

NIST HANDBOOK 150-18
2009 Edition

National
Voluntary
Laboratory
Accreditation
Program

FASTENERS
AND
METALS

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October 2009



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Foreword

The NIST Handbook 150 publication series sets forth the procedures, requirements, and guidance for the accreditation of testing and calibration laboratories by the National Voluntary Laboratory Accreditation Program (NVLAP). The series is comprised of the following publications:

- NIST Handbook 150, *NVLAP Procedures and General Requirements*, which contains the general procedures and requirements under which NVLAP operates as an unbiased third-party accreditation body;
- NIST Handbook 150-xx series program-specific handbooks, which supplement NIST Handbook 150 by providing additional requirements, guidance, and interpretive information applicable to specific NVLAP laboratory accreditation programs (LAPs).

The program-specific handbooks are not standalone documents, but rather are companion documents to NIST Handbook 150. They tailor the general criteria found in NIST Handbook 150 to the specific tests, calibrations, or types of tests or calibrations covered by a LAP.

NIST Handbook 150-18, *NVLAP Fasteners and Metals*, presents the technical requirements and guidance for the accreditation of laboratories under the NVLAP Fasteners and Metals LAP. The 2009 edition incorporates changes resulting from the release of the newest editions of ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*, and NIST Handbook 150, as well as editorial improvements. The 2009 edition of NIST Handbook 150-18 supersedes and replaces the 2006 edition.

The handbook was revised with the participation of technical experts in the field of fasteners and metals testing and was approved by NVLAP. The following significant changes have been made to this handbook with respect to the previous edition:

- all references to applicable international guides and standards have been updated;
- on-site assessment checklists are no longer included as appendices in order that they may be provided as separate documents, which can be updated at different intervals from that of the handbook;
- where appropriate, the body of the handbook has been restructured to conform with internationally accepted rules for the structure and drafting of standards to promote ease of use and understanding.

This handbook is also available on the NVLAP web site (<http://www.nist.gov/nvlap>).

Questions or comments concerning this handbook should be submitted to NVLAP, National Institute of Standards and Technology, 100 Bureau Drive, Stop 2140, Gaithersburg, MD, 20899-2140; phone: 301-975-4016; fax: 301-926-2884; e-mail: nvlap@nist.gov.

Introduction

The Fastener Quality Act (FQA), Public Law (PL) 101-592, was signed by President George H. W. Bush on November 16, 1990. The Act protects public safety by: (1) requiring that certain fasteners sold in commerce conform to the specifications to which they are represented to be manufactured; (2) providing for accreditation of laboratories engaged in fastener testing; and (3) requiring inspection, testing and certification in accordance with standardized methods.

The Act requires the Secretary of Commerce, acting through the Director of NIST, to establish a laboratory accreditation program for fastener testing laboratories under the procedures of the National Voluntary Laboratory Accreditation Program (NVLAP). The accreditation program includes test methods that are required by fastener specifications or standards covered by the Act. Since fastener testing involves a wide range of expertise, accreditation is offered in the areas of mechanical and physical testing and inspection, metallography, nondestructive inspection, dimensional inspection, and chemical analysis.

On March 7, 1996, President William J. Clinton signed the National Technology Transfer and Advancement Act of 1995, PL 104-113, which amended the FQA to further clarify and define the requirements of the original Act. Further amendments were promulgated by PL 105-234 (August 14, 1998), an act exempting certain fasteners approved by the Federal Aviation Administration from FQA coverage, and PL 106-34 (June 8, 1999), the FQA Amendments Act of 1999.

1 General information

1.1 Scope

1.1.1 This handbook specifies the technical requirements and provides guidance for the accreditation of laboratories under the NVLAP Fasteners and Metals Laboratory Accreditation Program (Fasteners and Metals Program). This handbook supplements the NVLAP programmatic procedures and general requirements found in NIST Handbook 150 and the superseding requirements found in the Fastener Quality Act.

1.1.2 NIST Handbook 150, this handbook, and the checklists (see 1.6) constitute the collective body of requirements that must be met by a laboratory seeking NVLAP accreditation for the Fasteners and Metals Program. The interpretive comments and additional requirements contained in this handbook make the general NVLAP criteria specifically applicable to the Fasteners and Metals Program. Specific circumstances under which departures from the NVLAP general procedures are allowable within the scope of the Fasteners and Metals Program are also addressed in this handbook (see 5.4.3).

1.1.3 This handbook is intended for information and use by accredited fasteners laboratories, assessors conducting on-site assessments, laboratories seeking accreditation, other laboratory accreditation systems, users of laboratory services, and others needing information on the requirements for accreditation under the Fasteners and Metals Program.

1.2 Organization of handbook

The numbering and titles of the first five clauses of this handbook match those of NIST Handbook 150. The primary subclauses in clauses 4 and 5 (e.g., 4.1, 4.2, etc.) are numbered and titled to correspond with the subclauses in NIST Handbook 150, even when there are no requirements additional to those in NIST Handbook 150.

Annex A (informative) contains a listing of the major areas of fasteners and metals testing and the types of test methods in each area offered for accreditation by NVLAP.

1.3 Program description

1.3.1 This accreditation program is designed to satisfy the requirement of the Fastener Quality Act (FQA) for accreditation of laboratories engaged in fastener testing.

1.3.2 Accreditation is available for standard test methods in mechanical and physical testing and inspection, metallography, nondestructive inspection, dimensional inspection, and chemical analysis. Non-standard or laboratory-developed test methods may be added to the program upon request if they are found to be appropriate by NVLAP.

1.4 References

The following documents are referenced in this handbook. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any

amendments) shall apply within one year of publication or within another time limit specified by regulations or other requirement documents.

— Fastener Quality Act, Public Law 101-592, as amended by P.L.104-113 and P.L. 105-234 and P.L 106-34, available at <<http://ts.nist.gov/WeightsAndMeasures/fqaregs2.cfm>>

— National Technology Transfer and Advancement Act of 1995, Public Law 104-113, 1995, available at <<http://ts.nist.gov/standards/information/113.cfm>>

— NIST Handbook 150, *NVLAP Procedures and General Requirements*, available at <<http://www.nist.gov/nvlap>>

— NIST Technical Note 1297, 1994 edition, *Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results*, available at <<http://physics.nist.gov/Pubs/guidelines/TN1297/tn1297s.pdf>>

1.5 Terms and definitions

For the purposes of this handbook, the terms and definitions given in NIST Handbook 150 and the Fastener Quality Act apply.

1.6 Program documentation

1.6.1 General

Assessors use checklists to ensure that each laboratory receives an assessment comparable to that received by others. Checklists assist assessors in documenting the assessment to the NVLAP requirements found in NIST Handbook 150, this handbook, and the checklists themselves. Checklists contain definitive statements or questions about all aspects of the NVLAP criteria for accreditation, and form part of the On-Site Assessment Report (see NIST Handbook 150). The current version of each checklist is available on the NVLAP web site <<http://www.nist.gov/nvlap>>.

1.6.2 NIST Handbook 150 Checklist

All NVLAP programs use the NIST Handbook 150 Checklist (formerly called the General Operations Checklist), which contains the requirements published in NIST Handbook 150. The checklist items are numbered to correspond to clauses 4 and 5 and annexes A and B of NIST Handbook 150.

1.6.3 NIST Handbook 150-18 Checklist

The NIST Handbook 150-18 Checklist (formerly called the Specific Operations Checklist) addresses the requirements specific to fasteners and metals testing given in NIST Handbook 150-18. The checklist may contain more detailed requirements than found in this handbook.

1.6.4 Test Method Review Summary

The assessor uses the *Test Method Review Summary* to review the laboratory's ability to perform the test methods. The review of the test methods by the assessor ranges from observing tests to having laboratory staff describe the test procedures.

1.6.5 NVLAP Lab Bulletins

NVLAP Lab Bulletins are issued to laboratories and assessors, when needed, to clarify program-specific requirements and to provide information about program additions and changes.

2 LAP establishment, development and implementation

This clause contains no information additional to that provided in NIST Handbook 150, clause 2.

3 Accreditation process

3.1 General

An overview of the laboratory accreditation process is provided in NIST Handbook 150, clause 3, and includes information pertaining to application for accreditation; on-site assessment; proficiency testing; accreditation decision; granting accreditation; renewal of accreditation; changes to scope of accreditation; monitoring visits; and suspension, denial, revocation, and voluntary termination of accreditation.

3.2 Management system review

3.2.1 Prior to applying to NVLAP for accreditation, a laboratory shall have a fully implemented management system.

3.2.2 The NVLAP assessor assigned to conduct the on-site assessment will request a copy of the laboratory's management system manual and relevant documented procedures in advance of the assessment to reduce time at the laboratory.

3.2.3 The assessor will review all relevant management system documentation for conformity with NVLAP requirements, including the requirements of NIST Handbook 150 and this handbook. During this review, the assessor may request additional management system documents and/or records, which will be returned upon request.

3.3 On-site assessment

3.3.1 The purpose of the on-site assessment is to determine if the laboratory is following its documented management system and to assess the competence of the laboratory's testing services. The laboratory shall be prepared to conduct test demonstrations, have equipment in good working order, and be ready for examination according to the requirements identified in this handbook, NIST Handbook 150,

the NIST Handbook 150-18 Checklist, and the laboratory's quality manual. The assessor will need time and workspace to complete assessment documentation during the visit.

3.3.2 In addition to the checklists, to help assure the completeness, objectivity, and uniformity of the on-site assessment, the assessor uses the NVLAP Test Method Review Summary to review the ability of laboratory personnel to perform the test methods. The test method review ranges from observing tests to having laboratory staff describe the test procedures. The assessor notes the depth to which each part of the test method was reviewed and records the results of the review on the summary.

3.3.3 An assessor performs the following activities during a typical on-site assessment:

- a) Conducts an opening meeting with the laboratory manager to explain the purpose of the on-site visit and to discuss the schedule for the assessment activities. At the discretion of the laboratory manager, other staff may attend the meeting.
- b) Reviews laboratory documentation not provided for review before the assessment. At least one laboratory staff member shall be available to answer questions; however, the assessor may wish to review the documents alone. Documents previously supplied will be returned.
- c) Physically examines equipment and facilities, observes the demonstration of selected procedures by appropriate personnel assigned to conduct the tests, and interviews those personnel. The demonstrations requested may be selective or all-inclusive and shall include sample test material(s), preparation and calibration of devices and equipment, and establishment of test conditions and the setup/use of major equipment. The assessor may provide proficiency test samples and request a specific demonstration.
- d) Completes an On-Site Assessment Report, which contains the NIST Handbook 150 Checklist, the NIST Handbook 150-18 Checklist, and the Test Method Review Summary, and conducts a closing meeting. At the closing meeting, the report is signed by the assessor and the laboratory's Authorized Representative to acknowledge the discussion. The Authorized Representative's signature does not necessarily indicate agreement, and challenges may be made through NVLAP.

3.3.4 The information gathered by the assessor is held in strict confidence.

3.4 Proficiency testing

3.4.1 Participation in proficiency testing is required for laboratories applying for accreditation for test methods under Rockwell hardness of fasteners (externally threaded), axial tensile strength of full-size threaded fasteners, wedge tensile strength of full-size threaded fasteners, tensile strength tests of machined aluminum and steel, fastener double shear, case depth, round dimensional, and chemical analysis. Proficiency testing is conducted biannually (twice a year) for each of these areas.

NVLAP may expand its requirements for proficiency testing to include other test methods in the major areas of testing.

3.4.2 If an accredited laboratory fails a proficiency test, it shall complete the following requirements to maintain its accreditation:

- a) Within 30 days of notification of failure, submit detailed, written documentation to NVLAP that includes an analysis of why the laboratory failed each part of the test and what corrective actions it

has taken (analyst training, revised procedures, quality assurance activities, etc.) to resolve its analytical problems so as to avoid similar errors in the future. Documented evidence that the corrective actions have been effectively implemented is also required.

b) Participate successfully in the next round of proficiency testing.

3.4.3 If a laboratory fails the same type of proficiency testing twice in succession, its accreditation for test methods of the type tested will be suspended. Accreditation will be reinstated upon successful participation in the next round of proficiency testing.

If a laboratory generally exhibits an erratic pattern in testing, NVLAP will review all current and previous proficiency testing results and advise the laboratory of what actions must be taken by the laboratory in response to the nonconformities causing the erratic testing. Failure to correct the nonconformities may result in suspension of accreditation. In some cases, to regain accreditation, the laboratory shall undergo a complete on-site assessment to determine the cause of the nonconformities and to determine by further proficiency testing that effective corrective actions have been implemented. The laboratory shall provide NVLAP with documentation within 30 days of the assessment that adequately demonstrates that the nonconformities noted by the assessor have been satisfactorily resolved. Failure to perform fully satisfactorily in the on-site assessment will result in accreditation remaining suspended.

The laboratory shall pay for the full cost of an on-site assessment in advance. NVLAP staff will make every effort to expedite these extraordinary assessments to give a laboratory every reasonable opportunity to demonstrate competence to perform the test method and regain accreditation.

3.4.4 Failure to participate in a round of proficiency testing will result in immediate suspension of accreditation for the specific test method(s) covered by the proficiency test, and the laboratory shall successfully participate in the next regularly scheduled round to have its accreditation reinstated.

3.4.5 In no case shall proficiency test samples be considered as calibration standards or standard reference materials or be used as substitutes for calibration standards that are traceable to national (i.e., NIST) or international standards laboratories.

4 Management requirements for accreditation

4.1 Organization

There are no requirements additional to those set forth in NIST Handbook 150.

4.2 Management system

There are no requirements additional to those set forth in NIST Handbook 150.

4.3 Document control

There are no requirements additional to those set forth in NIST Handbook 150.

4.4 Review of requests, tenders and contracts

There are no requirements additional to those set forth in NIST Handbook 150.

4.5 Subcontracting of tests and calibrations

4.5.1 Whenever a laboratory performs work under its scope of accreditation, it is implied that the report reflects work performed and results obtained by the personnel, equipment, and procedures of that laboratory. However, in some cases a laboratory may require the use of another facility (i.e., a subcontractor) due to equipment failure, need for specialized equipment, work overload, or the need to perform tests outside the laboratory's own scope of accreditation.

4.5.2 A competent subcontractor is one who is accredited to ISO/IEC 17025 by a mutually recognized third-party accrediting body (such as NVLAP) for the test method outsourced.

4.5.3 Criteria for selection, evaluation and re-evaluation of a subcontractor shall be established and documented in the laboratory management system.

4.5.4 Whenever a laboratory subcontracts the performance of any test or portion of a test to another laboratory, the subcontracting laboratory shall:

- a) place the work with a competent subcontractor as defined in 4.5.2;
- b) inform the customer in writing, before the fact, of the intent to subcontract the testing;
- c) clearly identify in its records and in the report to the customer specifically which test method(s) or portions of a test method(s) were subcontracted (see also NIST Handbook 150, Annex A, A.1 h) and i).

4.6 Purchasing services and supplies

There are no requirements additional to those set forth in NIST Handbook 150.

4.7 Service to the customer

There are no requirements additional to those set forth in NIST Handbook 150.

4.8 Complaints

4.8.1 The laboratory's complaint process shall include the activities of problem identification, cause analysis, counter measure, and remediation.

4.8.2 Where a complaint raises doubt concerning the laboratory's compliance with its management system, policies, procedures or any test method performance, the laboratory shall ensure that the area(s) in question is promptly audited in accordance with 4.14.

4.9 Control of nonconforming testing and/or calibration work

4.9.1 If a test report containing incorrect results was issued in conjunction with nonconforming testing, the laboratory shall revoke the incorrect test report in writing, and after all steps are completed, shall reissue the report with an indication that the test report is now a “corrected report.”

4.9.2 Records of the nonconforming work, including subsequent actions taken and concessions obtained, if any, shall be maintained for a minimum of three years.

4.10 Improvement

There are no requirements additional to those set forth in NIST Handbook 150.

4.11 Corrective action

4.11.1 Records of corrective actions shall be maintained by the lab.

4.11.2 The laboratory shall take the following steps in performing the corrective action process in addition to the requirements found in NIST Handbook 150:

- a) identification of nonconformities, including those arising from customer complaints;
- b) correction of the nonconformities with the test items and/or conditions at hand;
- c) identification of the same nonconformities with others of the same test-item group and/or conditions;
- d) identification of test items and/or conditions already in the test process, but not up to the step where the nonconformity was identified;
- e) continuation of the search until satisfied that all of the nonconformities are located and corrected.

4.12 Preventive action

Records of preventive actions shall be maintained by the laboratory.

4.13 Control of records

4.13.1 If a fastener testing laboratory is part of a fastener manufacturing business, “Records of Conformance,” as defined in the FQA, Section 3, *Definitions*, Part 13, designated for each lot of fasteners sold or offered for sale shall be retained by the laboratory for a minimum of five years. (See also NIST Handbook 150, 5.10.3 and PL 106-34.)

4.13.2 All other records shall be retained by the laboratory for a minimum of three years.

4.14 Internal audits

4.14.1 The internal audit shall cover compliance with NVLAP, laboratory management system, regulatory, contractual, and testing requirements.

4.14.2 An applicant laboratory shall conduct at least one complete internal audit prior to the first on-site assessment. The records will be reviewed by the NVLAP assessor before or during the on-site assessment visit.

4.14.3 For laboratories that have achieved accreditation, reports of internal audits conducted since the previous on-site assessment shall be made available for review.

4.14.4 Internal audits are separate and distinct from both management reviews (see 4.15) and NVLAP on-site assessments.

4.15 Management reviews

4.15.1 Periodic reviews of the management system shall reflect adherence to NVLAP requirements and the laboratory's quality objectives.

4.15.2 Management reviews shall include a review of all nonconformities and may reflect positive aspects of the management system.

4.15.3 An applicant laboratory shall perform at least one complete management review prior to the first on-site assessment. The records will be reviewed by the NVLAP assessor before or during the on-site assessment visit.

4.15.4 The report of the management review shall be available during the NVLAP on-site assessment.

5 Technical requirements for accreditation

5.1 General

There are no requirements additional to those set forth in NIST Handbook 150.

5.2 Personnel

5.2.1 The laboratory shall have a detailed, documented description of its training program for new and current staff members. The test results obtained by new staff members shall be checked by a staff member whose performance has been demonstrated to be acceptable until the new staff member demonstrates the required level of performance. Documented performance criteria shall be established to determine when a new staff member has achieved the required level of performance.

5.2.2 Each approved signatory shall have a written justification of his/her selection for these responsibilities that is signed by top management with executive-level responsibility.

5.2.3 The laboratory shall maintain a current summary of the information required in NIST Handbook 150, 5.2.5, in matrix format. The matrix shall correlate authorized staff with each test method on the laboratory's scope of accreditation.

5.2.4 Personnel records not available in the laboratory due to corporate regulations, governmental regulations, etc., shall be made accessible for review during the assessment from the department having the assigned jurisdiction.

5.3 Accommodation and environmental conditions

Original equipment manufacturer requirements for test laboratory equipment shall be considered by the laboratory when making decisions regarding the levels of accommodation and environmental conditions for the room where the equipment is used.

5.4 Test and calibration methods and method validation

5.4.1 Laboratories shall use standards and specifications that are published by a consensus standards organization or by a government agency, or standards from private industry sources in the five major areas of testing listed in 5.4.2. The laboratory shall have a copy of all standards, test methods, or specifications for which it seeks accreditation.

5.4.2 Testing conducted in the Fasteners and Metals Program is divided into five major areas of testing:

- a) mechanical and physical testing and inspection;
- b) nondestructive inspection;
- c) dimensional inspection;
- d) chemical analysis;
- e) metallography.

Each of these major areas is further divided into test groups, with the mechanical and physical testing and inspection area further divided into subgroups. Individual standards, test methods, and specifications fall under the test groups or subgroups. A breakdown of the five major areas is provided in Annex A.

5.4.3 The laboratory shall conform in all respects with the standard, test method, or specification employed for a given test, except when a departure becomes necessary for technical reasons. Laboratories utilizing departures from a test method shall have written procedures detailing how the analysis is conducted. These procedures shall include criteria to determine when such departures are warranted. The laboratory shall have data to demonstrate that departures do not detract from the expected precision and accuracy of a measurement.

5.4.4 Where a standard, test method, or specification does not adequately cover all aspects of testing (i.e., sampling, sample preparation, etc.), the laboratory shall have written procedures to address the necessary processes.

5.5 Equipment

5.5.1 All equipment shall be properly maintained to ensure protection from corrosion and other causes of deterioration (see NIST Handbook 150, 5.5.6). Instructions for proper maintenance of equipment that requires periodic maintenance shall be available.

5.5.2 When a test method is performed and/or has results reported on testing equipment controlled by computer software, the following requirements apply to the records maintained of the equipment in addition to the requirements of NIST Handbook 150, 5.5.5.

- a) When revisions, patches, upgrades and/or regular maintenance require the software to be altered, a description of the changes made shall be recorded in the applicable records retained by the laboratory, including new version number, date of revision, and evidence of validation of the proper performance of the testing equipment “as left.”
- b) A laboratory operator, knowledgeable of the equipment performance, shall make a written indication on the applicable records that the final status of the equipment “as left” is known to the laboratory, including changes in operation and/or the reporting format.

5.6 Measurement traceability

There are no requirements additional to those set forth in NIST Handbook 150.

5.7 Sampling

There are no requirements additional to those set forth in NIST Handbook 150.

5.8 Handling of test and calibration items

5.8.1 The laboratory shall have a test item log-in system that includes documentation of the date of receipt, identity of the customer, unique identification for each item, condition of the item, and the acceptance or rejection of the item. The laboratory shall have written criteria for acceptance or rejection of test items.

5.8.2 The laboratory shall have a chain-of-custody system that documents the following information:

- a) location of the item;
- b) personnel who have handled or worked with the item;
- c) any handling or storage that may affect the item.

5.9 Assuring the quality of test and calibration results

There are no requirements additional to those set forth in NIST Handbook 150.

5.10 Reporting the results

Corrections or additions to test reports shall specify which test result is in question, the content of the result, the explanation of the result, and the reason for acceptance of the result.

Annex A
(informative)

Fasteners and Metals Program major areas of testing

A.1 MECHANICAL AND PHYSICAL TESTING AND INSPECTION

A.1.1 Aerospace nut tests

- a) Flareability test of clinch and shank nuts
- b) Permanent set test of self-locking nuts
- c) Push-out test of floating plate nuts, gang channel nuts, and anchor nuts
- d) Reusability test of self-locking internally threaded fasteners
- e) Room temperature of three cycles test of floating plate nuts, gang channel nuts and anchor nuts
- f) Torque-out test
- g) Wrench torque test of externally wrenched nuts of spline and hexagon and double hexagon (12 point) wrenching configuration

A.1.2 Adhesion

Adhesion of metallic coatings on fasteners

A.1.3 Bend

- a) Bend test of bolts
- b) Bend test of full size eyebolts
- c) Flattening of steel pipe
- d) Ductility of metallic materials
- e) Steel products
- f) Ductility of welds

A.1.4 Coating/plating thickness

- a) Measurement of fastener coating thickness - eddy-current method
- b) Measurement of fastener coating thickness - magnetic methods
- c) Measurement of fastener coating thickness - microscopical method
- d) Measurement of fastener coating thickness - weight of coating method
- e) Measurement of fastener coating thickness - beta backscatter method
- f) Measurement of fastener coating thickness - coulometric method
- g) Measurement of fastener coating thickness - dimensional change method
- h) Measurement of fastener coating thickness - X-ray methods
- i) Endurance of solid film lubricants

A.1.5 Compression

Compression testing of metallic materials

A.1.6 Corrosion

- a) Salt spray testing of fasteners
- b) Humidity testing of fasteners
- c) Stress corrosion of fasteners
- d) Intergranular corrosion susceptibility in austenitic stainless steel fasteners - nitric acid test
- e) Intergranular corrosion susceptibility of austenitic stainless steel fasteners - oxalic acid etch test
- f) CASS test (copper-accelerated acetic acid-salt spray test) of fasteners
- g) Water immersion test - test for anodic surface contaminants on corrosion resistant fasteners
- h) Copper sulfate test - test for free iron on the surface of corrosion resistant fasteners
- i) Ferric sulfate - sulfuric acid test
- j) Ferric chloride test
- k) Sodium hydroxide etch test

A.1.7 Elevated temperature testing

Elevated temperature testing capability

A.1.8 Embrittlement

- a) Hydrogen embrittlement (stress durability) of externally threaded fasteners
- b) Hydrogen embrittlement (stress durability) of internally threaded fasteners
- c) Test for embrittlement of metallic coated externally threaded fasteners

A.1.9 Fatigue

Fatigue of full-size threaded fasteners

A.1.10 Hardness

- a) Brinell hardness of fasteners
- b) Film hardness
- c) Hardness preparation
- d) Microhardness of fasteners
- e) Rockwell hardness of fasteners
- f) Rockwell superficial hardness of fasteners
- g) Vickers hardness - test forces from 9.807 N to 1176 N (1 kgf to 120 kgf)

A.1.11 Impact

- a) Charpy impact (v-notch) testing
- b) Charpy impact (u-notch) testing
- c) Drop test
- d) Headsound test

A.1.12 Magnetic permeability

Magnetic permeability of fasteners using a low- μ permeability indicator

A.1.13 Prevailing torque

Prevailing torque of full-size prevailing-torque type nuts

A.1.14 Proof

- a) Cone proof load of internally threaded fasteners (nuts)
- b) Proof load of full-size externally threaded fasteners
- c) Proof load of full-size eyebolts
- d) Proof load of internally threaded fasteners (nuts)

A.1.15 Rotational capacity

Rotational capacity of full-size threaded fasteners

A.1.16 Screw tests

- a) Clamp load test
- b) Drill-drive test
- c) Drive test
- d) Ductility test of thread rolling and self-drilling tapping screws
- e) Proof torque test
- f) Torsional strength test of thread rolling and self-drilling tapping screws

A.1.17 Shear

- a) Single shear of externally threaded fasteners
- b) Double shear of externally threaded fasteners

A.1.18 Stress rupture

Stress rupture of fasteners

A.1.19 Tensile

- a) Axial tensile strength of full-size threaded fasteners
- b) Breaking strength of full-size eyebolts
- c) Tension testing of machined specimens from externally threaded fasteners
- d) Total extension at fracture of externally threaded fasteners
- e) Wedge tensile strength of full-size threaded fasteners
- f) Yield strength of full-size externally threaded fasteners

A.1.20 Torque/tension

- a) Torque-tension of full-size threaded fasteners
- b) Recess strength test in both the installation and removal directions
- c) Locking torque for self-locking, threaded fasteners

A.1.21 Vibration

Vibration of full-size threaded fasteners

A.1.22 Washer tests

- a) Compression load of compressible-washer-type direct tension indicators
- b) Embrittlement test of washers
- c) Recovery test of washers
- d) Temper test of lock washers
- e) Twist test of lock washers

A.2 METALLOGRAPHY

A.2.1 Decarburization and case depth measurement in fasteners

A.2.2 Determination of grain size of fasteners

A.2.3 Macroscopic examination of fasteners by etching

A.2.4 Microscopic examination of fasteners by etching

A.2.5 Surface discontinuities of externally threaded fasteners

A.2.6 Surface discontinuities of internally threaded fasteners

A.3 NONDESTRUCTIVE INSPECTION

A.3.1 Liquid penetrant inspection of fasteners

A.3.2 Magnetic particle inspection of fasteners

A.3.3 Ultrasonic inspection of steel plates, forgings, and welding

A.4 DIMENSIONAL INSPECTION

A.4.1 External thread parameters - system 21

A.4.2 External thread parameters - system 22

A.4.3 External thread parameters - system 23

A.4.4 External thread parameters - SAE fastener with MJ metric screw threads

A.4.5 External thread parameters - ISO

A.4.6 Internal thread parameters - system 21

- A.4.7 Internal thread parameters - system 22
- A.4.8 Internal thread parameters - system 23
- A.4.9 Internal thread parameters - SAE fastener with MJ metric screw threads
- A.4.10 Internal thread parameters - ISO
- A.4.11 Dimensions of general purpose fasteners and high-volume machine assembly fasteners
- A.4.12 Dimensions of special purpose fasteners and fasteners for highly specialized engineered applications
- A.4.13 Dimensions of ISO grade A and B fasteners
- A.4.14 Dimensions of ISO grade C fasteners
- A.4.15 Dimensions of fasteners - hexagon and double hexagon (12 point) and spline sockets
- A.4.16 Dimensions of fasteners - gaging for slotted nuts
- A.4.17 Dimensions of fasteners - flange screw heads and flange nuts
- A.4.18 Dimensions of fasteners - straightness
- A.4.19 Dimensions of fasteners - bearing surface squareness
- A.4.20 Dimensions of fasteners - concentric method of verification of size and geometry of threaded fasteners
- A.4.21 Dimensions of fasteners - flatness
- A.4.22 Surface texture
- A.4.23 Verification of size and geometry for threaded fasteners

A.5 CHEMICAL ANALYSIS

- A.5.1 Solution chemical analysis
- A.5.2 Combustion analysis for carbon, sulfur, oxygen, nitrogen, and hydrogen
- A.5.3 Optical emission spectrochemical analysis
- A.5.4 X-ray fluorescence (XRF) spectrochemical analysis
- A.5.5 Energy dispersive X-ray analysis
- A.5.6 Spot test analysis