in polyphenyl. Unirradiated specimens were held at 305°C for 13 months in polyphenyl before testing.

TENSILE STRENGTH OF SAE-1020

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Testing Temp., °C</u>	<u>Preirradiation Conditions, etc.</u>
1	NAA-SR-2570	315	Room	Hot rolled. Irradiation was done in polyphenyl. Unirradiated specimens were held at 305°C for 13 months in polyphenyl before testing.

FIG. 52 ELONGATION OF SAE-1020

FIG. 53 REDUCTION OF AREA OF SAE-1020

FIG. 54 CREEP OF SAE-1020

ELONGATION OF SAE-1020

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Testing Temp., °C</u>	<u>Preirradiation Conditions, etc.</u>
1	NAA-SR-2570	315	Room	Hot rolled. Irradiation was done in polyphenyl. Unirradiated specimens were held at 305°C for 13 months in polyphenyl before testing.

REDUCTION OF AREA OF SAE-1020

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Testing Temp., °C</u>	<u>Preirradiation Conditions, etc.</u>
1	NAA-SR-2570	315	Room	Hot rolled. Irradiation was done in polyphenyl. Unirradiated specimens were held at 305°C for 13 months in polyphenyl before testing.

CREEP OF SAE-1020

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Stress, psi</u>	<u>Preirradiation Conditions, etc.</u>
1	ANL-4792	20-60	10,000	-
2	ANL-4792	20-60	20,000	-

Length changes said to be within experimental error. No numbers reported.

FIG. 55 HARDNESS OF SAE-1042

FIG. 56 HARDNESS OF SAE-1045

HARDNESS OF SAE-1042

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Testing Temp., °C</u>	<u>Preirradiation Conditions, etc.</u>
1	AERE-M/TN-54	230-260	Room	Annealed
2	AERE-M/TN-54	230-260	Room	Hardened

HARDNESS OF SAE-1045

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Testing Temp., °C</u>	<u>Preirradiation Conditions, etc.</u>
1	<u>Nucleonics 12</u>	21-27	Room	Annealed
2	<u>Nucleonics 12</u>	21-27	Room	Hardened

Apparent decrease in hardness is unexplained.

FIG. 57 IMPACT ENERGY OF SAE-1045

FIG. 58 TRANSITION TEMPERATURE OF SAE-1045

IMPACT ENERGY OF SAE-1045

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Specimen Size</u>	<u>Preirradiation Conditions, etc.</u>
1	AERE-M/TN-54 (p. 39, item 13)	95	0.2" square, 1.10" between 60-mil-deep notches with 5-mil root radius	Hot rolled

TRANSITION TEMPERATURE OF SAE-1045

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Specimen Size</u>	<u>Preirradiation Conditions, etc.</u>
1	AERE-M/TN-54 (p. 39, item 13)	95	0.2" square, 1.10" between 60-mil-deep notches with 5-mil root radius	Hot rolled

FIG. 59 HARDNESS OF SAE-1095

FIG. 60 HARDNESS OF SAE-1113

FIG. 61 HARDNESS OF SAE-1141

HARDNESS OF SAE-1095

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Testing Temp., °C</u>	<u>Preirradiation Conditions, etc.</u>
1	AERE-M/TN-54 (p. 5)	230-260	Room	Annealed
2	AERE-M/TN-54 (p. 5)	230-260	Room	Hardened
3	AERE-M/TN-54 (p. 5)	21-60	Room	Annealed
4	AERE-M/TN-54 (p. 5)	21-60	Room	Hardened

HARDNESS OF SAE-1113

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Testing Temp., °C</u>	<u>Preirradiation Conditions, etc.</u>
1	AERE-M/TN-54 (p. 5)	230-260	Room	Annealed
2	AERE-M/TN-54 (p. 5)	230-260	Room	Hardened

HARDNESS OF SAE-1141

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Testing Temp., °C</u>	<u>Preirradiation Conditions, etc.</u>
1	AERE-M/TN-54 (p. 5)	230-260	Room	Annealed
2	AERE-M/TN-54 (p. 5)	230-260	Room	Hardened

FIG. 62 YIELD STRENGTH OF SAE-4130

FIG. 63 TENSILE STRENGTH OF SAE-4130

FIG. 64 ELONGATION OF SAE-4130

FIG. 65 REDUCTION OF AREA OF SAE-4130

YIELD STRENGTH OF SAE-4130

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Testing Temp., °C</u>	<u>Preirradiation Conditions, etc.</u>
1	NAA-SR-2570	315	Room	Normalized. Irradiation was done in polyphenyl. Unirradiated specimens were held at 305°C for 13 months in polyphenyl before testing.

TENSILE STRENGTH OF SAE-4130

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Testing Temp., °C</u>	<u>Preirradiation Conditions, etc.</u>
1	NAA-SR-2570	315	Room	Normalized. Irradiation was done in polyphenyl. Unirradiated specimens were held at 305°C for 13 months in polyphenyl before testing.

ELONGATION OF SAE-4130

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Testing Temp., °C</u>	<u>Preirradiation Conditions, etc.</u>
1	NAA-SR-2570	315	Room	Normalized. Irradiation was done in polyphenyl. Unirradiated specimens were held at 305°C for 13 months in polyphenyl before testing.

REDUCTION OF AREA OF SAE-4130

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Testing Temp., °C</u>	<u>Preirradiation Conditions, etc.</u>
1	NAA-SR-2570	315	Room	Normalized. Irradiation was done in polyphenyl. Unirradiated specimens were held at 305°C for 13 months in polyphenyl before testing.

FIG. 66 YIELD STRENGTH OF SAE-4340

YIELD STRENGTH OF SAE-4340

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Testing Temp., °C</u>	<u>Preirradiation Conditions, etc.</u>
1	TID-7515 (Vol. II, p. 62)	67	Room	As quenched from 1650°F
2	TID-7515 (Vol. II, p. 62)	67	Room	800°F draw
3	TID-7515 (Vol. II, p. 62)	67	Room	1000°F draw
4	TID-7515 (Vol. II, p. 62)	67	Room	1200°F draw
5	TID-7515 (Vol. II, p. 62)	67	Room	1600°F anneal

FIG. 67 TENSILE STRENGTH OF SAE-4340

TENSILE STRENGTH OF SAE-4340

<u>Data Points</u>	<u>Reference</u>	<u>Irradiation Temp., °C</u>	<u>Testing Temp., °C</u>	<u>Preirradiation Conditions, etc.</u>
1	TID-7515 (Vol. II, p. 62)	67	Room	As quenched from 1650°F
2	TID-7515 (Vol. II, p. 62)	67	Room	800°F draw
3	TID-7515 (Vol. II, p. 62)	67	Room	1000°F draw
4	TID-7515 (Vol. II, p. 62)	67	Room	1200°F draw
5	TID-7515 (Vol. II, p. 62)	67	Room	1600°F anneal

FIG. 68 IMPACT ENERGY OF SAE-4340

IMPACT ENERGY OF SAE-4340

Data Points	Reference	Irradiation Temp., °C	Specimen Size	Preirradiation Conditions, etc.
1	TID-7515 (Vol. II, p. 71)	<95 (Transition in mode of fracture disappears after irradiation.) See sketch # 1	0.204" OD, 0.164" root OD, 0.005" root radius, circumferential notches 1" apart	Subsize Izod, quenched from 1600°F, tempered at 400°F

SKETCH 1

2	TID-7515 (Vol. II, p. 71)	<95 (Transition in mode of fracture disappears after irradiation.) See sketch # 2	0.204" OD, 0.164" root OD, 0.005" root radius, circumferential notches 1" apart	Subsize Izod, quenched from 1600°F, annealed at 1650°F
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SKETCH 2

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