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SWAGE COLLAR FASTENERS

REVISION:	DATE:	DCN#
"NR"	07/24/2014	DCN#14-0464
"A"	11/24/2015	DCN#15-0055
"B"	06/01/2018	DCN#18-0126

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(Original Signed Document on File)

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1.0 SCOPE & APPLICATION:

1.1 This specification defines the requirements for titanium swage collars that are procured under Monogram Aerospace Fasteners (MAF) standard drawings.

1.2 The collar must be used with its mating pin to maintain the integrity of the fastening system and to obtain the mechanical properties specified in this specification and on applicable drawings.

2.0 APPLICABLE DOCUMENTS

Documents listed herein, of the issue in effect on date of contract are a part of this specification to the extent indicated. In case of conflict, the requirements herein shall take precedence.

2.1 ASME INTERNATIONAL SPECIFICATIONS

ASME B46.1	Surface Texture (Surface Roughness, Waviness and Lay)

2.2 ASTM INTERNATIONAL SPECIFICATIONS

ASTM B348	Commercially pure titanium.
ASTM E 3	Standard Practice for Preparation of Metallographic Specimens
ASTM E 18	Standard Test Methods for Rockwell Hardness and of Metallic Materials
ASTM E 407	Standard Practice for Microetching Metals and Alloys
ASTM E 1409	Standard Test Method for Determination of Oxygen and Nitrogen in Titanium and Titanium Alloys by Inert Gas Fusion Technique
ASTM E 1417	Standard Practice for Liquid Penetrant Examination
ASTM E 1444	Standard Practice for Magnetic Particle Examination
ASTM E 1447	Standard Test Method for Determination of Hydrogen in Titanium and Titanium Alloys by Inert Gas Fusion Thermal Conductivity/Infrared Detection Method

2.3 NATIONAL AEROSPACE STANDARDS COMMITTEE (NASC) SPECIFICATIONS

NAS 527	Inspection procedure for flush fasteners
NAS 621	Fasteners, titanium alloy, procurement specification
NAS1080	Collar, Swage Locking for Pull-Type and Stump-Type Lockbolts
NAS 1413	Pins & Collars, Swage Locking
NASM1312	Fastener Test Methods
AS9100	Quality Management Systems for Aviation, Space & Defense Org.

2.4 SAE INTERNATIONAL SPECIFICATIONS

AMS 2249	Chemical Check Analysis Limits, Titanium and Titanium Alloys
AMS 2644	Inspection Material, Penetrant
AMS 2750	Pyrometry
AMS 2801	Heat Treatment of Titanium Alloy Parts
AMS 4967	Titanium alloy (6Al-4V).
AMS-H-81200	Heat Treatment of Titanium and Titanium Alloys
ANSI/ASQ Z1.4	Sampling procedures and tables for inspection by attributes.

2.4 SAE INTERNATIONAL SPECIFICATIONS (CONTINUED)

AS5272	Lubricant, Solid Film, Heat Cured, Corrosion Inhibiting Procurement Specification
AS87132	Lubricant, Cetyl Alcohol, 1-Hexadecanol, Application to Fasteners

2.5 FEDERAL STANDARD:

PPP-B-566	Boxes, Folding, Paperboard
PPP-B-676	Boxes, Setup

2.6 MONOGRAM AEROSPACE FASTENER SPECIFICATIONS

MAFCSLFC-MV( )( )	Shear Flange Collar
MFC0000	Part Numbering System for Collars
METB000	Part Numbering System for Test Bolts

3.0 GENERAL REQUIREMENTS:

Unless otherwise specified by the referencing MAF 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.

3.1 MATERIALS:

Qualifications: The fasteners furnished under this specification shall be a product which has been tested according to and has met the performance requirements specified herein.

3.1.1 Engineering Requirements:

MAF is responsible for verifying raw material conformance per MAF standards.

3.1.2 Test Methods:

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

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 MAF. Alloy 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.

TABLE I
LOT INSPECTION REQUIREMENTS FOR SWAGE LOCKING COLLARS

Characteristic	Requirements and Test Methods Sections	Lot Sample Requirements
Material	3.1	Per material specification (see Section 3.1.3).Alloy Verification Required per Table III, Table IV and Table V as applicable.
Dimensions, general	3.2	Per Section 3.2.3 And Table II
Surface Texture	3.3	Table II Reduced Sampling
Fastener Identification	3.4	Visual and dimensional Inspection per Table II Reduced Sampling. Metallurgical Examination Of marking depth, if necessary, per Table II Full Sampling Class D
Heat Treatment	3.5	Mechanical Testing And Metallurgical Examination verify heat treatment
Tensile Strength	3.6	Table II Full Sampling Class D. Approximately half of the sample size shall be tested at the maximum grip condition & approximately half of the size shall be tested at the minimum grip condition.
Hardness	3.7	Table II Full Sampling Class D
Fatigue Life	3.8	Qualification Only
Preload	3.9	Table II Full Sampling Class D. the full sample size shall be tested at maximum grip and the full sample size shall be tested at minimum grip.
Discontinuities	3.10	Sample 100 percent of parts subject to a maximum of 315 pieces.
Microstructure	3.11	Table II Full Sampling Class D
Surface Contamination	3.12	Table II Full Sampling Class D
Grinding Burns	3.13	Table II, Full Sampling Class D.
Hydrogen Content	3.14	Check four random parts per lot, accept lot if requirement is met, reject lot if hydrogen content exceeds requirement.
Oxygen content	3.15	Qualification Only
Finish, General Requirements	3.16	Sample per finish specification unless otherwise directed in this specification, part standard, or engineering drawing
Lubricant	3.17	Table II Full Sampling Class C

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 MAF or material converter.

TABLE II
LOT SAMPLING REQUIREMENTS (1)

LOT SIZE	CLASS A	CLASS B	CLASS C	CLASS D	CLASS E
under 16	9	5	3	5	1
16 - 25	9	5	5	5	1
26 - 50	10	6	5	5	1
51 - 90	13	8	5	5	2
91 - 150	15	10	5	5	2
151 - 280	19	13	5	5	2
281 - 500	24	16	5	5	3
501 - 1000	31	19	5	8	3
1001 - 1200	31	19	10	8	3
1201 - 3000	35	23	10	8	3
3001 -3200	35	23	15	8	3
3201 - 10000	45	28	15	8	4
10001 - 20000	59	35	15	10	4
20001 - 35000	64	43	15	10	4
35001 - 50000	67	49	15	10	5
50,001 – 100,000	67	49	15	15	5
over 100,001	67	49	15	27	5

(1) Acceptance number in all cases is zero nonconformances.

3.1.3.3 Coil (All Alloys)

1. Unmarked Coil
   For each coil that is not individually marked with the alloy and mill heat lot number, the fastener manufacturer 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.

2. 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.

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)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.

3.1.3.4 Rod and Bar (All Alloys)

1. 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.

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 – 101	20
102 – 183	21
184 – 949	22
950 and Up	23

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

2. 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.

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

Bundle Size (Number of Rods or Bars	Sample Size (Number of Rods or Bars) (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.

3.2 DIMENSIONS, GENERAL:

3.2.1 Engineering Requirements:

3.2.1.1 Dimensions shall be in accordance with the MAF fastener standard and where applicable this part specification. MAF production drawings may also refer to this specification.

3.2.1.2 Except as otherwise noted on the standard, drawing, or this part specification, all dimensions apply before lubrication.

3.2.2 Test Methods:

Test by conventional measuring methods, including optical comparator.

3.2.3 Inspection Sampling:

3.2.3.1 Full Sampling

Unless otherwise stated, end-item sampling shall be in accordance with the Table II Full Sampling Class per the classification of characteristics as shown below:

Class A Characteristics for collars:
- Outside diameter
- Inside diameter
- Height

Class B Characteristics for collars:
- All other collar dimensional characteristics not listed above or otherwise specified

3.3 SURFACE TEXTURE:

3.3.1 Engineering Requirements:

3.3.1.1 Surface texture shall be in accordance with the MAF fastener standard or Engineering drawing.

3.3.1.2 Surface texture requirements apply prior to plating or coating

3.3.1.3 Unless otherwise specified on the MAF part standard or Engineering drawing, surface texture requirements for collars shall be 125 microinches Ra or better on all surfaces.

3.3.2 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.

3.4 FASTENER IDENTIFICATION

3.4.1 Engineering Requirements

Each fastener shall be marked for identification in accordance with the MAF fastener standard or Engineering drawing. Marking shall be legible at 5X magnification or less. Marking shall be raised or indented .010 maximum unless otherwise specified

3.4.2 Test Methods:

Inspect by visual examination and measurement by conventional methods. Depth of marking to be measured from an undisturbed surface. Referee method for measuring the depth of marking shall be metallurgical examination.

3.5 HEAT TREATMENT

3.5.1 Requirements:

3.5.1.1 Heat treatment shall develop tensile and shear properties required by the MAF fastener standard or engineering drawing without adverse effect on mechanical and metallurgical properties, as defined herein.

3.5.1.2 Production parts must be heat treated in the same manner as the qualification test parts.

3.5.1.3 Heat treatment shall conform to the requirements of AMS-H-81200 or AMS2801.

3.5.1.4 Facilities performing heat treatment in accordance with this specification shall be qualified and approved by MAF or their designee, as part of the part qualification process. Approval will be furnace(s) specific for the qualified parts. Facilities with multiple furnaces shall obtain MAF approval for each furnace which will be utilized to process MSC1000 parts. All engineering approved heat treatment facilities, processes and furnaces are subject to periodic MAF evaluation. Furnace relocation (even with a facility), refurbishing of an existing furnace or the addition of a new furnace to a facility shall require MAF approval prior to use for MAF collars manufactured in accordance with this specification.

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

3.5.1.6 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.

3.5.1.7 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.

3.5.2 Test Methods and Inspection Sampling:

Testing of tensile, shear, hardness and metallurgical properties verifies heat treatment.

3.6 TENSILE STRENGTH

3.6.1 Tensile strength for collars shall conform to Table VI

3.6.2 Test Methods:

Tensile test in accordance with MIL-STD-1312-8 in accordance with NASM1312-8. Install mating test parts in accordance with Section 7.0 as applicable. Lot acceptance tests to be conducted in minimum and maximum grip conditions. The overgrip capability is in addition to the minimum and maximum grip length as determined by the part standard. Qualification tests to be conducted in minimum and maximum pin protrusion conditions in accordance with Section 7.0 as applicable. Tolerance on minimum grip and minimum protrusion values is +.000/-.005. Tolerance on maximum grip and maximum protrusion values is +.005/-.000. Tensile testing may be performed at the specified load rate for preload testing when simultaneously tensile testing and preload testing on the same sample using the paddle method. Upon determination of the preload value, tensile testing to failure shall be run at the tensile test load rate. This test methodology may be utilized provided the preload does not exceed 80% of the actual ultimate tensile value.

3.6.3 Inspection Sampling:

Sample as follows in accordance with Table VI

TABLE VI TENSILE PROPERTIES (COLLARS)

COLLAR SIZE DASH NO.	**SHEAR COLLAR MAFCSLFC-MV( )( ) COMPOSITE APPLICATION (1)**
	MIN LBS WITH HLGPL9SP-V or Equivalent
5	1500
6	1900
8	3450
10	6000

(1) Parts are rejectable if the minimum tensile requirements of Table VI are not met when tested with the listed mating lockbolts installed in accordance with Section 7.0 as applicable.

3.7 HARDNESS
(Applicable to CP titanium collars)

3.7.1 Engineering Requirements:

Surface hardness for collars - 85.3 HR15T maximum.

3.7.2 Test Methods:

Test collars in accordance with ASTM E 18 using HR15T scale at base of collar, lubrication removed.

3.8 FATIGUE LIFE

For Qualification only.

3.8.1 Engineering Requirements:

Average fatigue life shall be a minimum of 65,000 cycles and minimum life shall be 45,000 cycles for lockbolts having a grip of 3 times the nominal diameter or greater. Continue tests to destruction or 130,000 cycles, whichever occurs first.

3.8.2 Test Methods:

Test in tension - tension fatigue in accordance with MIL-STD-1312-11 in accordance with NASM1312-11. Loads shall be in accordance with Table VII. Apply load at 250 to 18,000 cycles per minute (cpm) at room temperature. Count shall not be started until load is stabilized. Install collars in accordance with Section 7.0, as applicable. Qualification fatigue tests to be conducted in minimum (+.000/-.005) and maximum (+.005/-.000) pin protrusion conditions with Section 7.0, as applicable.

TABLE VII
FATIGUE LOADING LBS (TITANIUM)

FASTENER SIZE DASH NUMBER	**MAFCSLFC-MV( )( )**	
	High load	Low Load
5	615	61
6	800	80
8	1250	125
10	1920	192

3.9 PRELOAD
(Applicable to composite application collars.)

3.9.1 Engineering Requirements:

Preload for applicable collars shall conform to Table VIII.

3.9.2 Test Methods:

Preload tests shall be performed per the requirements of MIL-STD-1312-16 in accordance with NASM1312-16. The paddle or split shim methods are acceptable. The load cell method, however, is the referee method. Install collars in accordance with Section 7.0, as applicable.
Lot acceptance tests to be conducted in minimum and maximum grip conditions. The overgrip capability is in addition to the minimum and maximum grip length as determined by the part standard. Qualification tests to be conducted in minimum and maximum pin protrusion conditions in accordance with Section 7.0, as applicable. Tolerance on minimum grip and minimum protrusion values is +.000/-.005. Tolerance on maximum grip and maximum protrusion values is +.005/-.000.

TABLE VIII
PRELOAD REQUIREMENTS (1) (2)

FASTENER SIZE DASH NUMBER	MAFCSLFC-MV( )( ) COLLARS	
	LBS MIN	LBS MAX
5	700	1450
6	800	2020
8	1500	3200
10	2500	5350

(1) Install collars in accordance with Section 7.0. Additional driving of collars is not allowed
(2) Preload shall not exceed 80 percent of tested tensile strength on any individual part.

3.10 NON-DESTRUCTIVE INSPECTION AND METALLURGICAL EVALUATION:

3.10.1 Engineering Requirements:

3.10.1.1 No cracks are permitted in any location. A crack is a clean, irregular break passing through the grain or along the grain boundary. No surface contamination is allowed except as described in Section 3.12.

3.10.1.2 Discontinuities are permitted only as described in Table IX for collars.

3.10.1.3 Presence or lack of magnetic particle or penetrant indications, of themselves, shall not be cause for acceptance or rejection. Rejection or acceptance shall be based upon the results of metallurgical examination.

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

3.10.1.5 Fasteners shall not be indelibly marked for identification of magnetic particle or penetrant inspection.

3.10.2 Test Methods:

NOTE: Microstructure evaluation of completed collars is in addition to the in-process metallurgical evaluation of indications found during non-destructive inspection.

3.10.2.1 Parts shall be non-destructively inspected as indicated herein. Parts with the most severe indications shall be used for metallurgical examination.

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

3.10.3 Tests for Titanium:

3.10.3.1 Penetrant inspect in accordance with ASTM E 1417, Type I, Methods 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. Apply penetrant to collars subsequent to all machining, grinding, and fillet rolling, but before surface treatments such as abrasive cleaning, coating or lubrication which may seal up surface defects. Parts requiring penetrant inspection after an abrasive blast from a cleaning operation, a surface pretreatment, or peening operation shall be etched to remove smeared metal from the surface prior to examination.

3.10.3.2 Examine all surfaces exhibiting indications at a magnification of 10X to 30X inclusive.

3.10.3.3 Indications shall be subject to metallurgical examination in accordance with Section 3.11. Where multiple parts with similar indications are found the parts with the most severe indications shall be metallurgically evaluated.

3.10.3.4 If one or more discontinuities exceeding the specified limits of Table IX are found, the metallurgist may reject the entire lot or recommend 100 percent inspection for lot screening (per Section 4.1.3.1) to reject all parts with similar indications.

TABLE IX
COLLAR DISCONTINUITIES

LOCATIONS AND PERMISSIBLE CONDITIONS	DISCONTINUITY DEPTH			
	NOM DIA OF FASTENER (INCH)			
	0.164	**0.190**	**0.250**	**0.312**
Circumferential Laps at Ends of Collar to a Depth Parallel to Axis of Collar	0.005	0.005	0.005	0.006
Radial Discontinuities Depth or Width Normal to Surface	0.004	0.005	0.006	0.008
Longitudinal Discontinuities Depth or Width Normal to Surface	0.005	0.006	0.008	0.009

3.11 MICROSTRUCTURE AND METALLURGICAL PREPARATION

3.11.1 Engineering Requirements:

3.11.1.1 Each lot shall be metallurgically evaluated.

3.11.1.2 Microstructure shall be free from bursts, voids and evidence of overheating. Alloy segregation which adversely affects the mechanical or physical properties of the part is not acceptable.

3.11.2 Test Methods:

3.11.2.1 Metallurgical examination shall consist of macro and micro examination for each lot of collars with samples selected from completed parts at random.

3.11.2.2 Micro examination shall be on mounted, polished and etched specimens, cut as indicated by the arrows in Figure 1. See (for example) ASTM E 3, Standard Methods of Preparation of Metallographic Specimens.

3.11.2.3 Suggested etchants (percent by volume):
Mounts shall be reviewed with Oxalic-Alpha Case Reagent (2ml HF, 20gm Oxalic, 98 ml H_2O) for check of microstructure. Additionally, re-polish and etch with Kroll's etch (15 ml HF, 35 ml HNO_3, 950 ml H_2O) for contamination employing a 15 to 20 second drip (do not swab) and then remove the etchant with cold running water.

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

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

Shear Bands and Linear Discontinuities	Micro Examination: (200X using bright field illumination)
Head Grain Flow	Macro Examination: (50X or greater)
Discontinuities	Micro Examination: (100X to 250X)
Surface Contamination	Micro Examination: (400X minimum)

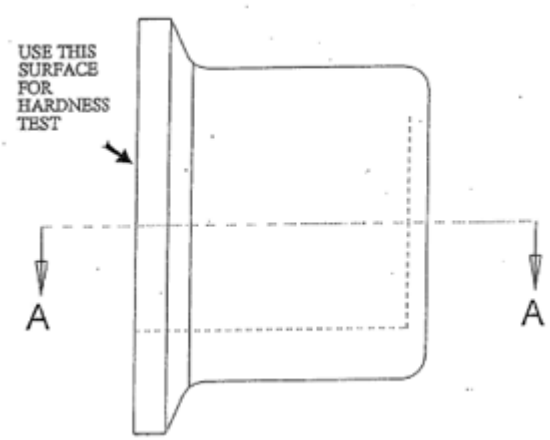


FIGURE 1 – METALLURGICAL SPECIMENS

3.12 SURFACE CONTAMINATION:

3.12.1 Engineering Requirements:

There shall be no indications of surface contamination, as evidenced by a higher density of primary alpha on the surface as compared to the core.

NOTE: Alpha case is a severe case of surface contamination and is a continuous layer consisting of 100 percent alpha phase.

3.12.2 Test Methods:

Metallurgically examine collars in accordance with Section 3.11.2. A solution of Oxalic-Alpha Case Reagent as described in Section 3.11.2.3 shall be used to detect the presence of surface contamination and alpha case on collars. A repolishing is required between the use of different etchants.

3.13 GRINDING BURNS:

3.13.1 Engineering Requirements:

Altered microstructure consisting of continuous or intermittent disturbed material (layer) or heat affected zone is considered grinding damage or abusive machining and is not acceptable. Exception: fasteners may have partial plus full microstructure change to a depth of .003 maximum on bearing surface of head only, exclusive of the head to shank fillet. Roll straightening of the fastener shank which results in a change to surface microstructure, as evident after etching by a darker continuous or intermittent layer along the shank, is acceptable to a depth of 8 percent of nominal shank diameter.

3.13.2 Fasteners shall be examined for grinding burns during metallurgical examination in accordance with Section 3.11.

3.14 HYDROGEN CONTENT:

3.14.1 Engineering Requirements:

Collars shall not have a hydrogen content exceeding .0080 percent (80 PPM). Variation per AMS 2249 is not allowed.

3.14.2 Test Methods:

3.14.1 Determine hydrogen content per ASTM E 1447 from a minimum of four random parts per lot.

3.14.2 Test using procedures and equipment that are capable of analyzing hydrogen to an accuracy of ±.0010 percent (10 PPM).

3.14.3 Determine hydrogen content from material removed from the outside diameter to flange fillet section.

3.14.4 Lubricant shall be removed prior to sampling. Lubricant removal may be accomplished using a solution of 16 oz. (nominal) ammonium nitrate per gallon of water, followed by a 1:1 (nominal) solution of nitric acid and water. Mechanical removal is acceptable provided the depth of material removed does not exceed .003. Test sample shall include a maximum amount of the fastener surface. Precautions should be taken to prevent overheating of the sample during any cutting operation.

3.15 OXYGEN CONTENT:

3.15.1 Engineering Requirements, Qualification only:

Collars shall not have an oxygen content exceeding .120 percent (1200 PPM). Variation per AMS 2249 is not allowed.

3.15.2 Test Methods;

3.15.2.1 Determine oxygen content per ASTM E 1409 from a minimum of one random part per lot.

3.15.2.2 Test using procedures and equipment that are capable of analyzing oxygen to an accuracy of ±.010 percent (100 PPM).

3.15.2.3 Determine oxygen content for collars from material removed from the outside diameter to flange fillet section.

3.15.2.4 Lubricant shall be removed prior to sampling. Lubricant removal may be accomplished using a solution of 16 oz (nominal) ammonium nitrate per gallon of water, followed by a 1:1 (nominal) solution of nitric acid and water. Mechanical removal is acceptable provided the depth of material removed does not exceed .003. Test sample shall include a maximum amount of the fastener surface. Precautions should be taken to prevent overheating of the sample during any cutting operation.

3.16 FINISH, GENERAL REQUIREMENTS

3.16.1 None.

3.17 LUBRICANT:

3.17.1 Engineering Requirements:

3.17.1.1 When cetyl alcohol is specified, it shall be in accordance with AS87132, Type I, Grade optional.

3.17.1.2 When solid film lubricant is specified, it shall be in accordance with AS5272, Type I. AS5272 shall be in accordance with the QPL in AS5272SUP.

3.17.1.3 Cured solid film lubricant shall adhere to the substrate and shall have a thickness of .0002 to .0005, unless otherwise specified.

3.17.2 Test Methods:

3.17.2.1 Cetyl alcohol shall be tested in accordance with AS87132. The coating shall be essentially uniform. Some localized buildup on fastener surfaces shall be allowed, but the localized buildup shall not be continuous on one side of the fastener. Localized buildup exhibits a uniform white appearance.

3.17.2.2 Test solid film lubricant in accordance with AS5272, except test adhesion as follows:

1. Apply a length of one inch wide 3M Number 250 tape by pressing the tape down firmly to the shank of the fastener or outside diameter of the collar to ensure continuous contact of the tape to the lubricant. Tape shall not be older than six months from date of manufacture.

2. Remove the tape in one abrupt motion perpendicular to the surface and examine the tape and part surface for lifting of the lubricant.

3. A uniform deposit of powdery material may cling to the tape, but lifting of any flakes or particles of the lubricant which exposes a bare metal surface on the fastener shall be cause for rejection.

4.0 QUALITY ASSURANCE PROVISIONS:

4.1 INSPECTION:

4.1.1 Inspection Tests:

Unless otherwise specified, the tests in Section 3 are mandatory for MAF each lot as defined in Section 4.1.2. Sufficient periodic surveillance testing shall be accomplished by the receiving contractor. The receiving contractor may either perform these tests in his 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 may be applied to any production lot of fasteners if there is any doubt about the quality.

4.1.2 Inspection Lot:

A lot shall consist of parts that are identified by one unique part number and fabricated from on mill heat of material in one continuous production run. Heat treating operations shall be performed by one continuous process utilizing a single furnace for each specific heat treat process with the same temperatures, times and specification controls. Finishing operations shall be performed by one continuous process.

The lot shall be identified and treated as a unique entity from which samples shall be drawn and inspected to determine conformance to all purchase order requirements. Any changes which affect the manufacturing processes or cause a statistical variation in that process shall require the assigning of a new distinguishing lot number and documented accordingly.

Previously submitted lots that have been rejected and reworked shall have complete traceability to the original lot.

4.1.3 Sampling:
Samples for 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 shear test, provided there are at least two diameters of undamaged shank available for the double shear test. A separate sample is necessary for metallurgical examination. Preload and tensile testing may be performed on the same sample.

4.1.3.1 Screening:
100 percent inspection (screening), accompanied by rejection of nonconforming parts, may be applied at the inspector's discretion to any lot which is not acceptable by sampling plans described herein. Screening may be applied 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.

4.1.4 Inspection Report;
Each shipment of collars 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:

1. A statement substantially as follows: "The parts contained in this shipment have been manufactured and inspected in accordance with applicable drawings and specifications".
2. Customer’s or receiving contractor’s name (and division, if applicable).
3. Purchase order number and date.
4. Customer part number if applicable (manufacturer's part number may also be included).
5. Part name or type.
6. Procurement specification number.
7. Inspection lot size and lot number.
8. Quantity shipped.
9. Shipper number.

10. Material producer
11. Material type.
12. Material heat number
13. Material composition based on mill heat report, independent lab test or part manufacturer's test - state which).
14. Hydrogen content and, if tested, oxygen content.
15. Mechanical property test results (hardness, shear, tensile, preload and/or fatigue, as appropriate). Report individual test results, averages or statistical analysis, as required, and required minimums.
16. Fluorescent penetrant inspection results.
17. Metallurgical test results (sample size, discontinuity depth, surface contamination results, etc.).
18. Deviations, if any (explanation required).
19. Other data desired by supplier.
20. Date of Manufacture.
21. The statement "Alloy Verification has been performed"

4.2 QUALIFICATION PROCEDURE:

Collars procured under this specification require MAF Engineering qualification, which consists of evaluation of test data from MAF and/or an independent laboratory

4.2.1 Approved Sources:

No changes in product design, methods of manufacture, plant site for any significant process or quality level shall be made without prior approval in writing from MAF Engineering.

4.2.2 Qualification:

Qualification tests per Table X.

5.0 PREPARATION FOR DELIVERY:

Packaging and package marking shall be as follows unless other instructions are on the MAF drawing or standard.

5.1 PACKAGING:

5.1.1 Packaging shall provide sufficient protection so that collars will not be damaged by impacts which will result in nicks, dings or scratches, exposed to undue weathering or harmful materials, or other hazards during handling, transportation, or storage.

TABLE X QUALIFICATION TESTS FOR COLLARS

CHARACTERISTICS	NUMBER OF PARTS TO BE TESTED IN ACCORDANCE WITH MATERIAL
	CP TITANIUM
DIMENSIONS, MARKING AND SURFACE TEXTURE	Inspect 25 qualification parts retain the identity of each specimen used for dimensional inspection. Record all inspection values including out of tolerance values and specimens with no-conforming features. Bolts used for dimension inspection shall be retained for further review and will not be used for any other testing unless otherwise directed by MAF engineering
MAGNETIC PARTICLE OR PENETRANT INSPECTION	Inspect all qualification parts. Record number of each specimen which shows any magnetic or penetrant indications
Tensile (1) (3) (5) (6)	14
Metallurgical (2)	6
Hardness	6
Fatigue (4) (5) (6)	8
Preload (6) (7)	14
Minimum Qualification Lot Quantity	100

(1) In order to qualify for tensile $X - 1.45S \geq M$. "X = average value for the seven specimens, "S" = best estimate of the standard deviation, "≥" = mathematical symbol for: "is equal to or greater than", "M" = minimum tensile or shear value in accordance with applicable Table and 1.45 = a statistical coefficient for single sample size of 7 used to determine the acceptability of a lot.
(2) Sample fasteners to be used for metallurgical examination shall first be subjected to salt spray test in accordance with Section 3. In order to qualify for salt spray requirements, all 6 specimens shall be free from corrosion products.
(3) Installation requirements and test lockbolts shall be in accordance with Table IX.
(4) In order to qualify fatigue characteristics, average life shall exceed 65000 cycles: minimum individual life shall exceed 45000 cycles. Continue tests to destruction or 130000 cycles whichever occurs first
(5) Strength requirements and test pin shall be in accordance with Table IX and Table X.
(6) Test one half of the sample at minimum pin protrusion (+.000/-.005) condition and one half the sample at maximum pin protrusion (+.005/-.000) in accordance with Section 7.0 as applicable.
(7) Preload testing required for composite application collars only

5.1.2 Packaging must allow economical transportation and conform to consolidated freight classification rules.

5.1.3 Collars of one type, size and part number only shall be packed in each unit container. An assortment of unit containers may be in larger packages.

5.1.4 Verify conformance by visual examination.

5.2 PACKAGE MARKING

5.2.1 Each unit package of fasteners shall be durably and legibly marked with at least the following information:
(1) Name of part
(2) The MAF part number or customer part number if needed
(3) Purchase order number
(4) Country of manufacture
(5) MAF Cage code
(6) MAF Lot number
(7) Date of manufacture

5.2.2 Marking shall be located so it will not be damaged when the package is opened.

5.2.3 Verify conformance by visual examination.

6.0 PROCESS CONTROLS:

6.1 KEY CHARACTERISTICS

There are no key characteristics applicable to swaged collars in this specification.

7.0 INSTALLATION & INSPECTION:

7.1 MANUFACTURING CONTROLS**:**

7.1.1 INSTALLATION OF LOCKBOLTS & COLLARS:

Lockbolts are permanent fasteners which consist of a bolt, which can have either annular (circular) grooves or can be threaded, and also consist of a collar which is upset/swaged onto the bolt. See Figure 2 for an illustration.
Unless otherwise approved by Engineering drawing, the fasteners shall not be reworked, degreased or have additional lubrication added.

LOCKBOLT PIN PART NUMBER:

HLGPL9SP-V or equivalent	Lockbolt, Protruding Head, Titanium, 95 ksi Shear for Use in Composites

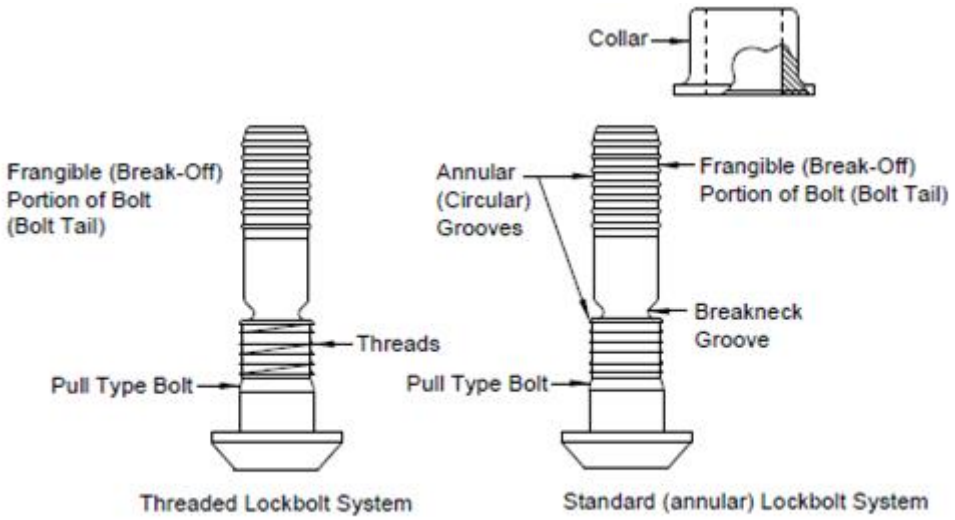


FIGURE 2 - TYPICAL LOCKBOLT FEATURES

TABLE XI
HOLE SIZES FOR LOCKBOLTS IN COMPOSITE STRUCTURES

Nominal Fastener Diameter (inch)	Hole size inch	
	Minimum	Maximum
0.1640	0.164	0.167
0.1900	0.190	0.193
0.2500	0.250	0.253
0.3125	0.3125	0.3155

7.1.2 Hole Size:

Hole size for lockbolts shall be as listed in Table XI unless otherwise stated on the Engineering drawing.

7.1.3 Grip Adjustment:

7.1.3.1. Washers are not permitted under lockbolt collars. Washers may not be used with flush head lockbolts.

7.1.3.2 Bolts used shall be as called out on the Engineering drawing. Grip length adjustment is necessary when the specified fastener grip length does not provide the required protrusion.

7.1.3.3 In cases where the drawing specified grip length is not available, a grip adjustment of one grip longer is allowed for protruding head lockbolts. Use a maximum of one countersunk washer under the fastener head.

7.1.3.4 Fillet relief washers are not permitted where the fastener hole is chamfered or radiused for the purpose of fillet relief.

7.1.4 Collars:

7.1.4.1 Collars as received are lubricated by the manufacturer. Degreasing or additional lubrication is not allowed.

7.1.4.2 MAFCSLFC-MV( )( ) collars require special orientation. Install as shown in Figure 3

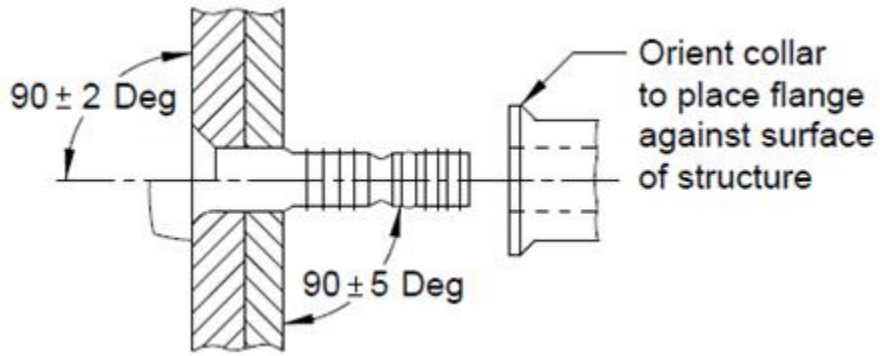


FIGURE 3 – MAFCSLFC-MV( )( ) COLLAR ORIENTATION

7.1.5 Installation:

7.1.5.1 Swaging dies shall not be tipped more than 3 degrees from lockbolt axis during installation.

7.1.5.2 Pull-type lockbolts using lightweight titanium collars shall be installed with pull tools having swage die cavity in accordance with Figure 4.

7.1.5.3 Except as allowed by 7.1.5.5, impact swaging of lockbolt collars is not permitted on composite structures.

7.1.5.4 When it is necessary to replace collars, impact methods shall not be used to remove collars. Collars and pins shall not be reused.

7.1.5.5 Single impact swaging of lockbolt collars using electromagnetic processes is permitted.

7.1.5.6 MAFCSLFC-MV( )( ) collars may be installed on surfaces with a slope of up to 5 degrees. See Figure 3. The 5 degrees slope allowance does not take into account tolerances or for hole angularity.

7.1.5.7 Reswaging of collars is not permitted. After installation, if a collar is found incompletely swaged, both the pin and collar shall be removed and replaced. lmpact methods shall not be used to remove collars.

7.1.5.8 lmpact driving of straight-shank fasteners (non sleeve-type) common to composite structures is not allowed.

7.1.5.9 Titanium bolts common to titanium interfaces shall be coated with NAS4006 to prevent fretting between bolt and structure (mitigation of titanium-titanium fretting).

7.1.5.10 Collar swaging and pin break-off shall be accomplished with a single stroke of the puller. No other method of pin break-off is permitted.

7.2 REWORK:

Document rework as required by the applicable Quality Assurance provisions.

7.3 MAINTENANCE CONTROL:

7.3.1 Lockbolt Collar Swage Die:

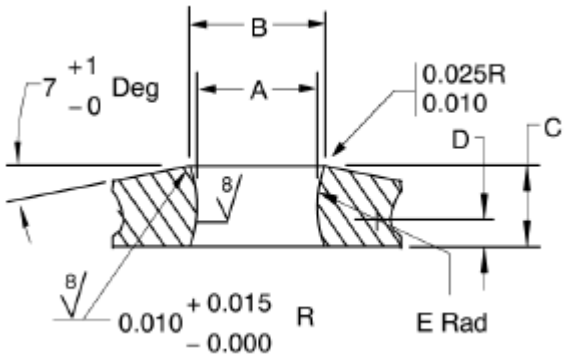


FIGURE 4 – TITANIUM COLLAR SWAGE DIE CAVITY LIMITS (INCH)

7.3.2 Lockbolt collar swage dies shall be verified at 6 month maximum intervals by Quality Assurance using the appropriate Go/No-Go gages for proper 'A' dimension to ensure that out of tolerance dies are not used.

7.3.3 Quality Assurance shall have a documented process for monitoring the condition of the dies for both manual and automated equipment to prevent the use of out-of-tolerance or damaged dies. Use the appropriate Go/No-Go gages to monitor the correct 'A' dimension.

TABLE XII
TITANIUM COLLAR SWAGE DIE REQUIREMENTS (INCH)

NOMINAL FASTENER DIAMETER	A		B	C	D	E
	+0.0010 -0.0010 (NEW DIES) (1)	MAX IN-SERVICE DIA. (2)	+0.0030 - 0.0000	+0.015 - 0.005	REF	(RADIUS) +/_ 0.005
0.1640 0.1900	0.2219 0.2450	0.2239 0.2470	0.2580 0.2813	0.103 0.120	0.0661 0.0670	0.126 0.130
0.2500 0.3125	0.3241 0.4062	0.3261 0.4082	0.3722 0.4667	0.157 0.195	0.0928 0.1201	0.188 0.250

(1) The A diameter shall be in accordance with the column for new dies.
(2) The A diameter shall be in accordance with the in-service column for used dies.

7.3.4 Product Acceptance Tools and Gages:

Tools used for product acceptance must comply with the requirements in AS9100.

7.4 QUALITY CONTROL:

Assure that the requirements of this specification are met by monitoring the process and examining the end-items in accordance with established Quality Assurance (QA) provisions.

7.5 REQUIREMENTS

7.5.1 LOCKBOLTS AND COLLARS

7.5.1.1 Holes:

Hole sizes for lockbolts shall be as listed in Section 7.1.2.

7.5.1.2 Inspection after Installation:

When collars are installed against a sloping surface, bolt protrusion, with the plane of the protrusion gage oriented at 90 degrees to the slope of the surface, shall meet values of Table XIII.

7.5.1.3 Lockbolt protrusion and collar swage shall meet the requirements of Table XIII when inspected in accordance with Figure 5. See Figure 6 for use of gages.

7.5.1.4 Discoloration of collars due to swage die contact during installation is acceptable. Coating peel off as a piece or flake is not acceptable.

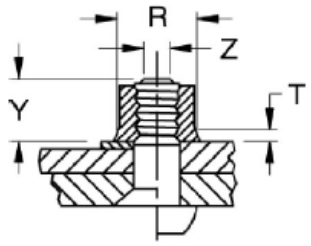
Collars shall not show evidence of cracks, nicks, or scratches on base metal of collar.

TABLE XIII - SWAGE COLLAR INSPECTION DIMENSIONS (INCH) (1)

NOMINAL FASTENER DIAMETER	LOCKBOLT PART NO.	COLLAR PART NO.	Y		Z	R ±.001	T		FIGURE NO.	GAGE NO (1)
			TOUCH -G0 +.002/-000	TOUCH -NO GO -.002/+.000			TOUCH -G0 +.002/-.000	TOUCH -NO GO -.002/+.000		
.1640	HLGPL9SP-V or Equivalent (2)	MAFCSLFC-MV( )( )	.168	.254	.120	.234	.070	.114	4	HG166-05
.1900			.177	.261	.144	.262	.067	.101		HG166-06
.2500			.237	.323	.187	.344	.081	.135		HG166-08
.3125			.321	.405	.244	.436	.092	.140		HG166-10

(1) These inspection gages do not detect the improper swage because of worn out swage dies. Hence, it is important to ensure that the swage dies are maintained in accordance with Section 7.3.1.

(2) Examples of equivalent lockbolts: HLGPLSP-V05B09AC, BACB30VY5HK9, HLGPLSP-V06B10AC, BACB30VY6HK10, HLGPLSP-V08B13AC, BACB30VY8HK13, HLGPLSP-V10B18AC, and BACB30VY10HK18.



R – Swaged Collar Ref. Dia.
T – Max. Height of R above sheet or washer
Y – Bolt Protrusion – Height of Z dia. above sheet or washer
Z – Ref. Dia. locates measuring point for Y

FIGURE 5– INSPECTION OF PULL-TYPE LOCKBOLTS AND COLLARS

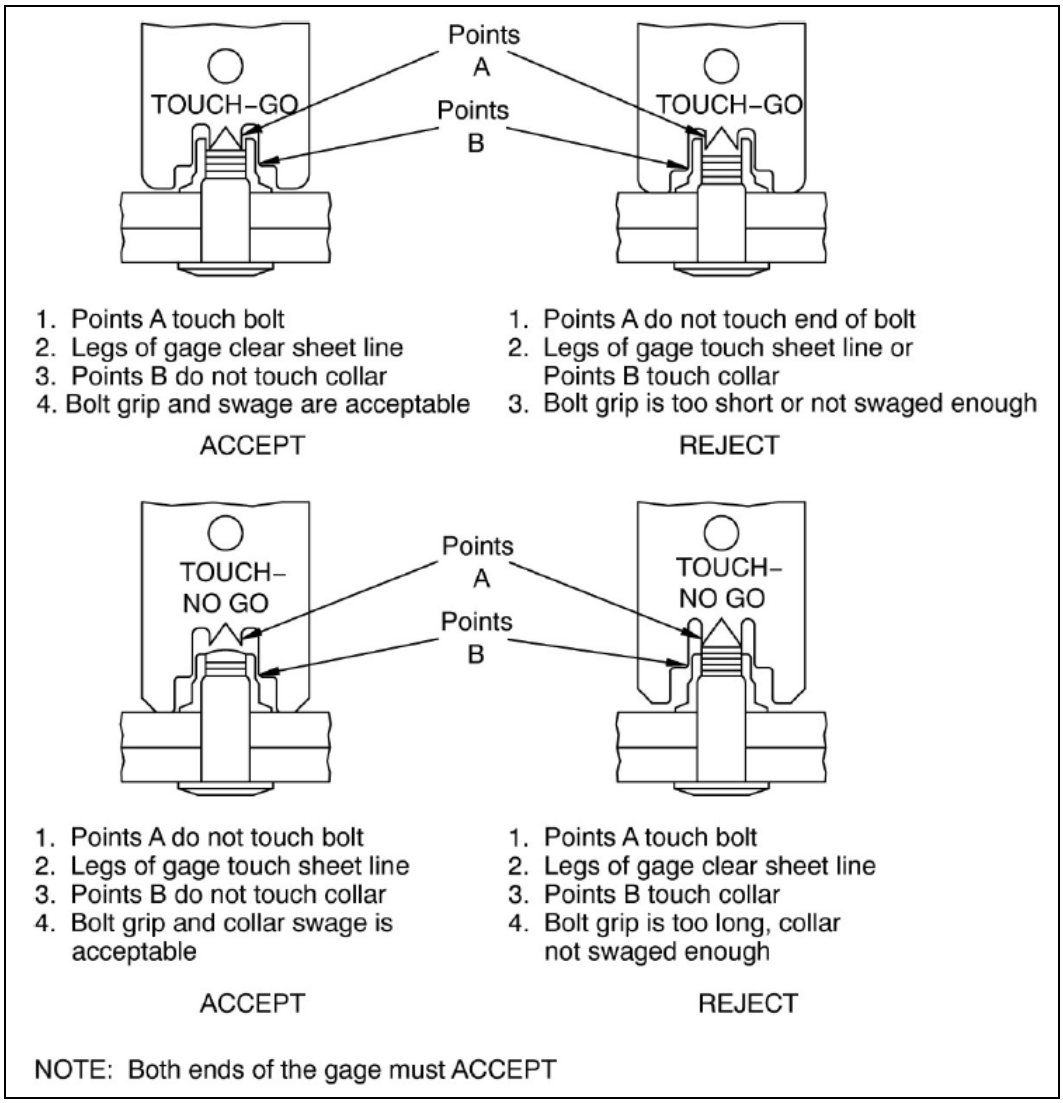


FIGURE 6 - USE OF INSTALLATION GAGES

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, etc.). Equipment employed shall be calibrated and certified in accordance with the fastener manufacturer or independent laboratory documented Metrology System.

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).

Independent Laboratory - A MAF or customer approved independent laboratory, other than the fastener manufacturer, used for alloy verification testing.

Original Mill Heat Lot Chemistry - Actual ladle, ingot or equivalent analysis from the original melt.