



SURFACE VEHICLE RECOMMENDED PRACTICE

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Categorization and Properties of Steel Sheet
for Automotive Cold Forming Applications

RATIONALE

This specification defines the commonly used steel sheet grades within the automotive industry. Most of these grades have evolved from the grades listed in SAE J2329, SAE J2340, and SAE J2745 through a combination of current practice and customer demand.

FOREWORD

This SAE Recommended Practice contains grades of steels that are currently available and used in the automotive industry that range from mild low carbon steel sheet to advanced high strength steel (AHSS) sheet. Mild steels are used for their high formability, whereas higher strength steels are desirable for dent resistance, increased load bearing capability, improved crash energy management, and/or part mass reduction through a decrease in sheet metal thickness.

An increase in strength generally leads to reduced ductility and formability. Care must be taken in designing automotive parts as well as related tooling, and fabrication processes to obtain the greatest benefit from higher strength steel sheet. Grade selection collaboration between steel supplier and user is recommended to ensure compatibility of the strength and forming characteristics.

The combination of strength and formability in these steels is achieved through chemical composition (alloying) and special processing. Special processing includes mechanical rolling techniques, temperature control in hot rolling, and time/temperature control in annealing of cold-rolled steel. Additional thermal treatment may modify the original mechanical properties.

1. SCOPE

This SAE Recommended Practice establishes and defines requirements for grades of continuously cast automotive steel sheet that can be formed, welded, assembled, and painted in automotive manufacturing processes. These sheet steels can be specified as hot-rolled, cold-rolled, uncoated, or coated. Steel sheet can be coated by hot dipping, electroplating, or vapor deposition of zinc, aluminum, or organic compounds. Not all combinations of material types, strength levels, and coating types may be commercially available. Consult your steel supplier for availability.

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Documents

Document Sharing Hub

2. REFERENCES

2.1 Applicable Documents

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 J1058	Standard Sheet Steel Thickness and Tolerances
SAE J1562	Selection of Zinc and Zinc-Alloy (Hot-Dipped and Electrodeposited) Coated Steel Sheet
SAE J2329	Categorization and Properties of Low-Carbon Automotive Sheet Steels
SAE J2340	Categorization and Properties of Dent Resistant, High Strength, and Ultra High Strength Automotive Sheet Steel
SAE J2745	Categorization and Properties of Advanced High Strength Automotive Sheet Steels

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 A1058	Standard Test Methods and Definitions for Mechanical Testing of Steel Products - Metric
ASTM E8	Standard Test Methods for Tension Testing of Metallic Materials
ASTM E29	Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
ASTM E517	Standard Test Method for Plastic Strain Ratio r for Sheet Metal
ASTM E646	Standard Test Method for Tensile Strain-Hardening Exponents (n -Values) of Metallic Sheet Materials

2.1.3 AWS Publications

Available from American Welding Society, 8669 NW 36 Street, #130, Miami, FL 33166-6672, Tel: 1-800-443-9353 or 305-443-9353, www.aws.org.

AWS D8.8M	Specification for Automotive and Light Truck Components Weld Quality - Arc Welding
AWS D8.9M	Test Methods for Evaluating the Resistance Spot Welding Behavior of Automotive Sheet Steel Materials

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

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 A463 Standard Specification for Cold Rolled Aluminum Coated Type 1 and Type 2 Steel Sheet

ASTM A568 General Requirements for Carbon and High Strength, Low Alloy Steel Sheet

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

ASTM A751 Standard Test Methods for Determining Chemical Composition of Steel Products

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

ASTM A1008 Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable

ASTM A1011 Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength

ASTM A1079 Standard Specification for Steel Sheet, Complex Phase (CP), Dual Phase (DP) and Transformation-Induced Plasticity (TRIP), Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

2.2.3 ISO Publications

Available from International Organization for Standardization, ISO Central Secretariat, 1, ch. de la Voie-Creuse, CP 56, CH-1211 Geneva 20, Switzerland, Tel: +41 22 749 01 11, www.iso.org.

ISO 6892-1 Metallic Materials - Tensile Testing - Part 1: Method of Test at Room Temperature

ISO 13887 Cold Reduced Steel Sheet of Higher Yield Strength with Improved Formability

ISO 16630 Metallic Materials - Sheet and Strip - Hole Expanding Test

2.2.4 JIS Publications

Available from Japanese Standards Association, Mita MT Bldg. 3-13-12 Mita, Minato-ku, Tokyo, 108-0073, Japan; Phone: +81-3-4231-8503, Fax: +81-3-4231-8650, www.jsa.or.jp/.

JIS Z 2241 Metallic Materials - Tensile Testing - Method of Test at Room Temperature

JIS Z 2248 Metallic Materials - Bend Test

2.2.5 VDA Publications

Available from Verband der Automobilindustrie e. V. Behrenstraße 35, 10117 Berlin, Phone +49 30 897842 - 0, Fax +49 30 897842 - 600, info@vda.de, www.vda.de.

VDA 238-100 Plate Bending Test for Metallic Materials

2.2.6 Verlag Stahleisen GmbH

Available from Verlag Stahleisen GmbH, Sohnstraße 65, 40237 Düsseldorf, Germany, https://infostore.saiglobal.com/en-us/standards/sep-1220-1-to-4-2011-1037143_saig_sep_sep_2420384/.

SEP 1220 Weld Quality Test Method Manual (AZ-017-02 295 1.0C RI)

3. DEFINITIONS, ABBREVIATIONS, ACRONYMS, AND SYMBOLS

AHSS: Advanced high strength steels.

AS: Hot dip coated with aluminum-silicon alloy.

ASTM: American Society for Testing and Materials.

AWS: American Welding Society.

BH: Bake hardening steel.

BHI: Bake hardening index.

BHI_l: Bake hardening index based on lower yield strength.

BHI_u: Bake hardening index based on upper yield strength.

CP: Complex phase.

CR: Cold reduced/cold rolled.

DP: Dual phase steel.

E: Exposed.

EG: Electrogalvanized zinc coating.

F: Inclusion shape control.

FB: Ferritic-bainitic steel.

GA: Hot dip coated with zinc-iron alloy (galvannealed).

GI: Hot dip zinc coating.

HAZ: Heat affected zone.

HER: Hole expansion ratio.

HR: Hot rolled.

HS: High strength.

IF: Interstitial free steel.

ISO: International Organization for Standardization.

JIS: Japanese Industrial Standards.

LA: Low alloy, high strength low alloyed or microalloyed steel with a defined minimum yield strength.

MPa: Mega pascal.

MS: Martensitic steel.

n-value: Strain hardening exponent.

P: Pre-phosphated.

r_m : Weighted average of r_x^y values.

r_x^y : Plastic strain ratio in x-direction (in degrees) relative to the rolling direction at plastic strain/plastic strain range of y%.

SWE: Secondary work embrittlement.

T: Minimum tensile strength.

TR: Transformation-induced plasticity (TRIP).

U: Unexposed.

UC: Uncoated.

UE: Uniform elongation.

VDA: Verband der Automobilindustrie (German Association of the Automotive Industry).

Y: Minimum yield strength.

ZM: Hot dip coated with zinc-magnesium alloy.

4. GENERAL INFORMATION

This document defines grades of steel based on material type and strength level. Tables 1 through 4 provide nomenclature information for various steel types and coatings. Tables 5 and 6 summarize cold roll and hot roll grades, respectively. Each material type and strength level are defined by chemical and mechanical property limits. Chemical composition, tensile strength, yield strength, and total elongation (as measured with ISO 6892-1 Type 1 or 2 tensile pieces) must be certified for all grades. All elements listed in the corresponding chemical composition table must be certified. Additional requirements certified as agreed to between steel supplier and user. For information on zinc-coated products, refer to SAE J1562.

Table 1 - Nomenclature of mild steels

Rolling Type	Grades	Alloying Concept (Optional)
CR = Cold rolled HR = Hot rolled	CR1 to CR5 (Table 8) and HR0 to HR3 (Table 9)	IF Non-IF

Table 2 - Nomenclature of high strength steels

Rolling Type	Minimum 0.2% Offset Yield Strength, MPa	Steel Type
CR = Cold rolled HR = Hot rolled	nnnY nnn = Minimum 0.2% offset yield strength	BH = Bake-hardening/bake hardenable IF = Interstitial free
LA = Low alloyed or microalloyed	F = With inclusion shape control (optional)	

Table 3 - Nomenclature of advanced high strength steels (AHSS)

Rolling Type	Mechanical Properties, MPa		Steel Type
CR = Cold rolled HR = Hot rolled	nnnY nnn = Minimum 0.2% offset yield strength	mmmT mmm = Minimum tensile strength	CP = Complex phase DP = Dual phase MS = Martensitic TR = TRIP FB = Ferritic bainitic

Table 4 - Nomenclature of coatings

Coating Type	Coating Mass	Surface Quality	Surface Treatment (Optional)
EG = Electrogalvanized zinc coating GI = Hot dip zinc coating (galvanized) GA = Hot dip coated with zinc-iron alloy (galvannealed) AS = Hot dip coated with aluminum-silicon alloy ZM = Hot dip coated with zinc-magnesium alloy UC = Uncoated	nn/mm nn = g/m ² on Side 1 mm = g/m ² on Side 2	U = Unexposed E = Exposed	P = Pre-phosphated

Table 5 - Cold roll steel grades

Material Type	Grade Designation	Available Strength Levels, MPa (Values Are Minimum Yield Strength Unless Otherwise Indicated)
Mild steels	Low carbon	CR grades 1 through 5
Bake hardenable	BH	180, 210, 240, 270, 300
High strength interstitial free	IF	160, 180, 210, 240
Solid solution strengthened/high strength low alloy	LA	210, 240, 270, 300, 340, 380, 420, 460, 500, 550
Dual phase ⁽¹⁾	DP	490, 590, 690, 780, 980 (three versions)
Transformation-induced plasticity (TRIP) ⁽¹⁾	TR	690, 780
Complex phase ⁽¹⁾	CP	780, 980, 1180
Martensitic ⁽¹⁾	MS	900, 1100, 1300, 1500, 1700

⁽¹⁾ For this grade classification, the strength grade is referenced by minimum tensile strength instead of minimum yield strength.

Table 6 - Hot roll steel grades

Material Type	Grade Designation	Available Strength Level(s), MPa (Values Are Minimum Yield Strength Unless Otherwise Indicated)
Mild steels	Low carbon	0, 1, 2, 3
Solid solution strengthened/high strength low alloy	LA	270, 300, 340, 380, 420, 500, 550, 700
Dual phase ⁽¹⁾	DP	580
Ferrite bainite ⁽¹⁾	FB	450, 580, 780
Complex phase ⁽¹⁾	CP	760, 980

⁽¹⁾ For this grade classification, the strength grade is referenced by minimum tensile strength instead of minimum yield strength.