

TECHNICAL SPECIFICATION

No. TS145™

**MANUFACTURING SPECIFICATION FOR BOLTS
(UNIFIED THREADS)
HEAT RESISTING ALLOY STEEL FV535,
CLASSIFICATION $R_m \geq 1000 \text{ MPa}$ (145,000 lbf/in²) @ T_A / +550°C**



RATIONALE

Fifth issue of Technical Spec.

General up-date to include latest material & other specs.

Addition of material spec prEN4245.

For full details of changes, refer to supplementary SAE ITC Amendment Record document TS145-AR.

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**SAE INDUSTRY TECHNOLOGIES CONSORTIA
AEROSPACE STANDARDS AND PART QUALIFICATION PROGRAM**

FOREWORD

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1. SCOPE

- 1.1 This Technical Specification covers the requirements for forged Bolts with unified threads, made from X8CrCoNiMo10-6 (FV535) heat resisting alloy steel material in accordance with prEN 2493 (FE-PM38) or prEN 4245 (FE-PM1708), with rolled underhead radii. The bolts shall develop a minimum tensile strength of 1000 MPa (145,000 lbf/in²) at ambient room temperature & are suitable for use up to a temperature of +550°C.

2. NORMATIVE REFERENCES

- 2.1 The following documents, in whole or in part, are normatively referenced in this specification. For dated / revision listed references, only the issue stated applies. For undated / revision listed references, the latest issue of the referenced document (including any amendments) applies :-

2.1.1 SAE Industry Technologies Consortium (ITC)

RS678	Fasteners, Rolled Threads, Chamfers, Lead Threads & Runouts
TS200	Qualified Manufacturers for SAE ITC Aerospace Industry Standard Parts
TS201	Method Change Approval for Qualified parts listed in TS200
TS202	Qualification Test Requirements & Procedures for Aerospace Industry Standard Parts

2.1.2 British Standards Institution (bsi.)

BS M 39	Method for Penetrant inspection of aerospace materials and components
BS 1134	Assessment of surface texture - Guidance and general information
BS 6072	Method for Magnetic particle flaw detection
(BS) EN 2002-1	Metallic materials - Test methods - Part 1 : Tensile testing at ambient temperature
(BS) EN ISO 6506-1	Metallic materials - Brinell hardness test - Part 1 : Test method
(BS) EN ISO 6507-1	Metallic materials - Vickers hardness test - Part 1 : Test method
(BS) EN ISO 6508-1	Metallic materials - Rockwell hardness test - Part 1 : Test method (scales A, B, C, D, E, F, G, H, K, N & T)

2.1.3 International Standards Organisation (ISO)

ISO 2859-1 : 1999	(BS 6001-1) Sampling procedure for inspection by attributes – Part 1 : Sampling schemes indexed by acceptance quality limits (AQL) for lot-by-lot inspection
ISO 3161	(BS A 346) UNJ threads - General requirements and limit dimensions

2.1.4 Euro Norm prestandard (ASD-STAN)

(pr)EN 2493	Heat Resisting Steel FE-PM38 - 1000 MPa ≤ Rm ≤ 1140 MPa – Bars – Aerospace Series
(pr)EN 4245	Heat resisting alloy FE-PM1708 - Vacuum arc remelted - As forged - Forging stock - De ≤ 300mm

2.1.5 American Society for Testing and Materials (ASTM)

ASTM E1417	Standard Practice for Liquid Penetrant Testing
ASTM E1444	Standard Practice for Magnetic Particle Testing

3. DEFINITIONS

For the purpose of this specification, the following definitions apply.

3.1 Authorities

3.1.1 Design Authority

The Design Authority is the SAE ITC Technical Standards Committee (TSC).

3.1.2 Qualification Testing Authority

In accordance with SAE ITC TS202, the Qualification Testing Authority shall be the Design Authority or other body nominated by the TSC to carry out the testing.

3.1.3 Quality Assurance Authority

The Quality Assurance Authority shall be as agreed by the design authority, but generally it will be that of the design activity.

3.2 Production Batch

A batch shall consist of bolts which are of the same type & thread diameter. They shall be fabricated by the same process from material of the same cast, heat-treated as one lot & produced as one continuous run. Production shall be free from any interruptions or changes, such as might be expected to result in a significant variation in the quality of the finished product.

3.3 Inspection Lot

An inspection lot consists of bolts from a single production batch of the same part number which completely defines the lot.

3.4 Discontinuities

3.4.1 **Crack** : A rupture in the material which may extend in any direction & which may be intercrystalline or transcrystalline in character.

3.4.2 **Seam** : An open surface defect.

3.4.3 **Lap** : A surface defect caused by folding over metal fins or sharp corners & then rolling or forging them into the surface.

3.4.4 **Inclusion** : Non-metallic particles originating from the material making process. They may exist as discrete particles or strings of particles extending longitudinally.

3.4.5 **Burr** : A rough edge or ridge left on the metal due to a cutting, grinding, piercing or blanking operation.

3.5 Test Temperature

The ambient temperature, unless otherwise specified.

3.6 Simple Random Sampling

The taking of n items from a population of N items, in such a way that all possible combinations of n items have the same probability of being chosen.

3.7 Critical Defect

A defect that according to judgement & experience, is likely to result in hazardous or unsafe conditions for individuals using, maintaining, or depending upon the considered product, is likely to prevent performance of the function of a major end item.

3.8 Major Defect

A defect other than critical, that is likely to result in a failure or to reduce materially, the usability of the considered product for its intended purpose.

3.9 Minor Defect

A defect that is not likely to reduce materially, the usability of the considered product for its intended purpose, or is a departure from established specification, having little bearing on the effective use or operation of the product.

3.10 Sampling Plan

A plan according to which, one or more samples are taken in order to obtain information to be able to reach a decision as to a lot's acceptance or rejection.

3.11 Limiting Quality LQ₁₀

In a sampling plan, a quality level which corresponds to a specified & relatively low probability of acceptance - in this case 10% probability of acceptance. It is the limiting lot quality characteristic that a lot of this quality would occur. When expressed as a percent defective, it may be referred to as a lot tolerance percent defective.

3.12 Acceptable Quality Level

A quality level which in a sampling plan, corresponds to a specified but relatively high probability of acceptance. It is the maximum percent defective (or the maximum number of defects per hundred units) that, for purposes of sampling inspection, can be considered satisfactory as a process average.

3.13 Finished Bolt

A bolt ready for use, inclusive of any possible treatments &/or surface coatings, as specified on the relevant bolt's SAE ITC drawing standard.

4. QUALITY ASSURANCE

4.1 General

4.1.1 Material & Surface Treatment

4.1.1.1 The bolt Manufacturer shall provide evidence to the Quality Assurance Authority that the controls for the bolt material & surface treatment process complies with the relevant specifications. They shall also show the identity of the bolt material has been maintained throughout all stages of manufacture.

4.1.2 Records

4.1.2.1 The Manufacturer shall establish a batch record chart (or card) to the satisfaction of the Quality Assurance Authority. The record shall show the batch quantity & the serial numbers of certificates covering approval of the material. The results of the inspections & tests made to the requirements of this specification, shall be recorded & correlated with the batch numbers & the batch chart (or card) shall show the serial numbers of those records to the satisfaction of the Quality Assurance Authority.

4.1.3 Dimensional Control during Manufacture

4.1.3.1 The manufacturer shall satisfy the Quality Assurance Authority that the frequency & results of inspections made at each operation during manufacture of each part, are adequate.

4.1.4 Dimensions & Gauging

4.1.4.1 All dimensions shall be controlled by a system of gauging which, with the type & quality of all gauges, projection apparatus, diagrams & inspection techniques, shall be to the satisfaction of the Quality Assurance Authority. In cases of dispute :-

- a) The full threads shall be checked with fixed limit gauges.
- b) Notwithstanding the reaction of the threads to the gauges, the overall profile must be acceptable when checked with an optical projector & line limit diagrams.

4.1.4.2 Each gauge & projection diagram shall be marked with its reference number (serial number) & in the case of non-adjustable gauges, marked with the gauging dimensions. Each gauge shall further be certified initially & thereafter the standard of accuracy of each gauge shall be maintained by regular certification, either at an approved gauge test house or if agreed with the Quality Assurance Authority, at the Manufacturer's own test room. The accuracy of each projection diagram shall be to the satisfaction of the Quality Assurance Authority.

4.1.4.3 A record card shall be maintained for each gauge, showing the initial dimensions of each gauging element, the frequency of the maintenance checks & the gauge dimensions resulting therefrom, to the satisfaction of the Quality Assurance Authority.

4.2 Qualification

4.2.1 A minimum of 25 finished bolts of each thread diameter for which qualification is required, manufactured in accordance with the requirements of this specification & by a technique which is to be used for future deliveries, shall be supplied by the bolt manufacturer for evaluation in accordance with SAE ITC TS202.

4.2.2 The qualification inspections & tests (requirements, methods, numbers of bolts) are specified in Table 1.

4.2.3 Table 2 indicates the allocation of bolt specimens for the inspections & tests.

4.2.4 Re-qualification may be called for from time-to-time at the discretion of the Design Authority.

4.2.5 If there is any proposed change in manufacturing source or method, the procedures specified in SAE ITC TS201 shall be initiated.

4.3 Acceptance

4.3.1 The purpose of acceptance inspections & tests, is to check as simply as possible using a method representative of actual conditions of use, with the uncertainty inherent in statistical sampling, that the bolts satisfy the requirements of this specification.

4.3.2 Acceptance inspections & tests are specified in Table 1. They shall be carried out on each production batch or inspection lot. Sampling shall meet the requirements of Tables 3, 4 & 5 unless more stringent requirements are agreed between the manufacturer & the purchaser. Bolts from the batch to be tested, shall be selected by simple random sampling.

4.3.3 Each bolt may be submitted to several inspections or tests. The bolts to be subjected to destructive inspections or tests, may be those on which non-destructive inspections or tests have already been carried out.

4.3.4 If a more stringent inspection (see clause 4.3.2) is deemed necessary, all or part of the qualification inspections or tests may be performed during the acceptance inspection & testing. In this case, the number of bolts submitted for these inspections tests is the same as that submitted for qualification inspections & tests.

4.3.5 Acceptance inspections & tests shall be carried out by the manufacturer, or under their responsibility.

4.4 Inspection & Test Report

4.4.1 A test report showing actual numerical values for the mechanical test results shall be provided.

4.4.2 The test report shall include a statement that dimensional inspection has been carried out to the latest issue of SAE ITC TS145 (this specification) & that all results conform to the bolt's SAE ITC drawing standard.

4.5 Qualified Manufacturers of the Forged Bolts

4.5.1 A list of qualified manufacturers of prEN 2493 or prEN 4245 material forged bolts is contained in SAE ITC TS200 (latest issue).

5. MANUFACTURING & TEST REQUIREMENTS

See Table 1.

TABLE 1 - MANUFACTURING & TEST REQUIREMENTS

Clause	Characteristic	Requirement	Inspection & test method	Q/A 1)	Sample size
5.1	Material	In accordance with or prEN 2493 or prEN 4245.	Chemical analysis or certificate issued by the material manufacturer.		
5.2	Dimensions, tolerances of form & position	In accordance with the relevant bolt SAE ITC drawing standard.	Standard gauging.	Q A	25 Tables 3 & 4
5.3	Manufacturing				
5.3.1	Forging	Bolts shall be formed by methods agreed with the Design Authority. If hot formed, the temperature of the part shall not exceed +1170°C. All heating equipment used for forming shall be of a type which ensures a consistent temperature throughout the bolt's feature being worked & throughout the batch. Any coating applied to the bar or wire shall be completely removed prior to heat treatment. Any lightening hole in the head may be machined or forged.	The method of forging shall be declared to & approved by the Design Authority.		
5.3.2	Heat treatment	Before machining, as in clause 5.3.3, the headed blanks shall be heat treated as follows :- If required by the manufacturer, post forge refine at +790°C ± 5°C for 2 hours followed by cooling in air to ambient room temperature. The headed blanks shall be preheated to +675°C ± 25°C, then heated to +1170°C ± 10°C, followed by oil or fast gas quench. The headed & hardened blanks shall then be tempered at +610°C ± 5°C for 2 to 5 hours & air cooled, followed by +635°C ± 15°C for 2 to 5 hours & air cooled. The heat treatment atmosphere or medium shall not cause any surface contamination except as permitted by clause 5.5.4. Any scale which cannot be removed by subsequent machining (i.e. from the bolt head) shall be removed by abrasive blasting by a method approved by the Design Authority, before machining to the requirements of clause 5.3.3.	The heat treatment equipment shall be approved by the Design Authority & shall be of a type which ensures a uniform temperature throughout the parts & shall be operated by automatic temperature controllers. The equipment for abrasive blasting shall be approved by the Design Authority.		

1) Q = Qualification, A = Acceptance