

SELECTING AND SPECIFYING HOT AND COLD ROLLED STEEL SHEET AND STRIP

Foreword—This Reaffirmed Document has been changed only to reflect the new SAE Technical Standards Board Format.

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 A109—Steel, Carbon, Cold Rolled Strip.
- ASTM A569—Steel, Carbon (0.15 maximum percent), Hot Rolled Sheet, Commercial Quality (HRCQ).
- ASTM A621—Steel, Sheet, Carbon, Hot Rolled, Drawing Quality (HRDQ).
- ASTM A622—Steel, Sheet, Carbon, Hot Rolled, Drawing Quality, Special Killed (HRDQSK).
- ASTM A568—Steel, Carbon and High-Strength Low-Alloy Hot Rolled Sheet, and Cold Rolled Sheet, General Requirements.
- ASTM A366—Steel, Carbon, Cold Rolled Sheet, Commercial Quality (CRCQ).
- ASTM A619—Steel, Sheet, Carbon, Cold Rolled, Drawing Quality (CRDQ).
- ASTM A620—Steel, Sheet, Carbon, Cold Rolled, Drawing Quality, Special Killed (CRDQSK).
- ASTM A749M—Steel, Carbon and High-Strength Low-Alloy, Hot Rolled Strip, General Requirements.
- ASTM A635—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.

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2. References

2.1 Applicable Publications—The following publications form a part of the specification to the extent specified herein. Unless otherwise indicated the latest revision of SAE publications shall apply.

2.1.1 ASTM PUBLICATIONS—Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM A109—Steel, Carbon, Cold Rolled Strip.

ASTM A569—Steel, Carbon (0.15 maximum percent), Hot Rolled Sheet, Commercial Quality (HRCQ).

ASTM A621—Steel, Sheet, Carbon, Hot Rolled, Drawing Quality (HRDQ).

ASTM A622—Steel, Sheet, Carbon, Hot Rolled, Drawing Quality, Special Killed (HRDQSK).

ASTM A568—Steel, Carbon and High-Strength Low-Alloy Hot Rolled Sheet, and Cold Rolled Sheet, General Requirements.

ASTM A366—Steel, Carbon, Cold Rolled Sheet, Commercial Quality (CRCQ).

ASTM A619—Steel, Sheet, Carbon, Cold Rolled, Drawing Quality (CRDQ).

ASTM A620—Steel, Sheet, Carbon, Cold Rolled, Drawing Quality, Special Killed (CRDQSK).

ASTM A749M—Steel, Carbon and High-Strength Low-Alloy, Hot Rolled Strip, General Requirements.

ASTM A635—Steel Sheet and Strip, Carbon, Hot Rolled Commercial Quality, Heavy Thickness Coils.
(Metric ASTM documents are designated by suffix M)

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

3.1 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 1A, Table 1B, and Table 4.)

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

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 3A, Table 3B.)

Equipment on which the metal will be handled and fabricated.

Steel industry product classification by size. (See Table 1A, Table 1B.)

3.3 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:

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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%.

$$FSI = (0.6e_2 + 15 + 350t) - e_1 \quad (\text{Eq. 1})$$

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

$$FSI = (1.5e_2 + 15 + 350t) - e_1 \quad (\text{Eq. 2})$$

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.

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

$$FSI = \left[0.6(10) + \frac{(in)}{15} + 350(0.080) \right] - 33 \quad (\text{Eq. 3})$$

$$FSI = 16$$

$$FSI = \left[0.6(10) + \frac{(mm)}{15} + 13.8(2.0) \right] - 33 \quad (\text{Eq. 4})$$

$$FSI = 16$$

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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:

$$FSI = \left[1.5(15) + \frac{(\text{in})}{15} + 350(0.036) \right] - 55 \quad (\text{Eq. 5})$$

$$FSI = -5$$

$$FSI = \left[1.5(15) + \frac{(\text{mm})}{15} + 13.8(0.09) \right] - 55 \quad (\text{Eq. 6})$$

$$FSI = -5$$

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 (comments in Table 2).

- 3.4 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.
- 3.5 E - Edge Condition**—Consider any necessary 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.
- 3.6 F - Dimensions**—Consider all dimensions required for the part.

Refer to ASTM A568 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 1-1/4 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—

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

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

SAE J126 Reaffirmed JUN86

3.7 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.

TABLE 1A—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	Over 300 thru 1200	Coils and Cut Lengths	A 569M, A 621M, or A 622M
	1.2–4.5	Over 1200		
	6.0–12.5	Over 300 thru 1200	Coils Only	A 635M
	4.5–12.5	Over 1200 thru 1800		
Hot Rolled Strip	1.2–5.0	Thru 200	Coils and Cut Lengths	A 569M, A 621M, or A 622M
	1.2–6.0	Over 200 thru 300		
	6.0–12.5	Over 200 thru 300		
Cold Rolled Sheet	0.35–2.0	Over 50 thru 300	See Note 1	A 366M, A 619M, or A 620M
	0.35 and Over	Over 300	See Note 2	
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.

TABLE 1B—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	Over 12 thru 48	Coils and Cut Lengths	A 569, A 621, or A 622
	0.045 thru 0.180	Over 48		
	0.230 thru 0.500	Over 12 thru 48	Coils Only	A 635
	0.180 thru 0.500	Over 48 thru 72		
Hot Rolled Strip	0.045 thru 0.203	Thru 6	Coils and Cut Lengths	A 569, A 621, or A 622
	0.045 thru 0.229	Over 6 thru 12		
	0.230 thru 0.500	Over 8 thru 12		
Cold Rolled Sheet	0.014 thru 0.082	Over 2 thru 12	See Note 1	A 366, A 619, or A 620
	Over 0.014	Over 12	See Note 2	
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.

**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	DQSK ^{(1) (2)}	DQSK ²	DQSK	DQ
DQ	DQSK ²	DQSK	DQ	CQ
CQ	DQSK	DQ	CQ	CQ ⁽³⁾

1. 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.
2. 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 Severity Index.)
3. 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.

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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)					Temper of Strip Normally Required
Stock Thickness in		Rockwell Hardness	Max (Approx.)	Bend Test Requirements	
Over	Thru	Min			
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 ⁽¹⁾	Bend 90 deg across rolling direction around a radius equal to that of the metal thickness. ⁽²⁾	No. 2 (Half-Hard)
0.025	0.040	30T63.5	30T73.5		
--	0.025	15T83.5	15T88.5		
0.040	--	B60	B75 ⁽¹⁾	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) ⁽²⁾
0.025	0.040	30T56.5	30T67.0		
--	0.025	15T80.0	15T85.0		
0.040	--	--	B65 ⁽¹⁾	Bend flat upon itself in any direction.	No. 4 (Skin Rolled) ⁽³⁾
0.025	0.040	--	30T60.0		
--	0.025	--	15T82.0		
0.040	--	--	B55 ⁽¹⁾	Bend flat upon itself in any direction.	No. 5 (Dead Soft) ⁽³⁾
0.025	0.040	--	30T53.0		
--	0.025	--	15T78.5		

1. 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.
2. 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.
3. 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.

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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 ⁽¹⁾	Bend 90 deg across rolling direction around a radius equal to that of the metal thickness. ⁽²⁾	No. 2 (Half-Hard)
0.6	1.0	30T63.5	30T73.5		
--	0.6	15T83.5	15T88.5		
1.0	--	B60	B75 ⁽¹⁾	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. ⁽²⁾	No. 3 (Quarter-Hard) ⁽²⁾
0.6	1.0	30T56.5	30T67.0		
--	0.6	15T80.0	15T85.0		
1.0	--	--	B65 ⁽¹⁾	Bend flat upon itself in any direction.	No. 4 (Skin Rolled) ⁽³⁾
0.6	1.0	--	30T60.0		
--	0.6	--	15T82.0		
1.0	--	--	B55 ⁽¹⁾	Bend flat upon itself in any direction.	No. 5 (Dead Soft) ⁽³⁾
0.6	1.0	--	30T53.0		
--	0.6	--	15T78.5		

1. 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.
2. To bend across the rolling direction means that the crease 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.
3. 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.

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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

^aU - unexposed is presently also designated as Class 2, Cold Rolled Sheet.

^bE - exposed is presently also designated as Class 1, Cold Rolled Sheet.

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