Selecting and Specifying Hot and Cold Rolled Steel Sheet and Strip – SAE J126 JUN81

SAE Recommended Practice
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PREPRINT

SELECTING AND SPECIFYING HOT AND COLD ROLLED STEEL SHEET AND STRIP—SAE J126 JUN81

SAE Recommended Practice

Report of the Iron and Steel Technical Committee, approved September 1969, last revised June 1981.

1. Scope—This SAE Recommended Practice outlines a procedure for selecting the proper specification for carbon steel sheet and strip which are purchased *to make an identified part.* Specifications considered are:

ASTM A 109, Steel, Carbon, Cold Rolled Strip.

ASTM A 569, Steel, Carbon (0.15 maximum percent), Hot Rolled Sheet, Commercial Quality (HRCQ).

ASTM A 621, Steel, Sheet, Carbon, Hot Rolled, Drawing Quality (HRDQ).

ASTM A 622, Steel, Sheet, Carbon, Hot Rolled, Drawing Quality, Special Killed (HRDQSK).

ASTM A 568, Steel, Carbon and High-Strength Low-Alloy Hot Rolled Sheet, and Cold Rolled Sheet, General Requirements.

ASTM A 366, Steel, Carbon, Cold Rolled Sheet, Commercial Quality (CRCQ).

ASTM A 619, Steel, Sheet, Carbon, Cold Rolled, Drawing Quality, (CRDQ).

ASTM A 620, Steel, Sheet, Carbon, Cold Rolled, Drawing Quality, Special Killed (CRDQSK).

ASTM A 749M, Steel, Carbon and High-Strength Low-Alloy, Hot Rolled Strip, General Requirements.

ASTM A 635, Steel Sheet and Strip, Carbon, Hot Rolled Commercial Quality, Heavy Thickness Coils.

(Metric ASTM documents are designated by suffix *M*)

It also describes how codes or symbols for specifying certain characteristics may be used in electronic data processing systems. Characteristics covered are:

(A) Hot or cold rolled.
(B) Sheet or strip.
(C) Severity of draw (*quality* of steel).
(D) Surface condition (finish, etc.).
(E) Edge condition.
(F) Dimensions.

It is intended that other characteristics and part identification be covered by a supplement to the specification, as necessary.

2. Procedure—Evaluate the part to determine the requirements for characteristics A–F, as follows:

A—Hot or Cold Rolled Product—Normally the finish or thickness of the metal required for a part will determine whether *hot-rolled* or *cold-rolled* product should be specified. (See Table 1 and Table 4.)

B—Sheet or Strip—Principal factors to consider in determining whether sheet or strip should be specified are:

φ TABLE 1A—STEEL SHEET OR STRIP PRODUCT CLASSIFICATION BY SIZE, INCH-POUND UNITS

Product	Thickness, in	Width, in	Other Limitations	Specification Symbol (ASTM No.)
Hot Rolled Sheet	0.045 thru 0.230 0.045 thru 0.180	Over 12 thru 48 Over 48	Coils and Cut Lengths	A 569, A 621, or A 622
	0.230 thru 0.500 0.180 thru 0.500	Over 12 thru 48 Over 48 thru 72	Coils Only	A 635
Hot Rolled Strip	0.045 thru 0.203 0.045 thru 0.229	Thru 6 Over 6 thru 12	Coils and Cut Lengths	A 569, A 621, or A 622
	0.230 thru 0.500	Over 8 thru 12	Coils Only	A 635
Cold Rolled Sheet	0.014 thru 0.082 Over 0.014	Over 2 thru 12 Over 12	See Note 1 See Note 2	A 366, A 619, or A 620
Cold Rolled Strip	Thru 0.250	Over 0.50 thru 23.9	See Note 3	A 109

Note 1. Cold rolled sheet, coils, and cut lengths, slit from wider coils with cut edge (only), thicknesses 0.014–0.082 in and carbon of 0.25% max by cast analysis.
Note 2. When no special edge or finish (other than matte, commercial bright, or luster) is required and/or single strand rolling of widths under 24 in is not required.
Note 3. Widths 2–12 in with thicknesses of 0.014–0.082 in are classified as "sheet" when slit from wider coils, have a cut edge only, and carbon of 0.25% max by cast analysis.

The φ symbol 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.

φ TABLE 1B—STEEL SHEET OR STRIP PRODUCT CLASSIFICATION BY SIZE, METRIC UNITS

Product	Thickness, mm	Width, mm	Other Limitations	Specification Symbol (ASTM No.)
Hot Rolled Sheet	1.2–6.0 1.2–4.5	Over 300 thru 1200 Over 1200	Coils and Cut Lengths	A 569M, A 621M, or A 622M
	6.0–12.5 4.5–12.5	Over 300 thru 1200 Over 1200 thru 1800	Coils Only	A 635M
Hot Rolled Strip	1.2–5.0 1.2–6.0	Thru 200 Over 200 thru 300	Coils and Cut Lengths	A 569M, A 621M, or A 622M
	6.0–12.5	Over 200 thru 300	Coils Only	A 635M
Cold Rolled Sheet	0.35–2.0 0.35 and Over	Over 50 thru 300 Over 300	See Note 1 See Note 2	A 366M, A 619M, or A 620M
Cold Rolled Strip	Thru 6.0	Over 12 thru 600	See Note 3	A 109M

Note 1. Cold rolled sheet, coils, and cut lengths, slit from wider coils with cut edge (only), thicknesses 0.35–2.0 mm and carbon of 0.25% max by cast analysis.
Note 2. When no special edge or finish (other than matte, commercial bright, or luster) is required and/or single strand rolling of widths under 600 mm is not required.
Note 3. Widths 50–300 mm with thicknesses of 0.35–2.0 mm are classified as "sheet" when slit from wider coils, have a cut edge only, and carbon of 0.25% max by cast analysis.

Size of part, or more specifically, size of flat steel required to develop part.
Thickness of metal required for the part.
Hot or cold rolled steel.
Selection and specification of temper for cold rolled strip. (See Table 3.)
Equipment on which the metal will be handled and fabricated.
Steel industry product classification by size. (See Table 1.)

C—Selection of Sheet Steel for Formability—For Cold Rolled Carbon Sheet and Hot Rolled Carbon Sheet and Strip, three levels of formability or drawability (called *quality* in the steel industry) are available as indicated in the Scope. They are commonly referred to as CQ, DQ, and DQSK.

The following procedure is based on a Forming Severity Index (FSI) which has been developed through experience in production forming of sheet metal stampings. The procedure is recommended for determining the quality needed for a specific part and fabrication operation.

1. Form a sample or prototype part from a specimen of known quality of steel using the gridding procedure outlined in SAE J863. (For the most accurate description of the quality of steel used for the gridded blank, the mechanical properties of a sample taken from material adjacent to the blank used for the gridded part should be known. This can be from the same blank, or the sheet preceding or following the sheet to be gridded.) If the specimen fractures, form another sample from the next better quality of steel.

2. Measure the e_1 and e_2 strains as described in SAE J863. (This should be done on a sample part which has not fractured during forming.)

3. Calculate the Forming Severity Index (FSI), for the critical area or areas of the sample part, using the following formulae:

NOTE: The e_2 strain is the associated strain (minor) measured perpendicular to the major strain, e_1.

When the e_2 strain as measured on the grid in the maximum stretch area is 0 to +30%.

$$FSI = (0.6e_2 + 15 + 350t) - e_1$$

When the e_2 strain is 0 to −30% (biaxial tension compression forming).

$$FSI = (1.5e_2 + 15 + 350t) - e_1$$

where: t = thickness of gridded panel in inches.
e_1 = major strain expressed as a percent (not a decimal value).
e_2 = minor strain expressed as a percent (not a decimal value).

The sign of e_2 is disregarded (an e_2 of −30 is expressed as 30 in the formula).

NOTE:

(a) The thickness t in the above formulae is only a correction factor for calculation of the FSI. Material formability may not be dependent on the sheet metal thickness.

(b) If t is expressed in millimeters, the multiplier will be 13.8 instead of 350.

(c) The reliability of the equations for stock over 0.125 in or 3 mm has not been established.

(d) The constant 15 in the above formulae can be modified by mutual consent of the supplier and user to provide the desired degree of risk of breakage. A constant of 15 approximates a safety factor of ten percentage of strain points for die, lubricant, press, and material variance of e_1 strain (major strain). A constant of 20 gives a safety factor of 5, and a constant of 10 gives a safety factor of 15.

4. Select the quality of steel sheet needed for the part from Table 2. When a change in material is indicated by Table 2, the selection should be verified using the new quality of sheet metal to form another sample part.

5. After a sufficient production history has been obtained through the use of the SAE Recommended Practice J424, Determination of Breakage Allowance for Steel Sheets, the quality of steel being used should be reviewed. For a given part an unusually high scrap rate indicates either a tool, lubricant, or material quality selection problem. If material quality is found to be the problem, upgrading should be considered. Conversely, an unusually low scrap rate indicates a less expensive quality should be considered. SAE Recommended Practice J863 should be followed to determine the most beneficial material change.

Examples: In the case of 0.080 in or 2.00 mm thick sheet steel with e_1 strain of 33% and an e_2 strain of +10%, the Forming Severity Index (FSI) would be:

(in)

$$FSI = [0.6(10) + 15 + 350(0.080)] - 33$$
$$FSI = 16$$

(mm)

$$FSI = [0.6(10) + 15 + 13.8(2.0)] - 33$$
$$FSI = 16$$

If the gridded panel was CRCQ steel, the FSI indicates the selection of a lower quality steel such as HRDQ (A621). Note that in cases such as this where the FSI is greater than +6 there are other factors than material which should be investigated to obtain the most economical production.

If the gridded panel was HRDQ, the indicated selection would be HRCQ (A569).

In the case of 0.036 in or 0.9 mm thick stock with an e_1 strain of 55% and an e_2 strain of −15%, the FSI would be:

(in)

$$FSI = [1.5(15) + 15 + 350(0.036)] - 55$$
$$FSI = -5$$

(mm)

$$FSI = [1.5(15) + 15 + 13.8(0.09)] - 55$$
$$FSI = -5$$

If the gridded panel was CRCQ and trouble was being encountered in forming production parts, the indicated selection would be to upgrade to CRDQ (A619). If the gridded panel was CRDQ, the indicated selection would be to upgrade to CRDQSK (A620) and if the panel was CRDQSK some other changes may be required in the forming operations or in the design of the part (see comments in Table 2).

D—Surface Condition (Finish, etc.)—Consider any surface conditions required for the part. Consult Table 4 for a description of surfaces applicable to the product selected in A, B, and C above. Designate surface, finish, coating, etc. by symbol shown.

E—Edge Condition—Consider any necesary edge conditions required for the part. Consult Table 5 for a description of edges applicable to the product selected in A, B, and C above. Designate the required edge condition by the symbol shown.

F—Dimensions—Consider all dimensions required for the part.

Refer to ASTM A 568 for thickness tolerance tables.

Designate dimensions in the following order: thickness, width, and length. (Note: Use the symbol *C* for length of material purchased in coil form.) When the measuring unit is inches, all fractions thereof shall be expressed as decimals and not as common fractions (for example, 1.25 in, not $1\frac{1}{4}$ in). State the thickness to three decimal places and width and length to two decimal places.

When metric units are used for dimensions, the thickness, width, and length should be expressed in millimeters. State thickness to one decimal place and width and length in whole numbers.

Example:

	(in)	(mm)
For cut length:	0.035 x 36.25 x 84.75	0.9 x 900 x 2153
For coil stock:	0.047 x 47.37 x C	1.2 x 1200 x C

(These units are not intended to indicate conversion of inch to metric units.)

G—For a more complete explanation of industry nomenclature for Cold Rolled or Hot Rolled Steel Sheet, the AISI Steel Customer Communication Handbooks are recommended.

φ **TABLE 2—SELECTION OF QUALITY OF STEEL SHEET AND STRIP BASED ON THE FORMING SEVERITY INDEX (FSI)**

Quality of Steel Used for the Gridded Sample Panel	Quality Suggested When the Forming Severity Index is Within the Range Given Below			
	−20 to −11	−10 to −1	0 to +5	+6 and Greater
DQSK DQ CQ	DQSK[a] DQSK[b] DQSK	DQSK[b] DQSK DQ	DQSK DQ CQ	DQ CQ CQ[c]

[a] This indicates too much is being expected of the sheet metal, a part redesign or breakdown into separate components may be necessary in addition to the factors below ([b]).

[b] This represents a part which is difficult to form, other factors, such as tools, design, drawing compound application, blank development, etc., should be considered to provide an adequate Forming Severity Index because further upgrading is not possible. (Premium quality grades of steel with a high plastic strain ratio (r_m) values may be necessary if the above factors cannot be modified to produce a more favorable Forming Serverity Index).

[c] The part should have no forming problems and if further economics are desired, factors other than material quality should be investigated, such as, thickness reduction, drawing compound change, or simplified tooling. In the appropriate thickness range HR should be considered in place of CR.

φ **TABLE 3A—(INCH-POUND UNITS)—SELECTION AND SPECIFICATION OF THE AMOUNT OF TEMPER (COLD WORK) (APPLICABLE TO COLD ROLLED STEEL STRIP ONLY)**

Requirement of Part (Relative to Hardness and Maximum Severity of Bend Involved in Forming the Part)					
Stock Thickness, in		Rockwell Hardness		Bend Test Requirements	Temper of Strip Normally Required
Over	Thru	Min	Max (Approx.)		
0.070	–	B84	–	No bending in any direction.	No. 1 (Hard)
0.040	0.070	B90	–		
0.025	0.040	30T76.0	–		
–	0.025	15T90.0	–		
0.040	–	B70	B85[b]	Bend 90 deg across rolling direction around a radius equal to that of the metal thickness.[a]	No. 2 (Half-Hard)
0.025	0.040	30T63.5	30T73.5		
	0.025	15T83.5	15T88.5		
0.040		B60	B75[b]	Bend 180 deg across rolling direction over one thickness of the strip and 90 deg in the direction of rolling around a radius equal to the thickness.	No. 3 (Quarter-Hard)[a]
0.025	0.040	30T56.5	30T67.0		
	0.025	15T80.0	15T85.0		
0.040	–	–	B65[b]	Bend flat upon itself in any direction.	No. 4 (Skin Rolled)[c]
0.025	0.040	–	30T60.0		
	0.025	–	15T82.0		
0.040	–	–	B55[b]	Bend flat upon itself in any direction.	No. 5 (Dead Soft)[c]
0.025	0.040	–	30T53.0		
–	0.025	–	15T78.5		

[a] To bend across the rolling direction means that the crease formed by the bend shall be at right angles to the length of the strip. To bend along the rolling direction means that the crease formed by the bend shall be parallel with the length of the strip.

[b] Rockwell hardness values apply to special killed steels and also rimmed or semi-killed steels at time of shipment only. Aging of these latter steels may result in slightly higher values when tested at a later date.

[c] Number 4 and 5 tempers may sometimes be ordered with a carbon range of 0.15–0.25%. In each instance the maximum hardness requirement is established by agreement.

φ **TABLE 3B—(METRIC UNITS)—SELECTION AND SPECIFICATION OF THE AMOUNT OF TEMPER (COLD WORK) (APPLICABLE TO COLD ROLLED STEEL STRIP ONLY)**

Stock Thickness, mm		Rockwell Hardness		Bend Test Requirements	Temper of Strip Normally Required
Over	Under	Min	Max (Approx.)		
1.8		B84	-	No bending in any direction.	No. 1 (Hard)
1.0	1.8	B90			
0.6	1.0	30T76.0			
	0.6	15T90.0	–		
1.0		B70	B85[b]	Bend 90 deg across rolling direction, around a radius equal to that of the metal thickness.[a]	No. 2 (Half-Hard)
0.6	1.0	30T63.5	30T73.5		
	0.6	15T83.5	15T88.5		
1.0		B60	B75[b]	Bend 180 deg across rolling direction over one thickness of the strip and 90 deg in the direction of rolling around a radius equal to the thickness.[a]	No. 3 (Quarter-Hard)
0.6	1.0	30T56.5	30T67.0		
	0.6	15T80.0	15T85.0		
1.0			B65[b]	Bend flat upon itself in any direction	No. 4 (Skin Rolled)[c]
0.6	1.0		30T60.0		
	0.6		15T82.0		
1.0			B55[b]	Bend flat upon itself in any direction	No. 5 (Dead Soft)[c]
0.6	1.0		30T53.0		
-	0.6		15T78.5		

[a] To bend across the rolling direction means that the crease formed by the bend shall be at right angles to the length of the strip. To bend along the rolling direction means that the crease formed by the bend shall be parallel with the length of the strip.

[b] Rockwell hardness values apply to special killed steels and also rimmed or semi-killed steels at time of shipment only. Aging of these latter steels may result in slightly higher values when tested at a later date.

[c] Number 4 and 5 tempers may sometimes be ordered with a carbon range of 0.15–0.25%. In each instance the maximum hardness requirement is established by agreement.

TABLE 4—SELECTION AND SPECIFICATION OF SURFACE CONDITION OF STEEL SHEET AND STRIP

Description of Surface	Surface Described Applicable To	Specification Symbol
Surface finish as normally used for unexposed automotive parts. Matte (dull) appearance. Normally annealed last.	Cold rolled sheet	U[a]
Surface finish as normally used for exposed automotive parts which require a good painted surface. Free from strain markings and fluting. Matte (dull) appearance. Temper rolled.	Cold rolled sheet	E[b]
Same as above, except commercial bright appearance.	Cold rolled sheet	B
Same as above, except luster appearance.	Cold rolled sheet	L
No. 1 or dull finish (no luster). Especially suitable for lacquer or paint adhesion. Facilitates drawing by reducing the contact friction between the die and the metal.	Cold rolled strip	1
No. 2 or regular bright finish (moderately smooth). Suitable for many applications, but not generally applicable for parts to be plated, unless polished and buffed.	Cold rolled strip	2
No. 3 or best bright finish (relatively high luster). Particularly suitable for parts to be plated.	Cold rolled strip	3
As rolled or black (oxide or scale not removed).	Hot rolled sheet and strip	A
Pickled (scale removed), not oiled.	Hot rolled sheet and strip	P
Same as above, except oiled.	Hot rolled sheet and strip	O

[a]U—unexposed is presently also designated as Class 2, Cold Rolled Sheet.
[b]E—exposed is presently also designated as Class 1, Cold Rolled Sheet.

ϕ TABLE 5—SELECTION AND SPECIFICATION OF EDGE CONDITION OF STEEL SHEET AND STRIP

Description of Edge	Edge Described Applicable To	Specification Symbol
Cut Edge.	Cold rolled sheet	None required
No. 1 Edge is a prepared edge of a specified contour (round, square, or beveled) supplied when a very accurate width is required, or where the finish of the edge is required to be suitable for electroplating, or both.	Cold rolled strip	1
No. 2 Edge is a natural mill edge carried through the cold rolling from the hot rolled strip without additional processing of the edge.	Cold rolled strip	2
No. 3 Edge is an approximately square edge produced by slitting, on which the burr is not eliminated.	Cold rolled strip	3
No. 4 Edge is a rounded edge produced by edge rolling the natural edge of hot rolled strip or slit-edge strip. This edge is produced when the width tolerance and edge condition are not as exacting as for No. 1 Edge.	Cold rolled strip	4
No. 5 Edge is an approximately square edge produced by rolling or filing of a slit-edge to remove burr only.	Cold rolled strip	5
No. 6 Edge is a square edge produced by edge rolling the natural edge of hot rolled strip or slit-edge strip, where the width tolerance and finish required are not as exacting as for No. 1 Edge.	Cold rolled strip	6
Mill Edge.	Hot rolled sheet and strip	M
Cut Edge.	Hot rolled sheet and strip	C
Square Edge (square and smooth, corners slightly rounded). Produced by rolling through vertical edging rolls during the hot rolling operation.	Hot rolled strip	S