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MFC 1000

FASTENER, PRELOAD COLLARS

REVISION:	DATE:	DCN#
"NR"	09-02-2014	DCN#14-0558
"A"	01-06-2016	DCN#16-0003

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1.0 **SCOPE**:

This specification establishes and defines the requirements for high strength, frangible/preload collars procured under part numbers listed on Monogram Aerospace standard drawings.

2.0 **APPLICABLE DOCUMENTS**:

The following publications of the issue in effect on the date of invitation for bids shall form a part of this specification to the extent specified herein. In areas of conflict, the requirements of this specification take precedence over those listed.

2.1 **INDUSTRY SPECIFICATIONS AND STANDARDS**

AMS-H-6875	Heat Treatment of Steel Raw Materials
AMS-H-81200	Heat Treatment of Titanium and Titanium Alloys
AMS-QQ-P-416	Plating Cadmium (Electrodeposited)
AMS2249	Chemical Check Analysis Limits Titanium and Titanium Alloys
AMS 2410	Plating, Silver, Nickel Strike, High Bake
AMS 2644	Inspection Material, Penetrant
AMS2700	Passivation Treatment of Corrosion Resisting Steel
AMS2750	Pyrometry
AMS2759	Heat Treatment of Steel Parts, General Requirements
AMS2801	Heat Treatment of Titanium Alloy Parts
AMS6415	Steel, Bars, Forgings, and Tubing 0.080Cr- 1.8Ni-0.25Mo (0.38-0.43C)(SAE 4340) UNS G43406
AMS 6484	Steel, Bars, Forgings, and Tubing 0.80Cr- 1.8Ni-025Mo (0.38-0.43C) (SAE 4340) Normalized and Tempered
AS5272	Lubricant, Solid Film, Heat Cured, Corrosion Inhibiting
AS8879	Screw Threads - UNJ Profile, Inch Controlled Radius Root With Increased Minor Diameter - FSC Thread
AS87132	Lubricant, Cetyl, Alcohol, 1 - Hexadeconal, Application to Fasteners
ASME B46.1	Surface Texture (Surface Roughness, Waviness and Lay
ASTM E 3	Standard Guide for Preparation of Metallographic Specimens
ASTM E 407	Standard Practice for Microetching Metals and Alloys
ASTM E 1417	Standard Practice for Liquid Penetrant Testing
ASTM E 1447	Standard Test Method for Determination of Hydrogen in Titanium and Titanium Alloys by the Inert Gas Fusion Thermal Conductivity Method
NAS4006	Aluminum Coating
NASM1312	Fastener Test Methods

2.2 **Monogram Standard Drawing & Procedures:**

MAFC1087-( )( )	Collar, Preload, Tension, Reduced Hex, CRES
MAFC1571( )( )( )	Collar, Shear, Titanium, Crimp-Locking
MAFC97( )( )	Collar, Preload, Shear, A286 CRES, 450 F and 900 F
MFCSC-( )( )	Collar, Reduced Hex, Preload, Shear, CRES
MAFC15( )( )	Collar, Shear, 17-4PH
MFCSVT-( )( )	Collar, Preload, Hex Drive, Shear, 3AL-2.5V Titanium
MAFC25( )( )	Collar, Tension, 17-4PH

2.2 **Monogram Standard Drawing & Procedures (Continued):**

MTB210-( )	Test Pin, 8740, Cad Plate, 108 ksi Shear
MTB270-( )	Test Pin, 6AL-4V Ti, Alum. Coat, 95 ksi Shear
MTB275-( )	Reduced Major Test Pin, 6AL-4V Ti, Alum. Coat, 95 ksi Shear
MTB280-( )	Test Pin, Inco 718, Alum. Coat, 125 ksi Shear
PRF1087	Pre-Load Fixture

3.0 **REQUIREMENTS**:

Unless otherwise specified by the referencing Monogram part standard or Engineering drawing, collars procured in accordance with this specification shall meet all applicable requirements herein when inspected in accordance with Table I.

Table I LOT INSPECTION REQUIREMENT

Characteristic	Requirements and Test Methods Section	Lot Sampling Requirements
Material	Section 3.1	Per Material specification. See Section 3.1.3. Table III, Table IV and Table V as applicable.
Machining and Forming	Section 3.2	Testing of mechanical and metallurgical properties verifies process
Threads	Section 3.3	Table II, Class A and Per Section 3.10
Crimping	Section 3.4	Testing of mechanical and metallurgical properties verifies process
Heat Treat	Section 3.5	Testing of mechanical and metallurgical properties verifies heat treatment
Non-Destructive Testing (NDT)	Section 3.6	Table II, Class D. Metallurgical evaluation required for all indications.
Surface Texture	Section 3.7	Table II, Class E
Finishes:		
Finishes, Corrosion Resistant Steel	Section 3.8	Non-Destructive Tests, Table II, Class A. Destructive Tests, Table II, Class C
Finishes, Titanium Alloys	Section 3.9	Non-Destructive Tests, Table II, Class A. Destructive Tests, Table II, Class C

Table I LOT INSPECTION REQUIREMENT (Continued)

Dimensions:		
Dimensions (Except for Threads and spherical radius on self-aligning collar washer base)	Section 3.10	Table II, Class B and Per section 3.10
Spherical radius on self-aligning washer base.	Section 3.10	Table II, Class C
Lubricants:		
Cetyl	Section 3.11.1	Table II, Class C
Solid Film Lubricant	Section 3.11.2	Table II, Class A
Contamination (Titanium Only):		
Hydrogen	Section 3.12	Check four random parts per inspection lot. If hydrogen is below maximum limit, lot shall be accepted. If not, reject lot.
Oxygen	Section 3.13	Qualification test only but may be applied to any lot. See Table XV
Identification:		
Identification	Section 3.14	Table II, Class E
Mechanical Testing:		
Tensile Strength	Section 3.15	Table II, Class C
Locking, Torque-Off (Wrench Hex) and Breakaway	Section 3.16	Table II, Class C
Preload & Minimum Thread Engagement	Section 3.17	Table II, Class C
Bearing Surface Squareness	Section 3.18	Table II, Class C
Metallurgical Evaluations		
Microstructure	Section 3.19	Table II, Class C
Discontinuities	Section 3.20	Table II, Class C
Alpha Case and Surface Contamination	Section 3.21	Table II, Class C
Plating Burns	Section 3.22	Table II, Class C
Color Marking	Section 3.27	Table II, Class B
Rework:		
Modification of Parts	Section 3.23	Sampling in accordance with normal procedures listed above
Salt Spray Test	Section 3.27	Table II, Class C

3.1 MATERIAL

3.1.1 ENGINEERING REQUIREMENTS

Per Monogram standard. Monogram is responsible for verifying raw material conformance.

3.1.2 TEST METHODS

Test methods are per material specification referenced on standard or drawings processes for Titanium Alloys and CRES.

LOT SIZE	FULL SAMPLING				
	CLASS A	CLASS B	CLASS C	CLASS D	CLASS E
Under 16	9	5	5	9	1
16-25	9	5	5	9	1
26-50	10	6	5	9	1
51-90	13	8	5	32	2
91-150	15	10	5	32	2
151-280	19	13	5	32	2
281-500	24	16	5	50	3
501-1000	31	19	8	80	3
1001-1200	31	19	8	80	3
1201-2500	35	23	8	80	3
2501-3000	35	23	8	80	3
3001-3200	35	23	8	80	3
3201-10,000	45	28	8	80	4
10,001-20,000	59	35	10	80	4
20,001-35,000	64	43	10	80	4
35,001-50,000	67	49	10	80	5
50,001-100,000	67	49	15	80	5
OVER 100,000	67	49	27	80	10

[1] Acceptance number in all cases is zero nonconformities.

3.1.3 SAMPLING

Fasteners manufactured to the requirements of this specification, shall comply with the following raw material inspection requirements:

3.1.3.1 **Alloy Verification**

All alloy verification shall be conducted by Monogram Aerospace. Allow verification is required on every receipt of raw material, even if the heat lot number has been verified with a previous delivery of raw material.

3.1.3.2 **Traceability**

All metal alloys shall require traceability to the original heat number, and shall comply with the current material specification revision in effect when melted. A copy of the original mill heat lot chemistry certification shall accompany each shipment of raw material to the fastener manufacturer or material converter. Material converters shall include a copy of the original mill heat lot chemistry certification along with the material converter's certification with each shipment of raw material.

3.1.3.3 **Coil (All Alloys)**

a. Unmarked Coil

For each coil that is not individually marked with the alloy and mill heat lot number, Monogram Aerospace or independent laboratory shall perform alloy verification of each coil in the shipment. The fastener manufacturer shall then identify each coil in the shipment with color-coding or other means to identify the material alloy. When alloys have multiple strength levels (i.e. A286) the color coding or other means of identifying shall distinguish the applicable amount of cold reduction or strength level.

b. Marked Coil

For each coil that is individually marked with the alloy and mill heat number, the fastener manufacturer shall sample each shipment of coil per Table III. A randomly selected sample of coils from each shipment shall be taken for verification. The raw material mill shall mark the coil, with the following exception: when the material is to undergo subsequent processing at a converter, the converter may apply material and heat lot marking after processing. Material converters are responsible to maintain heat lot traceability. Converters are prohibited from welding, brazing or otherwise joining coils, unless a documented procedure is followed which removes the welded, brazed or otherwise joined section prior to shipment. Each coil in the shipment shall be identified by color coding or other means of identify the material alloy. When alloys have multiple strength levels (i.e. A286) the color coding or other means of identifying shall distinguish the applicable amount of cold reduction or strength level.

3.1.3.4 **Rod and Bar (All Alloys)**

a. Unmarked Rod or Bar

For each rod or bar that is not individually marked with the alloy and mill heat lot number, the fastener manufacturer shall sample bundled rod or bar per Table IV. A randomly selected sample of bars or rods shall be taken from the bundle for verification. The fastener manufacturer shall then identify each rod or bar in the bundle with color-coding or other means to identify the material alloy. When alloys have multiple strength levels (i.e. A286) the color or other means of identifying shall distinguish the applicable amount of cold reduction or strength level.

b. Marked Rod or Bar

For each rod or bar that is individually marked with the alloy and mill heat number, the fastener manufacturer shall sample bundled rod or bar per Table V. A randomly selected sample of bars or rods shall be taken from the bundle for verification. The raw material mill shall mark the rod or bar, with the following exception: When the material is to undergo subsequent processing at a converter, the converter may apply material and heat lot marking after processing. Material converters are responsible to maintain heat lot traceability. Converters are prohibited from welding, brazing or otherwise joining rods or bars, unless a documented procedure is followed which removes the welded, brazed or otherwise joined section prior to shipment. Each rod or bar in the shipment shall be identified by color coding or other means to identify the material alloy. When alloys have multiple strength levels (i.e. A286) the color coding or other means of identifying shall distinguish the applicable amount of cold reduction or strength level.

TABLE III SAMPLING PLAN FOR MARKED COIL STOCK 92% IRR

Shipment Size (Number of Coils in the Heat Lot Shipment)	Sampling Size (Number of Coils) [1]
Up to 6	All
7 to 12	6
13 to 32	7
33 and Up	8

[1] No rejectable conditions permitted in sample. If one rejectable characteristic is found in the sample, the heat lot shipment must not be accepted.

TABLE IV SAMPLING PLAN FOR BUNDLED UNMARKED ROD AND BAR STOCK 97% IRR

Bundle Size (Number of Rods or Bars)	Sample Size (Number of Rods or Bars) [1]
Up to 17	All
18-37	17
38-44	18
45-68	19
69 to 101	20
102 to 183	21
184 to 949	22
950 and Up	23

[1] No rejectable conditions permitted in sample. If one rejectable characteristic is found in the sample, the bundle must not be accepted.

TABLE V SAMPLING PLAN FOR BUNDLED MARKED ROD AND BAR STOCK 92% IRR

Bundle Size (Number or Rods or Bars)	Sample Size [1] (Number of Rods or Bars)
Up to 6	All
7 to 12	6
13 to 32	7
33 and UP	8

[1] No rejectable conditions permitted in sample. If one rejectable characteristic is found in the sample, the bundle must not be accepted.

3.2 **MACHINING AND FORMING:**

Applicable to all collars.

3.2.1 **ENGINEERING REQUIREMENTS:**

a. Collars which are required to be heat treated shall be machined or formed prior to final heat treat.

b. When collars are formed with an upset forging process utilizing elevated temperatures the temperatures shall be adequately controlled to provide uniformity within the lot.

c. The process used to form the collars shall be suitable and appropriate for the specific raw material and condition of the raw material (i.e. cold reduction) to ensure subsequent tapping, crimping and finishing process can be completed without consequences which will result in a non-conforming product.

d. Qualification of a collar is linked to the process used (i.e. machining or forging), and the condition of the raw material utilized. Use of different processes (i.e. switching from machining to forging), or changes to the condition of the raw material condition or geometry require a separate qualification and review.

3.3 THREADS

Applicable to all collars.

3.3.1 ENGINEERING REQUIREMENTS

a. Thread size per standard or drawing. Unless otherwise specified, thread dimensions shall conform to requirements of AS8879, Class 3B prior to application of coating, plating, lubrication or locking feature and are not intended to be measured after final processing.

b. Collar threads shall be free of missing segments. (A missing segment is an interruption of the helical thread perpendicular to the thread profile).

c. Thread flanks, when evaluated using visual standards prior to surface treatment or metallurgical cross-section, shall have a surface finish of 100 microinches Ra maximum.

d. Steps on the thread flanks shall not exceed the maximum allowed discontinuity limits in Table XIV.

e. Incomplete thread form is acceptable on the first and last threads only.

f. Loose or hanging burrs and slivers shall be removed.

3.3.2 TEST METHODS

Threads shall conform to AS8879 as follows:

a. Prior to application of the self-locking feature, thread pitch diameter size acceptability shall be determined by the variables/indicating control method.

b. Acceptability of pitch diameter at maximum material condition shall be based upon functional measurement of pitch diameter using a go thread plug gage.

c. Acceptability of pitch diameter for -6 collars and larger at minimum material condition shall be based upon single element measurement of pitch diameter using a two or three element variables/indicating gage. Acceptability of pitch diameter for -5 size collars at minimum material condition shall be based upon a measurement of the pitch diameter using a go thread plug gage.

d. Gage dimensions shall be in accordance with the applicable thread gage specification requirements. Length of the pitch diameter functional indicating gage shall meet the standard "Go" ring gage thickness.

e. Acceptability of minor diameter dimensions shall be determined by any instrument, accurate to .0005 inch or better. Other elements, such as major diameter, taper, etc., shall also be within specification limits, even though the specifics for determination are not delineated herein.

3.4 CRIMPING

Applicable to all collars.

3.4.1 ENGINEERING REQUIREMENTS

a. Crimping or mechanical deformation to provide the self-locking feature may be accomplished prior to or subsequent to finishing.

b. Threads in locking section may be displaced in any manner, which provides self-locking characteristics as specified herein. Locking feature shall not damage or peel collar or bolt threads when tested as specified. The process or method of mechanical deformation (i.e. two point, oval lock or three point crimp) shall be document during the qualification. Any change in the process shall require a separate qualification with M.A.F. oversight and review.

c. The crimping process shall utilize process controls to provide a uniform amount of self-locking within a lot of collars.

d. Minimum bolt engagement of three quarters of one revolution, after lubrication, is mandatory when checked with a bolt having threads in accordance with AS8879 with "TD" major diameter in accordance with Figure 2.

3.5 HEAT TREATMENT

Applicable to all collars which require a heat treat process to manufacture the collars or to develop mechanical properties.

3.5.1 ENGINEERING REQUIREMENTS:

a. Heat treatment shall develop tensile properties without adverse effect on metallurgical properties, as defined herein.

b. All units of a lot shall be heated uniformly in a single furnace heat lot.

c. Production parts must be heat treated in the same manner and in the same equipment as the qualification parts. This includes soak temperatures, ramp up times and soak time, quench (when applicable), furnaces as well as pre heat treat cleaning processes. Heat treat shall conform to the requirements of AMS-H-6875 or AMS2759 (CRES), or AMS-H-81200 and or AMS2801(Titanium).

d. Facilities performing heat treatment in accordance with this specification shall be qualified and approved by Monogram or their appointed designee, as part of the part qualification process. Approval will be furnace (s) specific for the qualified parts. Facilities with multiple furnaces shall obtain Monogram approval for each furnace which will be utilized to process MFC1000 parts. All engineering approved heat treatment facilities, processes and furnaces are subject to periodic Monogram evaluation. Furnace relocation (even within a facility), refurbishing of an existing furnace or the addition of a new furnace to a facility shall require Monogram approval prior to use for Monogram collars manufactured in accordance with this specification.

e. The pyrometry and furnace temperature controls shall be in accordance with AMS2750, except as noted below. During initial engineering qualification, it may be necessary to exceed the number and placement of thermocouples, and adjust the survey technique in order to determine the capability of the equipment to meet the specification requirements.

f. The design and construction of heat treat furnaces and control equipment type shall be such that during the part heating up and soaking period, the temperature at any point in the working or soaking zone shall not exceed the maximum or fall below the minimum of the soaking temperature range per the specification requirements for the specific alloy and heat treating operation involved. For batch type furnaces, the term "soaking zone" and "working zone" are synonymous. For continuous type furnaces, the soaking zone is that part of the working zone in which the temperature is within the required range.

3.5.1 **TEST METHODS**

Verification of mechanical properties thru lot acceptance testing in accordance with the requirements of this specification confirms compliance to the engineering requirements of this section.

3.6 IN-PROCESS NON-DESTRUCTIVE TESTING

Applicable to all collars

3.6.1 **ENGINEERING REQUIREMENTS**

a. No cracks permitted in any location. A crack is a clean, irregular break passing through the grain or along the grain boundary.

b. Other discontinuities (laps, seams, and tool marks) are permitted on the body section provided they are not located on the bearing surface of the collar and do not exceed the limits specified in Table XIV. Discontinuities on the threads and mating surfaces shall not exceed the limits specified in Table XIV.

c. Presence or lack of penetrant indications, of themselves, shall not be cause for acceptance or rejection. Rejection or acceptance shall be based upon results of metallurgical evaluation.

d. Metallurgical mounts shall be kept for six months after completion and available for verification by the procuring agency or Monogram.

e. Collars shall not be marked to indicate the lot has been penetrant inspected.

f. Penetrant inspection is not required for collars with nominal thread size smaller than .1900-32.

3.6.2 **TEST METHODS**

a. Penetrant inspect in accordance with ASTM E 1417, Type I, Method B, or D. Use penetrant materials in accordance with AMS 2644, with sensitivity level 2 or greater and sources in accordance with QPL- AMS 2644 or Air Force letters of approval.

b. Penetrant inspection is subsequent to all mechanical operations including, forging, heading, machining, grinding, thread tapping and crimping. But before surface treatments such as abrasive cleaning, coating or lubrication which may seal up surface defects.

c. Collars which are finished prior to crimping shall be chemically stripped of all surface plating, finish and lubricants, prior to inspection in accordance with PS715 for inorganic finishes and PS746 for organic coatings. Mechanical removal of plating, finish and lubricants is not allowed. See Section 3.19 for metallurgical examination requirements.

d. Collars which must be stripped to perform penetrant inspection shall not be reintroduced into the original lot of collars. Examine all indications at a magnification of 10X to 30X inclusive.

e. All collars with Indications shall be subject to metallurgical examination in accordance with Section 3.19. Where multiple collars with similar indications are found, the collars with the most severe indications shall be metallurgically evaluated to determine if the indication is acceptable per Section 3.20.1 and Table XIV.

f. A metallurgist shall decide the amount of examination necessary to determine whether discontinuity indications reveal discontinuities exceeding specified limits.

NOTE: Microstructure evaluation of completed collars is to be after the application of all platings, coatings and finishes and is in addition to the in process metallurgical evaluation of indications found during nondestructive testing.

g. If determined appropriate by a metallurgist, increase to 100 percent inspection for screening if indications can be directly related to discontinuities exceeding specified limits of Table XIV.

3.7 SURFACE TEXTURE

Applicable to all collars

3.7.1 ENGINEERING REQUIREMENTS

a. Shall be measured prior to plating, coating or lubrication.

b. Shall be 63 microinches Ra on bearing and mating surfaces of collars and self-aligning washers.

c. Shall be 100 microinches Ra on threads unless otherwise stated.

d. Other surfaces shall be 125 microinches Ra.

3.7.2 TEST METHODS

Measure surface texture in accordance with ASME B46.1.The preferred procedure is to check surface texture using a profilometer, if practical (limited access or curved surfaces may preclude profilometer use.) Other methods approved by ASME B46.1 may be used.

3.8 FINISHES, CORROSION RESISTANT STEEL

Finishes shall be in accordance with the Monogram standard and the following, as applicable.

3.8.1 CORROSION RESISTANT STEEL, PASSIVATED WITH SOLID FILM LUBRICATION

3.8.1.1 Engineering Requirements

Passivation shall conform to AMS2700.
Salt spray test after passivation. No corrosion products shall appear when examined at 10X (nominal). This test is mandatory for qualification, but may be applied to any lot at the discretion of the receiving contractor.

3.8.1.2 Test Methods

a. Passivation test per AMS 2700

b. Salt spray testing is required for passivation per MIL-STD-1312-1 in accordance with NASM1312-1 except salt spray test for 4 hours minimum. Parts subjected to salt spray testing shall be considered destructively tested.

3.8.2 CORROSION RESISTING STEEL, CADMIUM PLATED PARTS

3.8.2.1 Engineering Requirements

a. Plating shall be per AMS-QQ-P-416, Type II, Class 2, except maximum plating thickness may be exceeded on exterior surfaces of collars and captive washers, and internal surfaces and threads must show complete coverage to achieve optimum plating coverage for performance. Collars and washers may be deformed after plating to provide self-locking feature or to form captive washer over collar. Plating thickness is waived in the deformed area and localized bare areas are acceptable at the point of contact in the deformed zone.

b. Salt spray test after plating except salt spray test for 96 hours minimum. No corrosion products shall appear when examined at 10X (nominal). This test is mandatory for qualification only, but may be applied to any lot at the discretion of the receiving contractor. Production control tests, which include salt spray tests, shall be conducted in accordance with AMS-QQ-P-416. The fastener manufacturer is responsible for ensuring compliance to the minimum production control sampling via audits for all outside processing.

c. No plating burns are allowed.

3.8.2.2 Test Methods

a. Test cadmium plate per AMS-QQ-P-416 requirements except the hydrogen embrittlement test shall not apply.

b. Salt spray test in accordance with NASM1312-1 after plating. Salt spray duration is 96 hours. Parts subjected to salt spray testing shall be considered destructively tested.

3.8.3 CORROSION RESISTANT STEEL, SILVER PLATED PARTS

3.8.3.1 Engineering Requirement

Silver plating shall conform to AMS2410. Thickness shall be .0002 minimum on any surface which can be touched by a .75 diameter ball. Threads shall show complete coverage, but thickness requirement is waived.

Collars shall be passivated in accordance with AMS2700 prior to plating and no corrosion products shall appear when examined at 10X (nominal).

3.8.3.2 **Test Methods**

a. Salt spray testing is required for passivation per MIL-STD-1312-1 in accordance with NASM1312-1 prior to plating except salt spray test for 4 hours minimum. Parts subjected to salt spray testing shall be considered destructively tested.

b. Test silver plating per AMS 2410.

3.8.4 **CORROSION RESISTING STEEL, ALUMINUM COATED PARTS PER NAS4006 AND PS823:**

3.8.4.1 **Engineering Requirements**

a. Coating shall be NAS4006 per PS823 except maximum coating thickness maybe exceeded on exterior surfaces of collars and captive washers, and internal surfaces and threads must show complete coverage to achieve optimum plating coverage for performance. Collars and washers may be deformed after coating to provide self-locking feature or to form captive washer over collar. Minimum coating thickness of .0002 is required for bearing surface and collar exteriors. Coating thickness is waived in the deformed area and localized bare areas are acceptable at the point of contact in the deformed zone.

b. Installation force testing does not apply.

c. Salt spray test after coating. No corrosion products shall appear when examined at 10X. This test is mandatory for qualification only, but may be applied to any lot at the discretion of the receiving contractor.

3.8.4.2 **Test Methods**

a. Suitability: To be determined by test for locking and breakaway torque.

b. Adhesion testing in accordance with PS823. Ensure the part is free of all cetyl alcohol prior to testing. Adhesion test with one inch wide Minnesota Mining and Manufacturing Co. (3M) No 250 tape. This tape shall be controlled in an environment of 40 F to 90 F and 10 to 70 percent relative humidity and shall have an age limit of one year from date of manufacture. Apply a length of the tape to a convenient area of the coated bearing or wrenching surfaces. Remove the tape with a quick motion and examine the tape and the part for lifting of the coating. A uniform deposit of powdery material may cling to the tape but the lifting of any flakes or particles of the coating which exposes a bare metal surface on the part shall be cause for rejection.

c. Coating thickness verification. Conventional methods. Referee testing will be metallurgical verification. Nondestructive test of coating thickness shall apply to each inspection lot (see Section 4.1.1). Receiving contractor may apply tests to any lot.

d. Salt spray test per MIL-STD -1312-1 in accordance with NASM1312-1.

e. Parts subjected to salt spray testing shall be considered destructively tested.

3.9 FINISHES TITANIUM ALLOYS

3.9.1 TITANIUM ALLOYS, HARD ANODIZE

3.9.1.1 Engineering Requirements

Proprietary coating, to be certified by the applicator, with both the product and the application process documented in the suppliers' PCD.

3.9.1.2 Test Methods

Testing by fastener manufacturer or receiving contractor not required.

3.9.2 TITANIUM ALLOYS, ALUMINUM COATED PARTS PER NAS4006 AND PS823

3.9.2.1 Engineering Requirements

a. Coating shall be NAS4006 per PS823 except maximum coating thickness may be exceeded on exterior surfaces of collars and captive washers, to achieve optimum coating coverage on the threads and inside diameters of collars and washers. Collars and washers may be deformed after coating to provide self-locking feature or to form captive washer over collar. Minimum coating thickness of .0002 is required for bearing surface and collar exteriors. Coating thickness is waived at the deformed area and localized bare areas are acceptable at the point of deformation only.

b. Installation force testing does not apply.

3.9.2.2 Test Methods

a. Suitability: To be determined by test for locking and breakaway torque.

b. Adhesion testing in accordance with PS823. Adhesion test with one inch wide Minnesota Mining and Manufacturing Co. (3M) No 250 tape. This tape shall be controlled in an environment of 40 F to 90 F and 10 to 70 percent relative humidity and shall have an age limit of one year from date of manufacture. Apply a length of the tape to a convenient area of the coated bearing or wrenching surfaces. Remove the tape with a quick motion and examine the tape and the part for lifting of the coating. A uniform deposit of powdery material may cling to the tape but the lifting of any flakes or particles of the coating which exposes a bare metal surface on the part shall be cause for rejection.

c. Coating thickness verification. Conventional methods. Referee testing will be metallurgical verification. Nondestructive test of coating thickness shall apply to each inspection lot (see Section 4.1.1). Receiving contractor may apply destructive or nondestructive tests to any lot.

3.10 DIMENSIONS

Applicable to all collars

3.10.1 ENGINEERING REQUIREMENTS

Dimensions shall be in accordance with the Monogram standard or Monogram engineering drawings except as otherwise stated on the standard or drawing. All dimensions apply after plating or coating but before lubrication, including solid film lubrication. Threads shall conform to the requirements of AS8879 Class 3B prior to the application of plating, coating, lubrication or locking feature and are not intended to be measured after final processing.

3.10.2 TEST METHODS

Conventional measuring methods.

3.11 LUBRICANTS

3.11.1 CETYL ALCOHOL

3.11.1.1 Engineering Requirements

Unless otherwise specified, if "Cetyl" or "Cetyl Alcohol" is specified, use AS87132, Type I or Type III; concentrations to be determined by manufacturer to meet the requirements for locking and breakaway torque herein.

a. The coating shall feel slippery to the touch.

b. The coating shall be non-wetting when dipped in water.

c. The coating may exhibit a slight frosty appearance.

d. The coating shall be essentially uniform with some localized buildup exhibiting a uniform white appearance allowed in the thread roots. The localized buildup shall not be continuous in the thread. This condition is caused by improper drying or packaging while still wet.

3.11.1.2 **Test Methods**

Test in accordance with AS87132. Suitability to be determined by test for locking and breakaway torque.

3.11.2 **SOLID FILM LUBRICANTS**

3.11.2.1 **Engineering Requirements**

When specified on the Monogram standard, solid film lubricants shall be in accordance with AS5272, Type I or Type II, color optional. Cured solid film coatings shall adhere to the substrate. Unless otherwise specified, the cured solid film lubricant average thickness shall be between .0003 and .0005 inch, with no single reading less than .0002 inch or greater than .0007 inch. Thickness requirement applies to the bearing surface of collar and washers only. Threads and other surfaces shall show complete coverage with no requirement for thickness verification other than visual. Threads and other surfaces have no maximum requirement for lubrication thickness except that it shall not impair proper functions such as bolt engagement. Lubricant accumulation in the threads shall not cause the observed torque to exceed the maximum locking torque prior to engagement of the locking feature area.

3.11.2.2 **Test Methods**

a. Suitability: To be determined by test for locking and breakaway torque.

b. Adhesion: test with one inch wide Minnesota Mining and Manufacturing Co. (3M) No 250 tape. This tape shall be controlled in an environment of 40 F to 90 F and 10 to 70 percent relative humidity and shall have an age limit of one year from date of manufacture. Apply a length of the tape to a convenient area of the coated bearing or wrenching surfaces. Remove the tape with a quick motion and examine the tape and the part for lifting of the coating. A uniform deposit of powdery material may cling to the tape but the lifting of any flakes or particles of the lubricant which exposes a bare metal surface on the part shall be cause for rejection.

c. Coating thickness verification by conventional inspection methods. Referee testing shall be by metallurgical verification.

3.12 HYDROGEN CONTAMINATION (TITANIUM ONLY)

3.12.1 ENGINEERING REQUIREMENTS

3.12.1.1 3AL-2.5V Titanium Alloy

Collars shall not have hydrogen contents exceeding .0080 percent (80 ppm). The check analysis allowances of AMS2249 do not apply.

3.12.1.2 6AL-4V Titanium Alloy

Collars shall not have hydrogen contents exceeding .0125 percent (125 ppm). The check analysis allowances of AMS2249 do not apply.

3.12.2 TEST METHODS

a. Determine the hydrogen content from material removed from the base of the collar. Sample shall include a maximum amount of the collar surface.

b. Plating and lubricant shall be removed. Mechanical removal is acceptable provided depth of plating plus basis material removed does not exceed .003.

c. Use procedures and equipment that are capable of analyzing hydrogen to an accuracy of +/- .0010 percent (10 ppm) using test method in ASTM E 1447.

3.13 OXYGEN CONTAMINATION (TITANIUM ONLY)

3.13.1 ENGINEERING REQUIREMENTS

3.13.1.1 3AL-2.5V Titanium Alloy

a. Collars shall not have oxygen contents exceeding .120 percent (1200 ppm). The check analysis allowances of AMS2249 do not apply.

b. Test for oxygen is not mandatory, but may be applied to any lot at the discretion of the receiving contractor.

3.13.1.2 6AL-4V Titanium Alloy

a. Collars shall not have oxygen contents exceeding .200 percent (2000 ppm). The check analysis allowances of AMS2249 do not apply.

b. Test for oxygen is not mandatory, but may be applied to any lot at the discretion of the receiving contractor.

3.13.2 **TEST METHODS**

a. Determine the amount of oxygen from material removed from the base of the collar. Sample shall include maximum amount of the collar surface.

b. Plating and lubricant shall be removed. Mechanical removal is acceptable provided depth of plating plus basis material removed does not exceed .003.

c. Use procedures and equipment that are capable of analyzing oxygen to an accuracy of .010 percent (100 ppm).

3.14 **IDENTIFICATION**

3.14.1 **ENGINEERING REQUIREMENTS**

Per Monogram standard: Marking shall be legible at 5X magnification or less.

3.14.2 **TEST METHODS**

Visual Examination after the application of all finishes and lubrications.

3.15 **TENSILE STRENGTH**

Applicable to all collars

3.15.1 **ENGINEERING REQUIREMENTS**

Collars shall withstand the minimum ultimate tensile values listed in Table VII.

3.15.2 **TEST METHODS**

a. Static tensile test in accordance with D2 – 2860 or MIL-STD-1312-8 in accordance with NASM1312-8, using the test bolts listed in Table VI or bolts equivalent to the bolts listed in Table VI, in material, thread form and strength.

b. For qualification testing use only the bolts listed in Table VI. For referee testing bolts listed in Table VI will be used.

c. Loads shall be applied until bolt or collar failure occurs. If bolt failure occurs before the minimum collar tensile load has been achieved the test is invalid (bolt failure shall not be cause for collar rejection).

d. When required by the standard, self-aligning collars shall be tensile tested at a 7° +/- 1/2° slope per MIL-STD-1312-8 in accordance with NASM1312-8 using a tapered spacer or tensile plate with the required angularity. The hole shall be the maximum shank diameter of the test bolt plus 0.005-inch with a tolerance of +0.003, -0.000 inch. Hole shall be perpendicular (+/- 1/2°) to the base (non sloped surface) of the spacer or plate. Equal full tensile samples shall be tested at both 0° and 7° degrees.

TABLE VI TEST BOLT REQUIREMENTS FOR TENSILE TESTING OF COLLARS

Collar Size Dash No.	Bolt Thread Size Per AS8879	Thread Major Diameter Dimensional Limits		Acceptable Tensile Test Bolt Part Numbers
		Max	Min	
-5	.1640-32 UNJC	.1595	.1570	MTB210 MTB270 MTB275 MTB280
-6	.1900-32 UNJF	.1840	.1810	
-8	.2500-28 UNJF	.2440	.2410	
-10	.3125-24 UNJF	.3060	.3020	
-12	.3750-24 UNJF	.3680	.3640	

TABLE VII COLLAR TENSILE STRENGTH

Collar Dash Number	300 Series CRES [1] A286 & Titanium Shear Collars	300 Series CRES [1] A286 & Titanium Shear Collars	17-4 PH CRES Shear Collar	17-4 PH CRES Tension Collar
-5	1,940	2,300	3,050	----
-6	2,500	2,750	4,000	4,500
-8	4,300	5,000	7,500	8,500
-10	6,300	8,300	11,750	13,300
-12	8,700	12,700	18,000	20,416

[1] Includes 302, 303SE, 305 and 18-19-LW (UNS S30430; 302HQ)

3.16 **LOCKING TORQUE, TORQUE-OFF (WRENCH HEX) AND BREAKAWAY**

Applicable to all collars.

3.16.1 **ENGINEERING REQUIREMENTS**

a. The locking torque, breakaway torque and torque-off are defined in Section 7.

b. Locking and breakaway torque values shall be in accordance with Table IX.

c. Torque-off shall be within values listed on Monogram standard or Engineering drawing.

3.16.2 **TEST METHOD MANUAL**

The Manuel test method includes the use of power assisted torque drivers. Collar torque rates shall not exceed 20 rpm.

NOTE: For optimum test results, a constant torque rate should be applied in the range of 10 rpm to 15 rpm

3.16.2.1 **Test Pins**

Test pins for collar torque tests shall meet the thread, material, finish and strength requirements in accordance with Figure 2, except as noted on Table VIII regarding. Monogram Test Pins MTB210, MTB270, MTB275 and MTB280. Additionally, all dimensions shall apply prior to lube. Test bolt grip and thread lengths shall be sufficient to accommodate pre–load release fixtures extended and retracted a minimum of 360 degrees of bushing rotation beyond both the minimum and maximum pin protrusion requirements. Monogram will provide test pins for the performance of customer's Receiving Inspection.

TABLE VIII MONOGRAM TEST PINS

Test Pin No.	Material	Finish	KSI
MTB210-( )	8740	Cad Plate	108
MTB270-( )	Titanium	Aluminum Coat	95
MTB275-( )	Titanium	Aluminum Coat	95
MTB280-( )	Inco 718	Aluminum Coat	125

Note: All Test Pins Conform to Figure 2 except Material, Finish, and KSI as noted above.

3.16.2.2 **Preload Release Fixture**

The pre–load release fixture shall essentially meet Monogram drawing requirements of PRF 1087.

3.16.2.3 **Collar Removal Tool**

The collar removal tool will essentially be a set of collet chucks.

3.16.2.4 **Locking Torque and Torque Off Tests**

a. Install a test bolt and collar in the preload release fixture at the maximum pin-protrusion values (P1) in accordance with Table X and Figure 1 using a tolerance of +.000/ -.020 inch. The bolt thread protrusion shall be controlled by the combination of preload release bushing height and test bolt length.

b. All torque measurement shall be performed by the application of torque applied to the collar with the bolt held stationary.

c. Measure and record the Locking Torque during installation of the collar.

d. Measure and record the Torque-Off during the installation of the collar.

3.16.2.5 **Breakaway Torque Test**

a. Remove the pre-load on the collar by releasing the preload. If necessary to facilitate removal of the pre-load without rotating the collar, grasp the collar at the base as shown in Figure 1. Collapse the pre-load release bushing a sufficient amount to remove all of the preload from the test bolt. Ensure that the collar does not rotate relative to the test bolt while the bushing is released.

b. Measure and record the breakaway torque value.

3.16.3 **TEST METHOD AUTOMATED**

The test shall be accomplished utilizing the test bolts, preload fixture and collar removal tool as specified in Section 3.16.2 except using an automated torque testing machine.

3.16.3.1 **Automated Equipment Requirement**

a. The machine shall have an uncertainty of less than or equal to +/- 1.0 percent of reading over the range of 0.5 in-lbs to 2000 in-lbs in both the clockwise and counter-clockwise direction.

b. The machine shall be able to control angular position to within +/- 20 arc seconds of any commanded angular position.

c. The machine shall be capable of controlling angular velocity to within +/- 0.1 percent of command over the range of 0.01 rpm to 90 rpm.

d. The machine shall be able to develop 2000 in-lbs at 90 rpm.

e. The machine shall have a resolution of at least 16 bits, bi -polar, with a control update rate of a minimum of 500 Hz and a sample rate of 40 kHz.

f. The machine shall be capable of resolving maximum and minimum torque values to within +/- 0.01 percent of full scale range.

g. The torque measurement instrumentation shall be accurate, as compared to N.I.S.T. traceable standards, to the larger of +/- 1.0 percent indicated reading (value) or +/- 0.1 in-lb.

h. The machine shall be programmed to install the collar between 10 – 15 rpm and to stop when the frangible portion of the collar (hex head) separates from the collar. Once the Torque Off portion of the test is completed, the program shall prompt the operator to remove the pre-load from the test bolt prior to continuing with the Breakaway portion of the test.

i. In the Breakaway portion of the test, the machine shall be programmed to measure the maximum Breakaway Torque during the first 90 degrees of rotation at a commanded velocity of 90 degrees per second and then return to zero degrees of angular position at 360 degrees per second.

j. Recorded test parameters shall be reported to the resolution specified above.

3.16.3.2 **Preliminary Test Set-up**

Install the test pin in the pre–load fixture and adjust the pin protrusion to the maximum protrusion values specified in Table X.

Install the collar finger tight against the locking element.

Install the test pin head into a socket adapted to the torque transducer.

Install the collar hex head into a socket adapted to the machine drive mechanism.

Adjust the machine support mechanism as necessary to insure that the test pin and collar are aligned with the centerline of the torque transducers.

3.16.3.3 **Locking Torque and Torque Off Tests**

With the test pin and collar installed in the machine at approximately zero degrees of rotation, balance the Peak Torque Reading Mechanism. Run the portion of test program which installs the collar. Once the hex head is separated from the collar and the machine stops, record the locking and torque–off values.

3.16.3.4 **Breakaway Torque Test**

Remove the pre–load release bushing, test pin and collar from the test setup. Collapse the pre–load release bushing a sufficient amount to remove all the pre–load from the test pin.

Insure that the collar does not rotate on the pin while the bushing is released. Install the collar removal tool on the collar and reinstall the bushing, test pin, collar and removal tool into the machine.

Insure the collar removal tool is installed on the machines drive mechanism.

Run the Breakaway portion of the test and record all test parameters after the machine returns to zero degrees of rotation.

3.16.3.5 **Recording of Data**

Locking, torque–off and breakaway torque values shall be automatically recorded without operator action.

TABLE IX LOCKING AND BREAKAWAY TORQUE

Collar Size Dash No.	Stud Thread Size		Locking Torque Inch-Lbs	
			Breakaway Minimum	Locking Maximum
-5	.1640-32	UNJC-3B	1.5	7
-6	.1900-32	UNJF-3B	2.0	12
-8	.2500-28	UNJF-3B	3.5	17
-10	.3125-24	UNJF-3B	6.5	35
-12	.3750-24	UNJF-3B	9.5	40

TABLE X PIN PROTRUSION

Fastener		For Standard Weight Collars		For Light Weight Collars	
First Dash Number	Nominal Thread	Minimum Protrusion	Maximum Protrusion	Minimum Protrusion	Maximum Protrusion
-5	.1640-32	.302	.384	.270	.352
-6	.1900-32	.315	.397	.280	.362
-8	.2500-28	.385	.467	.310	.392
-10	.3125-24	.490	.572	.370	.452
-12	.3750-24	.535	.617	.410	.492

Figure 1 - LOCKING TORQUE TEST (BREAKAWAY TORQUE)

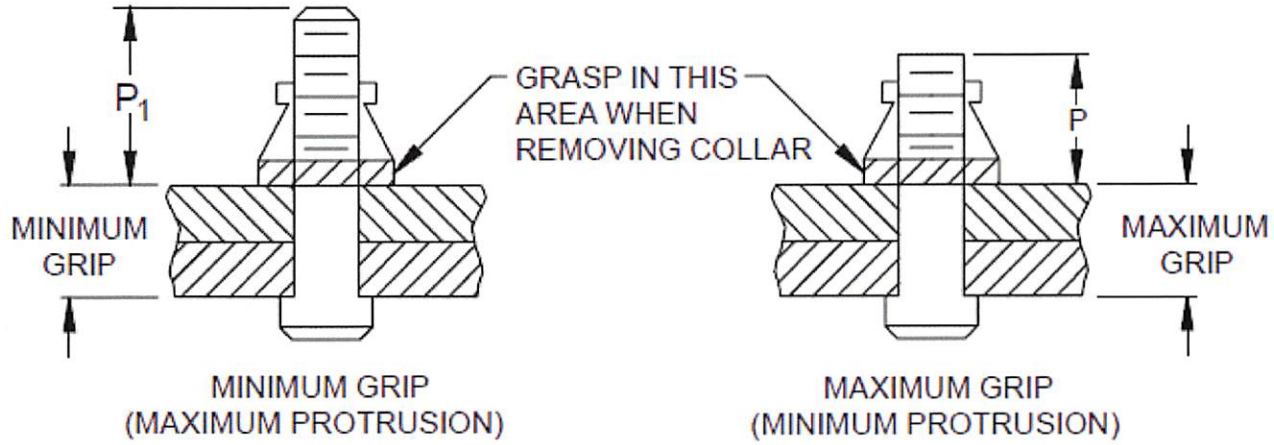
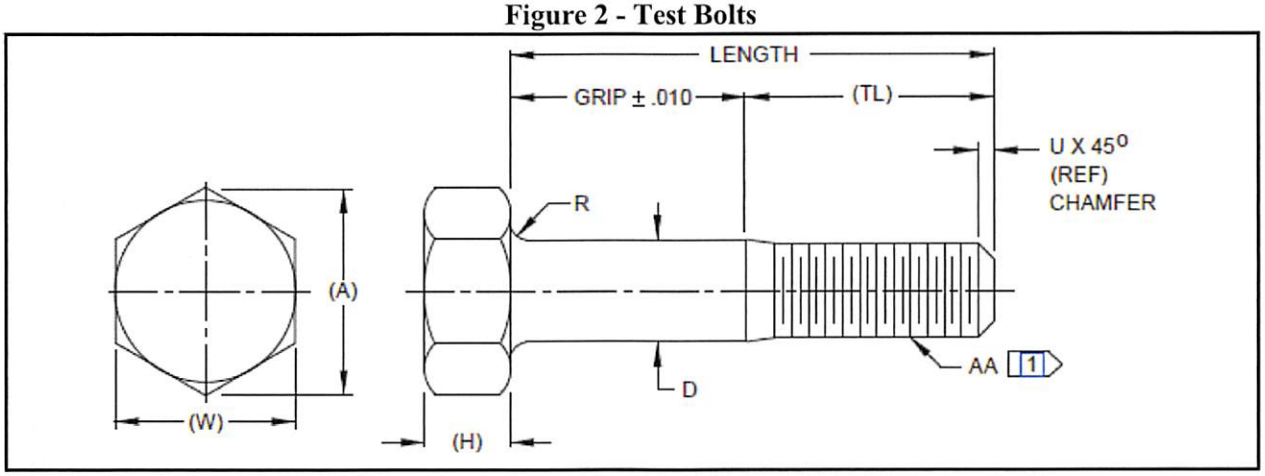


Figure 2 - Test Bolts



DIAMETER DASH NUMBER	AA NOMINAL THREAD SIZE 1	GRIP DASH SIZE	A (REF)	D		H (REF)	R	
				MAX	MIN		MAX	MIN
5	.1640 - 32	-8	0.344	0.1635	0.1575	0.095	0.030	0.015
6	.1900 - 32	-9	0.344	0.1895	0.1835	0.105	0.030	0.015
8	.2500 - 28	-11	0.484	0.2495	0.2435	0.150	0.030	0.015
10	.3125 - 24	-13	0.557	0.312	0.306	0.195	0.040	0.020
12	.3750 - 24	-15	0.624	0.3745	0.3685	0.226	0.040	0.020

Figure 2 - Test Bolts (Continued)

DIAMETER DASH NUMBER	AA NOMINAL THREAD SIZE [1]	GRIP DASH SIZE	TD		TL (REF)	THREAD PITCH [2]		FUNCTIONAL DIAMETER [3]	U (REF)	W HEX (REF)
			MAX	MIN		MAX	MIN	MAX		
5	.1640 - 32	-8	0.1595	0.1570	0.375	0.1425	0.1415	0.1430	0.031	0.313
6	.1900 - 32	-9	0.1840	0.1810	0.388	0.1684	0.1674	0.1689	0.031	0.313
8	.2500 - 28	-11	0.2240	0.2410	0.458	0.2253	0.2243	0.2258	0.031	0.438
10	.3125 - 24	-13	0.3060	0.3020	0.563	0.2837	0.2827	0.2842	0.047	0.500
12	.3750 - 24	-15	0.3680	0.3640	0.608	0.3460	0.3450	0.3465	0.047	0.563

[1] Threads per AS8879 except for reduction of thread major diameter per "TD".

[2] Pitch diameter for single element gage inspection.

[3] Functional diameter maximum for functional gage inspection.

[4] Grip lengths in table above are for reference. use appropriate grip length to meet the required protrusion in the preload fixture.

Material: Alloy Steel per AMS6415, AMS6484, AMS6382, AMS6349, AMS6322 OR AMS6327
Heat Treatment: 108,000 PSI Shear Minimum per AMS-H-6875
Finish: Cadmium Plate per AMS-QQ-P-416 Type II, Class 2, and Cetyl Alcohol Lube in accordance with Section 3.11.1.
Coding: First diameter dash number designates nominal diameter. second dash numbers designates grip length in .0625 increments (suggested).

3.17 PRELOAD AND MINIMUM THREAD ENGAGEMENT

Applicable to all collars

3.17.1 ENGINEERING REQUIREMENTS

a. Minimum bolt thread engagement of three quarters of one revolution, after lubrication, is mandatory when checked with a bolt having threads in accordance with AS8879 with "TD" major diameter in accordance with Figure 2.

b. Collars shall be tested for minimum preload. The requirements are shown in Table XI.

3.17.2 TEST METHODS

a. Use any suitable equipment for measuring preload.

b. For Titanium, A-286 and CRES (except 17-4PH) collars, use test bolts in accordance with Figure 2.

c. For 17-4 CRES collars use aluminum coated per PS823, Class A coated nickel alloy 718 bolts, with cetyl alcohol lubrication as test bolts. Use shear or tension bolts for shear collars. Use tension bolts for tension collars.

d. For MFCTPH collars, use test bolts called out on the part standard.

e. Set bolts that pin-protrusion is at a maximum in accordance with Table X, with tolerance of +.000/-.020 inch.

f. The collar shall bear against hardened steel surface. Surface shall be cleaned to remove all lubrications and/or finishes prior to each use.

TABLE XI MINIMUM PRELOAD

Collar Dash No.	Preload Lbs.			
	CRES, A286 & Titanium Collars		17-4 PH CRES Collars	
	Shear	Tension	Shear	Tension
-5	500	800	850	-----
-6	700	1100	1300	2150
-8	1600	2600	2200	3850
-10	2250	4150	3500	6150
-12	3250	5500	5000	9550

3.18 BEARING SURFACE SQUARENESS

Applicable to all non-self-aligning collars

3.18.1 ENGINEERING REQUIREMENTS

With collar on one of the two stud options per Figure 3 (option A or option B) or equivalent, the maximum gap shall not exceed the value specified in Table XII.

TABLE XII – BEARING SURFACE SQUARENESS MAXIMUM GAP

Collar Dash Number	5	6	8	10	12
Bearing Surface Maximum Gap	0.004	0.005	0.005	0.006	0.006

3.18.2 TEST METHODS

a. Bearing surface squareness shall be verified before or after incorporation of the locking feature and finishes. The collar shall be assembled on one of the threaded options below having a minimum thread length equal to the collar height.

b. Check collars on one of the two gage options per Figure 3 or equivalent.

Option A:

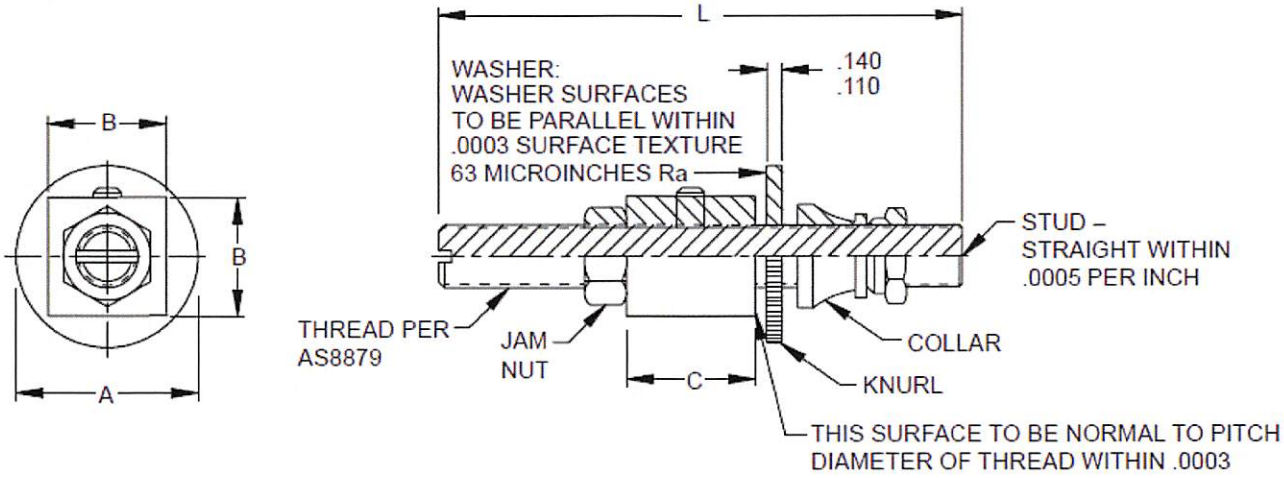
Option 'A' gage dimensions per Table XIII. Adjust block to allow collar to fit on stud with minimum of 1 pitch of stud protruding beyond the threads of the collar, and lock with jam nut. Thread the collar on the stud until the collar contacts the washer and creates a slight drag when the washer is rotated by fingers. Measure the maximum gap between washer and the bearing surface of the collar.

Option B:

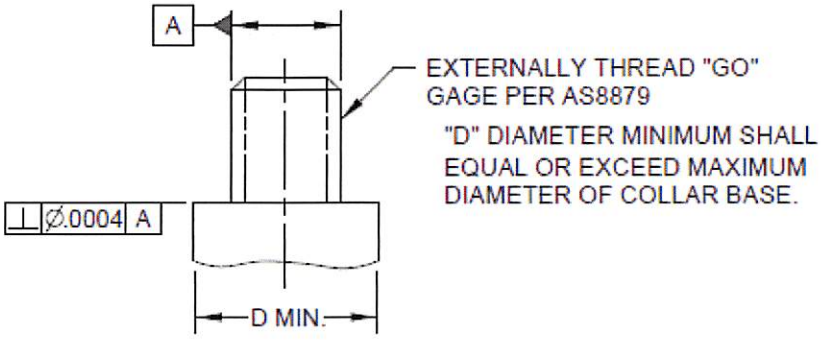
Determine bearing surface squareness of collar by turning collar on "Go" gage with minimum of 1 pitch of stud thread protruding beyond the threads of the collar and collar just contacts gage base with a slight drag. Use feeler gage to determine maximum gap under collar outside circumference of bearing surface.

Figure 3 – BEARING SURFACE SQUARENESS GAGE

GAGE FIXTURE OPTION A



GAGE FIXTURE OPTION B



GAGE FIXTURE OPTION B

TABLE XIII DIMENSIONS FOR FIGURE 3 GAGE FIXTURE OPTION A

Collar Size Dash No.	Stud Thread Size	ØA ±.015	B ±.015	C ±.015	L ±.015
-5	.1640-32 UNJC-3A	1.500	1.000	1.500	4.000
-6	.1900-32 UNJF-3A				
-8	.2500-28 UNJF-3A				
-10	.3125-24 UNJF-3A				5.000
-12	.3750-24 UNJF-3A				

3.19 **MICROSTRUCTURE AND METALLURGICAL PREPARATION**

3.19.1 **ENGINEERING REQUIREMENTS**

Each lot of collars shall be metallurgically evaluated

3.19.1.1 **Requirements For All Collars**

a. Macrostructure shall be uniform in quality and condition.

b. Microstructure shall be free from bursts, voids and evidence of overheating.

c. Alloy segregation which adversely affects the mechanical or physical properties of the part is not acceptable.

d. No cracks permitted in any location.

e. Discontinuities shall be as defined in Section 3.20 and within the limits of Table XIV and Figure 5.

3.19.1.2 **Requirements For 17-4PH, A286 and CRES Collars**

No evidence cadmium plating burns in any location as described in Section 3.22.

3.19.1.3 **Requirements for 6AI-4V and 3AL-2.5V Titanium Alloys**

a. The microstructure of 6Al-4V and 3AL-2.5V titanium collars shall be representative of alpha-beta processed material, and shall consist essentially of equiaxed primary alpha grains in a matrix of transformed beta. A microstructure which has been heated to or above the beta transus, consisting essentially of acicular alpha within prior beta grains and little or no primary alpha, is considered overheated. The overheated microstructure is not allowed.

b. No surface contamination (alpha case) on any location as described in Section 3.21.

3.19.2 **TEST METHODS**

a. Cut specimens as shown in Figure 4. Suggested etchants (percent by volume):

Suggested Etchants:

300 and	Ferric Chloride Reagent (SS # 9) (10 ml. HCl , 25 gm. FeCl3 , 90 ml H2O).
PH CRES	Application: Swab to keep oxide from Adhering. Kailings (5g CuCl2, 100ml HCL, 100ml Alcohol).
A286 CRES	Acid ferric chloride (10 gm FeCl3, 20 ml HCl, 5 ml HNO3, 40 ml H2O).
Titanium	Oxalic-Alpha Case Reagent (2ml HF, 20gm Oxalic, 98 ml H2O) 15 to 20 second drip (not swab and remove etchant with cold running water) for contamination, follow with Kroll's etch (15 ml HF, 35 ml HNO3, 950 ml H2O) for microstructure. Separate examinations. Re-polish between the two etchants.

Alternate etchants may be used. See (for example) ASTM E 407 Standard Practice for Microetching Metals and Alloys or ASM Handbook Volume 9, Metallography and Microstructures for additional etchant suggestions.

For a general guide of preparation of specimens see (for example) ASTM E 03 Standard Guide for Preparation of Metallographic Specimens.

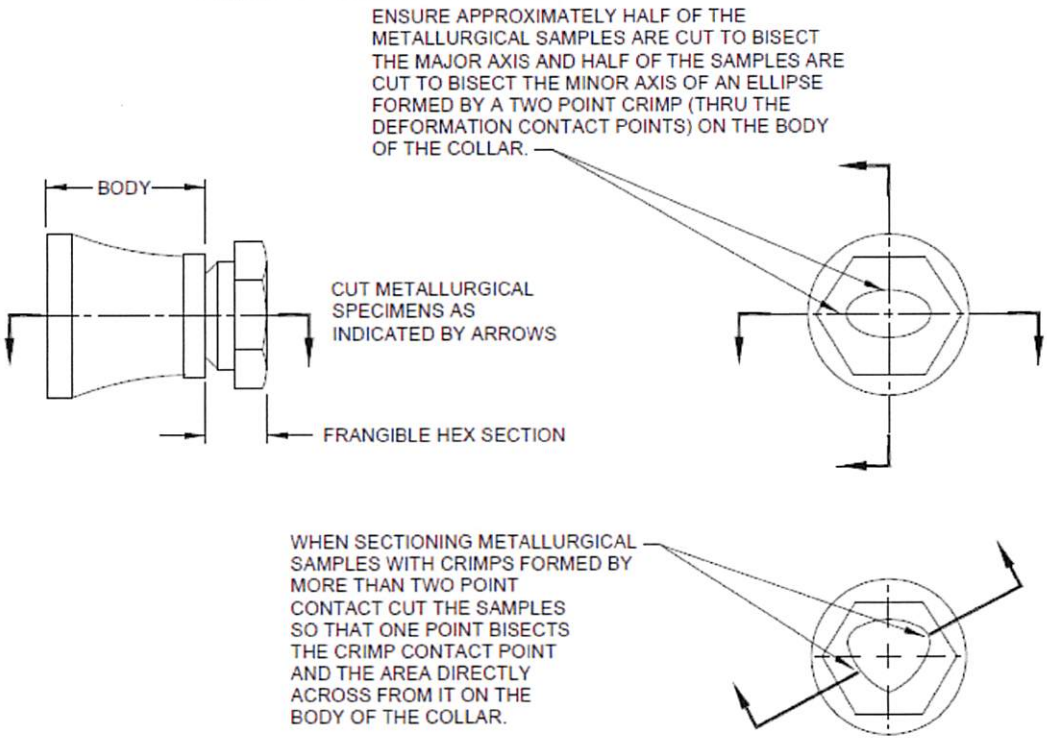
b. A metallurgist shall decide the amount of examination necessary to determine whether discontinuity indications reveal discontinuities exceeding specified limits.

c. Examine specimens at magnifications indicated below. Higher magnification may be used to quantify extent of indications.

Surface Contamination	(Titanium only) Micro examination 500X
Discontinuities	Micro examination (100 X or greater)
Intergranular Corrosion	Micro examination (100 X or greater)
Microstructure	Micro examination (100 X or greater)

d. Metallurgical mounts shall be kept for six months after completion and be available for verification by the procuring agency.

Figure 4 – METALLURGICAL SPECIMENS



3.20 DISCONTINUITIES

Applicable to all collars

3.20.1 ENGINEERING REQUIREMENTS:

a. No cracks are permitted in any location on the collar. This includes the body of the collar as well as the frangible portion of the collar.

b. Other discontinuities (laps, inclusions and tool marks) are permitted on the body section of the collar provided they are not located on the bearing surface of the collar or the self-aligning washer, do not impair flatness of the bearing surfaces, do not impair the function or fit of the collar or washer and they do not exceed the limits specified in Table XIV (see Figure 5).

3.20.2 TEST METHODS

a. Non-destructive testing with metallurgical review of all indications in accordance with Section 3.6.

b. Microstructure review in accordance with Section 3.19.

Figure 5 – BODY AND BEARING SURFACES

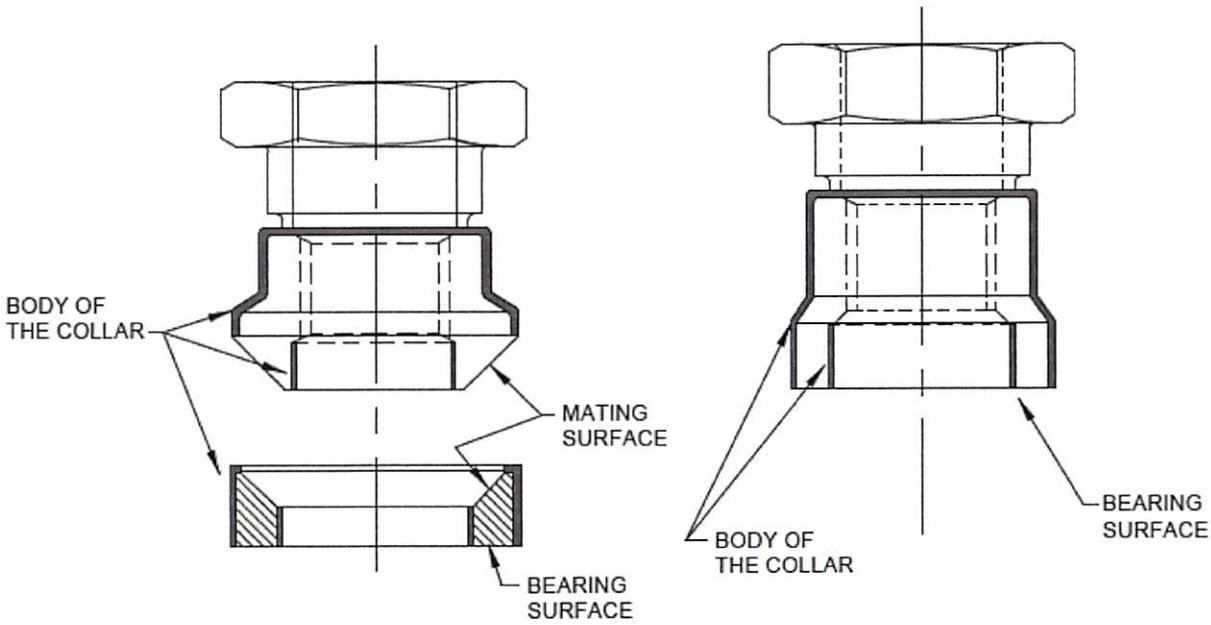


TABLE XIV – DISCONTINUITIES AND SURFACE CONTAMINATION

Collar Dash Number	5	6	8	10	12
Body Section Discontinuities, (Except Bearing Surface and Threads) Maximum Depth	0.005	0.005	0.005	0.005	0.006
Thread and Mating Surface Discontinuities Maximum Depth	0.002	0.002	0.002	0.003	0.003
Bearing Surface Discontinuities Maximum Depth	None [1]				
Frangible Hex Section Discontinuities Maximum Depth	0.010				
Surface Contamination (Titanium Only(	None				

[1] Discontinuities less than .0005 which do not protrude or have sharp edges as to impact the ability of the collars to be installed without damage to the structure are acceptable.

3.21 SURFACE CONTAMINATION

Applicable to 6Al-4V and 3Al-2.5V titanium collars only.

3.21.1 ENGINEERING REQUIREMENTS

There shall be no surface contamination, as evidenced by an oxygen enriched or a higher density of primary alpha on the surface as compared with the core as noted in Table XIV .

NOTE: Alpha case is an example of a more severe case of surface contamination, consisting of a continuous layer of 100 percent alpha phase.

3.21.2 **Test Methods**

Metallurgical examination in accordance with Section 3.19. All titanium collars are required to be secondarily etched with Kroll's as described in Section 3.19 to detect contamination and Alpha case. A re-polishing is required between the initial Oxalic-Alpha Case Reagent Etch and the secondary Kroll's etch.

3.22 PLATING BURNS

Applicable to all CRES, A286 and PH steel collars

3.22.1 **Engineering Requirements**

There shall be no indications of plating burns on plated collars.

3.22.2 **TEST METHODS**

Examine fasteners for plating burns during metallurgical examination per Section 3.19 or during a visual examination.

3.23 MODIFICATION OF PARTS

3.23.1 **ENGINEERING REQUIREMENTS**

a. There shall be no modification (altering a part from the condition accepted by Monogram's final inspection) by the receiving agency of finished parts after they once leave the original fastener manufacturer's facility. In–process rework does not constitute modification.

b. If approved by Engineering, only Monogram may modify a finished part.

c. Lot acceptance tests apply to parts prior to modification and after modification. The inspection report shall include the results of both examinations.

3.23.2 **TEST METHODS**

All applicable inspections and tests conducted prior to modification shall be repeated.

3.24 DISPOSITION OF DEFECTIVE LOTS

3.24.1 **ENGINEERING REQUIREMENTS**

Fastener lots that fail to meet requirements (after rework possibilities are exhausted) shall be scrapped by Monogram. The disposal method must prevent salvage and resale as Aerospace quality fasteners. Previously submitted lots that have been rejected and

reworked shall have complete traceability to the original lot and shall be clearly identified on the new certification. The preferred method of identifying a reworked lot is to add a suffix "R" to the original lot number.

3.25 PACKAGING

Packaging shall provide sufficient protection so that collars will not be damaged or exposed to undue weathering or harmful materials. Collars of one size and part number only shall be packaged in each unit container. An assortment of unit packages may be in larger packages.

3.26 MARKING

Each package and container shall be durably and legibly marked. Marking shall be located so it will not be damaged when the package is opened. Marking shall include at least the following: name of part, part number, purchase order number and manufacturer's inspection lot number.

3.27 COLOR MARKING

Applicable to all fastener types.

3.27.1 ENGINEERING REQUIREMENTS

Paint, dye, lacquer or other coloring agents used to meet standard or drawing requirements for color marking shall:

a. Be approximately true colors (i.e., when red is specified, shades of pink and orange are not acceptable).

b. Not be water soluble, except as otherwise specified.

c. Not be conductive to corrosion of plating, coating, or base metals when exposed to a 2 hours Salt Spray test. Salt Spray testing is only required for Qualification but may be applied to any lot at the discretion of the receiving contractor or Monogram Aerospace.

d. Not exceed .001 in thickness or affect performance properties due to overspray on threads or bearing surface.

e. Not affect performance properties due to overspray on threads or bearing surface.

3.27.2 **TEST METHODS**

Visual examination. For qualification only: Salt Spray test per MIL-STD-1312-1 in accordance with NASM1312-1.

3.27.3 **TEST METHODS**

Sample per Table II, Class B. For Qualification only, Salt Spray Test, sample per Table II, Class C.

4.0 QUALITY ASSURANCE PROVISIONS

4.1 INSPECTION TESTS

Unless otherwise specified, the tests in Section 3 are mandatory for Monogram on each lot as defined in Section 4.1.1. Sufficient periodic surveillance testing shall be accomplished by the receiving contractor. The receiving contractor may either perform these tests in their own laboratory or shall utilize the services of a commercial laboratory, qualified by the receiving contractor, to accomplish such testing. In addition to the inspection test, any or all qualification tests (see Table XV) may be applied to any production lot of fasteners if there is any doubt about the quality.

4.1.1 **INSPECTION LOT**

Inspection lot shall consist of parts which are of the same style and thread size, fabricated from the same material provided the receiving contractor has approved Monogram's material controls. Otherwise, parts must be from the same mill heat of material, heat treated and finished in one batch, and submitted for Monogram's inspection at the same time. Each inspection lot shall be identified by a number to be included in the packaging marking. Monogram shall maintain accurate in–process accountability of the parts within each inspection lot. Part counts shall be verified and documented on the lot manufacturing records for significant operations that are not readily end–item inspectable, such as heat treating, embrittlement relief baking, nondestructive testing, pre-finish inspection, laboratory testing and final inspection. Large lots may be weight counted using suitable scales.

4.1.2 **INSPECTION REPORT**

Each shipment shall be accompanied by an inspection report as part of or separate from the shipment notice. The report shall be in duplicate and be signed by an authorized employee of the shipper. This report shall provide the following:

a. A substantial statement is as follows: "The parts contained in this shipment have been manufactured and inspected in accordance with applicable drawings and specifications".

b. Monogram or receiving contractor's name (and division, if applicable).

c. Purchase order number and date.

d. Monogram part number (manufacturer's part number may also be included).

e. Part name or type.

f. Procurement specification number.

g. Thread specification number.

h. Inspection lot size and lot number.

i. Quantity shipped.

j. Shipper number.

k. Material producer.

l. Material type.

m. Material heat number.

n. Material composition (based on mill heat report, independent lab test or part manufacturer's test-state which).

o. Mechanical property test results (hardness, shear, tensile, preload and/or fatigue, as appropriate individual test results, averages or statistical analysis as required) and required minimums.

p. Salt spray test results.

q. Deviations, if any (explanation required).

r. Other data desired by manufacturer or required by the part standard or drawing.

s. Date of manufacture.

t. The statement "Alloy Verification has been performed." (Applies to parts or components with a date of manufacture on or after January 1, 2001).

u. Fluorescent penetrant inspection test results (Titanium and CRES only).

v. Hydrogen content, and if tested, oxygen content (Titanium only).

w. Metallurgical sample results.

4.2 **SAMPLING**

Samples for customer inspection shall be selected at random except as noted in Section 3 For metallurgical examination. The same sample may be used for inspection of dimensions, surface texture and identification. If this sample passes these inspections, the sample for destructive tests may be selected at random from this group. The sample used for tensile test may also be used for torque–off test. Separate sample is necessary for metallurgical examination. Penetrant indications shall not be cause for rejection and lack of indications shall not be cause for acceptance. Rejection of parts for unsatisfactory metallurgical properties shall be based upon metallurgical examination per Section 3.19.

4.2.1 **SCREENING**

Screening (100 percent inspection, accompanied by rejection of defective parts) is applicable only to characteristics inspected by non–destructive tests. For characteristics inspected by destructive tests, the entire lot shall be accepted or rejected according to test results of the prescribed sample.

5.0 QUALIFICATION

Qualification requirements shall be in accordance with the Monogram part standard and/or part specification listed on the part standard. In addition, a Process Control Document (PCD) shall be established to provide documentation of the manufacturing practices used for the qualification lot. The process documented in the PCD at the time of qualification shall henceforth be used by the manufacturer for all production lots. See Section 7.1 for Process Control Document requirements. The Process Control Document shall be established at the time of qualification and shall be approved by Monogram unless otherwise stated in writing.

TABLE XV – QUALIFICATION TESTS

Characteristics	Number of Collars To Be Tested	
	Corrosion Resistant Steel	Titanium
	25	25
Dimensions, Marking and Surface Texture <4>	Inspect the above required number of qualification parts. Identify, number and control each dimensioned collar (i.e. number indelibly stamped on the collar or collars individually bagged). Record all inspection values, including out of tolerance values and collars with non-conforming features. These dimensioned collars will not be used for any other testing and shall remain segregated.	
Penetrant Inspection	Inspect the entire lot of collars manufactured in support of the qualification. <5> Metallurgically evaluate the most severe penetrant indications. Provide photomicrographs in the qualification report with explanation of acceptability or cause for rejection of any indications.	
Salt Spray and Metallurgical <3>	8	<2> 8
Hydrogen and Oxygen	0	<6> 6

TABLE XV – QUALIFICATION TESTS (Continued)

Characteristics	Number of Collars To Be Tested	
	Corrosion Resistant Steel	Titanium
	25	**25**
Tensile Testing	14	14
Locking Torque, Breakaway, and Torque-Off	15	15
Preload	15	15
Minimum Number of Collars to be manufactured for each Qualification Lot. 7	200	200

1 In order to qualify for tensile, X - 1.45S ≥ M. "X" is the average of values, ``S" is the best estimate of the standard deviation, ``M" minimum tensile value per Table VII "≥" mathematical symbol for "is equal to or greater than", 1.45 = K factor for single sample size of 14 used to determine acceptability of lot at each pin protrusion condition. Seven of the tensile tests shall be run at minimum pin protrusion condition and seven of the tensile tests shall be run at maximum pin protrusion condition.

2 Salt spray test not required for titanium.

3 Sample collars to be used for metallurgical examination shall first be subjected to salt spray test per Section 3.8, if required. In order to qualify for salt spray requirements, all eight specimens shall be free from corrosion products. All discontinuities or other anomalies shall be noted and measured. All of this information shall be provided in the qualification report along with the rational for acceptance or rejection. These metallurgical evaluations are in addition to any metallurgical evaluations performed in support of the indications found during non-destructive testing and shall be performed on the finished product.

4 Dimensions include all dimensions specified on the part standard page, AS8879 and in this part specification. Dimensions shall include pitch diameter, functional pitch diameter, coating and plating thickness, surface roughness, proper part marking, depth of part marking, in addition to all dimensions on the standard page. Dimensions shall all be variable measurements. Words such as "Acceptable" or "OK" will not be accepted. Parts used for dimensional inspection shall not be used for any other qualification inspection testing except hardness testing and shall be free of molydisulfide, and cetyl alcohol. Any out of tolerance dimension shall be noted, along with an explanation as to the root cause and corrective action

5 100% of the lot manufactured for qualification shall be subjected to Non Destructive Testing (NDT). (i.e. if 400 collars are manufactured in the lot, 400 collars shall be subjected to NDT). Inspection shall be accomplished after all machining, forming and crimping operations are completed. If the manufacturing sequence is such that the collars are crimped after the application of plating, coating and/or lubrication then the minimum number of collars to be manufactured is 400 for each qualification lot. 200 of the completed collars from each lot shall be non-abrasively stripped. These 200 stripped collars will be subjected to the non-destructive testing. Where multiple collars have similar indications, metallurgically evaluate the worst indications. Mounts shall be retained in a readable condition. Note the acceptance or rejection of the condition.

TABLE XI – QUALIFICATION TESTS (CONTINUED)

6 In order to qualify, hydrogen and oxygen determinations shall be made on all qualification test lots of titanium alloy fasteners. Hydrogen and oxygen shall not exceed limits of Section 3.12.1 and Section 3.13.1 respectively

7 A minimum of one hundred parts are required for a short term capability study. Parts used for the short term capability study may be used for qualification testing provided the results of the study are acceptable. In addition to the above listed testing required by the manufacturer, an equal number of parts may be required for testing at Monogram. This additional testing requires that the minimum lot size be no less than the noted 200 collars. Part quantity may be reduced at the discretion of Monogram.

6.0 REQUALIFICATION

If qualification is not successful on the first attempt, a second qualification will not be initiated until satisfactory evidence of corrective actions are submitted and review of Monogram requirements indicates that another qualification test is desirable.

7.0 PROCESS CONTROLS

7.1 PROCESS CONTROL DOCUMENT (PCD'S)

a. The PCD shall be part, part series and/or part family specific and shall document the sequence of operations used in the manufacture of the part, indicating which operations and process parameters affect Key Characteristics.

(1) All information including raw material controls, individual operations, plant or facility site for all operations (if different than that of the qualified supplier), controls, testing, etc., must be fully documented or referenced in the PCD and approved by Monogram.

(2) Appropriate proprietary agreements between the manufacturer and Monogram shall be in place prior to qualification.

b. Applicable Key Characteristics and specification limits are identified by Monogram on the part standard. The manufacturer shall monitor Key Characteristics and identify Key Process Parameters using Statistical Process Control.

c. The creation and maintenance of the PCD is the responsibility of the manufacturer.

d. The PCD shall identify those materials, processes and sequences, equipment and settings, inspections, facility locations for all operations, all specific off loaded operations with specific processors names and addresses, etc., involved in manufacturing a specific part, part family or part series. The level of details contained within the PCD shall be such that the manufacturing plan/router for a specific part can be derived from the PCD.

e. The original version of the PCD shall reflect the manufacturing process utilized for the qualification lot of parts for which approval was granted. A copy of the original PCD used to produce qualification parts shall be maintained for the duration of time the manufacturer is listed as an approved manufacturer on the part standard.

f. All modifications to manufacturer's operations that affect established process parameters or sequences (or any other items as described in Section 7.1.d.) shall be documented. All modifications or changes to operations designated as significant or changes in sequencing of operations require Monogram approval. All manufacturing lots shall be traceable to a specific PCD revision level.

g. The manufacturer is responsible for verifying that any process modifications do not affect the original qualification requirements or Quality Conformance requirements, as specified on the Monogram part standard or Monogram part specification.

h. The PCD shall reflect the current manufacturing practices.

i. The PCD shall be treated as proprietary information of the manufacturer.

j. Parts produced by a process other than as documented in an approved PCD shall be deemed non-conforming. Parts reworked within the defined limitations and requirements of the Monogram part specification where the rework has been documented are not subject to PCD control in regards to sequencing.

7.2 KEY CHARACTERISTICS

The following key characteristics are applicable to all fasteners referencing this specification:

a. Locking Torque

b. Breakaway Torque

Process parameters affecting the above key characteristics shall be identified and controlled.

8.0 DEFINITIONS

Alloy Verification	Verification is a validation of specific alloy type or grade. Analysis of trace elements is not required. Verification may be accomplished with any of the following methods: x-ray fluorescence, optical emission spectrometry, or similar methods designed to identify specific alloy types being verified by the fastener manufacturer or independent laboratory (e.g., 2017, 2024, 7050, A286, 17-4PH, 6AI-4V, 15-3-3-3, 4340, 8740, etc.). Equipment shall be calibrated and certified in accordance with the fastener manufacturer or independent laboratory documented Metrology System.
Breakaway	The breakaway torque value shall be the peak torque value measured during the first quarter turn in the removal direction. This rotational torque shall be applied after twisting off the hex portion and after removal of the preload.

Date of Manufacture	The date on which the fastener manufacturer draws raw material from inventory for initial part or component lot processing (e.g., heading).
Discontinuities	Includes laps, nicks, gouges, non-continuous seams, inclusions and tool marks. Discontinuities do not include cracks, surface voids, steps from cutters or machining or missing material from incomplete fill from the forging process.
Independent Laboratory	A Monogram approved independent laboratory, other than the fastener manufacturer, used for alloy verification testing.
Installed	A collar is considered installed when the wrenching section has parted from the body section.
Locking Torque	The locking torque shall be considered to be the highest torque value obtained in the installation direction prior to contact with the preload release fixture. The bolt thread protrusion shall be controlled by the combination of preload release bushing height and test pin length.
Original Mill Heat Lot Chemistry	Actual ladle, Ingot, or Equivalent analysis from the original melt.
Refurbishing	As it relates to furnace repairs, modifications or reconstruction. Any work on a furnace which requires the furnace to be moved from the facility or moved out of the original work area. Repairs which require the furnace to be off line more than ten manufacturing days or any "furnace modifications" as exampled in AMS2750 which require the furnace to have a new Temperature Uniformity Survey performed.
Torque-off	The torque-off is the rotational force required to separate the wrenching element of the collar after contact with the structure or the preload release fixture.