



Designation: F594 – 09 (Reapproved 2015) F594 – 09 (Reapproved 2020)

Standard Specification for Stainless Steel Nuts¹

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This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 This specification covers the requirements for stainless steel nuts 0.25 to 1.50 in., inclusive, in nominal diameter in a number of alloys in common use and intended for service applications requiring general corrosion resistance.

1.2 Seven groups of stainless steel alloys are covered, including ten austenitic, two ferritic, four martensitic, and one precipitation hardening.

| Group | Alloys ^A | | Condition ^B |
|-------|---|------|--------------------------|
| 1 | 304, 305, 304L 384, 18–9LW, 302HQ ^C | (CW) | cold worked ^D |
| 2 | 316, 316L | (CW) | cold worked ^D |
| 3 | 321, 347 | (CW) | cold worked ^D |
| 4 | 430 ^E | (CW) | cold worked ^D |
| 5 | 410 ^F | (H) | hardened and tempered |
| 6 | 431 | (H) | hardened and tempered |
| 7 | 630 | (AH) | aged hardened |

^A Unless otherwise specified on the inquiry and order, the choice of an alloy from within a group shall be at the discretion of the fastener manufacturer (see 6.1).

^B See 4.2 for options.

^C When approved by the purchaser, alloys 303, 303Se, or XM1 may be furnished.

^D Sizes 0.75 in. and larger may be hot worked and solution annealed.

^E When approved by the purchaser, alloy 430F may be furnished.

^F When approved by the purchaser, alloy 416 or 416Se may be furnished.

1.3 Supplementary requirements of an optional nature are provided, applicable only when agreed upon by the manufacturer and the purchaser at the time of the inquiry and order.

1.4 Suitable bolts, hex cap screws, and studs for use with nuts included in this specification are covered by Specification F593. Unless otherwise specified, all bolts, hex cap screws, and studs used with these nuts shall conform to the requirements of Specification F593 and shall be of the same alloy group.

1.5 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 ASTM Standards:²

A262 Practices for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels

A342/A342M Test Methods for Permeability of Weakly Magnetic Materials

¹ This specification is under the jurisdiction of ASTM Committee F16 on Fasteners and is the direct responsibility of Subcommittee F16.04 on Nonferrous Fasteners. Current edition approved Sept. 1, 2015 April 1, 2020. Published November 2015 April 2020. Originally approved in 1978. Last previous edition approved in 2009 2015 as F594 – 09 (2015). DOI: 10.1520/F0594-09R15-10.1520/F0594-09R20.

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For Annual Book of ASTM Standards volume information, refer to the standard's Document Summary page on the ASTM website.

*A Summary of Changes section appears at the end of this standard

- A380 Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems
- A493 Specification for Stainless Steel Wire and Wire Rods for Cold Heading and Cold Forging
- A555/A555M Specification for General Requirements for Stainless Steel Wire and Wire Rods
- A564/A564M Specification for Hot-Rolled and Cold-Finished Age-Hardening Stainless Steel Bars and Shapes
- A582/A582M Specification for Free-Machining Stainless Steel Bars
- A751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products
- D3951 Practice for Commercial Packaging
- E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
- F593 Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs
- F606 Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, and Rivets (Metric) F0606_F0606M
- E1470 Test Method for Characterization of Proteins by Electrophoretic Mobility (Withdrawn 2014)³

2.2 *ASME Standards*:⁴

- B1.1 Unified Inch Screw Threads
- B18.2.2 Square and Hex Nuts

NOTE 1—The following ASTM standards are noted for information only as suitable sources of material for the manufacture of nuts to this specification: Specifications A493, A564/A564M, and A582/A582M.

3. Ordering Information

3.1 Orders for nuts under this specification shall include the following:

- 3.1.1 Quantity (number of pieces of each item and size),
- 3.1.2 Name of item,
- 3.1.3 Size (diameter and threads per inch),
- 3.1.4 Alloy group number (see 6.2.1), and
- 3.1.5 Condition (see 4.2).
- 3.1.6 Orders for nuts under this specification may include the following optional requirements:
 - 3.1.6.1 Forming (see 4.1.1),
 - 3.1.6.2 Composition (see 6.2),
 - 3.1.6.3 Corrosion resistance (see 8.1),
 - 3.1.6.4 Thread class (see 9.2),
 - 3.1.6.5 Finish (see 10.3),
 - 3.1.6.6 Test report (see 17.2),
 - 3.1.6.7 Rejection (see 16.1),
 - 3.1.6.8 Test rejection (see 16.1), and
 - 3.1.6.9 Special packaging (see 19.2).
- 3.1.7 Supplementary requirements, if any, to be specified on the order (see S1 through S8), and
- 3.1.8 ASTM specification and date of issue. When date of issue is not specified, fasteners shall be furnished to the latest issue.

NOTE 2—*Example*: 10 000 pieces, Hex Nut, 0.250 in. –20, Alloy Group 1, Condition CW, Furnish Test Report, Supplementary Requirement S3.

4. Manufacture

4.1 *Manufacture*:

4.1.1 *Forming*—Unless otherwise specified, the nuts shall be hot formed, cold formed, or machined from suitable material, at the option of the manufacturer.

4.2 *Condition*—The fasteners shall be furnished in the following conditions, unless specified to be furnished in one of the optional conditions:

| Alloy Group | Condition Furnished Unless Otherwise Specified | Optional Conditions (must be specified) |
|-------------|--|---|
| 1, 2, 3 | CW | AF, A, SH |
| 4 | CW | A |
| 5 | H | HT |
| 6 | H | HT |
| 7 | AH | none |

³ The last approved version of this historical standard is referenced on www.astm.org.

⁴ Available from Global Engineering Documents, 15 Inverness Way, East Englewood, CO 80112-5704, <http://www.global.ihs.com>.

| | |
|-----|--|
| A— | Machined from annealed or solution annealed stock thus retaining the properties of the original material; or hot formed and solution annealed. |
| AF— | Annealed after all threading is completed. |
| AH— | Solution annealed and age hardened after forming. |
| CW— | Annealed and cold worked. Sizes 0.75 in. and larger may be hot worked and solution annealed. |
| H— | Hardened and tempered at 1050°F (565°C) minimum. |
| H— | Hardened and tempered at 1050 °F (565 °C) minimum. |
| HT— | Hardened and tempered at 525°F (274°C) minimum. |
| HT— | Hardened and tempered at 525 °F (274 °C) minimum. |
| SH— | Machined from strain hardened stock. |

5. Heat Treatment

5.1 *Alloy Groups 1, 2, and 3 (Austenitic Alloys 303, 303Se, 304, 304L, 305, 316, 316L, 321, 347, 384, XMI, 18–9LW, and 302HQ):*

5.1.1 *Condition A*—When Condition A is specified, the austenitic alloys shall be heated to $1900 \pm 50^{\circ}\text{F}$ ($1038 \pm 28^{\circ}\text{C}$), at which time the chromium carbide will go into the solution, be held for a sufficient time, and then be cooled at a rate sufficient to prevent precipitation of the carbide and to provide the specified properties.

5.1.2 *Condition CW*—When Condition CW is specified, the austenitic alloys shall be annealed as specified in 5.1.1 and then cold worked to develop the specified properties.

5.1.3 *Condition AF*—When Condition AF is specified, the austenitic alloys shall be annealed as specified in 5.1.1 after all cold working, including forming and threading.

5.2 *Alloy Group 4 (Ferritic Alloys 430 and 430F):*

5.2.1 *Condition A*—The ferritic alloys shall be heated to a temperature of $1450 \pm 50^{\circ}\text{F}$ ($788 \pm 28^{\circ}\text{C}$), held for an appropriate time, and then air cooled to provide the specified properties.

5.2.2 *Condition CW*—When Condition CW is specified, the ferritic alloys shall be annealed in accordance with 5.2.1, generally by the raw material manufacturer, and then cold worked to develop the specified properties.

5.3 *Alloy Group 5 (Martensitic Alloys 410, 416, and 416Se):*

5.3.1 *Condition H*—When Condition H is specified, the martensitic alloys 410, 416, and 416Se shall be hardened and tempered by heating to $1850 \pm 50^{\circ}\text{F}$ ($1010 \pm 28^{\circ}\text{C}$) sufficient for austenitization, held for at least ½ h and rapid air- or oil-quenched, then reheating to ~~1050°F (565°C)~~ 1050°F (565°C) minimum for at least 1 h and air cooled to provide the specified properties.

5.3.2 *Condition HT*—When Condition HT is specified, the martensitic alloys 410, 416, and 416Se shall be hardened and tempered by heating to $1850 \pm 50^{\circ}\text{F}$ ($1010 \pm 28^{\circ}\text{C}$) sufficient for austenitization, held for at least ½ h and rapid air- or oil-quenched, then reheating to ~~525°F (274°C)~~ 525°F (274°C) minimum for at least 1 h and air cooled to provide the specified properties.

5.4 Alloy Group 6 (Martensitic Alloy 431):

5.4.1 *Conditions H and HT*—The martensitic alloy 431 shall be hardened and tempered as specified in 5.3.1 and 5.3.2 as applicable.

5.5 Alloy Group 7 (Precipitation Hardening Alloy 630):

5.5.1 *Condition AH*—The precipitation hardening alloy 630 shall be solution annealed and aged by heating to $1900 \pm 25^{\circ}\text{F}$ ($1038 \pm 14^{\circ}\text{C}$) for at least ½ h and rapid air or oil quenched to 80°F (27°C) maximum, then reheating to a temperature of $1150 \pm 15^{\circ}\text{F}$ ($621 \pm 8^{\circ}\text{C}$) for 4 h and air cooled to provide the specified properties.

6. Chemical Composition

6.1 *Alloy Groups*—It is the intent of this specification that fasteners shall be ordered by alloy group numbers that include alloys considered to be chemically equivalent for general purpose use. The alloy groupings are as shown below. When required, however, a specific alloy may be specified as permitted by 6.2.2.

| Alloy Group | Alloys |
|-------------|---|
| 1 | 304, 305, 304L 384, 18-9LW, 302HQ ^A |
| 2 | 316, 316L |
| 3 | 321, 347 |
| 4 | 430 ^B |
| 5 | 410 ^C |
| 6 | 431 |
| 7 | 630 |

^A When approved by the purchaser, alloys 303, 303Se, or XM1 may be furnished.

^B When approved by the purchaser, alloy 430F may be furnished.

^C When approved by the purchaser, alloys 416 or 416Se may be furnished.

6.2 Chemical Composition Limits:

6.2.1 *Ordering by Alloy Group*—Unless otherwise specified on the inquiry and order (see Supplementary Requirement S4), the choice of an alloy from within a group shall be at the discretion of the fastener manufacturer as required by his method of fastener fabrication and material availability. The specific alloy used by the fastener manufacturer shall be clearly identified on any certification required by the order and shall have a chemical composition conforming to the requirements of Table 1 for the specific alloy.

6.2.2 *Ordering by Specific Alloy*—When ordered by a specific alloy number, the fasteners shall conform to the chemical composition limits of Table 1 for the specific alloy.

6.3 Product Analysis:

6.3.1 Product analysis may be made by the purchaser from finished nuts representing each lot. The chemical composition thus determined shall conform to the requirements of Table 1 for the specific alloy subject to the Product Analysis Tolerance in Specification A555/A555M.

6.3.2 In the event of discrepancy, a referee chemical analysis of samples from each lot shall be made in accordance with 14.1.

7. Mechanical Properties

7.1 The finished fasteners shall meet the applicable mechanical properties of Table 2 for the specified alloy group and condition when tested in accordance with the mechanical property requirements as specified herein (see also Table 3).

8. Corrosion Resistance

8.1 Carbide Precipitation:

8.1.1 Rod, bar, and wire in the austenitic Alloy Groups 1, 2, and 3, except the free-machining grades, 303 and 303Se used to make fasteners in accordance with this specification, shall be capable of passing the test for susceptibility to intergranular corrosion as specified in Practice E of Practice A262.

8.1.2 As stated in Practice A262, samples may be subjected to the faster and more severe screening test in accordance with Practice A. Failing Practice A, specimens may be tested in accordance with Practice E and be considered satisfactory if passing Practice E.

9. Dimensions

9.1 Nuts:

9.1.1 Unless otherwise specified, the dimensions shall be in accordance with the requirements of ASME B18.2.2 for Hex Nuts.

9.1.2 When specified, the dimensions of nuts shall be in accordance with the requirements of ASME B18.2.2 (type as specified), or such other dimensions as may be specified.

9.2 *Threads* (see Table 4)—Unless otherwise specified, the nuts shall have Class 2B threads in accordance with ASME B1.1.

TABLE 1 Chemical Requirements

| Alloy Group | UNS Designation | Alloy | Composition, % maximum except as shown | | | | | | | | | |
|--------------------------------------|-------------------|-----------------|--|-----------------|------------------|------------------|-----------------|-------------------------|-------------------------|--------------|-----------------------------------|--------------------|
| | | | Carbon | Manganese | Phosphorus | Sulfur | Silicon | Chromium | Nickel | Copper | Molybdenum | Others |
| Austenitic Alloys | | | | | | | | | | | | |
| 1 | S30300 | 303 | 0.15 | 2.00 | 0.20 | 0.15 min | 1.00 | 17.0 to 19.0 | 8.0 to 10.0 | ... | 0.60 max ^A | ... |
| 1 | S30323 | 303Se | 0.15 | 2.00 | 0.20 | 0.060 | 1.00 | 17.0 to 19.0 | 8.0 to 10.0 | ... | ... | Se 0.15 min |
| 1 | S30400 | 304 | 0.08 | 2.00 | 0.045 | 0.030 | 1.00 | 18.0 to 20.0 | 8.0 to 10.5 | 1.00 | ... | ... |
| 1 | S30403 | 304L | 0.03 | 2.00 | 0.045 | 0.030 | 1.00 | 18.0 to 20.0 | 8.0 to 12.0 | 1.00 | ... | ... |
| 1 | S30500 | 305 | 0.12 | 2.00 | 0.045 | 0.030 | 1.00 | 17.0 to 19.0 | 10.5 to 13.0 | 1.00 | ... | ... |
| 1 | S38400 | 384 | 0.08 | 2.00 | 0.045 | 0.030 | 1.00 | 15.0 to 17.0 | 17.0 to 19.0 | ... | ... | ... |
| 1 | S20300 | XM1 | 0.08 | 5.0 to 6.5 | 0.040 | 0.18 to 0.35 | 1.00 | 16.0 to 18.0 | 5.0 to 6.5 | 1.75 to 2.25 | 0.50 max ^A | ... |
| 1 | S30430 | 18-9LW | 0.10 | 2.00 | 0.045 | 0.030 | 1.00 | 17.0 to 19.0 | 8.0 to 10.0 | 3.0 to 4.0 | ... | ... |
| 1 | S30433 | 302HQ | 0.03 | 2.00 | 0.045 | 0.030 | 1.00 | 17.0 to 19.0 | 8.0 to 10.0 | 3.0 to 4.0 | ... | ... |
| 2 | S31603 | 316L | 0.03 | 2.00 | 0.045 | 0.030 | 1.00 | 16.0 to 18.0 | 10.0 to 14.0 | ... | 2.00-3.00 [†] | ... |
| 2 | <u>S31603</u> | <u>316L</u> | <u>0.03</u> | <u>2.00</u> | <u>0.045</u> | <u>0.030</u> | <u>1.00</u> | <u>16.0 to 18.0</u> | <u>10.0 to 14.0</u> | ... | <u>2.00-3.00</u> | ... |
| 2 | S31600 | 316 | 0.08 | 2.00 | 0.045 | 0.030 | 1.00 | 16.0 to 18.0 | 10.0 to 14.0 | ... | 2.00-3.00 | ... |
| 3 | S32100 | 321 | 0.08 | 2.00 | 0.045 | 0.030 | 1.00 | 17.0 to 19.0 | 9.0 to 12.0 | ... | ... | Ti 5 × C min |
| 3 | S34700 | 347 | 0.08 | 2.00 | 0.045 | 0.030 | 1.00 | 17.0 to 19.0 | 9.0 to 13.0 | ... | ... | Cb + Ta 10 × C min |
| Ferritic Alloys | | | | | | | | | | | | |
| 4 | S43000 | 430 | 0.12 | 1.00 | 0.040 | 0.030 | 1.00 | 16.0 to 18.0 | ... | ... | 0.60 max ^A | ... |
| | S43020 | 430F | 0.12 | 1.25 | 0.060 | 0.15 min | 1.00 | 16.0 to 18.0 | ... | ... | 0.60 max ^A | ... |
| Martensitic Alloys | | | | | | | | | | | | |
| 5 | S41000 | 410 | 0.15 | 1.00 | 0.040 | 0.030 | 1.00 | 11.5 to 13.5 | ... | ... | ... | ... |
| 5 | S41600 | 416 | 0.15 | 1.25 | 0.060 | 0.15 min | 1.00 | 12.0 to 14.0 | ... | ... | 0.60 max ^A | ... |
| 5 | S41623 | 416Se | 0.15 | 1.25 | 0.060 | 0.060 | 1.00 | 12.0 to 14.0 | ... | ... | ... | Se 0.15 min |
| 6 | S43100 | 431 | 0.20 | 1.00 | 0.040 | 0.030 | 1.00 | 15.0 to 17.0 | 1.25 to 2.50 | ... | ... | ... |
| Precipitation Hardening Alloy | | | | | | | | | | | | |
| 7 | S17400 | 630 | 0.07 | 1.00 | 0.040 | 0.030 | 1.00 | 15.0 to 17.5 | 3.0 to 5.0 | 3.0 to 5.0 | ... | Cb + Ta 0.15-0.45 |

^A At manufacturer's option, determined only when intentionally added.

[†] Editorially corrected.

10. Workmanship, Finish, and Appearance

10.1 *Workmanship*—The nuts shall have a workmanlike finish, free of injurious burrs, seams, laps, irregular surfaces, and other defects affecting serviceability.

10.2 *Surface Finish*—The nuts shall have a surface finish produced in accordance with Practice **A380**.

10.3 *Protective Finishes*—Unless otherwise specified, the nuts shall be furnished without an additive chemical or metallic finish.

11. Sampling

11.1 A lot, for the purposes of selecting test specimens, shall consist of not more than 100 000 pieces offered for inspection at one time having the following common characteristics:

- 11.1.1 One type of item,
- 11.1.2 Same alloy and condition, and
- 11.1.3 One nominal diameter and thread series.

TABLE 2 Mechanical Property Requirements^A

| Stainless Alloy Group | Condition ^B | Alloy Mechanical Property Marking | Nominal Diameter, in. | Proof Stress, | Proof Stress, | Rockwell Hardness |
|--|------------------------|-----------------------------------|-----------------------|----------------------|---|-------------------|
| | | | | Hex Nuts ksi, min | Heavy Hex Nuts ksi, min ^C | |
| Austenitic Alloys | | | | | | |
| 1 (303, 304, 304L 305, 384, XM1, 18–9LW, 302HQ, 303Se) | AF | F594A | ¼ to 1½, incl | 70 | 76 | B85 max |
| | A | F594B | ¼ to 1½, incl | 75 | 81 | B65 to 95, incl |
| | CW1 | F594C | ¼ to ⅝, incl | 100 | 108 | B95 to C35, incl |
| | CW2 | F594D | ¾ to 1½, incl | 85 | 92 | B80 to C35, incl |
| | SH1 | F594A | ¼ to ⅝, incl | 120 | 130 | C24 to C36, incl |
| | SH2 | F594B | ¾ to 1, incl | 110 | 119 | C20 to C32, incl |
| | SH3 | F594C | 1½ to 1¼, incl | 100 | 108 | B95 to C30, incl |
| | SH4 | F594D | 1¾ to 1½, incl | 85 | 92 | B90 to C28, incl |
| 2 (316) 316L | AF | F594E | ¼ to 1½, incl | 70 | 76 | B85 max |
| | A | F594F | ¼ to 1½, incl | 75 | 81 | B65 to 95, incl |
| | CW1 | F594G | ¼ to ⅝, incl | 100 | 108 | B95 to C35, incl |
| | CW2 | F594H | ¾ to 1½, incl | 85 | 92 | B80 to C35, incl |
| | SH1 | F594E | ¼ to ⅝, incl | 120 | 130 | C24 to C36, incl |
| | SH2 | F594F | ¾ to 1, incl | 110 | 119 | C20 to C32, incl |
| | SH3 | F594G | 1½ to 1¼, incl | 100 | 108 | B95 to C30, incl |
| | SH4 | F594H | 1¾ to 1½, incl | 85 | 92 | B90 to C28, incl |
| 3 (321, 347) | AF | F594J | ¼ to 1½, incl | 70 | 76 | B85 max |
| | A | F594K | ¼ to 1½, incl | 75 | 81 | B65 to 95, incl |
| | CW1 | F594L | ¼ to ⅝, incl | 100 | 108 | B95 to C35, incl |
| | CW2 | F594M | ¾ to 1½, incl | 85 | 92 | B80 to C35, incl |
| | SH1 | F594J | ¼ to ⅝, incl | 120 | 130 | C24 to C36, incl |
| | SH2 | F594K | ¾ to 1, incl | 110 | 119 | C20 to C32, incl |
| | SH3 | F594L | 1½ to 1¼, incl | 100 | 108 | B95 to C30, incl |
| | SH4 | F594M | 1¾ to 1½, incl | 85 | 92 | B90 to C28, incl |
| Ferritic Alloys | | | | | | |
| 4 (430, 430F) | A | F594N | ¼ to 1½, incl | 55 | 59 | 85 max |
| | CW1 | F594V | ¼ to ⅝, incl | 60 | 65 | B75 to 98, incl |
| | CW2 | F594W | ¾ to 1½, incl | 55 | 59 | B65 to 95, incl |
| Martensitic Alloys | | | | | | |
| 5 (410, 416, 416Se) | H | F594P | ¼ to 1½, incl | 100 | 108 | C20 to 30, incl |
| | HT | F594R | ¼ to 1½, incl | 160 | 173 | C34 to 45, incl |
| 6 (431) | H | F594S | ¼ to 1½, incl | 125 | 135 | C25 to 32, incl |
| | HT | F594T | ¼ to 1½, incl | 180 | 194 | C40 to 48, incl |
| Precipitation Hardening Alloys | | | | | | |
| 7 (630) | AH | F594U | ¼ to 1½, incl | 135 | 146 | C28 to 38, incl |

^A Minimum values except where shown as maximum or as a range.

^B Legend of conditions:

A—Machined from annealed or solution annealed stock thus retaining the properties of the original stock; or hot formed and solution annealed.

AF—Annealed after all threading is completed.

AH—Solution annealed and age hardened after forming.

CW—Annealed and cold worked. Sizes 0.75 in. and larger may be hot worked and solution annealed.

H—Hardened and tempered at 1050°F (566°C) 1050 °F (566 °C) min.

HT—Hardened and tempered at 525°F (274°C) 525 °F (274 °C) min.

SH—Machined from strain hardened stock.

^C Proof stress values for heavy hex nuts are based on 1.08 times the value for corresponding hex nuts.

TABLE 3 Mechanical Test Requirements on Nuts

| Product | Proof Stress, psi | Tests Conducted using Full Size Product | |
|---------------------------|-------------------|---|------------|
| | | Hardness | Proof Load |
| Jam, slotted, castle nuts | all | A | B |
| All other nuts | up to 120 000 | A | A |
| | Over 120 000 | option A ^A | option B |

^A Denotes mandatory tests; where options are given, all the tests under an option shall be performed. Option B tests should be made whenever feasible. Option B is the referee test in case of arbitration.

^B Tests that are not mandatory.