



## SINTER-FORGED COPPER STEEL

WSS-M10A69-C1  
WSS-M10A69-C4  
WSS-M10A69-C5

## 1. SCOPE

The materials defined by these specifications are sinter-forged (also known as powder-forged) copper steels.

## 2. APPLICATION

These specifications were released originally for material used for connecting rods.

## 3. REQUIREMENTS

## 3.1 STANDARD REQUIREMENTS FOR PRODUCTION MATERIALS

Material suppliers and part producers must conform to the Company's Standard Requirements for Production Materials (WSS-M99P1111-A).

3.2 CHEMICAL COMPOSITION (After Hot Forming), % by Weight  
(ASTM E415 / ASTM E350 / ASTM E1019)

|              | <u>C1</u>   | <u>C4</u>   | <u>C5</u>   |
|--------------|-------------|-------------|-------------|
| Carbon       | 0.40 - 0.55 | 0.40 - 0.55 | 0.57 - 0.72 |
| Copper       | 1.80 - 2.20 | 2.70 - 3.30 | 3.00 - 3.50 |
| Manganese    | 0.30 - 0.50 | 0.30 - 0.50 | 0.30 - 0.50 |
| Phosphorus   | 0.04 max    | 0.04 max    | 0.04 max    |
| Sulfur       | 0.15 max    | 0.15 max    | 0.15 max    |
| Silicon      | 0.03 max    | 0.03 max    | 0.03 max    |
| Chromium     | 0.09 max    | 0.09 max    | 0.09 max    |
| Nickel       | 0.10 max    | 0.10 max    | 0.10 max    |
| Molybdenum   | 0.05 max    | 0.05 max    | 0.05 max    |
| Oxygen       | 0.050 max   | 0.050 max   | 0.050 max   |
| Others Each  | 0.02 max    | 0.02 max    | 0.02 max    |
| Others Total | 0.20 max    | 0.20 max    | 0.20 max    |
| Iron         | Balance     | Balance     | Balance     |

3.3 DENSITY, g/cc min  
(ISO 3369 / ASTM B311)

7.80

For in-process (IP) testing, the method and frequency of testing shall be specified in the Supplier Control Plan, and agreed upon between Ford and the supplier. The location(s) on the component designated for sampling shall be defined in the Engineering Specification or on the Engineering Drawing/CAD file.

| Date       | Action    | Revisions                                                    |
|------------|-----------|--------------------------------------------------------------|
| 2009 07 09 | Revised   | Added C5, see Summary of Revisions for details G. Weber, FNA |
| 2005 04 04 | Activated | G. Weber                                                     |



### 3.4 MECHANICAL PROPERTIES

In order to confirm Analytical Analysis calculations for new designs, the property specifications below shall be verified. Location(s), frequency and procedures of testing shall be outlined in the Engineering Specification and shall form part of the agreed Control Plan.

All test samples shall be machined from the as-sinter forged component, in the location(s) defined in the Engineering Specification or on the Engineering Drawing/CAD file. A sinter-forged test bar or a test bar machined from a sinter-forged blank may be used if the component dimensions or geometry prevent the machining of an adequately sized test bar, and provided that the microstructure and density are representative of the component. Note that these mechanical property limits represent  $-3\sigma$  values calculated from historical test data.

|                                                          | <u>C1</u> | <u>C4</u> | <u>C5</u> |
|----------------------------------------------------------|-----------|-----------|-----------|
| 3.4.1 Tensile Properties<br>(ISO 6892 / ASTM E 8M)       |           |           |           |
| Ultimate Tensile Strength, MPa, min                      | 770       | 890       | 1090      |
| 0.2% Offset Yield Strength, MPa, min                     | 490       | 610       | 720       |
| Elongation, %, min                                       | 10        | 8         | 6.5       |
| Reduction of Area, %, min                                | 17        | 13        | 10        |
| 3.4.2 Compressive Yield Strength, MPa, min<br>(ASTM E9M) | 510       | 600       | 735       |
| 3.4.3 Shear Strength, MPa, min<br>(ASTM B565)            | 500       | 625       | 720       |

### 3.5 CORE HARDNESS

(ISO 6506 / ASTM E10 / ASTM E18 / ASTM E140)

Core hardness shall be measured on a section cut from the I-beam. The exact location(s) for testing core hardness shall be defined in the component Engineering Specification or on the Engineering Drawing/CAD file. For in-process (IP) testing, the method and frequency of testing shall be agreed upon between Ford and the supplier, and documented in the Supplier Control Plan.

|    |               |
|----|---------------|
| C1 | 76 – 88.5 HRG |
| C4 | 25 – 35 HRC   |
| C5 | 30 – 40 HRC   |

Testing may be conducted using other hardness testers than the one specified for a particular material, with the result converted to the specified hardness scale by use of appropriate conversion tables, such as those found in ASTM E140.

When agreed between Ford and the supplier, surface hardness may also be measured. In this case, surface hardness limits shall be stated on the Engineering Drawing.