Designation: ~~A304 – 11~~ A304 – 16

Standard Specification for Carbon and Alloy Steel Bars Subject to End-Quench Hardenability Requirements[1]

This standard is issued under the fixed designation A304; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 This specification covers hot-worked alloy, carbon, and carbon-boron steels in a variety of compositions and sizes, which may attain specified depth of hardening in the end quench test. These steel compositions are identified by the suffix letter "H" added to the conventional grade number.

1.2 This specification provides for analyses other than those listed under Tables 1 and 2. Special hardenability limits are also permissible when approved by the purchaser and manufacturer.

1.3 The values stated in inch-pound units are to be regarded as standard. No other units of measurement are included in this standard.

2. Referenced Documents

2.1 *ASTM Standards:*[2]
A29/A29M Specification for General Requirements for Steel Bars, Carbon and Alloy, Hot-Wrought
A108 Specification for Steel Bar, Carbon and Alloy, Cold-Finished
A255 Test Methods for Determining Hardenability of Steel
E112 Test Methods for Determining Average Grain Size
E527 Practice for Numbering Metals and Alloys in the Unified Numbering System (UNS)
2.2 *Society of Automotive Engineers (SAE) Standard:*[3]
J 1086 Numbering Metals and Alloys

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*
3.1.1 *hardenability*—the relative ability of a steel to harden under heat treatment becomes apparent in the degree to which the material hardens when quenched at different cooling rates. It is measured quantitatively, usually by noting the extent or depth of hardening of a standard size and shape test specimen in a standardized quench. In the "end-quench" test the "depth of hardening" is the distance along the specimen from the quenched end to a given hardness.

4. Ordering Information

4.1 Orders for material under this specification should include the following information, in proper sequence:
4.1.1 Quantity (weight),
4.1.2 Name of material (alloy, carbon, or carbon-boron steel),
4.1.3 Cross-sectional shape,
4.1.4 Size,
4.1.5 Length,
4.1.6 Grade,

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[1] This specification is under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel and Related Alloys and is the direct responsibility of Subcommittee A01.15 on Bars.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the ~~standard's~~standard' Document Summary page on the ASTM website.

[3] Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096, http://www.sae.org.

***A Summary of Changes section appears at the end of this standard**

TABLE 1 Chemical Requirements of Alloy H Steels[A]

NOTE 1—Phosphorus and sulfur in ~~open-hearth steel is 0.035 %, max, and 0.040 %, max respectively. Phosphorus and sulfur in~~ electric-furnace steel (designated by the prefix letter "E") is 0.025 %, max.

NOTE 2—Small quantities of certain elements are present in alloy steels that are not specified or required. These elements are considered as incidental and may be present to the following maximum amounts: copper, 0.35 %; nickel, 0.25 %; chromium, 0.20 %; molybdenum, 0.06 %.

NOTE 3—Chemical ranges and limits shown in this table are subject to the permissible variation for product analysis shown in Specification A29/A29M.

NOTE 4—Standard "H" Steels can be produced with a lead range of 0.15–0.35 %. Such steels are identified by inserting the letter "L" between the second and third numerals of the grade designation, for example, 41L40H. Lead is generally reported as a range of 0.15–0.35 %.

UNS Designation[A]	Grade Designation	Chemical Composition, %					
		Carbon	Manganese	Silicon	Nickel	Chromium	Molybdenum
H 13300	1330 H	0.27–0.33	1.45–2.05	0.15–0.35	...	...	...
H 13350	1335 H	0.32–0.38	1.45–2.05	0.15–0.35	...	...	...
H 13400	1340 H	0.37–0.44	1.45–2.05	0.15–0.35	...	...	...
H 13450	1345 H	0.42–0.49	1.45–2.05	0.15–0.35	...	...	...
H 40270	4027 H	0.24–0.30	0.60–1.00	0.15–0.35	...	...	0.20–0.30
H 40280	4028 H[B]	0.24–0.30	0.60–1.00	0.15–0.35	...	...	0.20–0.30
H 40320	4032 H	0.29–0.35	0.60–1.00	0.15–0.35	...	...	0.20–0.30
H 40370	4037 H	0.34–0.41	0.60–1.00	0.15–0.35	...	...	0.20–0.30
H 40420	4042 H	0.39–0.46	0.60–1.00	0.15–0.35	...	...	0.20–0.30
H 40470	4047 H	0.44–0.51	0.60–1.00	0.15–0.35	...	...	0.20–0.30
H 41180	4118 H	0.17–0.23	0.60–1.00	0.15–0.35	...	0.30–0.70	0.08–0.15
H 41300	4130 H	0.27–0.33	0.30–0.70	0.15–0.35	...	0.75–1.20	0.15–0.25
H 41350	4135 H	0.32–0.38	0.60–1.00	0.15–0.35	...	0.75–1.20	0.15–0.25
H 41370	4137 H	0.34–0.41	0.60–1.00	0.15–0.35	...	0.75–1.20	0.15–0.25
H 41400	4140 H	0.37–0.44	0.65–1.10	0.15–0.35	...	0.75–1.20	0.15–0.25
H 41420	4142 H	0.39–0.46	0.65–1.10	0.15–0.35	...	0.75–1.20	0.15–0.25
H 41450	4145 H	0.42–0.49	0.65–1.10	0.15–0.35	...	0.75–1.20	0.15–0.25
H 41470	4147 H	0.44–0.51	0.65–1.10	0.15–0.35	...	0.75–1.20	0.15–0.25
H 41500	4150 H	0.47–0.54	0.65–1.10	0.15–0.35	...	0.75–1.20	0.15–0.25
H 41610	4161 H	0.55–0.65	0.65–1.10	0.15–0.35	...	0.65–0.95	0.25–0.35
H 43200	4320 H	0.17–0.23	0.40–0.70	0.15–0.35	1.55–2.00	0.35–0.65	0.20–0.30
H 43400	4340 H	0.37–0.44	0.55–0.90	0.15–0.35	1.55–2.00	0.65–0.95	0.20–0.30
H 43406	E4340 H	0.37–0.44	0.60–0.95	0.15–0.35	1.55–2.00	0.65–0.95	0.20–0.30
H 44190	4419 H	0.17–0.23	0.35–0.75	0.15–0.35	...	...	0.45–0.60
H 46200	4620 H	0.17–0.23	0.35–0.75	0.15–0.35	1.55–2.00	...	0.20–0.30
H 46210	4621 H	0.17–0.23	0.60–1.00	0.15–0.35	1.55–2.00	...	0.20–0.30
H 46260	4626 H	0.23–0.29	0.40–0.70	0.15–0.35	0.65–1.05	...	0.15–0.25
H 47180	4718 H	0.15–0.21	0.60–0.95	0.15–0.35	0.85–1.25	0.30–0.60	0.30–0.40
H 47200	4720 H	0.17–0.23	0.45–0.75	0.15–0.35	0.85–1.25	0.30–0.60	0.15–0.25
H 48150	4815 H	0.12–0.18	0.30–0.70	0.15–0.35	3.20–3.80	...	0.20–0.30
H 48170	4817 H	0.14–0.20	0.30–0.70	0.15–0.35	3.20–3.80	...	0.20–0.30
H 48200	4820 H	0.17–0.23	0.40–0.80	0.15–0.35	3.20–3.80	...	0.20–0.30
H 50401	50B40 H[C]	0.37–0.44	0.65–1.10	0.15–0.35	...	0.30–0.70	...
H 50441	50B44 H[C]	0.42–0.49	0.65–1.10	0.15–0.35	...	0.30–0.70	...
H 50460	5046 H	0.43–0.50	0.65–1.10	0.15–0.35	...	0.13–0.43	...
H 50461	50B46 H[C]	0.43–0.50	0.65–1.10	0.15–0.35	...	0.13–0.43	...
H 50501	50B50 H[C]	0.47–0.54	0.65–1.10	0.15–0.35	...	0.30–0.70	...
H 50601	50B60 H[C]	0.55–0.65	0.65–1.10	0.15–0.35	...	0.30–0.70	...
H 51200	5120 H	0.17–0.23	0.60–1.00	0.15–0.35	...	0.60–1.00	...
H 51300	5130 H	0.27–0.33	0.60–1.00	0.15–0.35	...	0.75–1.20	...
H 51320	5132 H	0.29–0.35	0.50–0.90	0.15–0.35	...	0.65–1.10	...
H 51350	5135 H	0.32–0.38	0.50–0.90	0.15–0.35	...	0.70–1.15	...
H 51400	5140 H	0.37–0.44	0.60–1.00	0.15–0.35	...	0.60–1.00	...
H 51450	5145 H	0.42–0.49	0.60–1.00	0.15–0.35	...	0.60–1.00	...
H 51470	5147 H	0.45–0.52	0.60–1.05	0.15–0.35	...	0.80–1.25	...
H 51500	5150 H	0.47–0.54	0.60–1.00	0.15–0.35	...	0.60–1.00	...
H 51550	5155 H	0.50–0.60	0.60–1.00	0.15–0.35	...	0.60–1.00	...
H 51600	5160 H	0.55–0.65	0.65–1.10	0.15–0.35	...	0.60–1.00	...
H 51601	51B60H[C]	0.55–0.65	0.65–1.10	0.15–0.35	...	0.60–1.00	...
H 61180	6118 H[D]	0.15–0.21	0.40–0.80	0.15–0.35	...	0.40–0.80	...
~~H61500~~	~~6150 H[E]~~	~~0.47–0.54~~	~~0.60–1.00~~	~~0.15–0.35~~	~~...~~	~~0.75–1.20~~	~~...~~
H 61500	6150 H[E]	0.47–0.54	0.60–1.00	0.15–0.35	...	0.75–1.20	...
H 81451	81B45 H[C]	0.42–0.49	0.70–1.05	0.15–0.35	0.15–0.45	0.30–0.60	0.08–0.15

TABLE 1 *Continued*

UNS Designation[A]	Grade Designation	Chemical Composition, %					
		Carbon	Manganese	Silicon	Nickel	Chromium	Molybdenum
H 86170	8617 H	0.14–0.20	0.60–0.95	0.15–0.35	0.35–0.75	0.35–0.65	0.15–0.25
H 86200	8620 H	0.17–0.23	0.60–0.95	0.15–0.35	0.35–0.75	0.35–0.65	0.15–0.25
H 86220	8622 H	0.19–0.25	0.60–0.95	0.15–0.35	0.35–0.75	0.35–0.65	0.15–0.25
H 86250	8625 H	0.22–0.28	0.60–0.95	0.15–0.35	0.35–0.75	0.35–0.65	0.15–0.25
H 86270	8627 H	0.24–0.30	0.60–0.95	0.15–0.35	0.35–0.75	0.35–0.65	0.15–0.25
H 86300	8630 H	0.27–0.33	0.60–0.95	0.15–0.35	0.35–0.75	0.35–0.65	0.15–0.25
H 86301	86B30 H	0.27–0.33	0.60–0.95	0.15–0.35	0.35–0.75	0.35–0.65	0.15–0.25
H 86370	8637 H	0.34–0.41	0.70–1.05	0.15–0.35	0.35–0.75	0.35–0.65	0.15–0.25
H 86400	8640 H	0.37–0.44	0.70–1.05	0.15–0.35	0.35–0.75	0.35–0.65	0.15–0.25
H 86420	8642 H	0.39–0.46	0.70–1.05	0.15–0.35	0.35–0.75	0.35–0.65	0.15–0.25
H 86450	8645 H	0.42–0.49	0.70–1.05	0.15–0.35	0.35–0.75	0.35–0.65	0.15–0.25
H 86451	86B45 H[C]	0.42–0.49	0.70–1.05	0.15–0.35	0.35–0.75	0.35–0.65	0.15–0.25
H 86500	8650 H	0.47–0.54	0.70–1.05	0.15–0.35	0.35–0.75	0.35–0.65	0.15–0.25
H 86550	8655 H	0.50–0.60	0.70–1.05	0.15–0.35	0.35–0.75	0.35–0.65	0.15–0.25
H 86600	8660 H	0.55–0.65	0.70–1.05	0.15–0.35	0.35–0.75	0.35–0.65	0.15–0.25
H 87200	8720 H	0.17–0.23	0.60–0.95	0.15–0.35	0.35–0.75	0.35–0.65	0.20–0.30
H 87400	8740 H	0.37–0.44	0.70–1.05	0.15–0.35	0.35–0.75	0.35–0.65	0.20–0.30
H 88220	8822 H	0.19–0.25	0.70–1.05	0.15–0.35	0.35–0.75	0.35–0.65	0.30–0.40
H 92600	9260 H	0.55–0.65	0.65–1.10	1.70–2.20	...	...	...
H 93100	9310 H	0.07–0.13	0.40–0.70	0.15–0.35	2.95–3.55	1.00–1.45	0.08–0.15
H 94151	94B15 H[C]	0.12–0.18	0.70–1.05	0.15–0.35	0.25–0.65	0.25–0.55	0.08–0.15
H 94171	94B17 H[C]	0.14–0.20	0.70–1.05	0.15–0.35	0.25–0.65	0.25–0.55	0.08–0.15
H 94301	94B30 H[C]	0.27–0.33	0.70–1.05	0.15–0.35	0.25–0.65	0.25–0.55	0.08–0.15

[A] New designations established in accordance with Practice E527 and SAE J 1086, Recommended Practice for Numbering Metals and Alloys (UNS).
[B] Sulfur content range is 0.035 to 0.050 %.
[C] These steels can be expected to have a 0.0005 % min boron content.
[D] Vanadium content range is 0.10 to 0.15 %.
[E] Minimum vanadium content is 0.15 %.

TABLE 2 Chemical Requirements of Carbon H-Steels[A]

UNS Designation[B]	Grade Designation	Chemical Composition, %				
		Carbon	Manganese	Phosphorus, max	Sulfur, max	Silicon
H 10380	1038 H	0.34–0.43	0.50–1.00	0.040	0.050	0.15–0.35
H 10450	1045 H	0.42–0.51	0.50–1.00	0.040	0.050	0.15–0.35
H 15220	1522 H	0.17–0.25	1.00–1.50	0.040	0.050	0.15–0.35
H 15240	1524 H	0.18–0.26	1.25–1.75	0.040	0.050	0.15–0.35
~~H 15260~~	~~1526 H†~~	~~0.21–0.30~~	~~1.00–1.50~~	~~0.040~~	~~0.050~~	~~0.15–0.35~~
H 15260	1526 H	0.21–0.30	1.00–1.50	0.040	0.050	0.15–0.35
H 15410	1541 H	0.35–0.45	1.25–1.75	0.040	0.050	0.15–0.35
H 15211[C]	15B21 H[C]	0.17–0.24	0.70–1.20	0.040	0.050	0.15–0.35
H 15351[C]	15B35 H[C]	0.31–0.39	0.70–1.20	0.040	0.050	0.15–0.35
H 15371[C]	15B37 H[C]	0.30–0.39	1.00–1.50	0.040	0.050	0.15–0.35
H 15411[C]	15B41 H[C]	0.35–0.45	1.25–1.75	0.040	0.050	0.15–0.35
H 15481[C]	15B48 H[C]	0.43–0.53	1.00–1.50	0.040	0.050	0.15–0.35
H 15621[C]	15B62 H[C]	0.54–0.67	1.00–1.50	0.040	0.050	0.40–0.60

~~†Correction made editorially~~

[A] Standard H Steels can be produced with a lead range of 0.15–0.35 %. Such steels are identified by inserting the letter "L" between the second and third numerals of the grade designation, for example, 15L22 H. Lead is generally reported as a range of 0.15–0.35 %.
[B] New designations established in accordance with Practice E527 and SAE J 1086, Recommended Practice for Numbering Metals and Alloys (UNS).
[C] These steels can be expected to have 0.0005 % min boron content.

4.1.7 End-quenched hardenability (see Section 9),
4.1.8 Report of heat analysis, if desired (see Section 7),
4.1.9 Special straightness, if required,
4.1.10 ASTM designation and date of issue,
4.1.11 End use or special requirements, and
4.1.12 Leaded steel, when required.

NOTE 1—A typical ordering description is as follows: ~~10 000~~ 10 000 lb, alloy bars, round, 4.0 in. dia by 10 ft, Grade 1340H, J 40⁄56 = 5⁄16 in., heat analysis required, ASTM A304, dated _____, worm gear.

4.2 The purchaser shall specify the desired grade, including the suffix letter "H," in accordance with Table 1 or Table 2.

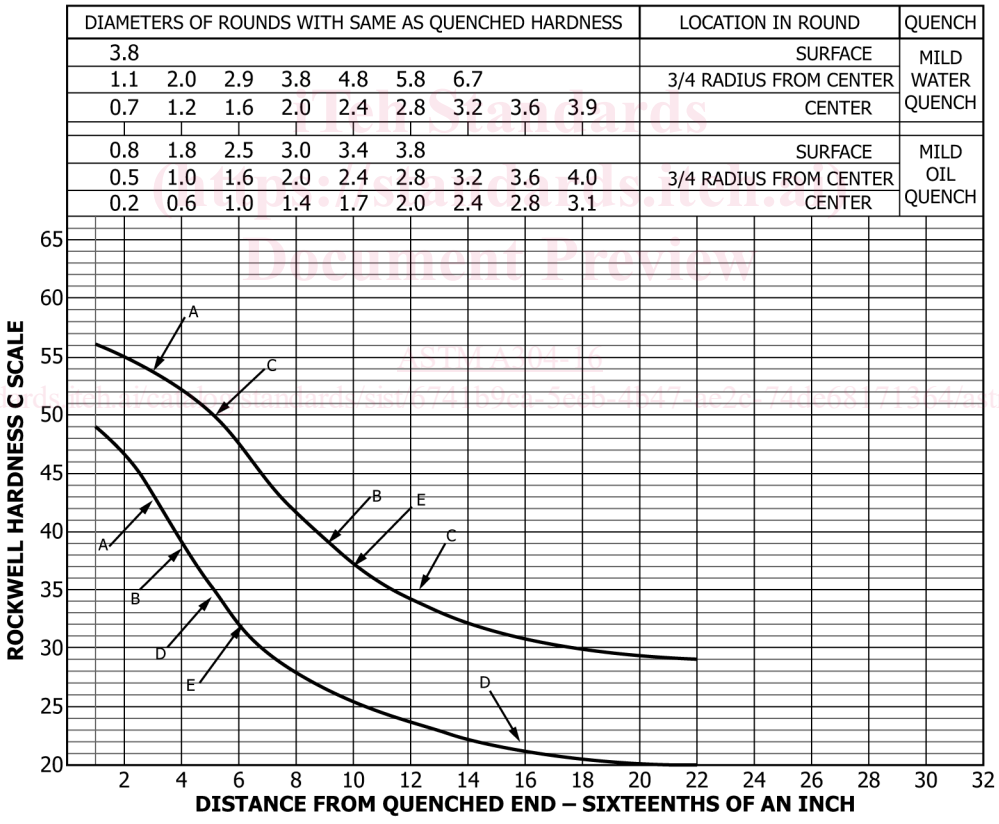
4.3 Band limits are shown graphically and as tabulations in Figs. 2-87, inclusive. For specifications purposes, the tabulated values of Rockwell C hardness are used. Values below 20 Rockwell C hardness (20 HRC) are not specified because such values are below the normal range of the C scale. The graphs are shown for convenience in estimating the hardness values obtainable at various locations on the end quench test bar and for various locations in oil or water quenched rounds. The relationship between end-quench distance and bar diameter is approximate and should be used only as a guide.

4.4 Two points from the tabulated values are commonly designated according to one of Methods A, B, C, D, or E, which are defined in the following paragraphs. Those various methods are illustrated graphically in Fig. 1.

4.4.1 *Method A*—The minimum and maximum hardness values at any desired distance. This method is illustrated in Fig. 1 as points *A-A* and would be specified as 43 to 54 HRC at J3. Obviously the distance selected would be that distance on the end quench test bar that corresponds to the section used by the purchaser.

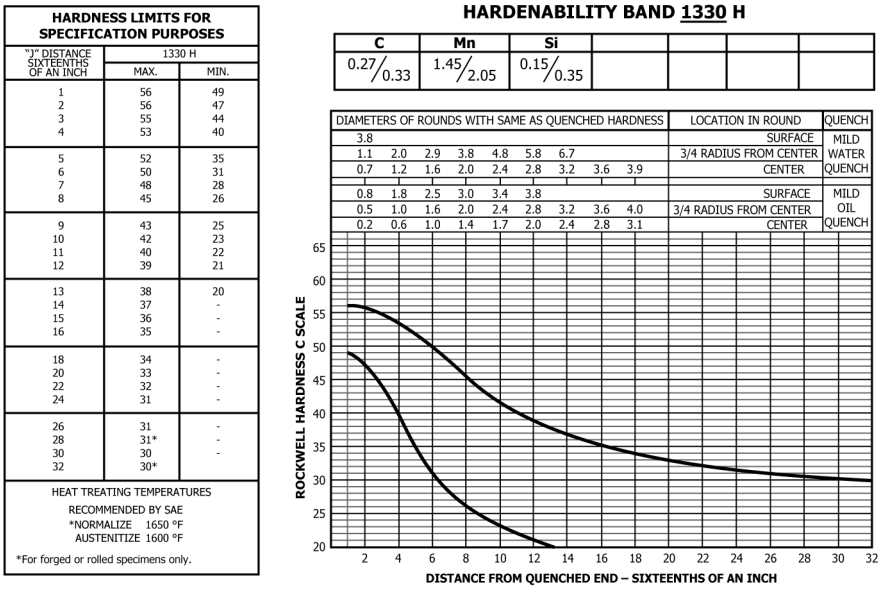
4.4.2 *Method B*—The minimum and maximum distances at which any desired hardness value occurs. This method is illustrated in Fig. 1 as points *B-B* and would be specified as 39 HRC at J4 minimum and J9 maximum. If the desired hardness does not fall on an exact sixteenth position, the minimum distance selected should be the nearest sixteenth position toward the quenched end and the maximum should be the nearest sixteenth position away from the quenched end.

Hardenability Band



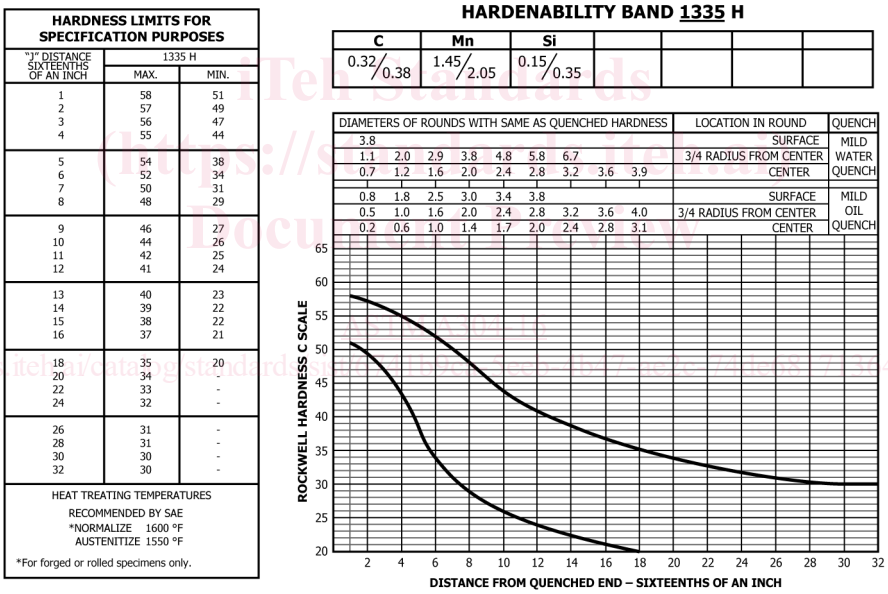
	Method	Points on Charts	Example—End Quench Hardenability
A	Minimum and maximum hardness values at a designated distance	A-A	HRC 43 to 54 at J3
B	A hardness value at minimum and maximum distances	B-B	HRC 39 at J4 minimum and J9 maximum
C	The maximum hardness values at two designated distances	C-C	HRC50 at J5 maximum HRC 34 at J12 maximum
D	Two minimum hardness values at two distances	D-D	HRC 35 at J5 minimum HRC 21 at J16 minimum
E	Any minimum hardness plus any maximum hardness	E-E	HRC 32 at J6 minimum HRC 37 at J10 maximum

FIG. 1 Examples Illustrating Alternative Method of Specifying Hardenability Requirements (tabulated hardness values are used in ordering)



NOTE 1—1 in. = 25.4 mm.

FIG. 2 Limits for Hardenability Band 1330 H



NOTE–1 in. = 25.4 mm.

FIG. 3 Limits for Hardenability Band 1335 H

4.4.3 *Method C*—Two maximum hardness values at two desired distances, illustrated in Fig. 1 as points *C-C*.

4.4.4 *Method D*—Two minimum hardness values at two desired distances, illustrated in Fig. 1 as points *D-D*.

4.4.5 *Method E*—Any minimum hardness plus any maximum hardness.

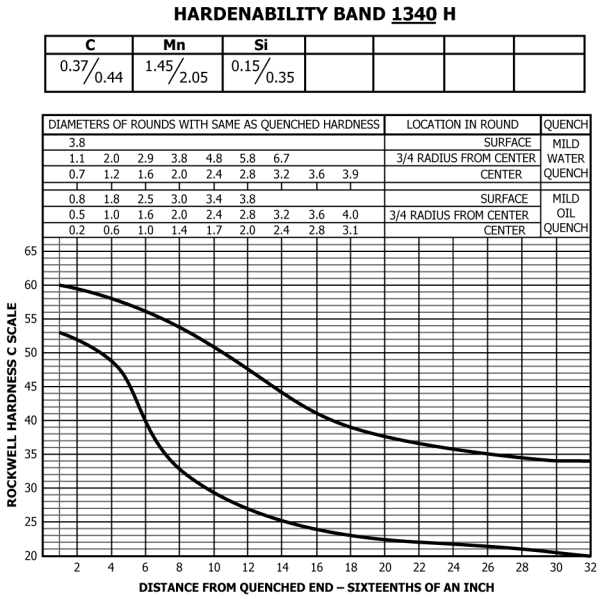
4.4.6 ~~*Method E*—Any minimum hardness plus any maximum hardness.~~ When hardenability is specified according to one of the above Methods A to E, the balance of the hardenability band is not applicable.

4.5 In cases when it is considered desirable, the maximum and minimum limits at a distance of 1⁄16 in. from the quenched end can be specified in addition to the other two points as previously described in 4.4.1 – 4.4.5, inclusive.

4.6 In cases when it is necessary to specify more than two points on the hardenability band (exclusive of the maximum and minimum limits at a distance of 1⁄16 in.), a tolerance of two points Rockwell C (HRC) over any small portion of either curve (except at a distance of 1⁄16 in.) is customary. This tolerance is necessary because curves of individual heats vary somewhat in shape from the standard band limits and thus deviate slightly at one or more positions in the full length of the curves.

HARDNESS LIMITS FOR SPECIFICATION PURPOSES		
"J" DISTANCE SIXTEENTHS OF AN INCH	1340 H	
	MAX.	MIN.
1	60	53
2	60	52
3	59	51
4	58	49
5	57	46
6	56	40
7	55	35
8	54	33
9	52	31
10	51	29
11	50	28
12	48	27
13	46	26
14	44	25
15	42	25
16	41	24
18	39	23
20	38	23
22	37	22
24	36	22
26	35	21
28	35	21
30	34	20
32	34	20

HEAT TREATING TEMPERATURES
RECOMMENDED BY SAE
*NORMALIZE 1600 °F
AUSTENITIZE 1550 °F
*For forged or rolled specimens only.

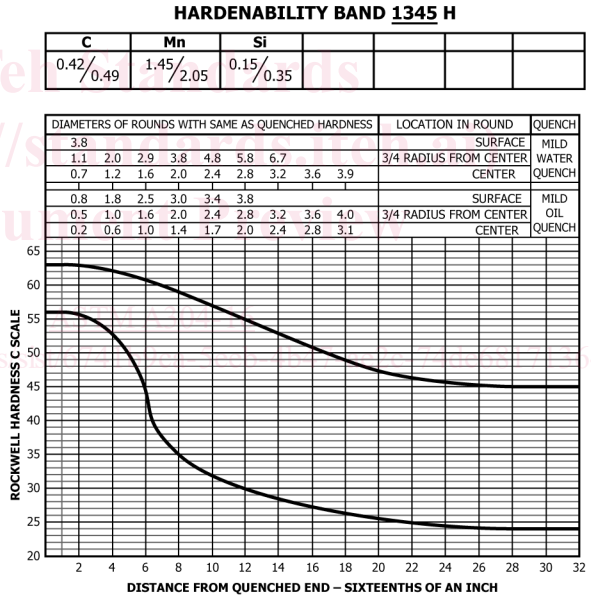


NOTE—1 in. = 25.4 mm.

FIG. 4 Limits for Hardenability Band 1340 H

HARDNESS LIMITS FOR SPECIFICATION PURPOSES		
"J" DISTANCE SIXTEENTHS OF AN INCH	1345 H	
	MAX.	MIN.
1	63	56
2	63	56
3	62	55
4	61	54
5	61	51
6	60	44
7	60	38
8	59	35
9	58	33
10	57	32
11	56	31
12	55	30
13	54	29
14	53	29
15	52	28
16	51	28
18	49	27
20	48	27
22	47	26
24	46	26
26	45	25
28	45	25
30	45	24
32	45	24

HEAT TREATING TEMPERATURES
RECOMMENDED BY SAE
*NORMALIZE 1600 °F
AUSTENITIZE 1550 °F
*For forged or rolled specimens only.



NOTE—1 in. = 25.4 mm.

FIG. 5 Limits for Hardenability Band 1345 H

5. Manufacture

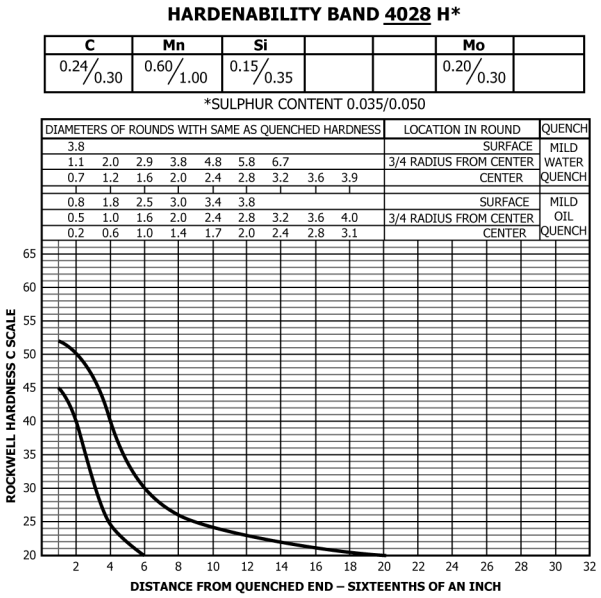
5.1 *Melting Practice*—The steel shall be made by ~~one or more of the following primary processes: open-hearth, basic-oxygen, or electric-furnace. The primary melting may incorporate separate degassing or refining and may be followed by secondary melting using electroslag remelting or vacuum arc remelting. Where secondary melting is employed, the heat shall be defined as all of the ingots remelted from a single primary heat.~~any commercially accepted process.

5.2 *Slow Cooling*—Immediately after hot working, the bars shall be allowed to cool when necessary to a temperature below the critical range under suitable conditions, to prevent injury by too rapid cooling.

6. General Requirements

6.1 Material furnished under this specification shall conform to the applicable requirements of the current edition of Specification A29/A29M or A108, unless otherwise provided for in this specification.

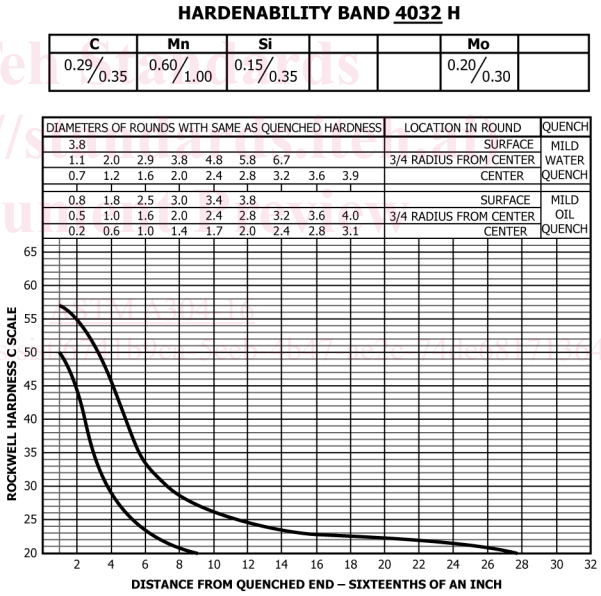
HARDNESS LIMITS FOR SPECIFICATION PURPOSES		
"J" DISTANCE SIXTEENTHS OF AN INCH	4027 H & 4028 H	
	MAX.	MIN.
1	52	45
2	50	40
3	46	31
4	40	25
5	34	22
6	30	20
7	28	-
8	26	-
9	25	-
10	25	-
11	24	-
12	23	-
13	23	-
14	22	-
15	22	-
16	21	-
18	21	-
20	20	-
22	-	-
24	-	-
26	-	-
28	-	-
30	-	-
32	-	-
HEAT TREATING TEMPERATURES RECOMMENDED BY SAE *NORMALIZE 1650 °F AUSTENITIZE 1600 °F		
*For forged or rolled specimens only.		



NOTE—1 in. = 25.4 mm.

FIG. 6 Limits for Hardenability Band 4027 H and 4028 H

HARDNESS LIMITS FOR SPECIFICATION PURPOSES		
"J" DISTANCE SIXTEENTHS OF AN INCH	4032 H	
	MAX.	MIN.
1	57	50
2	54	45
3	51	36
4	46	29
5	39	25
6	34	23
7	31	22
8	29	21
9	28	20
10	26	-
11	26	-
12	25	-
13	24	-
14	24	-
15	23	-
16	23	-
18	23	-
20	22	-
22	22	-
24	21	-
26	21	-
28	20	-
30	-	-
32	-	-
HEAT TREATING TEMPERATURES RECOMMENDED BY SAE *NORMALIZE 1650 °F AUSTENITIZE 1600 °F		
*For forged or rolled specimens only.		



NOTE—1 in. = 25.4 mm.

FIG. 7 Limits for Hardenability Band 4032 H

7. Chemical Composition

7.1 The heat analysis shall conform to the requirements as to chemical composition prescribed in Tables 1 and 2 for the grade specified by the purchaser.

7.2 When a steel cannot be identified by a standard grade number in accordance with Tables 1 and 2, other compositions may be specified, as agreed upon between the purchaser and the manufacturer. Generally, hardenability bands will not be available for such compositions.

7.3 When requested by the manufacturer, and approved by the purchaser, other steels capable of meeting the ~~purchaser's~~purchaser's specified hardenability may be furnished in place of the grade specified by the purchaser.

8. Grain Size Requirements

8.1 The steel shall conform to the fine austenitic grain size requirement of Specification A29/A29M.

8.2 Hardenability values specified in this specification are based on fine-grain steels and are not applicable to coarse-grain material. In case coarse-grain steel is desired, the hardenability values shall be negotiated between the purchaser and the manufacturer.

9. End-Quench Hardenability Requirements

9.1 The end-quench hardenability shall conform to the requirements specified on the purchase order.

9.2 The hardenability values shall be specified in accordance with the applicable values in Figs. 2-87 inclusive for the grade specified. See Fig. 1 for method of specifying hardenability.

9.3 When agreed upon between the purchaser and manufacturer, special hardenability limits may be ordered and shall be reflected on the purchase order.

10. Test Specimens

10.1 *Number and Location*—The number and location of test specimens shall be in accordance with the ~~manufacturer's~~manufacturer's standard practice and shall adequately represent the hardenability of each heat.

10.2 *Thermal Treatment*—All forged or rolled hardenability test specimens must be normalized prior to testing. Cast specimens need not be normalized.

11. Test Methods

11.1 *Grain Size*—Test Methods E112.

11.2 *End-Quench Hardenability*—Test Method A255.

12. Certification and Reports of Testing

12.1 When the full H-band is specified for alloy steels, the hardenability can be reported by listing hardness values at the following distances from the quenched end of the test specimen: 1 through 16 sixteenths, then 18, 20, 22, 24, 28, and 32 sixteenths of an inch.

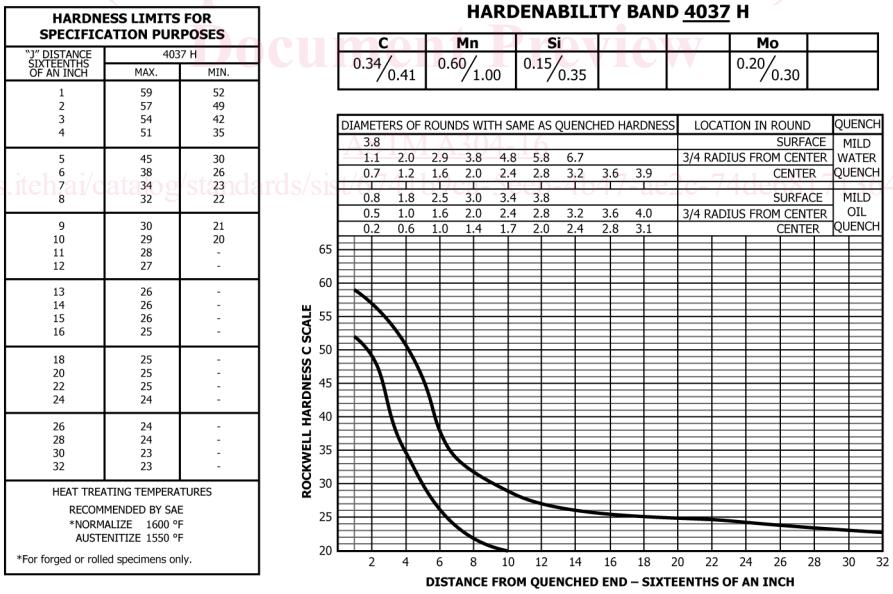
12.2 Tables 2-18 in Test Methods A255 are to be used to calculate hardenability from the chemical ideal diameter for the grades shown in 10.1 of Test Methods A255. Hardenability results are to be reported for the first 10 sixteenths (16 mm), then 12, 14, 16, 18, 20, 24, 28, and 32 sixteenths of an inch.

NOTE 2—The reporting hardenability using the calculated method differs from the procedure shown in 6.4 of Test Methods A255.

12.3 For carbon H-steels, distances from the quenched end may be reported by listing sixteenths or half sixteenths (rather than full sixteenths only as with alloy steels). Units of sixteenths rather than thirty-seconds are followed for all steels to avoid misunderstanding. When the full H-band is specified half sixteenths through 8 may be reported, as well as the distances listed in 12.1.

13. Keywords

13.1 alloy steel bars; carbon steel bars; end quench hardenability; steel bars



HARDNESS LIMITS FOR SPECIFICATION PURPOSES		
"J" DISTANCE SIXTEENTHS OF AN INCH	4037 H	
	MAX.	MIN.
1	59	52
2	57	49
3	54	42
4	51	35
5	45	30
6	38	26
7	34	23
8	32	22
9	30	21
10	29	20
11	28	-
12	27	-
13	26	-
14	26	-
15	26	-
16	25	-
18	25	-
20	25	-
22	25	-
24	24	-
26	24	-
28	24	-
30	23	-
32	23	-

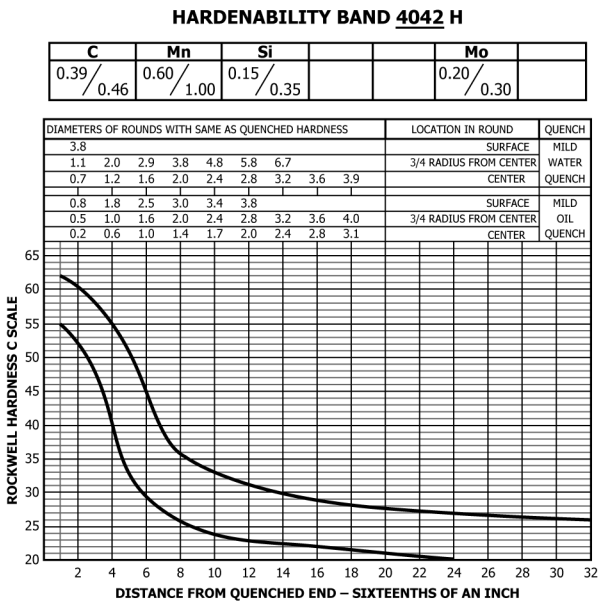
HEAT TREATING TEMPERATURES
RECOMMENDED BY SAE
*NORMALIZE 1600 °F
AUSTENITIZE 1550 °F
*For forged or rolled specimens only.

NOTE—1 in. = 25.4 mm.

FIG. 8 Limits for Hardenability Band 4037 H

HARDNESS LIMITS FOR SPECIFICATION PURPOSES		
"J" DISTANCE SIXTEENTHS OF AN INCH	4042 H	
	MAX.	MIN.
1	62	55
2	60	52
3	58	48
4	55	40
5	50	33
6	45	29
7	39	27
8	36	26
9	34	25
10	33	24
11	32	24
12	31	23
13	30	23
14	30	23
15	29	22
16	29	22
18	28	22
20	28	21
22	28	20
24	27	20
26	27	-
28	27	-
30	26	-
32	26	-

HEAT TREATING TEMPERATURES
RECOMMENDED BY SAE
*NORMALIZE 1600 °F
AUSTENITIZE 1550 °F
*For forged or rolled specimens only.

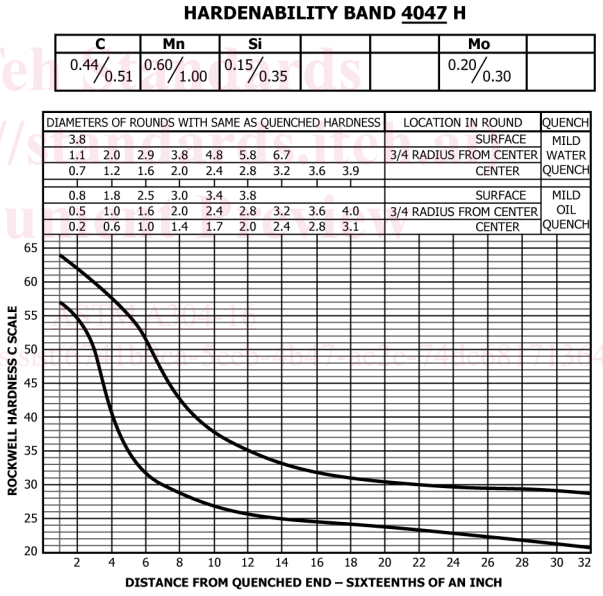


NOTE—1 in. = 25.4 mm.

FIG. 9 Limits for Hardenability Band 4042 H

HARDNESS LIMITS FOR SPECIFICATION PURPOSES		
"J" DISTANCE SIXTEENTHS OF AN INCH	4047 H	
	MAX.	MIN.
1	64	57
2	62	55
3	60	50
4	58	42
5	55	35
6	52	32
7	47	30
8	43	28
9	40	28
10	38	27
11	37	26
12	35	26
13	34	25
14	33	25
15	33	25
16	32	25
18	31	24
20	30	24
22	30	23
24	30	23
26	30	22
28	29	22
30	29	21
32	29	21

HEAT TREATING TEMPERATURES
RECOMMENDED BY SAE
*NORMALIZE 1600 °F
AUSTENITIZE 1550 °F
*For forged or rolled specimens only.



NOTE—1 in. = 25.4 mm.

FIG. 10 Limits for Hardenability Band 4047 H

SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this standard since the last issue (~~A304 – 05~~A304 – 11 ~~(2011))~~) that may impact the use of this standard. (Approved Dec. 1, 2016~~October 1, 2011.~~).)

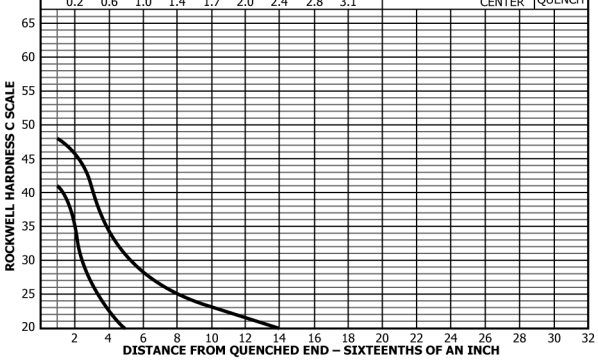
(1) ~~Changed~~In Table 1~~Silicon values from 0.15–0.30 to 0.15–0.35 on all except 15B62H in~~, deleted first sentence of Note 1 and added "H" to ~~Table 2.~~4626 in Grade Designation column.
(2) Added 2.2 for referenced document SAE Standard J 1086.
(3) Deleted second sentence of 4.4.5.
(4) Added new section 4.4.6.
(5) Revised language in 5.1.

HARDNESS LIMITS FOR SPECIFICATION PURPOSES		
"J" DISTANCE SIXTEENTHS OF AN INCH	4118 H	
	MAX.	MIN.
1	48	41
2	46	36
3	41	27
4	35	23
5	31	20
6	28	-
7	27	-
8	25	-
9	24	-
10	23	-
11	22	-
12	21	-
13	21	-
14	20	-
15	-	-
16	-	-
18	-	-
20	-	-
22	-	-
24	-	-
26	-	-
28	-	-
30	-	-
32	-	-
HEAT TREATING TEMPERATURES RECOMMENDED BY SAE *NORMALIZE 1700 °F AUSTENITIZE 1700 °F *For forged or rolled specimens only.		

HARDENABILITY BAND 4118 H

C	Mn	Si		Cr	Mo	
0.17/0.23	0.60/1.00	0.15/0.35		0.30/0.70	0.08/0.15	

DIAMETERS OF ROUNDS WITH SAME AS QUENCHED HARDNESS	LOCATION IN ROUND	QUENCH
3.8	SURFACE	MILD
1.1 2.0 2.9 3.8 4.8 5.8 6.7	3/4 RADIUS FROM CENTER	WATER
0.7 1.2 1.6 2.0 2.4 2.8 3.2 3.6 3.9	CENTER	QUENCH
0.8 1.8 2.5 3.0 3.4 3.8	SURFACE	MILD
0.5 1.0 1.6 2.0 2.4 2.8 3.2 3.6 4.0	3/4 RADIUS FROM CENTER	OIL
0.2 0.6 1.0 1.4 1.7 2.0 2.4 2.8 3.1	CENTER	QUENCH



NOTE—1 in. = 25.4 mm.

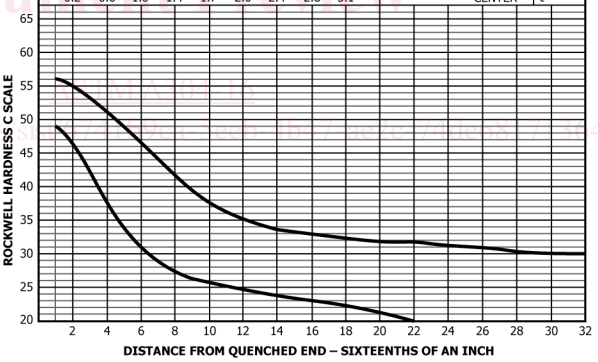
FIG. 11 Limits for Hardenability Band 4118 H

HARDNESS LIMITS FOR SPECIFICATION PURPOSES		
"J" DISTANCE SIXTEENTHS OF AN INCH	4130 H	
	MAX.	MIN.
1	56	49
2	55	46
3	53	42
4	51	38
5	49	34
6	47	31
7	44	29
8	42	27
9	40	26
10	38	26
11	36	25
12	35	25
13	34	24
14	34	24
15	33	23
16	33	23
18	32	22
20	32	21
22	32	20
24	31	-
26	31	-
28	30	-
30	30	-
32	29	
HEAT TREATING TEMPERATURES RECOMMENDED BY SAE *NORMALIZE 1650 °F AUSTENITIZE 1600 °F *For forged or rolled specimens only.		

HARDENABILITY BAND 4130 H

C	Mn	Si		Cr	Mo	
0.27/0.33	0.30/0.70	0.15/0.35		0.75/1.20	0.15/0.25	

DIAMETERS OF ROUNDS WITH SAME AS QUENCHED HARDNESS	LOCATION IN ROUND	QUENCH
3.8	SURFACE	MILD
1.1 2.0 2.9 3.8 4.8 5.8 6.7	3/4 RADIUS FROM CENTER	WATER
0.7 1.2 1.6 2.0 2.4 2.8 3.2 3.6 3.9	CENTER	QUENCH
0.8 1.8 2.5 3.0 3.4 3.8	SURFACE	MILD
0.5 1.0 1.6 2.0 2.4 2.8 3.2 3.6 4.0	3/4 RADIUS FROM CENTER	OIL
0.2 0.6 1.0 1.4 1.7 2.0 2.4 2.8 3.1	CENTER	QUENCH



NOTE—1 in. = 25.4 mm.

FIG. 12 Limits for Hardenability Band 4130 H

HARDNESS LIMITS FOR SPECIFICATION PURPOSES		
"J" DISTANCE SIXTEENTHS OF AN INCH	4135 H	
	MAX.	MIN.
1	58	51
2	58	50
3	57	49
4	56	48
5	56	47
6	55	45
7	54	42
8	53	40
9	52	38
10	51	36
11	50	34
12	49	33
13	48	32
14	47	31
15	46	30
16	45	30
18	44	29
20	42	28
22	41	27
24	40	27
26	39	27
28	38	26
30	38	26
32	37	26

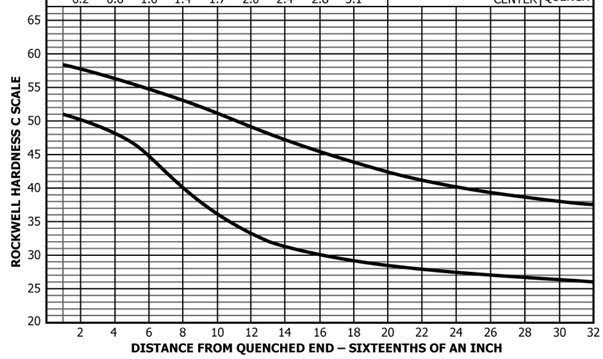
HEAT TREATING TEMPERATURES
RECOMMENDED BY SAE
*NORMALIZE 1600 °F
AUSTENITIZE 1550 °F

*For forged or rolled specimens only.

HARDENABILITY BAND 4135 H

C	Mn	Si		Cr	Mo	
0.32/0.38	0.60/1.00	0.15/0.35		0.75/1.20	0.15/0.25	

DIAMETERS OF ROUNDS WITH SAME AS QUENCHED HARDNESS									LOCATION IN ROUND	QUENCH
3.8									SURFACE	MILD WATER QUENCH
1.1	2.0	2.9	3.8	4.8	5.8	6.7			3/4 RADIUS FROM CENTER	
0.7	1.2	1.6	2.0	2.4	2.8	3.2	3.6	3.9	CENTER	
0.8	1.8	2.5	3.0	3.4	3.8				SURFACE	MILD OIL QUENCH
0.5	1.0	1.6	2.0	2.4	2.8	3.2	3.6	4.0	3/4 RADIUS FROM CENTER	
0.2	0.6	1.0	1.4	1.7	2.0	2.4	2.8	3.1	CENTER	



NOTE—1 in. = 25.4 mm.

FIG. 13 Limits for Hardenability Band 4135 H

HARDNESS LIMITS FOR SPECIFICATION PURPOSES		
"J" DISTANCE SIXTEENTHS OF AN INCH	4137 H	
	MAX.	MIN.
1	59	52
2	59	51
3	58	50
4	58	49
5	57	49
6	57	48
7	56	45
8	55	43
9	55	40
10	54	39
11	53	37
12	52	36
13	51	35
14	50	34
15	49	33
16	48	33
18	46	32
20	45	31
22	44	30
24	43	30
26	42	30
28	42	29
30	41	29
32	41	29

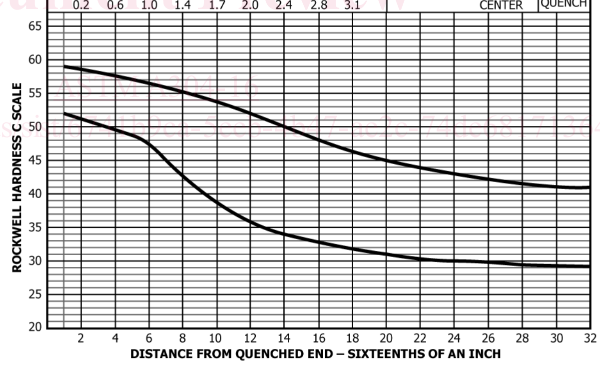
HEAT TREATING TEMPERATURES
RECOMMENDED BY SAE
*NORMALIZE 1600 °F
AUSTENITIZE 1550 °F

*For forged or rolled specimens only.

HARDENABILITY BAND 4137 H

C	Mn	Si		Cr	Mo	
0.34/0.41	0.60/1.00	0.15/0.35		0.75/1.20	0.15/0.25	

DIAMETERS OF ROUNDS WITH SAME AS QUENCHED HARDNESS									LOCATION IN ROUND	QUENCH
3.8									SURFACE	MILD WATER QUENCH
1.1	2.0	2.9	3.8	4.8	5.8	6.7			3/4 RADIUS FROM CENTER	
0.7	1.2	1.6	2.0	2.4	2.8	3.2	3.6	3.9	CENTER	
0.8	1.8	2.5	3.0	3.4	3.8				SURFACE	MILD OIL QUENCH
0.5	1.0	1.6	2.0	2.4	2.8	3.2	3.6	4.0	3/4 RADIUS FROM CENTER	
0.2	0.6	1.0	1.4	1.7	2.0	2.4	2.8	3.1	CENTER	



NOTE—1 in. = 25.4 mm.

FIG. 14 Limits for Hardenability Band 4137 H

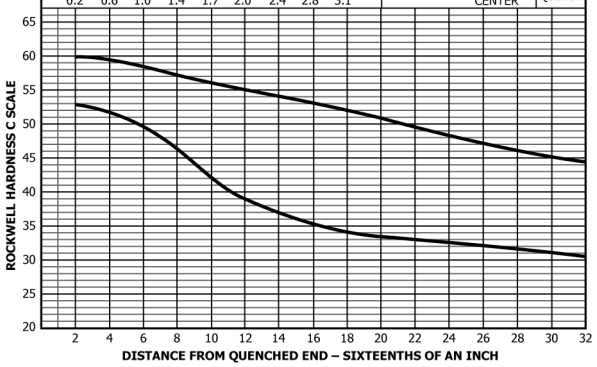
HARDNESS LIMITS FOR SPECIFICATION PURPOSES		
"J" DISTANCE SIXTEENTHS OF AN INCH	4140 H	
	MAX.	MIN.
1	60	53
2	60	53
3	60	52
4	59	51
5	59	51
6	58	50
7	58	48
8	57	47
9	57	44
10	56	42
11	56	40
12	55	39
13	55	38
14	54	37
15	54	36
16	53	35
18	52	34
20	51	33
22	49	33
24	48	32
26	47	32
28	46	31
30	45	31
32	44	30

HEAT TREATING TEMPERATURES
RECOMMENDED BY SAE
*NORMALIZE 1600 °F
AUSTENITIZE 1550 °F
*For forged or rolled specimens only.

HARDENABILITY BAND 4140 H

C	Mn	Si		Cr	Mo	
0.37/0.44	0.65/1.10	0.15/0.35		0.75/1.20	0.15/0.25	

DIAMETERS OF ROUNDS WITH SAME AS QUENCHED HARDNESS	LOCATION IN ROUND	QUENCH
3.8	SURFACE	MILD WATER QUENCH
1.1 2.0 2.9 3.8 4.8 5.8 6.7	3/4 RADIUS FROM CENTER	
0.7 1.2 1.6 2.0 2.4 2.8 3.2 3.6 3.9	CENTER	
0.8 1.8 2.5 3.0 3.4 3.8	SURFACE	MILD OIL QUENCH
0.5 1.0 1.6 2.0 2.4 2.8 3.2 3.6 4.0	3/4 RADIUS FROM CENTER	
0.2 0.6 1.0 1.4 1.7 2.0 2.4 2.8 3.1	CENTER	



NOTE—1 in. = 25.4 mm.

FIG. 15 Limits for Hardenability Band 4140 H

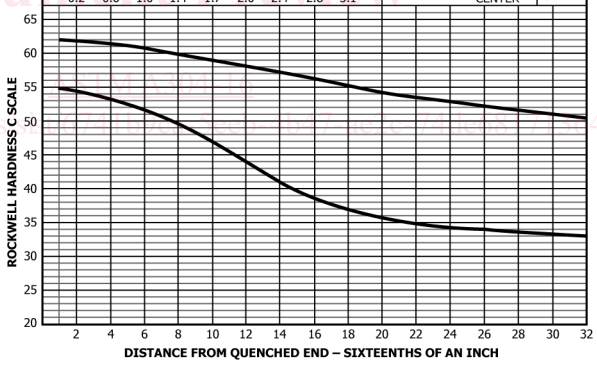
HARDNESS LIMITS FOR SPECIFICATION PURPOSES		
"J" DISTANCE SIXTEENTHS OF AN INCH	4142 H	
	MAX.	MIN.
1	62	55
2	62	55
3	62	54
4	61	53
5	61	53
6	61	52
7	60	51
8	60	50
9	60	49
10	59	47
11	59	46
12	58	44
13	58	42
14	57	41
15	57	40
16	56	39
18	55	37
20	54	36
22	53	35
24	53	34
26	52	34
28	51	34
30	51	33
32	50	33

HEAT TREATING TEMPERATURES
RECOMMENDED BY SAE
*NORMALIZE 1600 °F
AUSTENITIZE 1550 °F
*For forged or rolled specimens only.

HARDENABILITY BAND 4142 H

C	Mn	Si		Cr	Mo	
0.39/0.46	0.65/1.10	0.15/0.35		0.75/1.20	0.15/0.25	

DIAMETERS OF ROUNDS WITH SAME AS QUENCHED HARDNESS	LOCATION IN ROUND	QUENCH
3.8	SURFACE	MILD WATER QUENCH
1.1 2.0 2.9 3.8 4.8 5.8 6.7	3/4 RADIUS FROM CENTER	
0.7 1.2 1.6 2.0 2.4 2.8 3.2 3.6 3.9	CENTER	
0.8 1.8 2.5 3.0 3.4 3.8	SURFACE	MILD OIL QUENCH
0.5 1.0 1.6 2.0 2.4 2.8 3.2 3.6 4.0	3/4 RADIUS FROM CENTER	
0.2 0.6 1.0 1.4 1.7 2.0 2.4 2.8 3.1	CENTER	



NOTE—1 in. = 25.4 mm.

FIG. 16 Limits for Hardenability Band 4142 H

HARDNESS LIMITS FOR SPECIFICATION PURPOSES		
"J" DISTANCE SIXTEENTHS OF AN INCH	4145 H	
	MAX.	MIN.
1	63	56
2	63	55
3	62	55
4	62	54
5	62	53
6	61	53
7	61	52
8	61	52
9	60	51
10	60	50
11	60	49
12	59	48
13	59	46
14	59	45
15	58	43
16	58	42
18	57	40
20	57	38
22	56	37
24	55	36
26	55	35
28	55	35
30	55	34
32	54	34

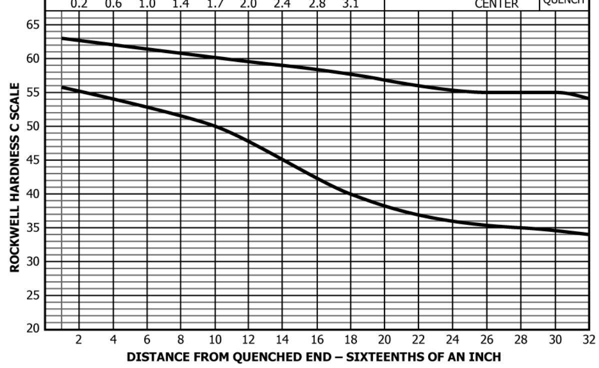
HEAT TREATING TEMPERATURES
RECOMMENDED BY SAE
*NORMALIZE 1600 °F
AUSTENITIZE 1550 °F

*For forged or rolled specimens only.

HARDENABILITY BAND 4145 H

C	Mn	Si		Cr	Mo	
0.42/0.49	0.65/1.10	0.15/0.35		0.75/1.20	0.15/0.25	

DIAMETERS OF ROUNDS WITH SAME AS QUENCHED HARDNESS	LOCATION IN ROUND	QUENCH
3.8	SURFACE	MILD WATER QUENCH
1.1 2.0 2.9 3.8 4.8 5.8 6.7	3/4 RADIUS FROM CENTER	
0.7 1.2 1.6 2.0 2.4 2.8 3.2 3.6 3.9	CENTER	
0.8 1.8 2.5 3.0 3.4 3.8	SURFACE	MILD OIL QUENCH
0.5 1.0 1.6 2.0 2.4 2.8 3.2 3.6 4.0	3/4 RADIUS FROM CENTER	
0.2 0.6 1.0 1.4 1.7 2.0 2.4 2.8 3.1	CENTER	



NOTE—1 in. = 25.4 mm.

FIG. 17 Limits for Hardenability Band 4145 H

HARDNESS LIMITS FOR SPECIFICATION PURPOSES		
"J" DISTANCE SIXTEENTHS OF AN INCH	4147 H	
	MAX.	MIN.
1	64	57
2	64	57
3	64	56
4	64	56
5	63	55
6	63	55
7	63	55
8	63	54
9	63	54
10	62	53
11	62	52
12	62	51
13	61	49
14	61	48
15	60	46
16	60	45
18	59	42
20	59	40
22	58	39
24	57	38
26	57	37
28	57	37
30	56	37
32	56	36

HEAT TREATING TEMPERATURES
RECOMMENDED BY SAE
*NORMALIZE 1600 °F
AUSTENITIZE 1550 °F

*For forged or rolled specimens only.

UNS H41470 Hardenability Band SAE/AISI 4147H

C	Mn	Si		Cr	Mo	
.44/.51	.65/1.10	0.15/0.35		.75/1.20	.15/.25	

Diameters of rounds with same as-quenched hardness, inches	LOCATION IN ROUND	QUENCH
2.4	SURFACE	MILD WATER QUENCH
1 2 3 4	3/4 RADIUS FROM CENTER	
0.5 1 1.5 2 2.5 3 3.5 4	CENTER	
1 2 3 4	SURFACE	MILD OIL QUENCH
0.5 1 1.5 2 2.5 3 3.5 4	3/4 RADIUS FROM CENTER	
0.5 1 1.5 2 2.5 3 3.5	CENTER	

FIG. 18 Limits for Hardenability Band 4147 H