Steel Products for Rollover Protective Structures (ROPS) and Falling Object Protective Structures (FOPS)

J1119

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STEEL PRODUCTS FOR ROLLOVER PROTECTIVE STRUCTURES (ROPS) AND FALLING OBJECT PROTECTIVE STRUCTURES (FOPS)—SAE J1119

SAE Information Report

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1. OBJECTIVE—This Information Report is intended to provide guidance to producers and users of steel products for Rollover Protective Structures (ROPS) and Falling Object Protective Structures (FOPS). Compositions, manufacturing processes, and mechanical properties are suggested for those wrought steels and steel castings that are likely to comprise the largest tonnage of ROPS usage – the readily weldable, low carbon, and high strength, low alloy steels.

This Information Report is intended to provide general guidelines that may be conducive to reducing cost of material and improving its availability. The information is for guidance and it must be recognized that particular designs may require material properties other than those presented herein. For convenience of reference, this Information Report is related to J1040 with a clear indication that the properties set forth in this Information Report are not mandatory nor is the option of running the J1040 evaluation at, or below, -18°C (0°F) in any way precluded.

2. SCOPE—The compositions and mechanical properties are only suggested to ensure good weldability and good formability in conjunction with control of mechanical properties. *The particular design must be considered to ensure that the materials selected are compatible with the design.* The indicated properties are intended to assure that the ROPS or FOPS will have meaningful resistance to brittle fracture. The impact toughness requirement is the conventional Charpy V Notch evaluation: it is primarily a quality control check and the indicated temperature does not directly relate to operating conditions.

Three steel product categories are covered: hollow structural members, plates, bars and shapes, and castings.

3. HOLLOW STRUCTURALS—of 4.8mm (3/16 in) or greater wall thickness

3.1 Manufacturing Process—All steel furnished to this description shall be made fully killed to fine grain practice. Tubing may be seamless or welded and may be hot formed or cold formed. Unless otherwise requested by the purchaser, thermal treatment is at the option of the steel producer.

Tube lengths furnished by the steel producer shall have no transverse welds. The longitudinal butt joint shall be welded across its thickness in such a manner that the structural design strength of the tubing shall be assured.

3.2 Chemical Composition—All grades must meet the requirements of Table 1. Columbium, Vanadium, Nitrogen, or other alloying elements may also be used. Limits of check analysis per SAE J409 are applicable.

3.3 Mechanical Properties—The mechanical properties are shown in Tables 2 and 3. All testing shall be in accordance with ASTM A370, "Methods and Definitions for Mechanical Testing of Steel Products", except that Charpy V-Notch specimen size and test temperature shall conform to Tables 3 and 4. Test specimens shall be taken from finished tubing. For welded tubing, the specimens shall not be taken from the weld or heat affected zone.

3.4 Test Frequency—Composition shall be determined for each heat or cast. One tensile test and one impact test (three specimens per ASTM A370) are to be run per lot. A lot is defined as follows for various steel mill practices:

TABLE 1—CHEMISTRY, MAX %

Product	Carbon	Manganese	Sulfur	Phosphorus	Silicon
Hollow structurals, Plates, Bars, & Shapes[a]	0.23	1.50	0.05	0.04	0.90
Castings	0.30	1.50	0.06	0.05	0.80

[a] Manganese may be increased by 0.05% for each 0.01% reduction of Carbon below 0.23%, up to a maximum of 1.65% Manganese.

(a) For products which are furnished as rolled or as rolled and stress relieved.

A lot is defined as one heat or cast rolled into one tube size in one continuous rolling and receiving the same stress relief, if stress relief is used. Stress relief is defined as heating below the lower critical temperature when such treatment is performed after final rolling.

(b) For products which receive a normalize, normalize and temper, or liquid quench and temper after final rolling.

A lot is defined as one heat or cast rolled into one tube size. and receiving the same thermal treatment. Normalizing is is defined as heating the entire tube above the upper critical temperature followed by air cooling.

(c) For products which cool at room temperature after welding are reheated for final rolling.

A lot is defined as one heat or cast which receives the same reheat and final rolling into one tube size.

4. PLATES, BARS, AND SHAPES—Of greater than 4.8 mm (3/16 in) Thickness

4.1 Manufacturing Process—All steel furnished to the description shall be made fully killed to fine grain practice. Unless otherwise requested by the purchaser, thermal treatment is at the option of the steel producer.

4.2 Chemical Composition—All grades must meet the requirement of Table 1. Columbium, Vanadium, Nitrogen or other alloying elements may also be used. Limits of check analysis per SAE J409 are applicable.

4.3 Mechanical Properties—The mechanical properties of these steels are shown in Tables 2 and 3. All testing shall be in accordance with ASTM A370 "Methods and Definitions for Mechanical Testing of Steel Products" except that Charpy V-Notch specimen size and temperature shall conform to Tables 3 and 4 of this document.

4.4 Test Frequency—Tension testing shall conform to ASTM A-6, "General Requirements for Delivery of Rolled Steel Plates, Shapes, Sheet Piling and Bars for Structural Use." Impact testing shall conform to ASTM A673, "Sampling Procedure for Impact Testing of Structural Steel;" "Frequency (H) Heat Testing for Plates, Shapes, and Bars," except where Tables 3 and 4 of this document cover testing temperatures of subsize specimens.

4.5 References—ASTM A572 and A573

5. CASTINGS

5.1 Heat Treatment—All castings shall be either annealed, normalized, normalized and tempered or quenched and tempered to fulfill the mechanical property requirements.

5.2 Chemical Composition—All grades shall meet the requirements of Table 1—check analysis in addition to melt analysis. Residuals or alloy additions of Nickel, Chromium, Molydbenum, and Copper are permitted to the extent they do not exceed a Carbon Equivalency (CE) of 0.55% as calculated by the following formula:

$$CE = \frac{\%C}{} + \frac{\%Mn}{6} + \frac{\%Ni}{20} + \frac{\%Cr}{10} + \frac{\%Mo}{10} + \frac{\%Cu}{40}$$

This limit is required to maintain weldability.

5.3 Mechanical Properties—Mechanical properties given in Table 5 apply to the castings after heat treatment. Testing shall be in accordance with ASTM A370 and ASTM E23. Location of mechanical test specimens shall be negotiated between supplier and user.

5.4 Quality Control—Upon sufficient testing to establish correlation between Keel Blocks and castings, mechanical testing may be performed from Keel Block specimens as agreed upon by supplier and user. For information purposes only, Keel Block properties listed in Table 6 will usually satisfy the casting properties given in Table 5 when heat treated similarly to the castings and at the same hardness. If Keel Block properties are to be used for quality control purposes, the actual Keel Block properties shall be as agreed upon by user and supplier.

TABLE 2–LONGITUDINAL TENSILE PROPERTIES

Grade	Yield Strength Minimum	Expected Yield Strength Range	Tensile Strength Minimum	Percent Elongation Minimum[a] In 200 mm (8 in)	Percent Elongation Minimum[a] In 50 mm (2 in)
205	205 MPa (29.7 ksi)	205-380 MPa (29.7-55.1 ksi)	310 MPa (45.0 ksi)	25	30
240	240 MPa (34.8 ksi)	240-440 MPa (34.8-63.8 ksi)	400 MPa (58.0 ksi)	20	24
290	290 MPa (42.1 ksi)	290-490 MPa (42.1-71.1 ksi)	435 MPa (63.1 ksi)	20	24
345	345 MPa (50.0 ksi)	345-545 MPa (50.0-79.0 ksi)	485 MPa (70.0 ksi)	18	20

[a] Elongation values are to meet the requirement for one of the gage lengths, not necessarily both.

5.5 Test Frequency–Chemical analysis shall be conducted for each heat, and mechanical properties test conducted for each lot (lot consisting of castings produced from a single heat and thermal treatment).

5.6 Marking, Inspection, Repair–The requirements of the latest issue of SAE J435 for Marking, Inspection and Repair are a part of the requirements of this Information Report.

5.7 References–SAE J435 (grades 0025 and 0030), ASTM A27 (grades 60-30, 65-35, and 70-40).

1. The maximum permissible test temperature is -29°C (-20°F); lower temperatures may be used if convenient.
2. Material 12mm (0.47 in) or greater in thickness must use 10 mm x 10mm specimens
3. Material less than 12mm (0.47 in) thick must use specimens whose width along the notch is at least one-half of the thickness.
4. When the width of the specimen along the notch is less than 80% of the thickness of the material being evaluated, the minimum impact value for that specimen shall be taken from Table 3, but the test must be performed at, or below, the applicable temperature as determined from Table 4.

This is an option that is intended to permit standardizing on convenient size specimens while maintaining performance requirements.

6. Hollow Structurals, Shapes, and Flat Products of thickness less than covered in paragraphs 3 and 4. (Hollow structurals of less than 4.8 mm [3/16 in], shapes and flat products of 4.8 mm [3/16 in] or less thickness).

6.1 Two categories are presented, they differ in maximum thickness, manufacturing process, chemistry, and specific Charpy V-Notch requirements. There is an intentional overlap in thickness that is permissible because of chemistry differences.

6.2 All thicknesses covered in 6.

6.2.1 Chemical Composition, Maximum Percentages–Carbon 0.25, Manganese 1.35, Sulfur 0.05, Phosphorus 0.04, and Silicon 0.30.

6.2.2 Manufacturing Processes–All steel made to this specification shall be either fully killed or semi-killed.

TABLE 3–CHARPY V-NOTCH IMPACT PROPERTIES

Specimen Size (mm)	Minimum Joules	Minimum ft-lbf
10 x 10	11.0	8.0
10 x 9	10.0	7.5
10 x 8	9.5	7.0
10 x 7.5	9.5	7.0
10 x 7	9.0	6.5
10 x 6.7	8.5	6.5
10 x 6	8.0	6.0
10 x 5	7.5	5.5
10 x 4	7.0	5.0
10 x 3.3	6.0	4.5
10 x 3	6.0	4.5
10 x 2.5	5.5	4.0

6.2.3 Impact Toughness–Charpy V-notch as prescribed by Tables 3 and 4 for thicknesses of 2.6 mm and greater. There is no CVN requirement for thicknesses of less than 2.6 mm.

6.3 Thickness of 3.2 mm (1/8 in) and less.

6.3.1 Chemical Composition, Maximum Percentages–Carbon 0.20, Manganese 1.35, Sulfur 0.05, Phosphorus 0.04, and Silicon 0.30.

6.3.2 Manufacturing Processes–Steel may be fully killed, semi-killed, or rimmed.

6.3.3 Impact Toughness–Testing is specifically not required.

6.4 Longitudinal Tensile Properties–Table 2 gives properties of grades that are expected to be most commonly used but use of grades not in Table 2 is in no way prohibited.

6.5 Refer to paragraphs 3 and 4 for any topic not specifically covered in this paragraph.