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|---|---|
| **STEEL, SHEET, COLD ROLLED, HIGH STRENGTH SOLID SOLUTION STRENGTHENED** | **WSS-M1A367-A11/A12/A13/A14** |
| **STEEL, SHEET, COLD ROLLED, HIGH STRENGTH BAKE HARDENABLE** | **WSS-M1A367-A21/A22/A23/A24/A25** |
| **STEEL, SHEET, COLD ROLLED, HIGH STRENGTH MICRO-ALLOYED HIGH-STRENGTH LOW-ALLOY** | **WSS-M1A367-A33/A34/A35/A36/A37/ A38/A39** |
| **STEEL, SHEET, HOT ROLLED, HIGH STRENGTH MICRO-ALLOYED HIGH-STRENGTH LOW-ALLOY** | **WSS-M1A367-A44/A45/A46/A47/A48/ A49/A50/A51/A52** |

Note: Steels shown in gray typeface are not in the Global material strategy and should not be used without approval from the Global Sheet Metal Tech Club.

## 1. SCOPE

The materials defined by these Global specifications are fully killed, fine grained, high strength steel sheet with specified minimum yield strength between 180 MPa and 700 MPa, suitable for cold forming such as stamping, roll forming and tube making, and use in automotive applications.

The specification applies to uncoated and coated steel sheet generally categorized as high strength steels:
- Cold Rolled, Solution Strengthened Variants
- Cold Rolled, Bake Hardenable Variants
- Cold Rolled, Micro-alloyed High-Strength Low-Alloy Variants
- Hot Rolled, Micro-Alloyed High-Strength Low-Alloy Variants

The steel sheet may achieve its final thickness by cold rolling, hot rolling, continuous thin-strip casting, or other means. All requirements of the specific variant are to be met regardless of the final thickness reduction method.

Specification WSS-M1P94-A shall be used where pre-coating by the steel supplier is required. All requirements of the specific variant are to be met with or without pre-coating, except as noted in these specifications or as noted as exceptions on the Engineering Drawing.

## 2. APPLICATION

These Global specifications were released originally for automotive body and chassis parts.

### 2.1 LIMITATIONS

Common Global Grade Names are provided for information purposes and are not intended to be used on Engineering Drawings or CAD files.

Not all grade / gauge / width / coating combinations are available. Contact Product Development Materials Engineering for assistance or Global Materials and Fastener Standards (gmfs@ford.com) for help in locating the responsible engineer.

Variants shown with an asterisk and gray typeface in Tables 1-4 presently are not in the Global material strategy and should not be used without approval from the Sheet Metal Tech Club.

| Date | Action | Revisions | Rev. 1 |
|---|---|---|---|
| | | | |
| 2017 09 06 | Revised | See Summary of Revisions | J. Schenk, EU |
| 2012 01 10 | Released | | D. Jordan, NA / A. Toennessen, EU |


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Sources for these grades may not exist in your region. Contact Product Development Materials Engineering for assistance or gmfs@ford.com for help in locating the responsible engineer.

Material supplied to these specifications may contain titanium or other transition metals as alloying additions. Such alloyed steels, if subsequently surface treated by a nitrocarburising and/or oxidizing process, risk becoming embrittled due to the formation of ultrafine TiN or other precipitates. Accordingly, special consideration should be given to low carbon steel that contains intentional additions of titanium or other transition metals for parts that may be subjected to nitrocarburising and/or oxidizing processes.

## 3. REQUIREMENTS

Note: Drawing Precedence – Any part specific exceptions or restrictions of requirements listed in paragraph 3 shall be recorded on the part drawing and have to be considered in all engineering testing and attribute confirmation checklists.

### 3.1 APPROVED SOURCES

This specification requires the use of approved sources. Only the sources identified on the Ford Approved Source List (ASL) can be used when this specification is listed on the drawing, CAD file, or other documents. The list of approved sources is located within Ford at www.mats.ford.com or available externally through a Ford Materials Engineer. See also paragraph 4.1.

### 3.2 CHEMICAL COMPOSITION AND MICROSTRUCTURE
(ASTM E112, JIS G0320, ISO 4967 / ASTM E45)

3.2.1 Chemical Composition

The upper and lower limits of chemical composition of the controlled elements shall be established by the supplier and included in the supplier's Control Plan. Guidelines for chemical composition are provided in section 4.4.

Heat and/or check analyses shall be provided as part of the initial material source approval process in a format suitable for upload into the Ford Material Database.

The choice of strengthening mechanism and the method of inclusion control, inclusion shape control, and/or stabilization shall be identified for the specific process path in the supplier's Control Plan.

3.2.2 Microstructure

The grain size number shall be established as part of the initial material source approval process and shall be consistent (within 1 unit) throughout the thickness of the sheet.

The steel sheet shall be free from internal defects that adversely affect manufacturing or part functionality. Examples of defects may include: pipe laminations, non-metallic inclusions, segregation, and blowholes. Non-metallic inclusion content shall not exceed a rating of 2.0 for thin and 2.0 for heavy when tested in accordance with ASTM E 45 Method D, Plate I-r, by analysis at 100X.

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## 3.3 MECHANICAL PROPERTIES

(ASTM E8M, ASTM E517, ISO 6892-1, EN 10325, ISO 10113, ISO 10275, JIS Z 2241, JIS Z 2254, ASTM E 646)

For initial approval requirements see paragraph 4.1.

Mechanical properties are valid in the longitudinal direction. Certification of ongoing production material shall be in accordance with regional and/or local requirements.

Yield Strength is defined as lower yield stress or 0.2% proof stress (for materials without marked yield point).

For the determination of mechanical properties, the material cross sectional area shall be defined as that of the steel substrate only; contribution of any metallic and/or organic coating to the cross-sectional area used for stress calculation is neglected. (i.e. Zn, e-coat and/or paint are not included). This method of determining the cross sectional area of the test bar will be used as the referee method in all cases where the mechanical properties of the incoming material are in dispute.

Note: UTS max values for Table 1-4 grades are not required attributes from the steel supplier but can be used as representative values for calculations that require a max value.

ASTM Total Elongation is measured with an ASTM (50 mm) test bar (ASTM E 8M).
EN Total Elongation is measured with an ISO II (80 mm) test bar (ISO 6892-1).
JIS Total Elongation is measured with a JIS #5 test bar (JIS Z 2241).

Plastic Strain Ratio (r-value) is defined for a specific test direction with respect to the rolling direction. It is measured at 20% total elongation (or maximum uniform elongation if less than 20%). See ASTM E 517, ISO 10113, or JIS Z 2254.

Average Plastic Strain Ratio ($r_{avg}$) is calculated as a weighted average of the individual r-values, i.e., $( 0^o + 90^o + 2 \times 45^o ) / 4$

For grades with ravg requirements, data is collected for initial source approval. Ongoing certification to ravg requirements is not required for all coils. However, disputes will be settled using longitudinal, transverse and diagonal test bars sampled from the suspect material.

Strain Hardening Exponent (n-value) is measured over the range 10-20% strain (or 10% to end of uniform elongation if less than 20%). See ASTM E646 or ISO 10275. If uniform elongation is less than 12%, n-value shall be reported as $n_{UE} = \varepsilon_{UE}$ (n at uniform elongation equals true strain at uniform elongation.) Required n-value measurements are only valid for material thicknesses up to 6.4 mm. For gauges over 6.4 mm n-values are not required.

BHI (Bake Hardening Index) is defined as the increase in lower yield strength due exclusively to the baking portion of the following:

- Strain 2% in the longitudinal direction, note stress and release load.
- Bake at 170 (+/- 2) deg C peak metal temperature for 20 (+/- 1) minutes.
- Determine post-bake yield strength per ASTM E 8M, ISO 6892-1, EN 10325, or JIS Z 2241.
- BHI is the difference between the pre-bake stress at 2% strain and the post-bake yield strength.

BHI neglects the contribution of work hardening to yield strength and includes only the contribution due to thermal response. Actual processing conditions (temperature profiles and strain conditions) dictate the observed strength levels of individual parts.

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Aging: Maximum storage time ("Aging limits") for BH grades have to be agreed with regional manufacturing / purchasing activities. See e.g. technical delivery conditions document in Europe.

Mechanical properties are reported following standard rounding rules.

Table 1: Mechanical Properties for Cold Rolled, Solution Strengthened Variants

| Variant | **A11** | **A12** | **A13** | A14 |
|---|---|---|---|---|
| Common Global Grade Name | CR180 | CR210 | CR240 | CR270 |
| Yield Strength, MPa (min) | 180 | 210 | 240 | 270 |
| Yield Strength, MPa (max) | 240 | 270 | 300 | 330 |
| Tensile Strength, MPa (min) | 300 | 320 | 340 | 360 |
| Tensile Strength, MPa (max) | 400 | 420 | 440 | 460 |
| ASTM Total Elongation, % (min) | 35 | 33 | 30 | 28 |
| EN Total Elongation, % (min) | 33 | 31 | 28 | 26 |
| JIS Total Elongation, % (min) | 39 | 37 | 34 | 32 |
| ravg (min) | 1.3 | 1.3 | 1.1 | 1.0 |
| r0 (min) | 1.2 | 1.1 | 1.0 | 1.0 |
| n value (min) | 0.20 | 0.19 | 0.15 | 0.14 |

Table 2: Mechanical Properties for Cold Rolled, Bake Hardenable Variants

| Variant | **A21** | **A22** | **A23** | **A24*** | A25 * |
|---|---|---|---|---|---|
| Common Global Grade Name | CR180B2 | CR210B2 | CR240B2 | CR270B2 | CR300B2 |
| Yield Strength, MPa (min) | 180 | 210 | 240 | 270 | 300 |
| Yield Strength, MPa (max) | 240 | 270 | 300 | 330 | 360 |
| Tensile Strength, MPa (min) | 300 | 320 | 340 | 360 | 390 |
| Tensile Strength, MPa (max) | 370 | 400 | 440 | 460 | 490 |
| BHI, MPa(min) | 30 | 30 | 30 | 30 | 30 |
| ASTM Total Elongation, % (min) | 35 | 33 | 30 | 28 | 26 |
| EN Total Elongation, % (min) | 33 | 31 | 28 | 26 | 24 |
| JIS Total Elongation, % (min) | 39 | 37 | 34 | 32 | 30 |
| ravg (min) | 1.3 | 1.1 | 1.1 | 0,9 | 0.9 |
| r0 (min) | 1.1 | 1.1 | 1.0 | 0.9 | 0.9 |
| n value (min) | 0.19 | 0.17 | 0.17 | 0.15 | 0.14 |

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