PROCESS SPECIFICATION

CODE IDENT NO. 23835

SPEC NO. FS511316 REV.J

ISSUE DATE 26 July 1993

SUPERSEDING FS511316 H

DATED 13 December 1991

CRITICAL FASTENERS

QUALIFICATION OF

DETAIL SPECIFICATION FOR

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CHANGE INCORPORATION LOG

CHG	RELEASE		AUTHORITY	PAGES	DATE	ENG APPROVAL	
LTR	INITIAL	SECTION		AFFECTED		INITIAL	SECTION
A	JVR	648	Standard	Init Rel	10 Dec 82	SAD	354
B	JVR	648	Standard		4 Jun 85	SNK	352
C	JVR	648	ECI 89539		16 Aug	EMC	354
D	JVR	648	Standard		11 May 88	RC	352
E	JVR	648	Standard		17 Nov 88	BK	355
F	JWA	648	Standard	All	19 Dec 89	CH	355
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H	JWA	648	Standard	All	13 Dec 91	CH	355
J	PEW	648	Standard	All	26 Jul 93	CH	355

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TABLES

1. SCOPE

1.1 Scope. This specification covers the detail requirements for qualifying external threaded fasteners loaded in tension or shear to be used as "Fracture Critical," "Shear Critical" or "Dual Fracture Critical and Shear Critical." Definition of various classes of fasteners is described in 1.2. Color identification of fasteners is described in 5.3.

1.1.1 Only high reliability threaded fasteners supported by a Fastener Acceptance Tag (FAT), JPL Document 2019 (1/89), will be acceptable for processing per the requirements of this specification. Additionally, only fasteners having a minimum ultimate tensile strength of 190 ksi based on the FED-STD-H28/2 stress area for the in-lb fasteners or 1310 MPa for metric fasteners will be processed. Any exception must be approved by the Structures and Materials Safety Review Committee (SAM-RC). The minimum value will be supported by the manufacturer's unique lot materials test report (MTR), or by a test report per 4.2.3.

1.1.2 This specification covers only threaded fasteners that will fail ultimately at the thread area under tensile load or fail ultimately in the shank area under shear load.

1.2 Classes. Fasteners qualified under this specification shall be divided into the following three (3) classes:

a. Class 1 - Fracture Critical.

   Fasteners shall be qualified by proof testing. Alternate nondestructive evaluation (NDE) may be considered with the concurrence of the Structures and Materials Safety Review Committee (SAM-RC).

b. Class 2 - Shear Critical.

   Shear critical fasteners shall be qualified by NDE in the grip area to the level and of the type required on the installation drawings.

c. Class 3 - Dual Fracture Critical and Shear Critical.

1.3 NDE.

a. Fasteners that fall within Class 1 may be qualified by NDE in lieu of the proof test of 3.4.2 if it is demonstrated to SAM-RC that the flaw sizes specified by NHB 8071.1 are detected with a 90% probability and a 95% confidence level. Fasteners shall be inspected by an inspector, who is qualified per the requirements of MIL-STD-410.

b. Fasteners that fall within Class 2 shall be inspected by an inspector, who is qualified per the requirements of MIL-STD-410.

2. APPLICABLE DOCUMENTS

The following documents, of the latest issue specified in the contractual instrument, form a part of this document to the extent specified herein.

SPECIFICATIONS

NASA

NHB 8071.1	Fracture Control Requirements for Payloads Using the National Space Transportation System (NSTS)

Jet Propulsion Laboratory

BS502673	Permanent Marking Ink (Wornowink, Series M/ (Catalyst A) Detail Specification for
CS502726	Fasteners, External Threaded, Nonmagnetic Heat and Corrosion Resistant Steel (A286) Detail Specifications for
NA 0026	Procurement Specification, Metric Fasteners, A286 CRES Externally Threaded, 1100 MPa Tensile, 660 MPa Shear

Federal

FED-STD-H28/2	Federal Standard, Screw Thread Standards for Federal Services
O-A-51	Acetone, Technical
O-T-620	Trichloroethane-1,1,1, Technical, Inhibited (Methyl Chloroform)
TT-T-548	Toluene, Technical
TT-I-735	Isopropyl Alcohol

Society of Automotive Engineers (SAE)

AMS 5726	Steel Bars and Wire, Corrosion and Heat Resistant (1800°F) Solution Treated and Work - Strengthened) (200 ksi Min. Tensile Ultimate)
AMS 5731	Steel, Corrosion and Heat Resistant (A286) (1800°F Solution Treated and Aged) (130 ksi Min. Tensile Ultimate)
ANS 5732	Steel, Corrosion and Heat Resistant (A286) (1800°F Solution Treated and Aged) (130 ksi Min. Tensil Ultimate)

AMS 5734	Steel, Corrosion and Heat Resistant (A286) (1650°F Solution Treated and Aged) (140 ksi Min. Tensile Ultimate)
AMS 5737	Steel, Corrosion and Heat Resistant (A286) (1650°F Solution Treated and Aged) (140 ksi Min. Tensile Ultimate)
AMS 5853	Steel Bars, Corrosion and Heat Resistant (1800°F Solution Treated and Work- Strengthened) (160 ksi Min. Tensile Ultimate)

STANDARDS

Military

MIL-STD-410	Nondestructive Testing Personnel Qualification and Certification (Eddy Current, Liquid Penetrant, Magnetic Particle, Radiographic and Ultrasonic)
MIL-STD-1312	Fasteners, Test Methods

PROCEDURES

Jet Propulsion Laboratory

QAP-141.31	Use of Fracture Critical Acceptance Tag JPL 0623(6/82)
QAP-62.3	Fracture Critical Flight Fastener Proof Loading Procedure
QAP-141.32	Use of Shear Critical Acceptance Tag JPL 1060(2/84)

TAGS

Jet Propulsion Laboratory

2019(1/89)	Fastener Acceptance Tag
0623(6/82)	Fracture Critical Fastener Acceptance Tag
1060(2/84)	Shear Critical Fastener Acceptance Tag

(Copies of specifications, standards, procedures, drawings, and publications required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by such activity.)

3. REQUIREMENTS

3.1 Conflicting requirements. In the case of conflict between the requirements of this specification and the requirements of any document referenced herein, the conflict shall be referred to the Section 512, Mechanical/Propulsion Quality Assurance (MPQA) representative who shall contact the appropriate Fastener and Material Specialists for resolution.

3.2 Qualification. The fasteners furnished under this specification shall be a product which has been tested, and has passed the qualification tests specified herein.

3.3 Materials. Fasteners shall be made from A286 heat and corrosion resistant steel conforming to the chemical composition of SAE AMS 5726, AMS 5731, AMS 5732, AMS 5734, AMS 5737 or AMS 5853. Note that tensile strength as specified in the above mentioned materials specification is not necessarily the same as the tensile strength of the fasteners due to the work-strengthening of the fasteners. Tensile strength of the fasteners shall be obtained per JPL Specification CS502726 or National Aerospace Standard NA 0026.

3.4 Fracture critical fastener qualification (Class 1). Fasteners used in fracture critical applications shall be qualified by Individual proof testing in accordance with 4.2.2. No "Strip" locking bolt feature is allowed.

3.4.1 Tensile strength values. Section 512 MPQA will verify that each of the tensile strength values noted on the Material Test Report (Physical) are in all cases equal to or in excess of 0.95 times the ultimate tensile strength values shown in Table IA for in -lb fasteners and Table IB for metric fasteners. Any exceptions shall be submitted to SAM -RC for approval.

Table IA. Ultimate Tensile Load (Equivalent to 200 ksi Ultimate Tensile Strength Based on FED-STD-28/2 Stress Area)

Bolt Size	Ultimate Tensile Load (lbs)
0-80	360
2-56	740
4-40	1,200
6-32	1,800
8-32	2,800
10-32	4,000
1/4-28	7,270
5/16-24	11,600
3/8-24	17,560
7/16-20	23,740
1/2-20	31,990

Table IB. Ultimate Tensile Load (Equivalent to 1379 MPa)

Thread		Tensile Stress Area (mm^2)	Minimum Tensile Force (N)
Dia (mm)	Pitch (mm)		
3	0.5	5.6	7,720
3.5	0.6	7.6	10,480
4	0.7	9.9	13,650
5	0.9	15.8	21,790
6	1.0	22.5	31,030
7	1.0	31.7	43,710
8	1.0	42.4	58,470
10	1.25	66.3	91,430
12	1.25	98.3	135,550
14	1.5	133.3	183,820
16	1.5	177.3	244,500
18	1.5	227.7	314,000
20	1.5	284.3	392,050
22	1.5	347.2	478,790
24	2.0	404.7	558,080

3.4.2 Proof loads. The required fastener proofloads shall be the ultimate tensile load times the multipliers given in Table II. The ultimate tensile load shall be defined as the average ultimate tensile load minus one standard deviation from the materials test report (MTR) obtained per JPL Specification CS502726 or NA 0026. Loading rate during proof testing shall be based upon 100,000 pounds per minute per square inch of nominal shank area for in -lb fasteners. The loading rate shall be 689.5 N per minute per square millimeter of nominal shank area for metric fasteners. Dwell time at proof load shall be as short as possible. No obvious non-linearity of the stress-strain curve from proof testing is allowed. A 10 X magnification visual inspection shall reveal no cracks after proof testing.

3.5 Shear critical fastener qualification (Class 2). Fasteners used in shear critical applications shall be qualified by individual nondestructive inspection at the grip area in accordance with 4.2.1.

3.5.1 Cracks. There shall be no observable cracks in any direction or location. A crack is defined as a crystalline break passing through a grain or grain boundary.

Table II. Proof Test Multiplier

Ultimate Tensile Load* / Table I Tensile Load	Proof Load / Ultimate Tensile Load*
1.00	0.75
0.99	0.76
0.98	0.77
0.97	0.78
0.96	0.79
0.95	0.80

*Ultimate tensile load is the average ultimate tensile load minus one standard deviation from the materials test report (MTR).

3.5.2 Laps and seams. Laps and seams shall not be permissible on the shank or at the fillet joining the head and shank.

3.6 Dual fracture and shear critical fastener qualification (Class 3). Fasteners requiring qualification for dual fracture and shear critical applications will be processed in accordance with 4.2.1 and 4.2.2.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. The responsibility for inspection and qualification of "Fracture Critical" or "Shear Critical" fasteners rests with the cognizant JPL hardware engineer in conjunction with the JPL Fastener Specialist. Testing may be performed at JPL or at a commercial laboratory acceptable to JPL.

4.1.1 Inspection records. Records of the test results shall be maintained in the same manner as those for all flight hardware at JPL. A Fracture Critical Acceptance Tag (FCAT) or Shear Critical Acceptance Tag (SCAT) shall be completed for each like group of fasteners (Ref. QAPs 141.31 and 141.32). A copy of the tag shall remain with the fasteners. When fasteners are processed to both fracture and shear critical requirements, a copy of both tags shall remain with the fasteners.

4.1.2 Strength verification. Section 512 MPQA will review the Materials Test Report (Physical) for strength acceptability per 3.4.1.

4.2 Qualification tests.

4.2.1 Nondestructive evaluation. Nondestructive evaluation shall be used to determine the presence of discontinuities such as cracks, seams, inclusions, and laps. When dye penetrant NDE is chosen, a pre-penetrant inspection etching is required. Waiving of etching has to be approved by SAM/RC.

4.2.2 Proof testing. Fasteners shall be tested in accordance with the applicable requirements of MIL-STD-1312 and JPL Procedure QAP-62.3, in tension between the head of the bolt and a nut or threaded adaptor of sufficient thickness to develop full strength of the bolt without stripping the bolt thread. The nut face or threaded adaptor shall be positioned with no more than one diameter thread engagement if there is no locking bolt feature. The nut face of a threaded adaptor shall be no more than 0.5 diameter toward the thread runout from the pellet centerline if there is a locking pellet. If the bolt is too short for tensile proof testing, an acceptable test procedure shall be developed with the approval of the JPL Fastener Specialist in conjunction with SAM-RC.

4.2.3 Tensile test of fasteners. JPL will pull to failure a sample lot of fasteners per 1.1.1 when either tensile strength values are not shown on the Materials Test Report (TMR), or the number of samples does not meet the requirements of Table III. The sample size to be tested is based upon the quantity received shown on the ORIGINAL Fastener Acceptance Tag (FAT). This quantity is shown ONLY on the original FAT. Using the quantity received as the lot size, find the sample size from Table III.

The serial number of the FAT supporting the group of fasteners to be processed as Fracture Critical will be noted on the Proof Loading Chart. Section 512 MPQA retains all original charts.

5. PREPARATION FOR STORAGE

5.1 Cleaning prior to marking and packaging. Clean before (per 5.1.1) and after (per 5.1.2) marking by immersion in the solvent with ultrasonic agitation. Rinsing per both 5.1.1 and 5.1.2 shall be by immersion in the solvent with or without ultrasonic agitation. For both 5.1.1 and 5.1.2 there shall be three solvent baths designated Bath No. 1, Bath No. 2, and Bath No. 3. Bath No. 1 shall be the cleaning bath. Bath No. 2 and Bath No. 3 shall be the first and second rinse baths, respectively. This sequence of use shall be adhered to. The volume of solvent in each bath shall be at least twice the bulk volume of the fasteners in the bath. When the solvent of Bath No. 1 becomes conspicuously contaminated, it shall be discarded. Bath No. 2 shall then become Bath No. 1 and Bath No. 3 shall become Bath No. 2. Fresh solvent shall be used to make up the new Bath No. 3.

5.1.1 Cleaning prior to marking per 5.3. Prior to marking per 5.3, all unspecified grease, oil, foreign particles and surface contaminants shall be removed from the fasteners. The cleaning and rinsing solvents shall be either

Table III. Sample Size for Destructive Tests

Lot Size	Sample Size
Under 250	4
250 to 500	6
500 or over	8

isopropyl alcohol (isopropanol) per TT-I-735, U.S.P. dehydrated ethyl alcohol, acetone per O-A-51, toluene (toluol) per TT-T-548, or inhibited 1,1,1trichloroethane (methyl chloroform) per O-T-620.

5.1.2 Cleaning subsequent to marking per 5.3. Subsequent to marking per 5.3, all unspecified grease, oil, foreign particles, and surface contaminants shall be removed from the fasteners without removing the intended markings. The cleaning and rinsing solvent shall be U.S.P. dehydrated ethyl alcohol.

5.2 Number to be qualified. The Cognizant Hardware Engineer shall determine the number of fasteners and spares that require qualification.

5.3 Material, marking - fastener heads. The heads of critical flight fasteners will be marked with Hysol M-series Wornowink (Ref: JPL Specification BS502673) per the requirements of 5.3.1 through 5.3.3, and cured per 5.3.4.

5.3.1 Class 1 fasteners. The heads of Class 1 fasteners will be marked with Wornowink Code No. M-5-N (Green).

5.3.2 Class 2 fasteners. The heads of Class 2 fasteners will be marked with Wornowink Code No. M-6-N (Blue).

5.3.3 Class 3 fasteners. The heads of Class 3 fasteners will be marked with Wornowink Code No. M-4-N (Yellow).

5.3.4 Vacuum bakeout. After head marking, the fasteners will be thermal-vacuum baked at a pressure of 1.0×10^{-3} Pa (10^{-5} torr) or less at a temperature of 105°C ± 5°C (225°F ± 10°F) for a period of six to eight hours.

5.4 Packaging. The fasteners shall be packaged and prepared for storage in accordance with the following paragraphs.

5.4.1 Preservation. Fasteners of 1/4 in. or 5 mm in diameter or larger shall have the thread and shank protected by means of a sleeve or other thread protection method approved by the fastener specialist.

5.4.2 Unit container. Only fasteners of the same type and size shall be packaged in each unit container which shall enclose, insofar as possible, a single "Ship-Set" of fasteners. Except as provided in 5.4.1, the innermost packing material of the unit container shall be 3M No. 2100.

5.4.3 Identification of unit container. Each unit container, which contains a part (or parts) that has (or have) been designated "fracture critical" in accordance with QAP-141.30, shall also contain a JPL Tag No. 0623(6/82) that identifies the contents as “fracture critical." Each unit container which contains a part (or parts) that has (or have) been designated "shear critical" in accordance with QAP-141.32, shall contain a JPL Tag No. 1060(2/84) that identifies the contents as "shear critical.” Each unit container, which contains a part (or parts) which has (or have) been designated "Fracture Critical" and “Sheer Critical" shall contain both JPL tags identifying the contents as "Dual Fracture Critical and Shear Critical."

6. NOTES

Not applicable.