AEROSPACE STANDARD

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Superseding AS7481B

Studs, Steel, UNS S66286 Aged After Roll Threaded Procurement Specification For

FSC 5307

RATIONALE

This document has been determined to contain basic and stable technology which is not dynamic in nature. This standard has been stabilized.

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1. SCOPE:

1.1 Type:

This procurement specification covers studs made from a corrosion and heat resistant age hardenable iron base alloy of the type identified under Unified Numbering System as UNS S66286 and of 130 ksi tensile strength at room temperature, with maximum test temperature of parts at 1200 °F.

1.2 Application:

Primarily for aerospace propulsion system applications where the coefficient of expansion of the stud is more compatible in light alloys, and where stress-rupture and creep resistance are of primary importance at elevated temperatures.

1.3 Safety - Hazardous Materials:

While the materials, methods, applications, and processes described or referenced in this specification may involve the use of hazardous materials, this specification does not address the hazards which may be involved in such use. It is sole responsibility of the user to ensure familiarity with the safe and proper use of any hazardous materials and to take necessary precautionary measures to ensure the health and safety of all personnel involved.

2. REFERENCES:

2.1 Applicable Documents:

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AMS 2759/3	Heat Treatment of Precipitation Hardening, Corrosion Resistant and Maraging Steel Parts
AMS 5731	Steel Bars, Forgings, Tubing, and Rings, Corrosion and Heat Resistant, 15Cr 25.5Ni 1.2Mo 2.1Ti 0.006B 0.30V, Consumable Electrode Melted, 1800 °F (982 °C), Solution Heat Treated
AS3062	Bolts, Screws, and Studs, Screw Thread Requirements
AS3063	Bolts, Screws, and Studs, Geometric Control Requirements

2.1.2 U.S. Government Publications: Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-S-7742	Screw Threads, Standard, Optimum Selected Series; General Specification for
MIL-S-8879	Screw Threads, Controlled Radius Root With Increased Minor Diameter; General Specification For
MIL-STD-1312-6	Fastener Test Methods, Method 6, Hardness
MIL-STD-1312-8	Fastener Test Methods, Method 8, Tensile Strength
MIL-STD-1312-10	Fastener Test Methods, Method 10, Stress-Rupture

2.1.3 ASTM Publications: Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM E 8	Tension Testing of Metallic Materials
ASTM E 112	Determining Average Grain Size
ASTM E 139	Conducting Creep-Rupture, and Stress-Rupture Tests of Metallic Materials
ASTM E 140	Standard Hardness Tables for Metals
ASTM E 1417	Liquid Penetrant Examination
ASTM D 3951	Commercial Packaging

2.1.4 ANSI Publication: Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002.

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

2.2 Definitions:

BURR: A rough edge or ridge left on the metal due to a cutting, grinding, piercing, or blanking operation.

COLD ROLLING: Forming material below the recrystallation temperature.

CRACK: Rupture in the material which may extend in any direction and which may be intercrystalline or transcrystalline in character.

DEFECT: Any nonconformance of the unit of product with specified requirements.

DEFECTIVE: A unit of product which contains one or more defects.

DISCONTINUITY: An interruption in the normal physical structure or configuration of a part; such as a lap, seam, inclusion, crack, machining tear, or stringer.

INCLUSION: Nonmetallic particles originating from the material making process. They may exist as discrete particles or strings of particles extending longitudinally.

LAP: Surface imperfection caused by folding over metal fins or sharp corners and then rolling or forging them into the surface. The allowable lap depth shall not exceed the limit specified herein. The minimum condition that shall be rated as a lap is a fold having its length equal to or greater than three times its width with a depth of 0.0005 inch when viewed at 200X magnification.

MACHINING TEAR: A pattern of short, jagged individual cracks, generally at right angles to the direction of machining, frequently the result of improperly set cutting tools, or dull cutting tools.

PRODUCTION INSPECTION LOT: Shall be all finished parts of the same part number, made from a single heat of alloy, heat treated at the same time to the same specified condition, produced as one continuous run, and submitted for vendor’s inspection at the same time.

SEAM: Longitudinal surface imperfection in the form of an unwelded, open fold in the material.

STRINGER: A solid nonmetallic impurity in the metal bar, often the result of inclusions that have been extended during the rolling process.

TIGHT BURR: A burr closely compacted and binding in the periphery of a part without any loose ends and is within the dimensional limits of the parts.

2.3 Unit Symbols and Abbreviations:

°	- degree, angle
°C	- degree Celsius
°F	- degree Fahrenheit
cm^3	- cubic centimeter
g	- gram (mass)
%	- percent (1% = 1/100)
lbf	- pounds force
ksi	- kips (1000 pounds) per square inch
sp gr	- specified gravity
HRC	- hardness Rockwell C scale
PD	- pitch diameter

3. TECHNICAL REQUIREMENTS:

3.1 Material:

Shall be AMS 5731 corrosion and heat resistant steel heading stock or bar.

3.2 Design:

Finished (completely manufactured) parts shall conform to the following requirements:

3.2.1 Dimensions: The dimension of finished parts, after all processing including plating or coating, shall conform to the part drawing. Dimensions apply after plating but before coating with dry film lubricants.

3.2.2 Surface Texture: Surface texture of finished parts, prior to plating or coating, shall conform to the requirements as specified on the part drawing, determined in accordance with ANSI/ASME B46.1.

3.2.3 Threads: Screw thread shall be UN profile and dimensions in accordance with MIL-S-7742 or UNJ profile and dimensions in accordance with MIL-S-8879, unless otherwise specified on the part drawing. Tolerances for pitch diameter of the stud end thread shall be as specified on the part drawing. The special stud end thread variations shall be in accordance with AS3062 for the following requirements:

a. Lead and half-angle variation
b. Taper
c. Out-of-roundness
d. Stud leads threads
e. Stud thread runout

3.2.3.1 The requirements for thread crest variations, locking holes in the nut end thread, incomplete lead threads and thread runout in the nut end threads shall be as specified in AS3062.

3.2.3.2 Chamfer: The entering end of the thread shall be chamfered as specified on the part drawing.

3.2.4 Geometric Tolerances: Part features shall be within geometric tolerances specified on the part drawing and, where applicable, controlled in accordance with AS3063.

3.3 Fabrication:

3.3.1 Blanks: Heads shall be machined sufficiently to remove surface defects. Blanks may be produced by machining, upsetting, extruding or a combination of these methods. Heading stock to be upset shall not be heated to a temperature higher than 2100 °F.

3.3.1.1 When a shoulder or shoulders are produced by upsetting, the metal removed from the bearing surface shall be as little as practical to provide a clean, smooth surface.

3.3.2 Heat Treatment: Shall conform to the technical requirements and other provisions specified in AMS 2759/3 for A286, 1800 °F solution treatment, and 1325 °F aging treatment.

3.3.2.1 Solution Heat Treatment: Upset, extruded or machined blanks, except blanks machined from solution heat treated stock, shall, before oxide removal and rolling the threads, be solution heat treated as in 3.3.2, observing the following requirements:

a. Aging heat treatment shall follow the oxide removal and rolling the threads on upset, extruded, or machined blanks.

b. If machined from solution heat treated stock, only aging heat treatment is necessary.

3.3.2.2 Aging Heat Treatment: After removal of oxide as in 3.3.3 and rolling the threads as in 3.3.4, parts shall be heat treated by aging as in 3.3.2.

3.3.3 Oxide Removal: Surface oxide and oxide penetration, resulting from prior solution heat treatment, shall be removed from the full body diameter and bearing surface of shoulders, as applicable, of the solution heat treated blanks prior to rolling the threads. The oxide removal process shall produce no intergranular attack or corrosion of the blanks.

3.3.4 Thread Rolling: Threads shall be formed on the heat treated and finished blanks by a single cold rolling process for each end after removal of oxide as in 3.3.3 and prior to aging heat treatment as in 3.3.2.2.

3.3.5 Cleaning: Parts, after finishing, shall be degreased and submerged in one of the following solutions for the time and temperature shown:

a. One volume of nitric acid (sp gr 1.42) and 9 volumes of water for not less than 20 minutes at room temperature.

b. One volume of nitric acid (sp gr 1.42) and 4 volumes of water for 30 to 40 minutes at room temperature.

c. One volume of nitric acid (sp gr 1.42) and 4 volumes of water for 10 to 15 minutes at 140 to 160 °F.

3.3.5.1 Water Rinse: Immediately after removal from the cleaning solution, the parts shall be thoroughly rinsed in (70 to 200 °F) water.

3.4 Product Marking:

Each part shall be marked for oversize on the stud end thread and material code on the nut end thread as specified by the part drawing. The markings may be formed by stamping, depressed 0.010 inch maximum, with rounded root form on depressed characters.

3.5 Mechanical Properties:

Parts shall conform to the requirements of 3.5.1, 3.5.2, and 3.5.3. Threaded members of gripping fixtures for tensile and stress-rupture tests shall be of sufficient size and strength to develop the full strength of the part without stripping the thread. The loaded portion of the shank shall have two to three full thread turns from the thread runout exposed between the loading fixtures during the tensile and stress-rupture tests. Finished parts shall be tested in accordance with the following test methods:

a. Hardness: MIL-STD-1312-6
b. Ultimate Tensile Strength at Room Temperature: MIL-STD-1312-8
c. Stress-Rupture Strength at 1200 °F: MIL-STD-1312-10

3.5.1 Ultimate Tensile Strength at Room Temperature:

3.5.1.1 Finished Parts: Parts shall have an ultimate tensile not lower than that specified in Table 2 and shall be tested to failure in order to observe fracture location, first measuring and recording the maximum tensile load achieved. If the size or shape of the part is such that failure would occur outside the threaded section but the part can be tested satisfactorily, such as parts having a shank diameter equal to or less than the thread root diameter (smaller thread root diameter for studs with unequal size threads) or having an undercut, parts shall have an ultimate tensile strength not lower than 130 ksi; for such parts, the diameter of the area on which stress is based shall be the actual measured minimum diameter of the part.

3.5.1.2 Machined Test Specimens: If the size or shape of the part is such that a tensile test cannot be made on the part, tensile tests shall be conducted in accordance with ASTM E 8 on specimens prepared as in 4.4.7. Specimens may be required by the purchaser to perform confirmatory tests. Such specimens shall meet the following requirements:

a. Ultimate Tensile Strength, minimum: 130 ksi
b. Yield Strength at 0.2% Offset, minimum: 85 ksi
c. Elongation in 2 inches or 4D, minimum: 15%
d. Reduction of Area, minimum: 20%

3.5.1.2.1 When permitted by purchaser, hardness tests on the end of parts may be substituted for tensile tests of machined specimens.

3.5.2 Hardness: Shall be uniform within the range 24 to 36 HRC (see 8.1), but hardness of the threaded section may be higher as a result of the cold rolling operations. Parts shall not be rejected on the basis of hardness if the tensile strength properties specified in 3.5.1 are met.

3.5.3 Stress-Rupture Strength at 1200 °F:

3.5.3.1 Finished Parts: Parts, maintained at 1200 °F ± 3 °F while the tensile load specified in Table 2 is applied continuously, shall not rupture in less than 23 hours. If the shank diameter of the part is less than the maximum minor (root) diameter of the thread but the part can be tested satisfactorily, parts shall conform to the requirements of 3.5.3.1.1.

3.5.3.1.1 Parts having a shank diameter less than the maximum minor (root) diameter of the thread shall be tested as in 3.5.3.1, except that the load shall be as specified in 3.5.3.2. The diameter of the area on which stress is based shall be the actual measured minimum diameter of the part.

3.5.3.2 Machined Test Specimens: If the size or shape of the part is such that a stress-rupture test cannot be made on the part, a test specimen prepared as in 4.4.7, maintained at 1200 °F ± 3 °F while a load sufficient to produce an initial axial stress of 65 ksi is applied continuously, shall not rupture in less than 23 hours. Tests shall be conducted in accordance with ASTM E 139. Specimens may be required by purchaser to perform confirmatory tests.

3.6 Quality:

Parts shall be uniform in quality and condition, free from burrs (tight burrs may be acceptable if part performance is not affected), foreign materials, and from imperfections detrimental to the usage of the part.

3.6.1 Macroscopic Examination: Specimens cut from finished parts shall be etched in a suitable etchant and examined at a magnification of 20X to determine conformance to the requirements of 3.6.1.1 and 3.6.1.2.

3.6.1.1 Flow Lines: Examination of a longitudinal section through the threaded ends shall show evidence that the threads were forming by rolling. This evidence shall include traces of flow lines that follow the general thread contour, and shall be of maximum density at root of thread (see Figure 1). Below the thread roots, flow lines not affected by forming shall be parallel to the axis, except that on the nut end of parts formed by extruding, the flow lines may be oblique to the axis for a distance form the end of the larger diameter to the smaller diameter equal to 1.5 times the "B" dimension of Table 2 of AS3062.

3.6.1.2 Internal Defects: Examination of longitudinal section of the part shall reveal no cracks, laps, or porosity. Thread imperfection as in 3.6.2.4 shall be examined in accordance with 3.6.2

3.6.2 Microscopic Examination: Specimens cut from parts shall be polished, etched in Kalling's reagent [100 cm^3 of absolute ethyl alcohol, 100 cm^3 of hydrochloric acid (sp gr 1.19), and 5 g of cupric chloride], Marble's reagent [20 cm^3 of hydrochloride acid (sp gr 1.19), 20 cm^3 of water, and 4 g of cupric sulfate pentahydrate], or other suitable etchant, and examined at a magnification not lower than 100X to determine conformance to the requirements of 3.6.2.1, 3.6.2.2, 3.6.2.3, and 3.6.2.4.

3.6.2.1 Microstructure: Parts shall have microstructure of completely recrystallized material except in the area of the threads.

3.6.2.2 Grain Size: Shall be ASTM No. 5 or finer as determined by the comparison method of ASTM E 112. Up to 25% of the areas examined may exhibit a grain size as large as ASTM No. 2. Such areas shall be separated by at least 0.025 inch. Bands of fine or coarse grains are not permitted. In case of dispute, the intercept (Heyn) method shall be used.

3.6.2.3 Surface Hardening: Parts shall have no change in hardness from core to surface except as produced during rolling of threads. There shall be no evidence of carburization or nitriding. In case of dispute over results of the microscopic examination, microhardness testing shall be used as a referee method; a Vickers hardness reading of an unrolled surface which exceeds the reading in the core by more than 30 points shall be evidence of nonconformance to this requirement.

3.6.2.4 Threads:

3.6.2.4.1 Root defects such as laps, seams, notches, slivers, folds, roughness, and oxide scale are not permissible (see Figure 2).

3.6.2.4.2 Multiple laps on thread flanks are not permissible regardless of location.

3.6.2.4.3 Single Lap on Thread Profile: Shall conform to the following:

a. Lap: See definition under 2.2.

b. Thread Flank Above the Pitch Diameter: A slight lap is permissible along the flank of the thread above the pitch diameter on either the pressure or nonpressure flank (one lap at any cross-section through the thread) provided it extends towards the crest and generally parallel to the flank (see Figure 3). The lap depth shall not exceed the limit specified in Table 1 for the applicable thread pitch. A lap extending toward the root is not permissible (see Figure 4).

c. Thread Flank Below the Pitch Diameter: A lap along the thread flank below the pitch diameter, regardless of direction it extends, it is not permissible (see Figure 5).

3.6.2.4.3 (Continued):

d. Crest craters, crest laps, or a crest lap in combination with a crest crater are permissible provided that the imperfections do not extend deeper than the limit specified in Table 1 as measured from the thread crest when the thread major diameter is at minimum size (see Figure 6). The major diameter of the thread shall be measured prior to sectioning. As the major diameter of the thread approaches maximum size, values for depth of crest crater and crest lap imperfections listed in Table 1 may be increased by one-half of the difference between the minimum major diameter and actual major diameter as measured on the part.

3.6.3 Fluorescent Penetrant Inspection: Prior to any required plating or coating, parts shall be subject to fluorescent penetrant inspection in accordance with ASTM E 1417, Type I, Sensitivity Level 2.

3.6.3.1 The following conditions shall be cause for rejection of parts inspected.

3.6.3.1.1 Discontinuities transverse to grain flow (i.e., at an angle of more than 10° to the axis of the shank), such as grinding checks and quench cracks.

3.6.3.1.2 Longitudinal indications (i.e., at an angle of 10° or less to the axis of the shank) due to imperfections other than seams, forming laps and nonmetallic inclusions.

3.6.3.2 The following conditions shall be considered acceptable on parts inspected.

3.6.3.2.1 Parts having longitudinal indications (i.e., at an angle of 10° or less to the axis of the shank) of seams and forming laps parallel to the grain flow that are within the limits specified in 3.6.3.2.2 through 3.6.3.2.5 provided the separation between indications is not less than 0.062 inch in all directions.

3.6.3.2.2 Sides of Shoulders: There shall be not more than three indications per shoulder. The length of each indication may be the full height of the surface but no indication shall break over either edge to a depth greater than 0.031 inch or the equivalent of the 2H/3 thread depth (see Table 1), whichever is less.

3.6.3.2.3 Shank or Stem: There shall be not more than five indications. The length of any indication may be the full length of the surface but the total length of all indications shall not exceed twice the length of the surface. No indication shall break into a fillet or over an edge.

3.6.3.2.4 Threads: There shall be no indication, except as permitted in 3.6.2.4.

3.6.3.2.5 End of Stem: The number of indication is not restricted but the depth of any individual indication shall not exceed 0.010 inch, as shown by sectioning representative samples. No indication, except those of 3.6.3.2.2 shall break over an edge.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection:

The vendor of parts shall supply all samples and shall be responsible for performing all required tests. Purchaser reserves the right to perform such confirmatory testing as deemed necessary to ensure that the parts conform to the requirements of this specification.

4.2 Responsibility for Compliance:

The manufacturer's system for parts production shall be based on preventing product defects, rather than detecting the defects at final inspection and then requiring corrective action to be invoked. An effective manufacturing in-process control system shall be established, subject to the approval of the purchaser, and used during production of parts.

4.3 Production Acceptance Tests:

The purpose of production acceptance tests is to check, as simply as possible, using a method which is inexpensive and representative of the part usage, with the uncertainty inherent in random sampling, that the parts comprising a production inspection lot satisfy the requirements of this specification.

4.3.1 Tests for all technical requirements are acceptance tests and shall be performed on each production inspection lot. A summary of acceptance tests is specified in Table 3.

4.4 Acceptance Test Sampling:

4.4.1 Material: Sampling for material composition on each heat shall be in accordance with AMS 5731.

4.4.2 Nondestructive Test - Visual and Dimensional: A random sample of parts shall be taken from each production inspection lot; the size of the sample to be as specified in Table 4. The classification of dimensional characteristics shall be as specified in Table 5. All dimensional characteristics are considered defective when out of tolerance.

4.4.3 Fluorescent Penetrant Inspection: A random sample shall be selected from each production inspection lot; the size of the sample shall be as specified in Table 4 and classified as in Table 5. The sample units may be selected from those that have been subjected to and passed the visual and dimensional inspection, with additional units selected at random from the production inspection lot as necessary.

4.4.4 Stress-Rupture Test: A random sample of one part (or one specimen where required) shall be selected from each production inspection lot.

4.4.5 Destructive Tests: A random sample shall be selected from each production inspection lot; the size of the sample shall be as specified in Table 6. The sample units may be selected from those that have been subjected to and passed the nondestructive tests and the fluorescent penetrant inspection, with additional units selected at random from the production inspection lot as necessary.

4.4.6 Acceptance Quality: Of random samples tested, acceptance quality shall be based on zero defectives.

4.4.7 Test Specimens: Specimens for tensile and stress-rupture testing of machined test specimens shall be of standard proportions in accordance with ASTM E 8 with either 0.25 inch diameter at the reduced parallel gage section or smaller specimens proportional to the standard when required. Specimens shall be machined from finished parts or coupons of the same lot of alloy and be processed together with the parts they represent. Specimen shall be machined from the center of parts 0.750 inch and under in nominal diameter, from the center of coupons 0.800 inch and under in nominal diameter or distance between parallel sides, and from mid-radius of larger size parts or coupons.

4.5 Reports:

The vendor of parts shall furnish with each shipment a report stating that the chemical composition of the parts conforms to the applicable material specification, showing the results of tests to determine conformance to the room temperature ultimate tensile property, hardness, and stress-rupture requirements, and stating that the parts conform to the other technical requirements. This report shall include the purchase order number, AS7481, lot number, contractor or other direct supplier of material, part number, nominal size, and quality.

4.6 Rejected Lots:

If a production inspection lot is rejected, the vendor of parts shall perform corrective action to screen out or rework the defective parts, resubmit for acceptance tests inspection as in Table 3, or scrap the entire lot. Resubmitted lots shall be clearly identified as reinspected lots.

5. PREPARATION FOR DELIVERY:

5.1 Packaging and Identification:

5.1.1 Packaging shall be in accordance with ASTM D 3951.

5.1.2 Parts having different part numbers shall be packed in separate containers.

5.1.3 Each container of parts shall be marked to show not less than the following information:

FASTENERS, STEEL, CORROSION AND HEAT RESISTANT
AS7481
PART NUMBER
LOT NUMBER
PURCHASE ORDER NUMBER
QUANTITY
MANUFACTURER'S IDENTIFICATION

5.1.4 Threaded fasteners shall be protected from abrasion and chafing during handling, transportation, and storage.

6. ACKNOWLEDGMENT:

A vendor shall mention this specification number in all quotations and when acknowledging purchase orders.

7. REJECTIONS:

Parts not conforming to this specification, or to modification authorized by purchaser, will be subject to rejection.

8. NOTES:

8.1 Hardness Conversion Tables:

Hardness conversion tables for metals are presented in ASTM E 140.

8.2 Key Words:

Studs, Procurement Specification

8.3 The change bar (|) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document.

FIGURE 1 - Flow Lines, Rolled Thread

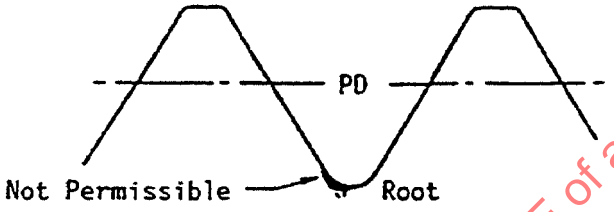


FIGURE 2 - Root Defects, Rolled Thread

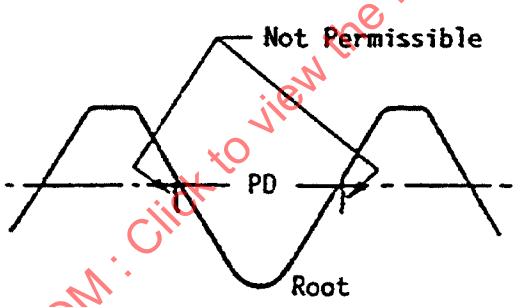


FIGURE 3 - Laps Below PD Extending Toward Root, Rolled Thread

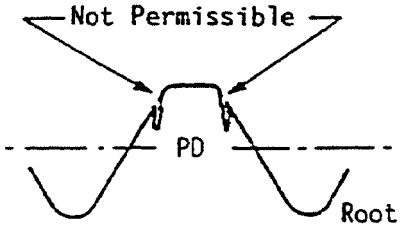


FIGURE 4 - Laps Above PD Extending Toward Root, Rolled Thread

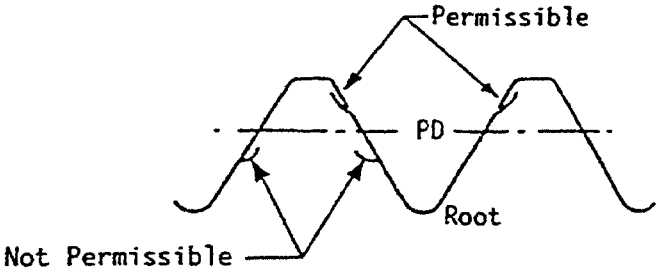
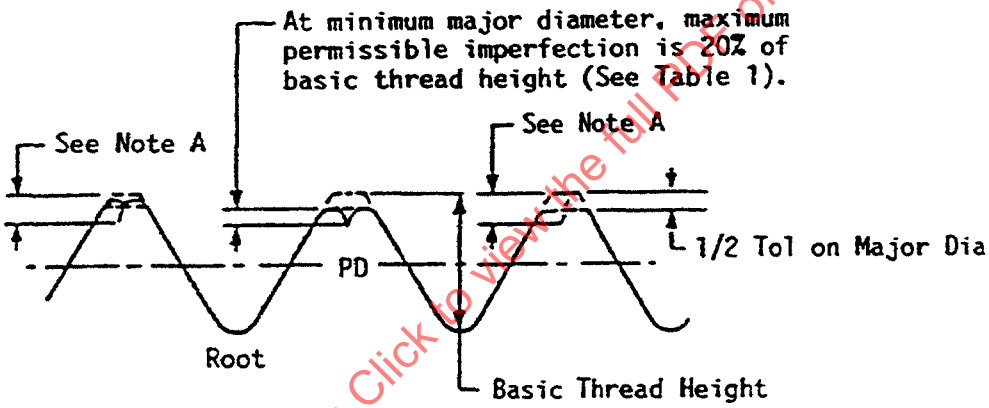


FIGURE 5 - Laps Extending Towards Crest, Rolled Thread



Note A: Maximum depth of imperfection equals 20% of basic thread height plus 1/2 the difference of the actual major diameter and minimum major diameter.

FIGURE 6 - Crest Craters and Crest Laps, Rolled Thread