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SURFACE VEHICLE RECOMMENDED PRACTICE

Submitted for recognition as an American National Standard

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(R) HIGH STRENGTH CARBON AND ALLOY DIE DRAWN STEELS

FOREWORD

This reaffirmed document has been changed only to reflect the new SAE Technical Board format.

Die drawing of hot rolled bars increases the strength and hardness. At the same time, the ratio of yield strength to tensile strength is increased and the notched bar impact values are reduced. Various factors control the degree of change in the mechanical properties. The final properties are dependent upon chemical composition, hot rolled microstructure (except in the case of alloy steel where a normalize treatment is used prior to drawing), size, shape, and the amount of reduction in cross-sectional area, die geometry, straightening procedures, and manner or temperature level of the stress relieving operation.

As noted in Table 1, carbon and alloy steels of medium carbon content respond readily to this special processing. Compositional additives may be employed to improve machinability.

In the production of these products, drafts of approximately 10 to 35% reduction in cross-sectional area are employed at either room or elevated temperatures depending on the practices and facilities of the individual producer. Stress relieving temperatures vary over a similarly wide range, depending on producer facilities and the end product requirements.

Die drawn and stress relieved bars are employed instead of quenched and tempered bars because of their unique combinations of properties. The die drawn and stress relieved bars can be machined more readily than quenched and tempered bars, and except when the latter have high hardenability, the die drawn and stress relieved bars have more uniform hardness throughout the cross section. When dimensional stability is critical during or after machining, or after cold forming operations, the individual producer should be consulted for special processing to meet such conditions.

FOREWORD (Continued)

The torsional strength and endurance limit are similar to those of quenched and tempered grades at the same strength level. The wear resistance of these special processed steels is approximately equal to that of quenched and tempered bars of the same surface hardness.

1. SCOPE:

This SAE Recommended Practice is intended to provide basic information on properties and characteristics of high strength carbon and alloy steels which have been subjected to special die drawing. This includes both cold drawing with heavier-than-normal drafts and die drawing at elevated temperatures.

2. REFERENCES:

2.1 Applicable Documents:

SAE J429, Mechanical and Material Requirements for Externally Threaded Fasteners

3. HARDNESS:

The hardness values for all grades are shown in Table 1. The typical hardness ranges indicated for the 825 MPa tensile strength steels are subject to negotiation between producer and consumer. Hardness determinations are commonly made on a flat ground on the outside diameter or on a cross section from the midradius to within 6 mm of the surface. If, when testing the finished product, there is disagreement between the typical hardness and tensile or yield strength values, the latter properties shall govern.

4. IMPACT CHARACTERISTICS:

The impact test values of special die drawn bars, as measured by the Izod or Charpy notched bar test, are lower than those of quenched and tempered carbon bars and they are significantly lower than those of quenched and tempered alloy steels. Failures of machine components usually result from fatigue, corrosion, wear or shock loading. With the possible exception of the latter, there is no known correlation between the cases of failure and the notched bar impact test. In the case of shock loading, whatever relation exists must be derived empirically, that is, from experience. When low temperatures or high pressures are involved and where doubt exists as to the suitability of these steels, the design of the part should be reviewed.

TABLE 1 – Minimum Mechanical Properties

Tensile Strength MPa	Tensile Strength ksi	Yield Strength MPa	Yield Strength ksi	Elongation in 50 mm (2 in), %	Reduction in Area, %[a]	Brinell Hardness	Grades	Size Range mm	Size Range in	Tolerance
CARBON STEELS										
825	120	690	100	10.0	25.0	241/321[b]	1541 1045 1052 1141	up to 80 (round) 6–90 (round)	3 1/4 – 3-1/2	See Table 4
						248/321[b]	1144 1151	6–120 (round) 6–55 (hexagon)	1/4 – 4-1/2 1/4 – 2	See Table 4
965	140	860	125	5.0	15.0	280	1144	6–60 (round) 6–40 (hexagon)	1/4 – 2-1/2 1/4 – 1-1/2	See Table 5
ALLOY STEELS										
860	125	725	105	14.0	45.0	269	41XX 51XX[c]	12–90 (hexagon)	7/16 – 3-1/2	See Table 6
1035[d]	150	895	130	10.0	35.0	302	41XX[c] 51XX[c]			
1170	170	1070	155	5.0	20.0	355	41XX[c]			

[a] Typical minimum
[b] Typical hardness ranges, subject to negotiation. Hardness to be taken on a flat below decarb or on the midradius. In case of disagreement between hardness and tensile or yield strength, the latter properties govern.
[c] May contain Pb or Te or other additives for improved machinability.
[d] See SAE J429.

5. SURFACE FINISH:

A number of surface finishes are available depending on producers' facilities and end use requirements. Bars can be supplied in the die drawn condition turned and polished, or ground and polished from die drawn or turned bars. The bars frequently have a dark appearance when the last operation is stress relieving. Surface finishes are subject to negotiation with each producer. The ranges of Arithmetical Average (AA) values in Table 2 are considered normal for each condition.

TABLE 2 - Ranges of Arithmetical Average (AA) Values

	μm		μin
Cold Drawn	1.25/3.20	AA	(50/125)
Turned and Polished	0.40/1.00	AA	(15/40)
Cold Drawn-Ground and Polished	0.20/0.50	AA	(8/20)
Turned-Ground and Polished	0.20/0.50	AA	(8/20

6. MACHINABILITY:

Machinability values for any given grade or condition will vary considerably from shop to shop as a function of equipment, tooling grade and design, set up conditions, lubrication, and personnel. The ratings in Table 3 which are considered typical and which are offered only for purposes of comparison are based on a value of 100% for SAE 1212.

TABLE 3 - Typical Machinability Ratings

SAE Grade	Heavy Drafted, Stress Relieved, %
1045	56
1050	54
1141	67
1144	85
High Tensile 1144	80
41XX, 51XX 1035 MPa (150 ksi), TS	75 with free machining additives
41XX 1170 MPa (170 ksi), TS	60 with free machining additives

TABLE 4 - Size Tolerances for Carbon Steels

	Size Range, mm (in)	Tolerance, mm[a]	Tolerance, in[a]
Rounds	6 - 40, incl (1/4 - 1-1/2)	0.10	0.004
	Over 40 - 60, incl (Over 1-1/2 - 2-1/2, incl)	0.12	0.005
	Over 60 - 100, incl (Over 2-1/2 - 4, incl)	0.15	0.006
	Over 100 - 120, incl (Over 4 - 4-1/2, incl)	0.18	0.007
Hexagons	7 - 18, incl (1/4 - 3/4, incl)	0.10	0.004
	Over 18 - 36, incl (Over 3/4 - 1-1/2, incl)	0.12	0.005
	Over 36 - 55, incl (Over 1-1/2 - 2, incl)	0.15	0.006

[a]All tolerances are minus.

TABLE 5 - Size Tolerances for Carbon Steels

	Size Range, mm (in)	Tolerance, mm[a]	Tolerance, in[a]
Rounds	8 to less than 12 (5/16 to less than 7/16)	0.10	0.004
	12 - 40, incl (7/16 - 1-1/2, incl)	0.12	0.005
	Over 40 - 60, incl (Over 1-1/2 - 2-1/2, incl)	0.15	0.006
Hexagons	7 to less than 10 (1/4 to less than 3/8)	0.10	0.004
	10 to less than 13 (3/8 to less than 7/16)	0.12	0.005
	13 - 36, incl (7/16 - 1-1/2, incl)	0.15	0.006

[a]All tolerances are minus.

TABLE 6 - Size Tolerances for Alloy Steels (Rounds)

Size Range, mm (in)	Tolerance, mm[a]	Tolerance, in[a]
12 - 40, incl (7/16 - 1-1/2, incl)	0.12	0.005
Over 40 - 60, incl (Over 1-1/2 - 2-1/2, incl)	0.15	0.006
Over 60 - 90, incl (Over 2-1/2 - 3-1/2, incl)	0.18	0.007

[a]All tolerances are minus.

The (R) is for the convenience of the user in locating areas where technical revisions have been made to the previous issue of the report. If the symbol is next to the report title, it indicates a complete revision of the report.

RATIONALE:

This SAE Recommended Practice was developed to provide basic information on the characteristics of die drawn steels and guidance on the mechanical properties which may be expected in these products. Additional information on product sizes and tolerances, machinability, and surface finish are provided to aid the designer in the selection of the most appropriate material grade and condition.

RELATIONSHIP OF SAE STANDARD TO ISO STANDARD:

Not applicable.

APPLICATION:

This SAE Recommended Practice is intended to provide basic information on properties and characteristics of high strength carbon and alloy steels which have been subjected to special die drawing. This includes both cold drawing with heavier-than-normal drafts and die drawing at elevated temperatures.

REFERENCE SECTION:

SAE J429, Mechanical and Material Requirements for Externally Threaded Fasteners

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