SURFACE VEHICLE INFORMATION REPORT

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Estimated Mechanical Properties and Machinability of Steel Bars

RATIONALE

The technical report covers technology, products, or processes which are mature and not likely to change in the foreseeable future.

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***Foreword*—**This Document has also changed to comply with the new SAE Technical Standards Board format.

1. ***Scope*—**This SAE Information Report is intended to provide a guide to mechanical and machinability characteristics of some SAE steel grades. The ratings and properties shown are provided as general information and not as requirements for specifications unless each instance is approved by the source of supply. The data are based on resources which may no longer be totally accurate. However, this report is retained as a service in lieu of current data.

2. ***References***

2.1 **Applicable Publication—**The following publication forms a part of this specification to the extent specified herein.

U. S. Air Force Machinability Report, Volume 2, 1951, published by Curtiss-Wright Corporation

2.2 **Related Publications—**The following publications are provided for information purposes only and are not a required part of this document.

Metals Handbook, 8th ed., Volume 3, Machining, American Society for Metals, Metals Park, OH 44073.
Machining Data Handbook, Volumes 1 and 2.
Machinability Data Center, Metcut Research Associates, 3980 Rosslyn Drive, Cincinnati, OH 45209.

3. ***Carbon Steel*—**Mechanical properties and machinability ratings for carbon steel grades 10xx, 11xx, 12xx, and 15xx are listed in Tables 1, 2, and 3. These properties can generally be expected from bars ranging in size from 20 to 30 mm (3/4 to 1-1/4 in) based on the standard round tensile test specimen with 50 mm (2 in) gage length.

Sizes under 20 mm (3/4 in) will show a strength which is slightly higher than those shown in the Tables. The mass effect of larger sections has a direct influence on mechanical properties and results in slightly lower values as the section size increases.

Properties of turned and polished or turned and ground types of cold finished material will correspond to the hot rolled values.

The cold drawn properties are based on conventional production from hot rolled bars.

Cold drawn carbon steel bars in grades 1042 and higher are frequently thermally treated prior to cold drawing to enhance machinability.

4. ***Alloy Steel—***Hardness and machinability ratings for cold drawn alloy steel bars are listed in Table 4 with the appropriate microstructure. The microstructure listed for alloy steels in Table 4 is identified as follows:

   a. Type A—Predominantly lamellar pearlite and ferrite.
   b. Type B—Predominantly spheroidized.
   c. Type C—This is a hot rolled structure which depends upon grade, size, and rolling conditions of the producing mill. The structure may be coarse or fine pearlite or bainite. The pearlite at low magnification may be blocky or acicular. For descriptive information, see U.S. Air Force Machinability Report, Volume 2, 1951, published by Curtiss-Wright Corporation.
   d. Type D—This is a structure resulting from a subcritical anneal or temper anneal. It is usually a granular or spheroidized carbide condition confined to the hot rolled grain pattern, which may be blocky or acicular.

5. ***Machinability—***While it is recognized that the views regarding alloy steel machinability vary considerably, it is believed that the ratings contained in this report reflect current industry experience. The data on which the ratings were based were obtained by a detailed survey of both producers and users. The data summarize the combined experience of both groups. Various factors influence machinability and, therefore, results shown in Table 1 are average and may be affected to some degree by the amount of cold reduction, mechanical properties, grain size, microstructure, type of tooling, and machining operation(s) performed.

   The machinability ratings listed are based on a value of 100% for SAE 1212 cold drawn steel. This value involves turning at a cutting speed of 55 m (180 surface feet) per minute for feeds up to 0.18 mm (0.007 in) per revolution and depths of cut up to 6.4 mm (0.250 in), using appropriate cutting fluids with high speed steel tools, SAE Grade T-1 (18-4-1) hardened to 63-65 HRC (SAE J437, J438).

   Most low carbon alloy steels are machined in the as-rolled or as-rolled and cold drawn or cold finished condition. Higher carbon alloy steels and high hardenability low carbon steels, such as SAE 9310, may be conditioned for machining by a variety of heat treatments. Thermal treatments used to condition these steels for machining include subcritical annealing, annealing for softening to no specified structure, annealing to a specified structure such as lamellar pearlite or a percentage of lamellar pearlite and spheroidization, or to a fully spheroidized condition.

   The structures imparted to the bars are evaluated in the machining operation by the tooling setup and the type of tool used. It is possible to use widely diverging hardnesses and structures with different tooling setups and obtain satisfactory results both as to finish and parts per hour.

TABLE 1—ESTIMATED MECHANICAL PROPERTIES AND MACHINABILITY RATINGS OF NONRESULFURIZED CARBON STEEL BARS, MANGANESE 1.00% MAXIMUM

UNS No.	SAE and/or AISI No.	Type of Processing	Tensile Strength MPa	Tensile Strength psi	Estimated Minimum Values Yield Strength MPa	Estimated Minimum Values Yield Strength psi	Estimated Minimum Values Elongation in 2 in, %	Reduction in Area %	Brinell Hardness	Average Machinability Rating (Cold Drawn) 1212=100%
G10060	1006	Hot Rolled	300	43 000	170	24 000	30	55	86	
		Cold Drawn	330	48 000	280	41 000	20	45	95	50
G10080	1008	Hot Rolled	303	44 000	170	24 500	30	55	86	
		Cold Drawn	340	49 000	290	41 500	20	45	95	55
G10100	1010	Hot Rolled	320	47 000	180	26 000	28	50	95	
		Cold Drawn	370	53 000	300	44 000	20	40	105	55
G10120	1012	Hot Rolled	330	48 000	180	26 500	28	50	95	
		Cold Drawn	370	54 000	310	45 000	19	40	105	55
G10150	1015	Hot Rolled	340	50 000	190	27 500	28	50	101	
		Cold Drawn	390	56 000	320	47 000	18	40	111	60
G10160	1016	Hot Rolled	380	55 000	210	30 000	25	50	111	
		Cold Drawn	420	61 000	350	51 000	18	40	121	70
G10170	1017	Hot Rolled	370	53 000	200	29 000	26	50	105	
		Cold Drawn	410	59 000	340	49 000	18	40	116	65
G10180	1018	Hot Rolled	400	58 000	220	32 000	25	50	116	
		Cold Drawn	440	64 000	370	54 000	15	40	126	70
G10190	1019	Hot Rolled	410	59 000	220	32 500	25	50	116	
		Cold Drawn	460	66 000	380	55 000	15	40	131	70
G10200	1020	Hot Rolled	380	55 000	210	30 000	25	50	111	
		Cold Drawn	420	61 000	350	51 000	15	40	121	65
G10210	1021	Hot Rolled	420	61 000	230	33 000	24	48	116	
		Cold Drawn	470	68 000	390	57 000	15	40	131	70
G10220	1022	Hot Rolled	430	62 000	230	34 000	23	47	121	
		Cold Drawn	480	69 000	400	58 000	15	40	137	70
G10230	1023	Hot Rolled	370	56 000	210	31 000	25	50	111	
		Cold Drawn	430	62 000	360	52 500	15	40	121	65
G10250	1025	Hot Rolled	400	58 000	220	32 000	25	50	116	
		Cold Drawn	440	64 000	370	54 000	15	40	126	65
G10260	1026	Hot Rolled	440	64 000	240	35 000	24	49	126	
		Cold Drawn	490	71 000	410	60 000	15	40	143	75

TABLE 1—ESTIMATED MECHANICAL PROPERTIES AND MACHINABILITY RATINGS OF NONRESULFURIZED CARBON STEEL BARS, MANGANESE 1.00% MAXIMUM (CONTINUED)

UNS No.	SAE and/or AISI No.	Type of Processing	Tensile Strength MPa	Tensile Strength psi	Estimated Minimum Values Yield Strength MPa	Estimated Minimum Values Yield Strength psi	Estimated Minimum Values Elongation in 2 in, %	Reduction in Area %	Brinell Hardness	Average Machinability Rating (Cold Drawn) 1212=100%
G10300	1030	Hot Rolled	470	68 000	260	37 500	20	42	137	
		Cold Drawn	520	76 000	440	64 000	12	35	149	70
G10350	1035	Hot Rolled	500	72 000	270	39 500	18	40	143	
		Cold Drawn	550	80 000	460	67 000	12	35	163	65
G10370	1037	Hot Rolled	510	74 000	280	40 500	18	40	143	
		Cold Drawn	570	82 000	480	69 000	12	35	167	65
G10380	1038	Hot Rolled	520	75 000	280	41 000	18	40	149	
		Cold Drawn	570	83 000	480	70 000	12	35	163	65
G10390	1039	Hot Rolled	540	79 000	300	43 500	16	40	156	
		Cold Drawn	610	88 000	510	74 000	12	35	179	60
G10400	1040	Hot Rolled	520	76 000	290	42 000	18	40	149	
		Cold Drawn	590	85 000	490	71 000	12	35	170	60
G10420	1042	Hot Rolled	550	80 000	300	44 000	16	40	163	
		Cold Drawn	610	89 000	520	75 000	12	35	179	60
		NCD[1]	590	85 000	500	73 000	12	45	179	70
G10430	1043	Hot Rolled	570	82 000	310	45 000	16	40	163	
		Cold Drawn	630	91 000	530	77 000	12	35	179	60
		NCD[1]	600	87 000	520	75 000	12	45	179	70
G10440	1044	Hot Rolled	550	80 000	300	44 000	16	40	163	
G10450	1045	Hot Rolled	570	82 000	310	45 000	16	40	163	
		Cold Drawn	630	91 000	530	77 000	12	35	179	55
		ACD[2]	590	85 000	500	73 000	12	45	170	65
G10460	1046	Hot Rolled	590	85 000	320	47 000	15	40	170	
		Cold Drawn	650	94 000	540	79 000	12	35	187	55
		ACD[2]	620	90 000	520	75 000	12	45	179	65
G10490	1049	Hot Rolled	600	87 000	330	48 000	15	35	179	
		Cold Drawn	670	97 000	560	81 500	10	30	197	45
		ACD[2]	630	92 000	530	77 000	10	40	187	55
G10500	1050	Hot Rolled	620	90 000	340	49 500	15	35	179	
		Cold Drawn	690	100 000	580	84 000	10	30	197	45
		ACD[2]	660	95 000	550	80 000	10	40	189	55

TABLE 1—ESTIMATED MECHANICAL PROPERTIES AND MACHINABILITY RATINGS OF NONRESULFURIZED CARBON STEEL BARS, MANGANESE 1.00% MAXIMUM (CONTINUED)

UNS No.	SAE and/or AISI No.	Type of Processing	Tensile Strength MPa	Tensile Strength psi	Estimated Minimum Values Yield Strength MPa	Estimated Minimum Values Yield Strength psi	Estimated Minimum Values Elongation in 2 in, %	Reduction in Area %	Brinell Hardness	Average Machinability Rating (Cold Drawn) 1212=100%
G10550	1055	Hot Rolled	650	94 000	360	51 500	12	30	192	
		ACD[2]	660	96 000	560	81 000	10	40	197	55
G10600	1060	Hot Rolled	680	98 000	370	54 000	12	30	201	
		SACD[3]	620	90 000	480	70 000	10	45	183	60
G10640	1064	Hot Rolled	670	97 000	370	53 500	12	30	201	
		SACD[3]	610	89 000	480	69 000	10	45	183	60
G10650	1065	Hot Rolled	690	100 000	380	55 000	12	30	207	
		SACD[3]	630	92 000	490	71 000	10	45	187	60
G10700	1070	Hot Rolled	700	102 000	390	56 000	12	30	212	
		SACD[3]	640	93 000	500	72 000	10	45	192	55
G10740	1074	Hot Rolled	720	105 000	400	58 000	12	30	217	
		SACD[3]	650	94 500	500	73 000	10	40	192	55
G10780	1078	Hot Rolled	690	100 000	380	55 000	12	30	207	
		SACD[3]	650	94 000	500	72 500	10	40	192	55
G10800	1080	Hot Rolled	770	112 000	420	61 500	10	25	229	
		SACD[3]	680	98 000	520	75 000	10	40	192	45
G10840	1084	Hot Rolled	820	119 000	450	65 500	10	25	241	
		SACD[3]	690	100 000	530	77 000	10	40	192	45
G10850	1085	Hot Rolled	830	121 000	460	66 500	10	25	248	
		SACD[3]	690	100 500	540	78 000	10	40	192	45
G10860	1086	Hot Rolled	770	112 000	420	61 500	10	25	229	
		SACD[3]	670	97 000	510	74 000	10	40	192	45
G10900	1090	Hot Rolled	840	122 000	460	67 000	10	25	248	
		SACD[3]	700	101 000	540	78 000	10	40	197	45
G10950	1095	Hot Rolled	830	120 000	460	66 000	10	25	248	
		SACD[3]	680	99 000	520	76 000	10	40	197	45

1. NCD represents normalized cold drawn.
2. ACD represents annealed cold drawn.
3. SACD represents spheroidized annealed cold drawn.

TABLE 2—ESTIMATED MECHANICAL PROPERTIES AND MACHINABILITY RATINGS OF RESULFURIZED CARBON STEEL BARS(1)

UNS No.	SAE and/or AISI No.	Type of Processing	Tensile Strength MPa	Tensile Strength psi	Estimated Minimum Values Yield Strength MPa	Estimated Minimum Values Yield Strength psi	Estimated Minimum Values Elongation in 2 in, %	Reduction in Area %	Brinell Hardness	Average Machinability Rating (Cold Drawn) 1212=100%
G11080	1108	Hot Rolled	340	50 000	190	27 500	30	50	101	
		Cold Drawn	390	56 000	320	47 000	20	40	121	80
G11170	1117	Hot Rolled	430	62 000	230	34 000	23	47	121	
		Cold Drawn	480	69 000	400	58 000	15	40	137	90
G11320	1132	Hot Rolled	570	83 000	310	45 500	16	40	167	
		Cold Drawn	630	92 000	530	77 000	12	35	183	75
G11370	1137	Hot Rolled	610	88 000	330	48 000	15	35	179	
		Cold Drawn	680	98 000	570	82 000	10	30	197	70
G11400	1140	Hot Rolled	540	79 000	300	43 500	16	40	156	
		Cold Drawn	610	88 000	510	74 000	12	35	170	70
G11410	1141	Hot Rolled	650	94 000	360	51 500	15	35	187	
		Cold Drawn	720	105 100	610	88 000	10	30	212	70
G11440	1144	Hot Rolled	670	97 000	370	53 000	15	35	197	
		Cold Drawn	740	108 000	620	90 000	10	30	217	80
G11460	1146	Hot Rolled	590	85 000	320	47 000	15	40	170	
		Cold Drawn	650	94 000	550	80 000	12	35	187	70
G11510	1151	Hot Rolled	630	92 000	340	50 500	15	35	187	
		Cold Drawn	700	102 000	590	86 000	10	30	207	65
G12110	1211	Hot Rolled	380	55 000	230	33 000	25	45	121	
		Cold Drawn	520	75 000	400	58 000	10	35	163	95
G12120	1212	Hot Rolled	390	56 000	230	33 500	25	45	121	
		Cold Drawn	540	78 000	410	60 000	10	35	167	100
G12130	1213	Hot Rolled	390	56 000	230	33 500	25	45	121	
		Cold Drawn	540	78 000	410	60 000	10	35	167	135
G12144	12L14	Hot Rolled	390	57 000	230	34 000	22	45	121	
		Cold Drawn	540	78 000	410	60 000	10	35	163	160

1. All 1100 and 1200 series steels are rated on the basis of 0.10% maximum silicon or coarse grain melting practice.

TABLE 3—ESTIMATED MECHANICAL PROPERTIES AND MACHINABILITY RATINGS OF NONRESULFURIZED CARBON STEEL BARS, MANGANESE MAXIMUM OVER 1.00%

UNS No.	SAE and/or AISI No.	Type of Processing	Tensile Strength MPa	Tensile Strength psi	Estimated Minimum Values Yield Strength MPa	Estimated Minimum Values Yield Strength psi	Estimated Minimum Values Elongation in 2 in, %	Reduction in Area %	Brinell Hardness	Average Machinability Rating (Cold Drawn) 1212=100%
G15240	1524	Hot Rolled	510	74 000	280	41 000	20	42	149	
		Cold Drawn	570	82 000	480	69 000	12	35	163	60
G15270	1527	Hot Rolled	520	75 000	280	41 000	18	40	149	
		Cold Drawn	570	83 000	480	70 000	12	35	163	65
G15360	1536	Hot Rolled	570	83 000	310	45 500	16	40	163	
		Cold Drawn	630	92 000	530	77 500	12	35	187	55
G15410	1541	Hot Rolled	630	92 000	350	51 000	15	40	187	
		Cold Drawn	710	102 500	600	87 000	10	30	207	45
		ACD (1)	650	94 000	550	80 000	10	45	184	60
G15480	1548	Hot Rolled	660	96 000	370	53 000	14	33	197	
		Cold Drawn	730	106 500	620	89 500	10	28	217	45
		ACD(1)	640	93 500	540	78 500	10	35	192	50
G15520	1552	Hot Rolled	740	108 000	410	59 500	12	30	217	
		ACD(1)	680	98 000	570	83 000	10	40	193	50

1. ACD represents annealed cold drawn.