



## **Steel Bar for Forged Crankshafts**

### **1 Scope**

**1.1 Material Description.** This standard provides chemical composition and processing requirements for steel bar used in the manufacture of crankshafts in spark-ignition and diesel engines.

**1.2 Symbols.** Not applicable.

**1.3 Applicability.** Steel for forged crankshafts in spark-ignition and diesel engines.

**1.4 Remarks.** This standard does not supplant additional requirements that may be listed in drawings, Component Technical Specifications (CTS), Vehicle Technical Specifications (VTS), Statements of Requirements (SOR), Bill of Materials (BOM)/Bill of Process (BOP)/Bill of Design (BOD), or other documents.

### **2 References**

**Note:** Only the latest approved standards are applicable unless otherwise specified.

#### **2.1 External Standards/Specifications.**

|           |           |              |          |
|-----------|-----------|--------------|----------|
| ASTM A370 | ASTM E10  | ASTM E381    | SAE J404 |
| ASTM A534 | ASTM E45  | DIN EN 10250 |          |
| ASTM A29M | ASTM E112 | ISO 6506     |          |

#### **2.2 GM Standards/Specifications.**

GMW3059

### **3 Requirements**

**3.1 Steel Mill Qualification.** All steel mills providing product to the requirements of this specification shall be approved by GM Materials and GM Product Engineering.

Prior to any steel procurement, a GM Steelmaking Practice Survey must be completely filled out for each grade and mill that will be used for steel manufacturing, see Appendix B. The completed surveys shall be reviewed by the responsible GM Materials Engineer. The steel survey shall accurately reflect the process for all grades produced per this specification. The mill survey and review for qualification shall show capability to produce special bar quality (SBQ) steel product, as described in this section.

If the survey is deemed acceptable, the GM Materials Engineer and GM Product Engineer may define additional qualification requirements to complete approval.

Upon a successful part qualification, the supplier shall be added to the relevant approved supplier list.

**3.2 Steelmaking.** The steels described by this specification require maximum molten metal stream protection from oxidation to meet all requirements described herein.

Steelmaking practice shall minimize inclusions. Slag practice shall be optimized for steel quality. This includes processes which remove slag prior to casting such as slag raking and level control in the tundish which maximizes slag separation from the molten metal.

Steel shall be fully killed/deoxidized. Aluminum fine grain practice to control grain size in subsequent heat treatment shall be used. Refer to the aluminum content limits, where applicable, in Tables A1 and A3. The steel shall be stirred and refined in the ladle metallurgy station. Vacuum degassing is required. Steel shall be bottom poured from the ladle and/or tundish. The pour stream shall be protected from oxidation during teeming or casting. Ingot cast product must be bottom filled (uphill teemed).

Addition of calcium or calcium alloys for deoxidation or inclusion shape control is not permitted. Continuous cast product shall be electromagnetically stirred in an oscillated mold during solidification where applicable.

Material shall be sufficiently reduced and homogenized such that banding meets the requirements of the Hardness Method for determining Banding in ASTM A534, Supplemental Requirements Section S5.1, or is acceptable based on photomicrographs which have been approved by GM and the Seller. Samples for ASTM A534 are to be obtained from incoming steel bar.

### 3.3 Bar Product.

**3.3.1 As-Received Bar Stock.** All bar stock as-received in forging plants shall be hot rolled, in forging quality standard as required by the forger.

**3.3.2 Bar Size Tolerance.** Bar diameter and length dimensions, straightness, in as-received condition must conform to ASTM A29M or forger's specification.

**3.3.3 Surface Quality.** Bar surfaces shall be free from pits, laps, and any other imperfections that would be detrimental to the finished part functions. Maximum seam depth allowance is 0.5 mm. Surface decarburization must be well controlled. No free ferrite layer is allowed and acceptable total decarburization depth is 0.4 mm maximum.

**3.3.4 Reduction Ratio.** Reduction ratio of the cast strand or ingot to the final bar diameter shall be, based on the cross-sectional area:

- Ingot cast: 6 to 1 minimum
- Continuous-cast strand: 4 to 1 minimum
- Continuous-cast rotary vertical strand: 3 to 1 minimum

**3.4 Chemical Composition.** Compositions of steel grades listed in Table A1 and Table A3 represent typical heat analysis. Steel grades not covered in this specification shall be preapproved by GM Materials Engineering and GM Product Engineering. Steel compositions of grades not covered in this specification shall follow ASTM, DIN, EN, ISO, JIS, or SAE standards.

**3.5 Mechanical Property Requirements.** It is routine practice that steel bar stock is tested for mechanical properties by the steel mill for certification. Properties including hardness, yield and ultimate tensile strengths, and elongation shall be certified for each lot. Typical properties are listed in Table A2 and Table A4.

**3.5.1 Hardness Requirements.** Brinell hardness 10/3000 shall be determined per ISO 6506 or ASTM E10. Forgers may specify a high hardness limit to facilitate bar cut-off operation.

**3.5.2 Tensile Properties.** Tensile testing is to follow requirements per ASTM A370.

**3.6 Internal Cleanliness.** Inclusion types, shapes, and size controls per ASTM E45, Method A, Worst Fields. As permitted in ASTM specifications ASTM A534 and ASTM E45, inclusion ratings shall be based on 0.5 increments, not integer increments. Heat acceptance shall be based on the worst inclusion rating, not average ratings. The rating limits are defined, per steel type, in Table 1.

Equivalent alternative cleanliness rating methods based on regional rating practices such as DIN 50602, EN 10247, or JIS G0555 may be utilized with the agreement of the GM Product Engineer and GM Materials Engineer.

Table 1: Inclusion Rating Limits for Bars based on ASTM E45, Method A, Worst Fields

| Category               | Inclusion Type | Rating Limit      |                          | Inclusion Type Definition |
|------------------------|----------------|-------------------|--------------------------|---------------------------|
|                        |                | Microalloy Steels | Quench and Temper Steels |                           |
| Thin Inclusion Series  | A              | 4.0               | 3.0                      | A = Sulfides              |
|                        | B              | 2.0               | 2.0                      | B = Aluminates            |
|                        | C              | 2.0               | 2.0                      | C = Silicates             |
|                        | D              | 2.0               | 2.0                      | D = Oxides                |
| Heavy Inclusion Series | A              | 2.0               | 2.0                      | A = Sulfides              |
|                        | B              | 2.0               | 2.0                      | B = Aluminates            |
|                        | C              | 2.0               | 2.0                      | C = Silicates             |
|                        | D              | 2.0               | 2.0                      | D = Oxides                |

**3.7 Macrostructure.** Macrostructure is to be examined per ASTM E381 and compared with Plate I to the following limits:

- Subsurface condition class: 3 maximum
- Random condition class: 3 maximum
- Central segregation class: 3 maximum

**3.8 Grain Size.** Average grain size shall be checked per ASTM E112 using the McQuaid-Ehn test. Fine grain size is required within range 5 to 8 per Plate IV.

**3.9 Steel Mill Certificate.** Steel product certificate must be provided with each shipment to the forger. The mill certificate must include test results or information such as steel grade, chemistry, size, weight, condition, mechanical properties (hardness, yield and ultimate tensile strength, elongation, etc.) decarburization, macro and microstructural results, internal cleanliness ratings, and any additional information as required by the forger.

**3.10** All materials supplied to this standard must comply with GMW3059, **Restricted and Reportable Substances**, including the requirement to obtain a GM-approved International Material Data System (IMDS) submission.

## 4 Manufacturing Process

See Section 3.

## 5 Rules and Regulations

**5.1 Legal Regulations.** All materials must satisfy applicable laws, rules, regulations and recommendations valid in the country of usage.

**5.2 Language.** In the event of conflict between the English and domestic language, the English language shall take precedence.

**5.3 Inspection and Rejection.** Samples of components or materials released to a GM material specification shall be tested for conformity with the requirements of this material specification and approved by the responsible Engineering department prior to commencement of delivery of bulk supplies.

A new approval must be received for any changes, e.g., properties, manufacturing process, location of manufacture, etc. If not otherwise agreed, all testing and documentation normally required for initial release must be completed.

It is the responsibility of the supplier to inform the customer in a timely manner, without solicitation, and to include documentation of all modifications of materials and/or processes and to apply for a new release.

## 6 Approved Sources

Materials supplied to this specification must be approved by General Motors (Materials Engineering).

The appropriate GM Materials Engineering department(s) must confirm material as meeting the requirements of this specification. Any test data sheets of material submitted to General Motors for such confirmation (e.g., during Production Part Approval Process (PPAP)) under this material specification must list all properties and must apply corresponding test methods of this material specification.

## 7 Notes

**7.1 Glossary.** Not applicable.

**7.2 Acronyms, Abbreviations, and Symbols.**

|              |                                                  |
|--------------|--------------------------------------------------|
| <b>BOD</b>   | Bill of Design                                   |
| <b>BOM</b>   | Bill of Materials                                |
| <b>BOP</b>   | Bill of Process                                  |
| <b>CTS</b>   | Component Technical Specifications               |
| <b>EL</b>    | Tensile Elongation                               |
| <b>GSSLT</b> | Global Subsystem Leadership Team                 |
| <b>HBW</b>   | Brinell Hardness Number (with Tungsten Indenter) |
| <b>IMDS</b>  | International Material Data System               |
| <b>PPAP</b>  | Production Part Approval Process                 |
| <b>SBQ</b>   | Special Bar Quality                              |
| <b>SOR</b>   | Statement of Requirements                        |
| <b>UTS</b>   | Ultimate Tensile Strength                        |
| <b>VTs</b>   | Vehicle Technical Specifications                 |
| <b>YS</b>    | Tensile Yield Strength                           |

## 8 Coding System

This standard shall be referenced in documents, drawings, etc. as illustrated by the example in Figure 1:

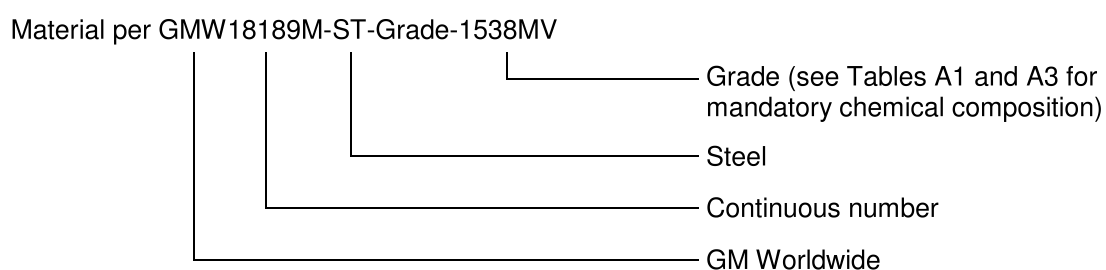


**Figure 1: Alloy Callout Example with All Required Codes**

## 9 Release and Revisions

This standard was originated in June 2019. It was first approved by Materials – Ferrous Materials and Sheet Metal Global Subsystem Leadership Team (GSSLT) in September 2019. It was first published in September 2019.

| Issue | Publication Date | Description (Organization) |
|-------|------------------|----------------------------|
| 1     | SEP 2019         | Initial publication.       |

## Appendix A: Chemical Composition and Mechanical Properties

### A1 Microalloy Steels

**Table A1: Mandatory Chemical Composition for Microalloy Steels**

| Grade     | Composition (wt%) |              |        |                |              |         |              |         |              |         |                |              |                |
|-----------|-------------------|--------------|--------|----------------|--------------|---------|--------------|---------|--------------|---------|----------------|--------------|----------------|
|           | C                 | Mn           | P, Max | S              | Si           | Ni, Max | Cr           | Mo, Max | V            | Cu, Max | Al             | Ti           | N              |
| 1538MV    | 0.36 to 0.40      | 1.30 to 1.45 | 0.02   | 0.050 to 0.065 | 0.50 to 0.65 | 0.15    | 0.10 to 0.20 | 0.05    | 0.08 to 0.12 | 0.25    | 0.03 max       | 0.025 max    | 0.013 to 0.017 |
| 44MnSiVS6 | 0.41 to 0.45      | 1.4 to 1.5   | 0.025  | 0.020 to 0.035 | 0.6 to 0.8   | 0.15    | 0.2 to 0.3   | 0.05    | 0.12 to 0.17 | 0.2     | 0.01 to 0.03   | 0.01 to 0.02 | 0.014 to 0.020 |
| S38MS1V-A | 0.38 to 0.42      | 1.33 to 1.45 | 0.03   | 0.040 to 0.055 | 0.60 to 0.70 | 0.20    | 0.14 to 0.20 | 0.05    | 0.14 to 0.18 | 0.30    | 0.02 max       | 0.025 max    | 0.008 to 0.015 |
| S38MS1V-H | 0.38 to 0.43      | 1.3 to 1.5   | 0.03   | 0.04 to 0.07   | 0.5 to 0.7   | 0.2     | 0.1 to 0.2   | 0.05    | 0.2 to 0.3   | 0.2     | 0.015 to 0.060 | 0.025 max    | 0.008 to 0.015 |
| S40MS1V   | 0.39 to 0.46      | 1.4 to 1.6   | 0.03   | 0.04 to 0.07   | 0.5 to 0.7   | 0.2     | 0.1 to 0.2   | --      | 0.2 to 0.3   | 0.3     | --             | 0.025 max    | 0.008 to 0.015 |

max = maximum

**Table A2: Typical Minimum Mechanical Properties for Microalloy Steels**

| Grade     | UTS (MPa) | YS (MPa) | EL (%) | Hardness HBN <sub>w</sub> |
|-----------|-----------|----------|--------|---------------------------|
| 1538MV    | 830       | 550      | 10     | 255                       |
| S38MS1V-A | 860       | 560      | 8      | 248                       |
| S38MS1V-H | 880       | 580      | 8      | 250                       |
| S40MS1V   | 940       | 650      | 8      | 280                       |
| 44MnSiVS6 | 950       | 660      | 10     | 278                       |