



AEROSPACE MATERIAL

Society of Automotive Engineers, Inc. SPECIFICATION

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CONTROL OF FORGINGS REQUIRING FIRST ARTICLE APPROVAL

1. SCOPE:

- 1.1 Purpose: This specification covers the procedures for obtaining first-article (preproduction) approval of forgings and the controls to be exercised in producing subsequent production forgings.
- 1.2 Application: Primarily for forgings which require preproduction approval and where assurance is required that production lots are of essentially the same metallurgical quality and are produced by the same basic procedures as the forging originally qualified.

2. APPLICABLE DOCUMENTS: None.

3. TECHNICAL REQUIREMENTS:

3.1 Forging Stock:

- 3.1.1 The forging vendor shall determine that the stock conforms to the applicable material specification and will yield acceptable forgings except that tests which are characteristic of a heat or lot and which are conducted by the forging stock vendor need not be repeated by the forging vendor.
- 3.1.2 When specified, forging stock shall be procured from sources approved by the purchaser.

3.2 Preproduction Forgings:

- 3.2.1 Procedure: The forging vendor shall produce and heat treat to final condition, one or more preproduction forgings and shall test a forging or sections thereof to determine conformance to all requirements of the material specification, the drawing, and any additional requirements specified by the purchaser. The preproduction forgings shall be made by the practices to be used on production forgings and, unless otherwise specified, may be produced as part of the initial production run. A duplicate preproduction forging or the remaining section of such a forging shall be submitted to the purchaser for confirmatory testing, when requested.

- 3.2.1.1 When forgings are to be supplied in other than the final heat treated condition, the test forging(s) shall be heat treated to the final heat treated condition of the part. If the as-forged section size is too large to achieve proper heat treatment response, the forging, or a section thereof, shall be machined to a configuration of the same equivalent round as that of the heaviest section of the heat treat configuration.

- 3.2.2 Specimen Locations: The location(s) from which coupons for mechanical property tests and the sections for grain flow examination shall be as specified by the purchaser. The forging vendor shall perform the required tests on specimens from these locations. If locations are not specified, the forging vendor shall select representative areas for testing and, when required, shall obtain concurrence of the purchaser. Mechanical property test specimens shall be taken in the transverse direction whenever practicable unless only longitudinal properties are specified in the material specification.

3.2.2.1 **Grain Flow:** A representative forging shall be sectioned as indicated on the drawing and the sections shall be suitably etched to show the grain flow. Photographs showing the grain flow pattern shall be made of each section and the photographs shall be identified so as to be related to the corresponding sections in the forging. The grain flow shall conform to the requirements of the drawing and good forging practice consistent with the part shape. When the specified alloy is not conducive to good grain flow determination, a substitute alloy or melting practice showing good grain flow and having equivalent forgability shall be substituted and so indicated in the test report.

3.2.2.2 **Mechanical Properties:** Test specimens from the representative forging(s) shall meet the specified mechanical properties for the part in the final heat treated condition.

3.2.3 **Hardness:** Hardness surveys shall be made across the heaviest section of test forgings of carbon and alloy steels, corrosion and heat resistant steels and alloys, copper alloys, and aluminum alloys.

3.2.4 **Conductivity:** Conductivity surveys shall be made across the heaviest section of test forgings of aluminum alloys.

3.2.5 **Microstructure:** Sections shall be taken from the fully heat-treated forging at the center of the heaviest usable section and at the surface of the heaviest and thinnest sections and prepared for metallographic examination. There shall be no detrimental microstructural abnormalities related to improper forging or heat treating practice or to forging stock quality. Photographs of the microstructures shall be submitted and any abnormal microstructural conditions identified.

3.3 **Control Factors:** A resume of the control factors (See 4.4.2.1) established for producing forgings of each part number shall be submitted with the results of tests on the preproduction forging(s); when permitted by purchaser, the resume need not be submitted with the test results but shall be kept on file for review by the purchaser.

3.4 **Production Forgings:** Shall be produced using essentially the same operations, practices, and control factors used on the approved preproduction forging(s).

3.4.1 Production forgings shall not be shipped until the forging vendor has received written approval of the preproduction forging(s), unless preshipment approval is waived by purchaser.

4. QUALITY ASSURANCE PROVISIONS:

4.1 **Responsibility for Inspection:** The forging vendor shall supply all samples and shall be responsible for performing all required tests. Results of such tests shall be reported to the purchaser as required by 4.7. Purchaser reserves the right to perform such confirmatory testing as he deems necessary to ensure that the forgings conform to the requirements of this specification.

4.2 Classification of Tests:

4.2.1 **Acceptance Tests:** Tests of forging stock and forgings to determine conformance to the applicable material specification (3.2.1) and to any additional requirements specified by purchaser are classified as acceptance tests. Such tests of forging stock shall be performed prior to the use of a new heat or lot for production forgings.

4.2.2 **Preproduction Tests:** Tests of preproduction forgings to determine conformance to all technical requirements of the material specification, to grain flow (3.2.2.1), mechanical properties (3.2.2.2), hardness (3.2.3), and microstructure (3.2.5) requirements, and to any additional requirements specified by purchaser are classified as preproduction tests and shall be conducted under the following circumstances:

- Ø 4.2.2.1 The first production of a new forging.
- 4.2.2.2 At any time a change is made in forging design or in control factors (4.4.2.1) which could affect the preproduction tests results.
- 4.2.2.2.1 Forger shall obtain purchaser's concurrence on changes which he deems as not affecting pre-production tests results.
- 4.2.3 For direct U. S. Military procurement of forgings, substantiating test data and, when requested, preproduction test forgings shall be submitted to the cognizant agency as directed by the procuring activity, the contracting officer, or the request for procurement.
- 4.3 Sampling: Shall be as follows; a lot shall be all forgings of the same part number or configuration, opposite hands being considered one configuration, produced from the same heat of forging stock, heated and forged in the same manner, and heat treated in a continuous furnace or in a series of batch-type furnace operations with no change in furnace settings or interruption of power.

4.3.1 Acceptance Tests: As specified in the material specification and as follows:

- 4.3.1.1 Mechanical properties shall be determined on each forging or on a prolongation of each forging furnished heat treated to the final condition of the part when serialization of forgings is required, unless otherwise specified.
- 4.3.1.2 Samples shall be taken from the first shipment of forging stock of each heat to determine ability of stock from that heat to yield acceptable forgings and to meet all acceptance test and periodic test requirements of the material specification.
- 4.3.2 Preproduction Tests: As specified in Section 3, tests shall be conducted at the time of the first production of a new forging by a vendor and following any change in configuration of the forging design.
- 4.3.3 Mechanical Property Test Specimens: Shall be taken in the locations and directions specified by the purchaser.

4.4 Approval:

- 4.4.1 Preproduction forgings and the forging procedure shall be approved by purchaser before production forgings are supplied. Approval of preproduction test results and forging procedures shall in no way relieve the forging vendor of responsibility for continued conformance to all requirements.
- 4.4.2 The forging vendor shall establish for each part number or configuration the parameters for the control factors of processing, which will produce forgings conforming to the requirements of this specification and the material specification. These shall constitute the approved manufacturing procedures and shall be used for production forgings. If any change is necessary in parameters for control factors of processing, the forging vendor shall submit for reapproval a statement of the proposed changes and, when requested, perform preproduction tests of revised forgings. Production forgings incorporating the revised operations shall not be shipped prior to receipt of reapproval.

4.4.2.1 Control factors for producing forgings include, but are not limited to, the following:

Type (ingot, bloom, billet, or bar), nominal size (cross-sectional area), shape, and nominal multiple-weight of forging stock; rounds and round-corner-squares of the same nominal cross-sectional area are considered the same shape

Inspection and qualification of forging stock

Processing sequence or number of operations that would result in different cross-sectional structure, grain flow, or working of the metal

Type of forging equipment (e.g., press, hammer, ring roll, etc)

Description of dies

Thermal cycling, including heating of stock for forging, annealing, and heat treatment of forgings

Protective atmosphere and/or coatings

Cleaning operations, (e.g., chemical descaling, blasting)

Inspection procedures

4.4.2.1.1 Any of the above control factors of processing for which the parameters are considered proprietary by the vendor may be assigned a code designation. Each variation in such factors shall be assigned a modified code designation. The vendor shall maintain complete records of all proprietary processes and factors.

4.5 Records:

4.5.1 **Maintenance of Facilities:** Each forging vendor shall keep records demonstrating that the facilities used to produce control, measure, and test forging stock and forgings during manufacture and inspection are properly maintained and are checked for accuracy at stated intervals against acceptable standards for accuracy. Records shall be on file for not less than 7 years, unless otherwise specified.

4.5.2 **Process Sheets:** For each forging part number or configuration, opposite hands being considered a single configuration, the forging vendor shall prepare and maintain documented instructions defining the processing methods and routing in manufacturing and inspection cycles.

4.6 **Surveillance Visits:** The forging vendor shall, when requested, permit purchaser's authorized personnel to survey all facilities and controls related to production of forgings to this specification and to review vendor's control of materials and of chemical and metallurgical processing during production.

4.7 **Reports:** The forging vendor shall furnish with the preproduction forging(s) or sections thereof a report showing the results of tests to determine conformance to the technical requirements of this specification, the applicable material specification, and the drawing and shall include photographs of the grain flow and microstructures.