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Introducing the Structural Alloys Handbook in PDF format.

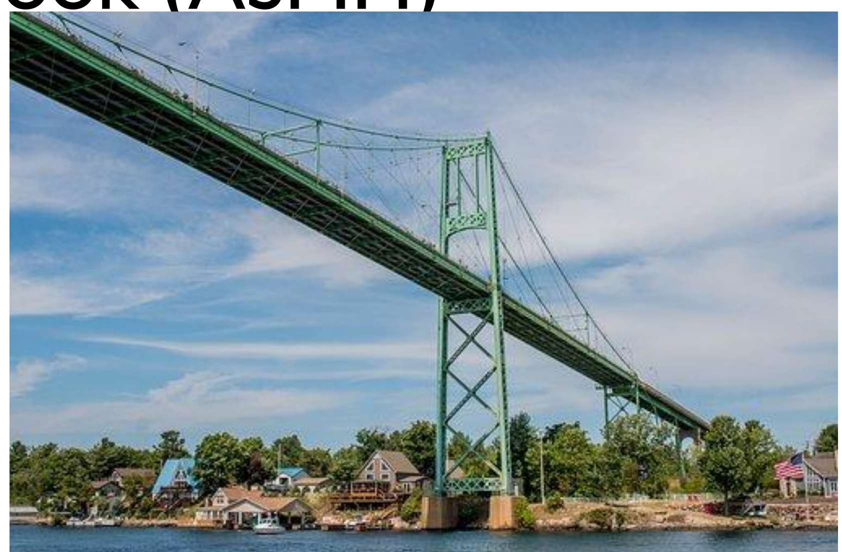
Materials Properties

- Change with Temperature
  - Strength, ductility
  - Dimensions: expansion, contraction
- Some properties change with Time

- People who design structures (cars, airplanes, bridges, ships, turbines, oil infrastructures, etc.) need reliable materials data to pick the right material for the application.
  - Always want the best performance and lowest cost

Structural Alloys Handbook (SAH)

- Provides current, dynamic tools for selection process
- Originally prepared as companion reference to the Aerospace Structural Metals Handbook (ASMH)



Contents of SAH

- 80 % of the materials in the SAH are NOT in the ASMD
- -Wrought and cast steel,
- -Wrought and cast aluminum,
- -Cast iron, wrought stainless steel
- -Copper, bronze, brass,
- -Titanium and magnesium

Characteristics of SAH

- Offers characterization
  - In-depth and up to date, common metals and alloys
  - Construction, machine tool, heavy equipment
  - Infrastructure, chemical and food processing
  - Automotive and general manufacturing

Each alloy chapter

- Data representing property-influencing variables
  - Hostile environments
  - Elevated temperatures
  - Surface coatings and finishes
  - Test procedures
  - Specimen configurations
  - Process practices

Organization of Database

- 2500 pages
- Preliminary Selector Charts
  - Tables assist in selecting alloy from broad family
- Specific alloy chapters
  - Detailed characterization data to assist in selection
  - Well-defined data
  - Reduce in-house testing

CINDAS LLC Global Benchmark for Critically Evaluated Materials Properties Data

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Select Material Group:
(6 material groups)

Select one of 6 material groups

Supplemental Index

- 01 - Foreword
- 02 - Acknowledgments
- 03 - Introduction
- 11 - Symbols and Abbreviations
- 12 - Test Types
- 13 - The Well Defined Test
- 14 - Conversion Factors and Tables

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Back to top

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Structural Alloys Handbook (SAH)

Browse By:

Select Material Group:

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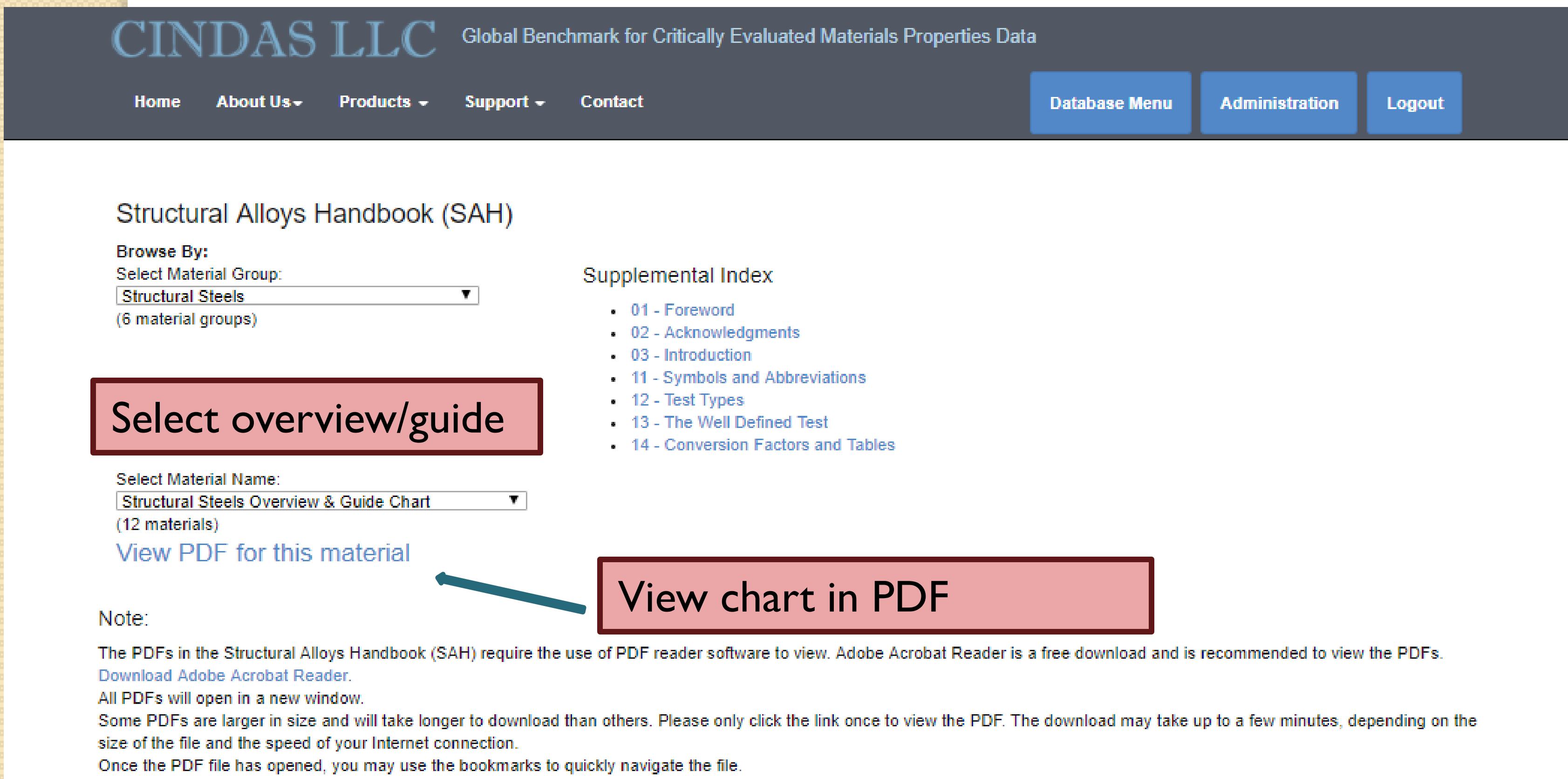
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Select Material Group:
Structural Steels
(6 material groups)
Supplemental Index
01 - Foreword
02 - Acknowledgments
03 - Introduction
11 - Symbols and Abbreviations
12 - Test Types
13 - The Well Defined Test
14 - Conversion Factors and Tables
Select overview/guide
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Selection of Structural Steels—Overview

Table 2. Impact Testing Temperature Zones (ASTM A 709)

Zone	Minimum Service Temperature, °F (°C)
1	0 (-18)
2	below 0 to -30 (-18 to -34)
3	below -30 to - 60 (-18 to -51)

Table 3. Non-Fracture Critical Impact Test Requirements (ASTM A 709)

Grade	Thickness, in. (mm) and Joining Method	Minimum Average Energy, ft-lbf (J)		
		Zone 1	Zone 2	Zone 3
36T[A]	to 4 (102) incl, mechanically fastened or welded	15 (20) at 70°F (21°C)	15 (20) at 40°F (4°C)	15 (20) at 10°F (-12°C)
50T[A,B], 50WT[A,B]	to 2 (51) incl, mechanically fastened or welded	15 (20) at 70°F (21°C)	15 (20) at 40°F (4°C)	15 (20) at 10°F (-12°C)
	over 2 to 4 (51 to 102) incl, mechanically fastened	15 (20) at 70°F (21°C)	15 (20) at 40°F (4°C)	15 (20) at 10°F (-12°C)
	over 2 to 4 (51 to 102) incl, welded	20 (27) at 70°F (21°C)	20 (27) at 40°F (4°C)	20 (27) at 10°F (-12°C)
70WT[C,D]	to 2 1/2 (64) incl, mechanically fastened or welded	20 (27) at 50°F (10°C)	20 (27) at 20°F (-7°C)	20 (27) at -10°F (-23°C)
	over 2 1/2 to 4 (64 to 102) incl, mechanically fastened	20 (27) at 50°F (10°C)	20 (27) at 20°F (-7°C)	20 (27) at -10°F (-23°C)
	over 2 1/2 to 4 (64 to 102) incl, welded	25 (34) at 50°F (10°C)	25 (34) at 20°F (-7°C)	25 (34) at -10°F (-23°C)
100T[C], 100WT[C]	to 2 1/2 (64) incl, mechanically fastened or welded	25 (34) at 30°F (-1°C)	25 (34) at 0°F (-18°C)	25 (34) at -30°F (-34°C)
	over 2 1/2 to 4 (64 to 102) incl, mechanically fastened	25 (34) at 30°F (-1°C)	25 (34) at 0°F (-18°C)	25 (34) at -30°F (-34°C)
	over 2 1/2 to 4 (64 to 102) incl, welded	35 (48) at 30°F (-1°C)	35 (48) at 0°F (-18°C)	35 (48) at -30°F (-34°C)

[A] The CVN-impact testing shall be "H" heat frequency testing in accordance with Specification A 673/A 673M.

[B] If the yield point of the material exceeds 65 ksi (450 MPa), the testing temperature for the minimum average energy required shall be reduced by 15°F (8°C) for each increment of 10 ksi (70 MPa) above 65 ksi (450 MPa). The yield point is the value given on the certified "Mill Test Report."

[C] The CVN-impact testing shall be "P" piece frequency testing in accordance with Specification A 673/A 673M.

[D] If the yield strength of the material exceeds 85 ksi (585 MPa), the testing temperature for the minimum average energy required shall be reduced by 15°F (8°C) for each increment of 10 ksi above 85 ksi (585 MPa). The yield strength is the value given on the certified "Mill Test Report."

Table 4. Fracture Critical[A] Impact Test Requirements (ASTM A 709)

Grade	Thickness, in. (mm) and Joining Method	Minimum Average Energy[B], ft-lbf (J)		
		Zone 1	Zone 2	Zone 3[B]
36F[C]	to 1 1/2 (40) incl, mechanically fastened or welded	25 (34) at 70°F (21°C)	25 (34) at 40°F (4°C)	25 (34) at 10°F (-12°C)
	over 1 1/2 to 4 (40 to 102) incl, mechanically fastened or welded	25 (34) at 70°F (21°C)	25 (34) at 40°F (4°C)	25 (34) at -10°F (-23°C)
50F[C], 50WF[C]	to 1 1/2 (40) incl, mechanically fastened or welded	25 (34) at 70°F (21°C)	25 (34) at 40°F (4°C)	25 (34) at 10°F (-12°C)
	over 1 1/2 to 2 (40 to 51) incl, mechanically fastened or welded	25 (34) at 70°F (21°C)	25 (34) at 40°F (4°C)	25 (34) at -10°F (-23°C)
	over 2 to 4 (51 to 102) incl, mechanically fastened	25 (34) at 70°F (21°C)	25 (34) at 40°F (4°C)	25 (34) at -10°F (-23°C)
	over 2 to 4 (51 to 102) incl, welded	30 (41) at 70°F (21°C)	30 (41) at 40°F (4°C)	30 (41) at -10°F (-23°C)
70WF[D]	to 1 1/2 (40) incl, mechanically fastened or welded	30 (41) at 20°F (-7°C)	30 (41) at 20°F (-7°C)	30 (41) at -10°F (-23°C)
	over 1 1/2 to 2 1/2 (40 to 64) incl, mechanically fastened or welded	30 (41) at 20°F (-7°C)	30 (41) at 20°F (-7°C)	30 (41) at -30°F (-34°C)
	over 2 1/2 to 4 (64 to 102) incl, mechanically fastened	30 (41) at 20°F (-7°C)	30 (41) at 20°F (-7°C)	30 (41) at -30°F (-34°C)
	over 2 1/2 to 4 (64 to 102) incl, welded	35 (48) at 20°F (-7°C)	35 (48) at 20°F (-7°C)	35 (48) at -30°F (-34°C)
100F, 100WF	to 2 1/2 (64) incl, mechanically fastened or welded	35 (48) at 0°F (-18°C)	35 (48) at 0°F (-18°C)	35 (48) at -30°F (-34°C)
	over 2 1/2 to 4 (64 to 102) incl, mechanically fastened	35 (48) at 0°F (-18°C)	35 (48) at 0°F (-18°C)	35 (48) at -30°F (-34°C)
	over 2 1/2 to 4 (64 to 102) incl, welded	45 (61) at 0°F (-18°C)	45 (61) at 0°F (-18°C)	Not Permitted

Portion of one of 41 pages in this selection document

Another example for Wrought Steels with Medium Carbon Content

Structural Alloys Handbook (SAH)

Browse By:

Select Material Group:

Wrought Steels ▼

(6 material groups)

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Back to top

Key sections in the SAH

- Composition tables
- Tensile, yield, % E, RA, hardness, impact
- Cold working effects on mechanical properties
- Temperature effects
- Stress strain curves
- Cold work effects on impact properties
- Fatigue comparison cast versus wrought
- Fatigue crack propagation
- Summary
- References

COMPOSITION

MEDIUM CARBON STEELS

CHEMICAL COMPOSITION OF VARIOUS MEDIUM CARBON STEEL SPECIFICATIONS (68)

Specification	Form	C Min	C Max	Mn Min	Mn Max	P Max	S Max	Si Min	Si Max	Ni Min	Ni Max	Mo Min	Mo Max	Other
ASTM A442-72, Gr.55	Plate, 1 in or under		.22	.8	1.10	.040	.050							
ASTM A375-64	Sheet & strip		.22		1.25		.050							
SAE 1021	Steel products	.18	.23	.60	.90	.040	.050							
SAE 1021	Steel shapes	.18	.23	.60	.90	.040	.050							
SAE 1022	Steel products	.18	.23	.70	1.00	.040	.050							
SAE 1022	Steel shapes	.17	.24	.70	1.00	.040	.050							
AISI 1021		.18	.23	.60	.90	.040	.050							
AISI 1022		.18	.23	.70	1.00	.040	.050							
ASTM A510-71, 1022	Rod & wire	.18	.23	.70	1.00	.040	.050							
ASTM A545-71, Gr.1022	Wire	.18	.23	.70	1.00	.035	.045							
ASTM A548-71, 1022	Wire	.18	.23	.70	1.00	.035	.045							
ASTM A548-68, 1022M	Wire	.18	.23	.80	1.10	.035	.045							
ASTM A375-64	Sheet & strip		.22		1.25		.050							
ASTM A523-68, Gr.A	Pipe, seamless		.22		.90	.040	.050							
ASTM A544-72, Gr.1022	Wire	.18	.23	.70	1.00	.035	.045							
ASTM A285-72, Gr.B	Plate, 3/4-2 in.		.22		.80	.050	.040							Cu-0.20-0.35
SAE 1023		.20	.25	.30	.60	.040	.050							
AISI 1023		.20	.25	.30	.60	.040	.050							
ASTM A510-68, 1023	Rod & wire	.20	.25	.30	.60	.040	.050							
ASTM A414-71, Gr.B	Firebox		.23		.80	.040	.040							Cu-0.20
SAE J429d, Gr.2	Bolts, screws, studs		.23			.048	.058							
SAE 1024	Carbon steel	.19	.25	1.35	1.65	.040	.050							
AISI 1024	Carbon steel	.19	.25	1.35	1.65	.040	.050							
ASTM A510-71, 1024	Rod & wire	.19	.25	1.35	1.65	.010	.050							
ASTM A442-72, Gr.55	1-1-1/2 inch	.24		.60	.90	.040	.050	.15	.30					
ASTM A442-72, Gr.60	1 in. or under	.24		.08	1.10	.040	.050							
SAE 1524		.19	.25	1.35	1.65	.040	.050							
ASTM A36-69	Plate, shapes, bar		.26			.040	.050							Cu-0.20
ASTM A108-69, Gr 1025	Bar	.22	.28	.30	.60	.040	.050		.30					
ASTM A245-64, Gr A, B, C	Sheet		.25			.040	.050							Cu-.20 min.
SAE 1025		.22	.28	.30	.60	.040	.050							
AISI 1025		.22	.28	.30	.60	.040	.050							
ASTM A512-66, Gr.1025	Tubing	.22	.28	.30	.60	.040	.050							
ASTM A510-71, 1025	Wire	.22	.28	.30	.60	.040	.050							
ASTM A519-72, 1025	Tubing	.22	.28	.30	.60	.040	.050							
ASTM A533-72a, Gr.A	Plate		.25	1.15	1.50	.035	.040	.15	.30			.45	.60	
ASTM A533-72l, Gr.B	Plate		.25	1.15	1.50	.035	.040	.15	.30	.40	.70	.45	.60	
ASTM A533-72a, Gr.C	Plate		.25	1.15	1.50	.035	.040	.15	.30	.70	1.0	.45	.60	
ASTM A109-72, Tempers 1, 2, 3	Strip		.25		.60	.040	.050							Cu-.20
ASTM A303-64, Gr.A, B, C,	Structural strip		.25			.040	.050							Cu-.20
ASTM A155-72a, Gr. CM75	Pipe	.23	.28		.90	.040	.050	.15	.30			.45	.60	
ASTM A515-72, Gr 55	Plate	.20	.28		.90	.035	.040	.15	.30					
ASTM A336-70a	Seamless drum forgings	.20	.30	.60	.90	.040	.040	.20	.35			.40	.60	
ASTM A325-71a	Carbonized washers		.25	1.00		.040	.050							
ASTM A31-72, Gr.B	Rivets		.28	.30	.80	.045	.050							
ASTM A178-71, Gr.C	Tube		.25		.80	.050	.060							

Five pages of composition tables

Portion of tables on Cold-working effects

TENSILE
COLD WORK EFFECTS

MEDIUM CARBON STEELS

TYPICAL LONGITUDINAL PROPERTIES OF COLD WORKED 1040 STEEL BARS (39)

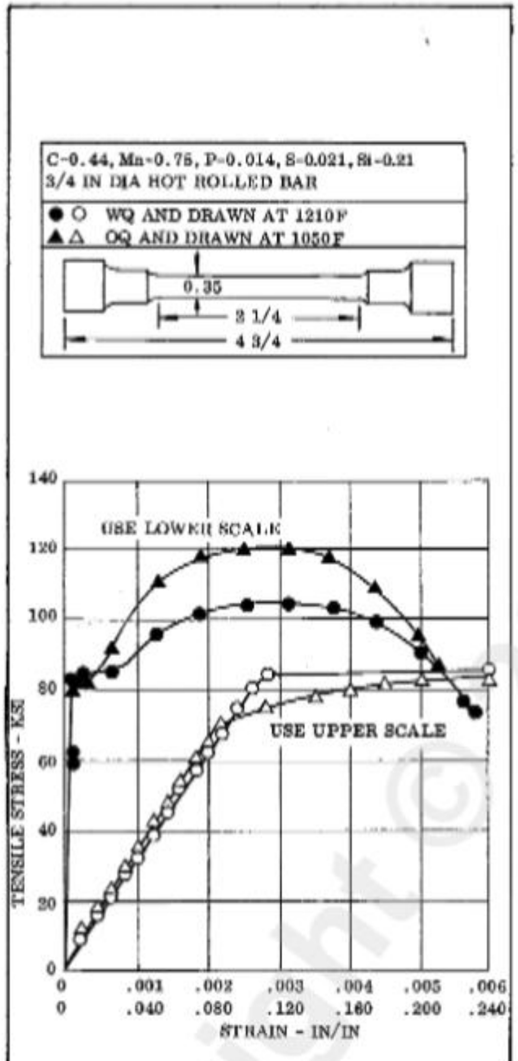
Amount of Cold Work (%)	Hardness (R_b)	Tensile Test Values: Yield Strength (0.2%) (ksi)	Tensile Test Values: Tensile Strength (ksi)	Tensile Test Values: Elongation (%)	Tensile Test Values: Reduction of Area (%)	Charpy V-Notch Impact: Energy R.T. (ft-lbs)	Charpy V-Notch Impact: Energy -40F (ft-lbs)	Charpy V-Notch Impact: Transition Temp. (F)	Fatigue Endurance Limit At 10^6 Cycles (ksi)
AS COLD DRAWN									
0	89	59	97	23	51	35	9	130	50
5	91	84	103	19	48	21	7	170	51
10	95	93	108	15	46	17	6	190	53
20	98	97	117	13	44	14	6	200	54
30	99	100	121	13	42	13	6	190	55
40	C 22	113	129	12	39	12	5	185	57
50	C 25	124	140	8	25	11	5	180	60
AS COLD DRAWN AND STRESS RELIEVED 2 HR. AT 900F									
0	89	59	97	24	51	35	9	130	50
5	91	73	108	20	49	19	8	160	53
10	95	85	111	18	47	15	7	185	55
20	98	94	118	16	44	13	7	195	58
30	99	98	120	16	42	16	8	175	61
40	C 22	106	126	16	42	21	8	140	63
50	C 25	116	133	13	28	31	9	70	66

2 inch diameter bars normalized 1 hour at 1650F, specimens from 1/2 radius
Specimens 0.505 inch diameter, 2 inch gage length
Transition temperature for 100% fibrous fracture

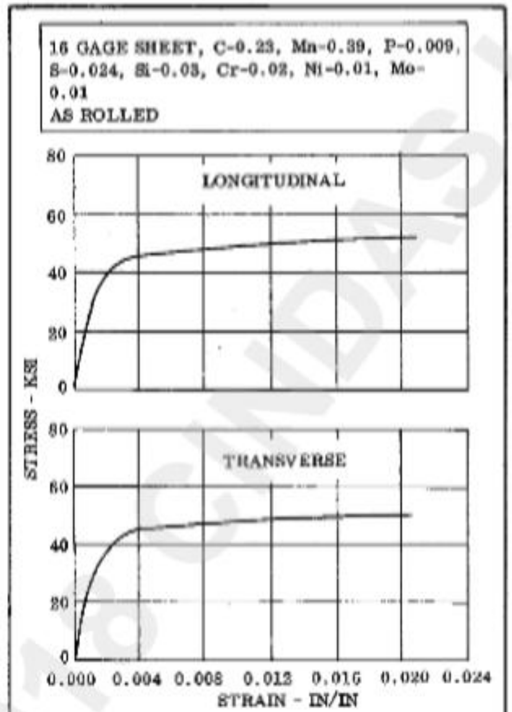
MEDIUM CARBON STEELS

TENSILE
STRESS – STRAIN

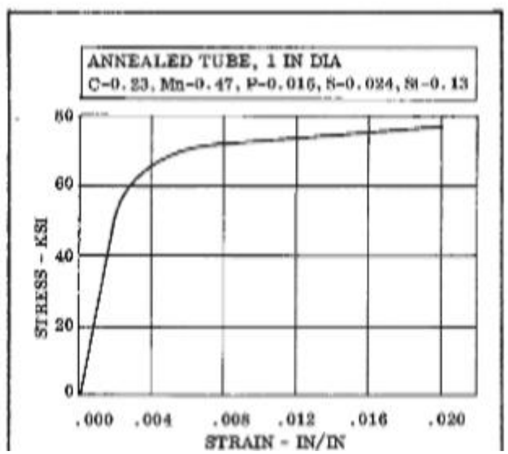
Stress-Strain Curves



TENSILE STRESS-STRAIN CURVES FOR SAE 1045 STEEL (43)



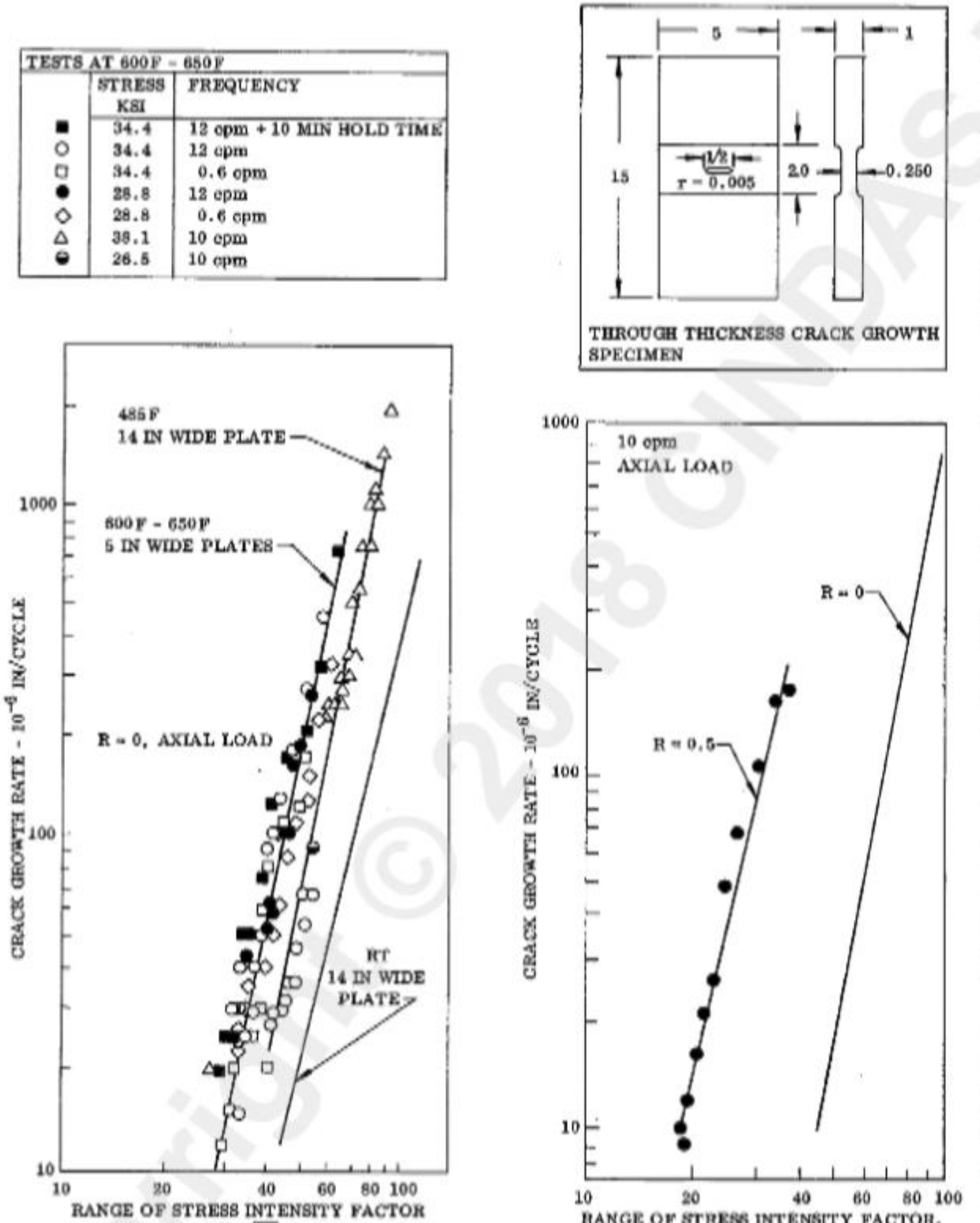
TENSILE STRESS-STRAIN CURVES OF AISI 1023 SHEET STEEL (40)



MEDIUM CARBON STEELS

FATIGUE
CRACK PROPAGATION

TESTS AT 600F - 650F	STRESS KSI	FREQUENCY
■	34.4	12 cpm + 10 MIN HOLD TIME
○	34.4	12 cpm
□	34.4	0.6 cpm
●	28.8	12 cpm
◇	28.8	0.6 cpm
△	38.1	10 cpm
◒	26.5	10 cpm



Fatigue crack propagation

MEDIUM CARBON STEELS

REPORT SUMMARIES AND CONCLUSIONS

TENSILE

The effects of grain size on the strength properties of 1045 steel were determined at U.S. Steel Corporation. It was shown that the yield strength increased from about 60 ksi to more than 100 ksi as the austenite grain size was reduced from 3.5 to 13.5. These ultra fine grains were produced in thin sheet material with four repetitive cycles involving a rapid quench (within 20 seconds) from the austenitizing temperature of 1500F (8).

A summary of some twenty-five technical reports on cold working plain carbon and very low alloy steels was compiled by the Case Institute of Technology. The data were obtained from a test program at Case from 1948 to 1953 designed to find the extent to which more fully cold worked steels might replace the more strategic heat treated alloy steels. Part of the reason for this test program was stated as follows: "The interdependent factors of an ordinarily good supply of heat treated alloy steels, and the limited demand for heavily cold worked steels, have created a situation of general ignorance of the extent to which severely cold worked steels may be utilized". It was shown that, in general, initial small amounts of cold work caused large increases in the tensile and yield strengths with moderate losses in ductility. Intermediate amounts of cold work produced little or no added change in either strength or ductility, however, large amounts of cold work gave large additional gains in strength with only moderate losses in ductility. The maximum amounts of cold drawing reduction without failure varied from about 50% for 1040 to about 40% for 1060. An increase in the carbon content or in the low alloy addition raised the maximum strengthening and hardening effects of cold working by raising the hardness and strength of the base-line material in the normalized condition. It was also shown that high amounts of work hardening produced a slight reduction in the fatigue endurance limit-tensile strength ratio but that this effect was completely removed by a thermal stress relief. Other benefits of cold worked steels were close tolerances of finished parts, superior machinability and surface finish, and a high ratio of yield to tensile strength. Also, the cold working cost was more than offset by the elimination of alloying elements, quenching, tempering and surface cleaning operations. The cold worked steels gave no evidence of notch sensitivity or directionality of properties with a

The effects of various types and severity of internal defects on the tensile properties of annealed cast Class B steel plate (C-0.26%) were determined at the U.S. Naval Applied Science Laboratory. The defects were qualitatively measured with radiographic techniques on specimens that measured 3 inches by 2 inches in cross section. It was shown that most types of defects had little effect on the yield strength, however, the ultimate strength and elongation values were drastically reduced in some cases (21).

The effects of strain rates on the tensile properties of several steels were summarized in a study conducted by Materials Technology Corporation. It was shown that both the upper and lower yield point of 1045 steel were increased by 2.25 ksi for a 10-fold increase in the strain rate in the range of 0.1 to 10% per minute (53).

HEAT TREATMENT

Tensile, hardness and impact tensile tests were conducted at Columbia University on several experimental medium carbon steels that were isothermally transformed to produce bainite. For ultimate strength levels greater than about 210 ksi, it was shown that 1062 material with a bainitic microstructure had greater ductility and a lower transition temperature than did tempered martensitic material (46).

Tests were conducted on 1060 steel at Columbia University to determine if this material was subject to the 550F embrittlement. It was shown that the ductility of 1060 exhibited a gradual rise with an increase in tempering temperature and thus was not subject to this type of temper embrittlement. It was also shown that commercial 1340 steel was subject to the 550F embrittlement whereas laboratory vacuum melted 1340 material was not (47).

The effects of various quench rates on the impact properties of 1040 and several other steels were determined at the Watertown Arsenal. It was shown that in all cases, for a given steel and hardness level, the fully quenched and tempered structure produced superior impact properties than did the slack-quenched and tempered structure (48).

The effect of cold work on the tempering response of as-

Summary and conclusions

MEDIUM CARBON STEELS

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