



SURFACE VEHICLE RECOMMENDED PRACTICE

J2329™

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Categorization and Properties of Low-Carbon Automotive Sheet Steels

RATIONALE

J2329 has been updated to reflect changes in Tables 1, 2, and 3.

FOREWORD

- a. **Categorization** - Mechanical property, surface quality, and manufacturing requirements for automotive sheet steels, together with improvements in steel manufacturing and processing techniques, have made earlier methods of categorizing sheet steel obsolete. Classification of steel quality by deoxidation process is no longer appropriate. Uniformity of material properties is of major importance. This SAE Recommended Practice furnishes a categorization procedure to aid in selecting low-carbon sheet steel for identified parts and fabrication processes.

It is necessary for both the steel user and producer to know the mechanical properties and the range in these properties. There is a wide variety of parts within the automotive industry, and different levels of specific mechanical properties, e.g., r_m value, n value, yield strength, and total elongation, may be required for specific applications. With the recent advent of computer simulation of the steel deformation process during die design, it is vitally important that certain minimum levels of formability exist within a particular category or grade of steel. It is suggested that the steel user and steel supplier consult early in the part and die design process to determine specific grade requirements. In the past, yield strength has been chosen as a major discriminator of the categorization system since this property has meaning to both automotive and steel engineers; this document builds on that rationale but also addresses certain minimum elongation and n value and r_m value discriminators. In this document, low-carbon sheet steel is classified by five grade levels with yield strength, tensile strength, elongation, r_m value, and n value requirements. In addition, surface quality and/or aging characteristics are an important consideration. Thus, the categorization system is as follows:

1. The first two alphabetic characters will designate hot-rolled or cold-rolled method of manufacture.
2. The third numeric character defines grade based on yield strength range, minimum tensile strength, minimum percent elongation, minimum r_m value, and minimum n value.
3. The fourth alphabetic character classifies the steel type with regard to surface quality and/or aging character.
4. An optional fifth alphabetic character may restrict the carbon content to a minimum of 0.015%.

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- b. **Properties** - The mechanical properties of the substrate (ductility, work hardening, and plastic anisotropy) determine the ability of the steel to withstand strain in various modes of forming (such as stretching and deep drawing). Mechanical properties are important to the formability of uncoated and coated steels, both cold rolled and hot rolled. Compared with uncoated steel sheets, hot-dip and electroplated coated steels have different characteristics, which may affect automotive manufacturing operations such as stamping, welding, and painting. Material-related factors greatly influence the formability of coated sheets. Coating characteristics, although less important to forming than the substrate, can have a significant influence on forming because the coating can affect metal flow over tool and die surfaces.

Definition of steel sheet properties is contained in Appendix A.

1. SCOPE

This SAE Recommended Practice establishes mechanical property ranges for low-carbon automotive hot-rolled sheet, cold-rolled sheet, and metallic-coated sheet steels. It also contains information that explains the different nomenclature used with these steels.

2. REFERENCES

2.1 Applicable Publications

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE J416 Tensile Test Specimens

SAE J863 Methods for Determining Plastic Deformation in Sheet Metal Stampings

SAE J1392 Steel, High Strength, Hot Rolled Sheet and Strip, Cold Rolled Sheet, and Coated Sheet

SAE J1562 Selection of Zinc and Zinc-Alloy (Hot-Dipped and Electrodeposited) Coated Steel Sheet

2.1.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM A370 Standard Test Methods and Definitions for Mechanical Testing of Steel Products

ASTM E8 Standard Test Methods of Tension of Metallic Materials

ASTM E517 Standard Test Method for Plastic Strain Ratio for Sheet Metal

ASTM E646 Standard Test Method for Tensile Strain-Hardening Exponents (n value) of Metallic Sheet Materials

2.1.3 ASM Publications

Available from ASM International, Attn: MSC/Book Order, P. O. Box 473, Novelty, OH 44072-9901.

ASM Metals Handbook, Vol. 1 (9th ed.) (1978). American Society for Metals.

2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

2.2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE J810 Classification of Common Imperfections in Sheet Steel

SAE J940 Glossary of Carbon Steel Sheet and Strip Terms

SAE J1058 Standard Sheet Steel Thickness and Tolerances

2.2.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM A366/A366M Specification for Steel, Sheet, Carbon, Cold-Rolled, Commercial Quality

ASTM A568/A568M Specification for Steel, Sheet, Carbon, and High Strength, Low Alloy, Hot-Rolled and Cold-Rolled, General Requirements for

ASTM A569/A569M Specification for Steel, Carbon (0.15 Maximum, Percent), Hot-Rolled Steel and Strip, Commercial Quality

ASTM A619A/619M Specification for Steel, Sheet, Carbon Cold-Rolled Drawing Quality

ASTM A620/A620M Specification for Steel, Sheet, Carbon, Drawing Quality, Special Killed, Cold-Rolled

ASTM A621/A621M Specification for Steel, Sheet and Strip, Carbon, Hot-Rolled, Drawing Quality

ASTM A622/A622M Specification for Steel, Sheet and Strip, Carbon, Drawing Quality, Special Killed, Hot-Rolled

ASTM A642/A642M Specification for Steel Sheet, Zinc-Coated (Galvanized by the Hot-Dip Process, Drawing Quality, Special Killed)

ASTM A653/A653M Steel Sheet, Zinc Coated (Galvanized) or Zinc-Iron Alloy Coated (Galvannealed) by the Hot-Dip Process

ASTM A924/A924M General Requirements for Steel Sheet, Metallic Coated by the Hot-Dip Process

2.2.3 Other Publications

Steel Products Manual, Sheet Steel. (1988). Iron and Steel Society.

3. GRADES

The specific grades are identified by a maximum of five characters. The first two characters will be letters defining method of manufacture of steel: "HR" for hot rolled and "CR" for cold rolled. The third character will consist of a single-digit number defining the chemical and forming characteristics as specified in Tables 1 through 3. The fourth character, an alphabetic character, will define the type of steel as outlined in Section 4. An additional fifth suffix character, C, may be added if restriction to low-carbon steelmaking is desired by the purchaser. The single-digit number specifies the mechanical requirements for yield and tensile strength in MPa, elongation %, r_m value, and n value.

Table 1 - Cold-rolled steel sheet, coated and uncoated, mechanical properties^(1, 2)

SAE J2329 Designation	Yield Strength (MPa) at 0.2% Offset	Tensile Strength (MPa) Min	Total % Elongation in 50 mm Min	r _m value ⁽³⁾ Min	n Value ⁽⁴⁾ Min
Grade 1	N/R	N/R	N/R	N/R	N/R
Grade 2	140 to 260	270	34	N/R	0.16
Grade 3	140 to 205	270	38	1.5	0.18
Grade 4	140 to 185	270	40	1.6	0.20
Grade 5	110 to 170	270	42	1.7	0.22

⁽¹⁾ N/R = Not required.

⁽²⁾ ASTM A370, test parameters in longitudinal and transverse orientations relative to the rolling direction.

⁽³⁾ ASTM E517, parameter for r calculated at 17% strain, r_m calculation by $(r_0 + r_{90} + 2r_{45})/4$. The r_m value can be up to 0.2 lower for thickness greater than 1.4 mm and/or Galvanneal products.

⁽⁴⁾ ASTM E646, n value calculated from 10 to 20% strain or 10% to end of uniform elongation when uniform elongation is less than 20%.

Table 2 - Hot-rolled steel sheet, coated and uncoated, mechanical properties^(1, 2)

SAE J2329 Designation	Yield Strength (MPa) at 0.2% Offset	Tensile Strength (MPa) Min	Total % Elongation in 50 mm Min	n Value ⁽³⁾ Min
Grade 1	N/R	N/R	N/R	N/R
Grade 2	180 to 290	270	34	0.16
Grade 3	180 to 240	270	38	0.18

⁽¹⁾ N/R = Not required.

⁽²⁾ ASTM A370, test parameters in longitudinal and transverse orientations relative to the rolling direction.

⁽³⁾ ASTM E646, n value calculated from 10 to 20% strain or 10% to end of uniform elongation when uniform elongation is less than 20%.

Table 3 - Hot-rolled and cold-rolled steel sheet, low-carbon, chemical composition⁽¹⁾

SAE J2329 Designation	Carbon % Max ⁽²⁾	Manganese Max %	Phosphorus Max %	Sulfur Max %	Aluminum Min %
Grade 1	0.13	0.60	0.035	0.035	--
Grade 2	0.10	0.50	0.035	0.030	0.02
Grade 3	0.10	0.50	0.030	0.030	0.02
Grade 4	0.08	0.40	0.025	0.025	0.02
Grade 5	0.02	0.30	0.025	0.025	0.02

⁽¹⁾ Ladle or heat analysis

⁽²⁾ Carbon minimum requirement of 0.015% if suffix C is used. C cannot be specified for Grade 5.

Under certain circumstances, particular parts may require steel properties that do not conform exactly to the specific grades defined herein. These deviations should be resolved through agreement between the steel user and the steel producer.

Cold-rolled and metallic-coated cold-rolled coated steels specified to a 180 MPa or greater minimum yield strength are considered high-strength steels.

Hot-rolled and metallic-coated hot-rolled steels specified to a 260 MPa or greater minimum yield strength are considered high-strength steels.

Titanium, niobium, and other alloy elements can be used in combination if fully stabilized product is required. Stabilization elements must be reported on chemical certification.