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## MILITARY SPECIFICATION

## GUN BARRELS: GENERAL SPECIFICATIONS FOR

## 1. SCOPE

1.1 Scope. - This specification covers requirements of a general nature, pertinent to all types and classes of Naval gun barrels. When used in conjunction with the detailed specification of the specific gun barrel desired it furnishes all requirements necessary for the procurement of service gun barrels.

1.2 Classification. - Gun Barrels shall be of the following types and classes.

## Type I - Monobloc

Class 1 - Not subject to radial expansion.

Class 2 - Subject to radial expansion.

## Type II - Built Up

Class 1 - No part subject to radial expansion.

Class 2 - One or more parts subject to radial expansion.

## Type III - Loose Liner

Class 1 - Two components, no parts assembled by shrinkage, no part radially expanded.

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Class 2 - Multiple components, two or more parts assembled by shrinkage, no parts radially expanded.

2. APPLICABLE DOCUMENTS

2.1 The following standards and publications, of the issue in effect on date of invitation for bids, forms a part of this specification.

STANDARDS

MILITARY

- MIL-STD-8 - Dimensioning and Tolerancing.
- MIL-STD-10 - Surface Roughness, Waviness and Lay.
- MIL-STD-129 - Marking for Shipment and Storage.
- MIL-STD-130 - Identification Marking of U. S. Military Property.

BUREAU OF ORDNANCE

- NAVORD OSTD 2 - Method of Marking Ordnance Material.
- NAVORD OSTD 4 - Standard Finishes, Tolerances and Allowances.

PUBLICATIONS

BUREAU OF ORDNANCE

- NAVORD OP 400 - General Instructions for the Design, Manufacture and Inspection of Ordnance Equipment.
- NAVORD OP 1105 - Preservation and Preservation Maintenance of Ordnance Equipment in Shore Storage.
- NAVORD OP 1810 - Ordnance Shipping Instructions.
- NAVORD FORM 2310 - Gun Manufacturing Records.

(Copies of standards and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

2.2 Other Publications. - The following document forms a part of this specification. Unless otherwise indicated, the issue in effect on date of invitation for bids shall apply.

### NATIONAL BUREAU OF STANDARDS

Handbook H-28 - Screw-Thread Standards for Federal Services (with Supplement).

(Applications for copies should be addressed to the Superintendent of Documents, Government Printing Office, Washington 25, D. C.)

## 3. REQUIREMENTS

3.1 General. - Processes and methods necessary to obtain the desired product, except for those specified herein, shall be determined by the contractor. However, it is the responsibility of the contractor to satisfy the procuring agency as to full compliance with the contract, applicable drawings and documents. At the request of the contractor, the procuring agency will furnish lists, drawings, or sketches of processes and methods used in the production of desired product, provided such processes and methods have been predetermined. These lists, drawings, or sketches are intended only for guidance and shall not serve to relieve the contractor of his responsibility for the procurement of gages, tools, jigs, fixtures and equipment as may be required for the manufacture of the product.

3.1.1 Definitions. - The following definitions shall apply to the terminology used in this specification. (See figure 1 through figure 5 for pictorial representation). Terms not defined herein shall be as designated in Webster's New International Dictionary.

3.1.1.1 Gun barrel. - A gun barrel is a tubular structure generally rifled and chambered. The breech end of the barrel may be designed to receive case or bag type ammunition. Gun barrels may be either Monobloc, Built-up, or Loose Liner types.

3.1.1.2 Monobloc. - Descriptive of a gun barrel made from a single piece of metal.

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3.1.1.3 Built-up. - Descriptive of a gun barrel made of two or more metal components, with all strength members that resist internal pressure being assembled by shrinkage.

3.1.1.4 Loose liner. - Descriptive of a gun barrel made of two or more metal components in which the liner is assembled with diametrical clearance.

3.1.1.5 Liner. - A liner, when used, is the innermost member of a gun barrel having more than one strength component. It is normally chambered and rifled. The exterior surfaces are generally tapered and frequently stepped to facilitate assembly. It may or may not be assembled by shrinkage in the tube. If it is not shrunk in the tube it is assembled with diametrical clearance and is held in position by a retaining ring and key or some other mechanical device.

3.1.1.6 Tube. - The tube is normally the principal component around which the outer components are assembled and within which a liner, if used, is assembled. The tube may be chambered and rifled, or machined to accommodate a liner.

3.1.1.7 Jacket. - The jacket is the component located immediately outside of and over the breech portion of the tube and extends to some point forward of the origin of the bore.

3.1.1.8 Hoop. - A hoop is a component of a built-up gun barrel which is assembled over the tube, jacket, or another hoop.

3.1.1.9 Locking ring. - A locking ring is a ring used to prevent longitudinal motion of components relative to each other.

3.1.1.9.1 Liner locking ring. - A liner locking ring is a ring secured to the breech end of a gun barrel to prevent the rearward movement of a liner.

3.1.1.10 Origin of bore. - The origin of bore is that point in the gun barrel at which the rifling grooves first attain full depth characteristics.

3.1.1.11 Bore. - The bore is the minimum innermost surface of the barrel forward of the origin of the bore.

3.1.1.12 Origin of rifling. - Origin of rifling is the intersection of the bottom of the rifling groove with the diameter of the chamber.

3.1.1.13 Rifling. - The rifling consists of alternate lands and grooves extending through the gun barrel from the origin of rifling forward. Rifling may be uniform twist or increasing twist or a combination. Uniform twist is expressed as "one turn in a specified number of calibers" commonly called the pitch. Increasing twist is expressed as "one turn in a specified number of calibers to one turn in a different number of calibers commonly called variable pitch. In addition, rifling can be uniform or increasing in depth or width.

3.1.1.14 Chamber. - The chamber is that portion of the interior of a gun barrel extending from the breech face of the barrel to the origin of bore, where case type ammunition is used and from the forward face of the screw box recess to the origin of bore for gun barrels using bag type ammunition. Nomenclature of various parts of this chamber are shown in figures 3 and 4.

3.1.1.15 Screw box. - The screw box is the threaded recess in the breech end of a gun barrel in which the screw box liner of a breech mechanism is assembled.

3.1.1.16 Slide cylinder. - The slide cylinder is the exterior surfaces of the gun barrel which is in contact with the slide.

3.1.1.17 Chase. - The chase is that portion of a gun barrel, generally tapered, which extends from the forward end of the slide cylinder to the smallest diameter at the rear of the muzzle cylinder or bell.

3.1.1.18 Muzzle cylinder. - The muzzle cylinder is the exterior surface of a gun barrel which extends from the muzzle to the chase.

3.1.1.19 Muzzle bell. - The muzzle bell is the exterior surface of a gun barrel which extends from the muzzle toward the chase when that surface has a variable diameter larger than the minimum diameter of the chase.

3.1.1.20 Runout. - Runout is defined as the total displacement relative to a fixed point, registered by an indicator held in contact with the gun barrel's surface, at any transverse section of an end centered gun during one complete revolution. Runout may refer to either inside or outside measurements.

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3.1.1.21 Radial expansion. - This term, as used herein, refers to a means of improving the resistance of gun barrels by the application of relatively high internal hydrostatic pressure.

3.1.1.22 Diametral stage. - A diametral stage is a portion of a component over which the exterior diameter is uniform, or over which the ratio of exterior diameter to bore diameter is uniform.

3.1.1.23 Expansion stage. - An expansion stage is that portion of a component subjected to a prescribed uniform hydrostatic pressure. An expansion stage may include one or more diametral stages.

3.1.1.24 Permanent set. - Permanent set is the increase of exterior diameter or of bore diameter remaining after the release of the internal hydrostatic pressure.

3.1.1.25 Creep. - Creep is the difference between the dilation (external diametral enlargement) as measured when an internal pressure is acting momentarily and the dilation as measured when the same pressure has been maintained constant for a period of several minutes. In general it is an increase in dilation with no increase in pressure.

3.1.2 Nomenclature of gun barrel components. - Moving radially from the bore and forward from the breech end, the parts of a gun barrel are generally designated as listed below. (See figures 1 through 5 for their location and 3.1.1 through 3.1.1.25 for their definitions.)

- (a) Liner (when used).
- (b) Tube - A1.
- (c) Jacket or Hoop - B1, B2, B3, etc.
- (d) Hoops - C1, C2, etc.
- (e) Locking rings - C3, D1, etc. (depending on radial location).

3.1.3 Identification. - Gun barrels shall be identified as indicated on Method of Marking Drawing of specific gun barrel desired. Other identifying marks are generally required and can be found on the applicable drawings and in applicable documents for the specific gun barrels involved.

3.1.4 Records. - The contractor shall obtain the information needed for conformance with this specification and shall furnish this information to the Government inspector, to enable him to complete NAVORD Form 2310. The contractor shall retain this information for the duration of his responsibility as specified in the contract or order.

3.1.5 Corrosion protection. - All parts of gun barrels shall be cleaned and preserved for protection against corrosion at all times.

3.2 Material. - Material shall be as specified in the detailed specifications and applicable drawings for the specific gun barrel on order. This material shall be free from cracks, pits, flakes, inclusions, burrs, gouges, or other visual defects in its final machined condition.

3.3 Machining. - Care shall be exercised in rough machining to insure that stresses which cause distortion are relieved prior to final machining.

3.4 Straightness. - The gun barrels shall be straight to the extent of allowing free passage of a bore plug gage, both before and after proof firing. This gage shall be four (4) calibers in length and its diameter shall be 0.001-inch per inch of bore diameter smaller than the bore diameter.

3.4.1 Runout. - The gun barrel shall conform to the runout requirement shown on the applicable drawings.

3.4.2 Pressing. - Should a bend occur during machining operations the gun barrel may be straightened by pressing at the discretion and risk of the contractor. Under no circumstances is such a gun barrel to be straightened by hammering or heating, other than by steam heating. Steam heating may be employed provided the barrel temperatures do not rise above 150°F below the last tempering temperature.

3.5 Gas check seats. - The gas check seats of gun barrels shall be reamed undersize to allow for finish reaming to required dimensions after proof firing. The seat dimensions before proof firing shall be as specified in the detailed specifications, as shown on the applicable drawings, or as specified by the procuring agency.

3.6 Position marking. - Prior to machining the extractor pockets or location of the hinge lug, the gun barrel's 12-o'clock position shall be established. This shall be accomplished by clamping the breech end, supporting the barrel at its forward slide bearing position and with the bore running

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true at the points of support, rotate until the runout at the muzzle end is a maximum. The 12-o'clock position shall then be permanently marked on the breech face at the same o'clock position at which the maximum runout occurs.

3.7 Screw threads. - Screw threads shall conform to the applicable drawings and the National Bureau of Standard Handbook H-28 and the Not-Go gaging practices shall be as set forth in the supplement to the aforementioned handbook.

3.8 Chromium plating. - All plating shall be as shown on the applicable drawings, as specified herein and in the detailed specifications. The chromium plating process shall be such as to affect the bore and chamber surface properties only (i.e., hardness, erosion, corrosion and coefficient of friction).

3.8.1 Dimensions prior to plating. - The required dimensions before plating shall be obtained by electropolishing, by mechanical removal of metal, or by a combination of these methods. Sufficient material shall be removed to insure proper plating thickness when the barrel has been chromium plated to the specified drawing dimensions. When stargage measurements are taken after electropolishing, the gun barrel before being plated shall be reimmersed and reactivated by a short electropolishing operation of from 3 to 5 minutes. This electropolishing does not appreciably change the gun barrel dimensions.

3.8.2 Plating appearance. - The chromium deposit shall be smooth, homogeneous, uniform in appearance and shall be free of visual defects such as unplated areas, trees, cracks, pits or gouges. Burnt or frosty deposits are not acceptable. The plating shall be bright on the tops of the lands. A dull or slightly milky deposit on the bottom of the grooves will be acceptable. The plating shall not show any visual evidence of non-adhesion such as flaking or blisters prior to proof firing, nor excessive flaking after proof firing.

3.8.3 Dimensions after plating. - If the size of the bore does not conform to drawing dimensions after plating within the prescribed tolerances, the bore and chamber shall be deplated and replated. No mechanical honing or similar operations shall be performed on the tops of the lands to bring the dimensions of an undersize bore within drawing size. Mechanical honing or similar operations are permitted in the chamber to correct undersize dimensions.



3.9 Tolerances and allowances. - Tolerances and allowances shall conform to the applicable drawings and standard NAVORD OSTD 4.

3.10 Surface roughness. - Surface roughness shall conform to the applicable drawings and as interpreted by standard MIL-STD-10.

3.11 Gaging. -

3.11.1 Stargaging. - The chamber and bore shall be star-gaged in accordance with the detailed specifications for the specific gun barrel on order and as specified herein.

3.11.2 After proof gaging. - The after proof gaging of the bore and chamber shall be conducted in accordance with and shall not deviate from the limits prescribed by the detailed specification.

3.12 Identification markings. - All parts of gun barrels shall be marked in accordance with applicable drawings, standards (MIL-STD-130, NAVORD OSTD 2), detail specifications or as directed by the procuring activity.

3.13 Types and procedures. -

3.13.1 Type 1 gun barrels. - The gun barrels of this type shall be of monobloc construction and shall be either Class 1 or Class 2 as specified.

3.13.1.1 Class 1. - This class of barrel is made from unexpanded material. The characteristics of the material being such as to produce the desired product without being radially expanded.

3.13.1.2 Class 2. - This class of barrel is made from material that has been subjected to radial expansion for the purpose of increasing its resistance to internal pressure. This class shall be radially expanded as specified herein and in the detailed specification applying to a specific gun barrel.

3.13.1.2.1 Radial expansion. - The sequence specified herein and on the applicable drawings shall be followed in the expansion of the barrel. The gages to be used for measuring pressures, and the instruments to be used for measuring external and internal diameters, shall meet the approval of and be calibrated in a manner satisfactory to the procuring agency.

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3.13.1.2.1.1 Machining prior to expansion. - The basic material shall be machined to the condition shown on the applicable drawings prior to expansion. The finish of the bore surfaces shall be equal to a surface roughness of 63 RMS, or better and that of the outer surfaces shall be 250 RMS or better except at the indicated measuring stations. Finishes at measuring stations shall be as shown on applicable drawings. After machining the barrel shall be indicated for runout. The runout shall not exceed that specified on the applicable drawings. Should the runout exceed that specified, the gun barrel shall be straightened in accordance with 3.3.2.

3.13.1.2.1.2 Barrel condition prior to expansion. - After machining for radial expansion and before attempting the first expansion operation, the bore diameters shall be determined at one-inch intervals throughout the length and the condition of the bore shall be observed for material or machining defects. The outside diameters at the specified measuring stations shall also be obtained. If, in the opinion of the Government inspector, defects have occurred which could result in the rejection of the material, the contractor shall be notified and further work will be at his own risk.

3.13.1.2.1.3 Assembly of apparatus. - first stage expansion. - The expanding apparatus shall be assembled and the packings located for the expansion of the first stage described on the applicable drawings.

3.13.1.2.1.4 Dilation and permanent set. - Dilations and permanent sets shall be determined at the prescribed measuring stations and between stations and at different clock positions if necessary to determine a section undergoing abnormal dilation. The maximum diameter of a cross section undergoing abnormal dilation shall be determined.

3.13.1.2.1.5 Application of pressure (normal dilation). - The first increment of hydrostatic pressure shall be applied to the first stage and shall be the highest multiple of 5000 psi (pounds per square inch) that is not in excess of the pressure corresponding to the end of the elastic period as indicated on the pressure dilation curves in the detailed specifications. The increment loading above the initial pressure level shall be made in steps of 10,000 psi, generally, provided the last increment shall be 5000 psi, or less, and is preceded by at least one 5000 psi. increment. The interval between applications of successive pressure levels shall not be less than one minute. When the prescribed expanding pressure is obtained, it shall be held for five minutes, and the creep determined. Material that withstands the prescribed pressure within a tolerance of 1000 psi will be acceptable.

3.13.1.2.1.6 Application of pressure (abnormal dilation.) - Pressures shall be applied in increments, as specified in 3.13.1.2.1.5 until the dilation of any cross section is 150 per cent of the maximum dilation indicated on the dilation chart in the detailed specifications. If the dilation exceeds 150 per cent of the maximum dilation shown on the dilation charts before the prescribed expanding pressure is reached the pressure shall be relieved, the apparatus disassembled, and the stage shall be re-expanded in accordance with 3.13.1.2.1.9 after stabilizing heat treatment. In the event the prescribed pressure is reached and because of creep, the dilation exceeds 150 per cent of that shown on the dilation charts, re-expansion after stabilizing heat treatment shall be accomplished in accordance with 3.13.1.2.1.9. Following the release of pressure, if dilation has occurred, the bore and outside diameters shall be determined.

3.13.1.2.1.7 Remaining stages expansion process. - The remaining stages shall be expanded in decreasing pressure sequence, with the expansion of each stage following the procedure outlined in 3.13.1.2.1.3. Should abnormal dilations occur in any stage of expansion, dimensions of all stages shall be redetermined for required values. After all stages have been expanded and after the release of pressure the bore diameters shall be determined at one-inch intervals throughout the length. The exterior diameters at the measuring points and the overall length of the material shall be obtained. The material shall be checked for runout in accordance with the applicable drawings.

3.13.1.2.1.8 Stabilizing heat treatment. - The expanded material shall be subjected to a stabilizing heat treatment after radial expansion of all stages or after a stage has failed to withstand the expanding pressure. The temperature and duration of this heat treatment shall be as specified by the procuring agency for each individual contract (for reference see Jeansen's Treatise on Radial Expansion). Stabilizing heat treatment shall be accomplished in a furnace to be approved by prior action of the Naval Inspector. When undergoing stabilizing heat treatment in a verticle furnace, the material shall be placed in the furnace with the muzzle ends down. When treatment is accomplished in a furnace by the radiant heat process, the expanded material shall be placed centrally in the furnace and the furnace temperature (Pyrometer reading) shall be increased until the prescribed temperature has been obtained. Only one component at a time shall be treated in this type furnace. In furnaces of indirectly fired recirculated air type, multiple components may be treated at the same time provided that adequate pyrometer installations and records are made to assure an equal

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distribution of heat throughout the furnace. When the prescribed furnace temperature has been obtained, the components shall be soaked at that temperature for the prescribed length of time. Following this treatment the components shall be allowed to cool in a place free from draft and then aged for a period of 48 hours at shop temperatures. The components shall be indicated for runout after the aging period. Components that do not comply with the requirements of 3.3.1 shall be straightened in accordance with 3.3.2.

3.13.1.2.1.9 Re-expansion of deficient stages. - Those components which failed to withstand the prescribed expanding pressure for any expansion stage shall be re-expanded following stabilizing heat treatment. The deficient stage of the material shall be subjected to the maximum pressure attained during the preceding attempt to expand that stage. Dilation shall then be determined. If abnormal dilation has not occurred the material shall be checked for additional permanent set. In the event additional permanent set has occurred, the material shall be subjected to further stabilizing heat treatment in accordance with 3.13.1.2.1.8 and again re-expanded as specified above until the material withstands the maximum pressure previously applied without showing additional permanent set. When this condition has been obtained, bore pressure shall be applied in increments of 10,000 psi, until the pressure equals that previously applied in that stage. Further pressure shall be applied in increments of 1000 psi or less, until the total maximum dilation of any cross section, referred to the original exterior diameter of the material, equals 200 per cent dilation indicated for the prescribed expanding pressure. Any material, in which any stage, which upon re-expansion, fails to withstand the prescribed pressure shall be referred to the procuring activity for decision.

3.14 Type II gun barrels. - Gun barrels of this type shall be composed of two or more strength components, assembled by shrinkage and shall be either class 1 or class 2. In gun barrels of this type, shall not be finish bored, finish chambered, or rifled until after assembly has been completed. Sufficient material must be retained on the exterior surfaces of the outer member to permit finished machining after shrinkage.

3.14.1 Procedure - prior to assembly. - The bore of the enveloping cylinder shall be finished to the final dimensions shown on the applicable drawings. The bore diameters shall then be determined at one-inch intervals throughout the length. The outside diameters of the enveloped cylinder shall be turned to the bore diameters of the enveloping cylinder plus the shrinkage in accordance with the applicable shrinkage

drawings. The outside diameters of the enveloped cylinder shall then be determined at one-inch intervals throughout the length. All interior diameters of gun components with the exception of tube or liner shall be finished machined to applicable drawing dimensions. These diameters shall be determined at one-inch intervals throughout the length. Sufficient material shall be retained on the exterior surfaces of the outermost component to permit finished machining after shrinkage.

3.14.2 Assembling. - The various processes and methods employed in assembling the components, except those specified herein, shall be determined by the contractor subject to the approval of the procuring agency. This approval shall be obtained prior to any assembly operation. In any assembly involving more than two components the various components shall be assembled on the tube. Whenever a liner is required in an assembly, it shall be the last component assembled.

3.14.2.1 Assembling procedure. - The tube shall be rough bored and its external diameters machined to the diameters of its enveloping cylinder plus the shrinkage as shown on the applicable drawing. The outside diameters shall be determined at one-inch intervals throughout its length and the actual shrinkage shall be determined. The bore diameters of the tube shall be determined for each inch of length. The tube's enveloping component shall then be placed in a furnace and subjected to heat for a sufficient length of time to permit the assembly of the tube with this component. In any assembly process the temperature of the heated components shall not be allowed to rise above 800°F, and neither shall they be struck nor set by means of blows while thus heated or afterwards. When the enveloping component is sufficiently heated the tube shall be assembled with the proper shoulder of this component in a pit. The heated component shall then be cooled in such a manner as to insure seating of the components on their proper bearing shoulders. This process has generally been accomplished by assembling cylinders inside perforated coils that permit water to be sprayed on the desired areas in the sequence necessary to insure proper seating. The assembly shall then be permitted to cool in the pit to shop temperature. After the assembly has cooled, it shall be removed from the pit. The interior diameters of the enveloped component shall be determined at one-inch intervals throughout its length to determine the amount of compression due to shrinkage. The exterior diameters shall then be machined to the next enveloping cylinder's interior diameters plus the shrinkage as specified on the applicable drawings. This process shall be repeated for each component until all of the components, with the exception of the liner, have been assembled. The tube



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shall then be finished bored to applicable drawing dimensions and the interior diameters determined at one-inch intervals throughout its length. The liner shall be rough bored, leaving sufficient material at the bore surfaces to insure straightening and finished machining. The exterior diameters of the liner shall be finish machined to the interior diameters of the tube plus the shrinkage as shown on the applicable shrinkage drawings. During the machining, the exterior diameters of the liner shall be determined for each inch of length and the actual shrinkage also determined. The internal diameter of the liner shall be determined for each inch of length. The external surfaces of the liner shall then be coated with some antisieze compound such as graphite or molybdenum disulphide. Plug the muzzle end of the liner with a plug, having three pipes extending through the bore to the contact shoulder position and with two entrance and one exit connection for cold water. Place the tube assembly in a furnace, muzzle end down and subject to heat for a sufficient length of time to permit the assembly of the liner. Fill the bore of the liner with cold water and assemble in the tube until it seats. Assemble jack on breech end of liner and fasten cold water connection to water inlet pipe, at the same time opening the water inlet valve and exit pet cock. Drop the water level in the liner according to schedules prescribed by the procuring agency to insure seizure of the liner by its enveloping component(s) progressively from the breech end to the muzzle. When assembling the liner, precautions shall be taken to insure that the collar or shoulder of the liner make contact and remains in contact with the mating shoulder in the tube as indicated on the applicable drawings. Dimensions shall be obtained both before and after assembly to determine whether or not contact has been maintained. Unless a smaller amount is specified the liner shall not be off shoulder in excess of 0.02-inch the assembly, if otherwise satisfactory, will be accepted. Should off shoulder condition of the liner exceed the amount specified the procuring activity shall be notified and all the work discontinued pending decision of the procuring activity.

3.14.3 Class 1. - The components for this class of gun barrel are made from unexpanded material the properties of which are of such a nature as to produce the desired product without being subjected to radial expansion.

3.14.4 Class 2. - In this class of gun barrel, one or more components shall be subjected to radial expansion in order to improve its resistance to internal pressure. The components

designated on the applicable drawings to be radially expanded shall be expanded in accordance with the procedure outlined for Type 1 class 2 gun barrels specified herein (See Para. 3.13.1.2 through 3.13.1.2.1.9).

3.15 Type II gun barrels. - Gun barrels of this type shall be composed of two or more strength members. The liners of these barrels can be removed and replaced by mechanical means, without being subjected to heat. Components of this type may or may not be radially expanded. These barrels may be either Class 1 or Class 2.

3.15.1 Class 1. - Gun barrels of this class are composed of tube and liner and no parts are subjected to radial expansion.

3.15.2 Class 2. - The gun barrels of this class shall be composed of three or more components. All components shall be assembled on the tube by shrinkage as prescribed for Type 2 (See paragraph 3.14) gun barrels, with the exception of the liner. The liner shall be the last component assembled and shall be assembled with diametrical clearance.

3.16 Workmanship. - Work shall be performed by competent workmen of the trades involved. The workmanship shall be such as to produce gun barrels in accordance with the requirements of the applicable documents.

#### 4. QUALITY ASSURANCE PROVISIONS AND TEST REQUIREMENTS

4.1 General. - General testing and inspection procedures shall be in accordance with Publication OP 400.

4.1.1 Conditional acceptance. - The inspector at the contractor's plant shall conditionally accept all gun barrels which meet all the requirements of the contract, drawings, and applicable specifications. This conditional acceptance shall not mean that title to the gun barrels has transferred to the procuring activity, nor shall it preclude subsequent rejection for discovered or developed defects. All components which do not meet all the requirements within the allowed tolerances shall be referred to the procuring agency for disposition. Each such request shall be accompanied by a complete and detailed statement describing wherein the requirements are not fulfilled, together with the inspector's recommendations.

4.1.2 Final acceptance. - Final acceptance of each gun barrel shall be based on inspection establishing satisfactory condition after proof firing. Final acceptance shall not be claimed because of any failure to discover defects earlier.

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4.2 Sampling. - Unless otherwise specified in the individual specification for the gun barrel on order, each gun barrel, its components, and parts shall be individually inspected and tested for all requirements of this specification, the applicable drawings, and other documents of the contract.

4.3 Inspection. -

4.3.1 Material. - Prior to any manufacturing processes, the inspector shall ascertain that the basic material (forgings, bar stock, castings) of the components that have been procured under separate drawings or specifications have been inspected, tested and accepted in accordance with their respective specifications and drawings. The inspector shall observe, witness and measure any components, operation, or detail at any stage of manufacture to insure that all requirements of this specification are met.

4.3.2 Visual inspection. - The interior surfaces of all gun barrels shall be illuminated and carefully inspected to determine conformance with this specification, the detail specification for the gun barrel on order, and the applicable drawings of the aforementioned barrel. Plated barrels shall be inspected before and after plating.

4.3.2.1 Measurements prior to plating. - Stargage measurements of the interior diameters of the barrel shall be taken after machining or may be taken after electropolishing as specified in 3.8.1 as required. These measurements shall be obtained as directed in the contract, applicable drawings and documents, or as requested by the procuring agency or Naval Inspector of Ordnance. Measurements shall be recorded on NAVORD Form 2310C.

4.3.2.2 Measurements after plating. - Stargage measurements of the interior diameters of the barrel shall be obtained, after plating, in the same locations as those taken prior to plating. These measurements shall be recorded on NAVORD Form 2310C.

4.3.3 Thickness of chromium deposit. - At each transverse section, the maximum, minimum and average thickness of the chromium plating on the top of the lands, on the bottom of the grooves and in the chamber shall be checked with a "Magne Gage" or an instrument which performs a comparable function. Measurements shall be taken on every quarter of the bore at least every twelve inches, beginning at the 12, 3, 6, and 9 o'clock locations (breech time) at the origin of the bore. Measurements shall be taken on every quarter of the chamber at least every six inches beginning at the 12, 3, 6, and 9



o'clock locations (breech time) at the breech face. If thicknesses of the chromium plate do not conform to those specified on the applicable drawings, the gun barrel shall be stripped and replated.

4.3.3.1 Exceptions. - Thickness measurements in gun barrels having a tapering depth rifling cannot be made throughout the entire bore with a "Magne-Gage" type instrument which requires guidance by a lug inserted in the rifling groove. The distance from the breech face that can be measured is limited by the location of the point at which the diminishing land height will not permit passage of the measuring head. In such instances, thickness measurements shall be made with the "Magne-Gage" up to the point that further passage of the instrument becomes difficult. In measuring smooth bores however, the guide shall be removed from the instrument and measurements taken as indicated in 4.3.3. Thickness measurements in bores and chambers of gun barrels whose bore size is too small to permit the use of "Magne-Gage" type instruments shall be made by stargaging the bore and chamber both before and after plating. In gun barrels having a thin coating of chromium plating (0.0005-inch thick) the number of measurements specified in 4.3.3 shall not be required, but shall be sufficient to establish the order of magnitude of the chromium deposit.

4.3.4 Plating inspection. - All gun barrels, plated by the contractor's process and plating equipment, shall be inspected as stipulated herein until the process consistently produces satisfactory chromium deposits. Thereafter the plated barrels produced shall be inspected in accordance with sampling instructions provided by the procuring activity.

4.3.5 Straightness. - Conformance to the straightness requirements of 3.3 shall be verified before and after proof firing each gun barrel.

4.3.5.1 Runout. - Each gun barrel shall be inspected for the runout requirements of 3.3.1.

4.3.6 Measurement. -

4.3.6.1 Type 1 Class 1 gun barrels. - Obtain and record on NAVORD Form 2310 the measurements required by paragraphs 4 to 4.3.4 inclusive.

4.3.6.2 Type 1 Class 2 gun barrel. -

4.3.6.2.1 Prior to expansion. - Measurements of the bore diameters shall be taken at one-inch intervals throughout its length and the outside diameters at the specified measuring

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stations shall also be measured. All measurements shall be recorded on NAVORD Forms 2310E and 2310F. The bore shall be visually inspected for material or machining defects. Should any defects occur, their location, size and description shall be recorded on NAVORD Form 2310. In addition the overall length of the gun barrel shall be measured and recorded on the aforementioned form.

#### 4.3.6.2.2 During expansion (first stage). -

4.3.6.2.2.1 Normal dilation. - Measurements of the outside diameters of the barrels shall be taken at the prescribed measuring stations during the application of pressure increments in accordance with 3.13.1.2.1.5. Dilation shall be determined by subtracting the original diameter before pressure application from the diameter when pressure increment is applied. When the prescribed expanding pressure has been reached the dilation shall be determined at once. When this pressure level has been maintained for five minutes the outside diameters shall again be measured. The creep which is the difference between the measured diameter after the pressure level has been held for five minutes, and the reading at that diameter when that pressure level was first obtained, shall be determined. All measurements of the diameters at the various pressure levels shall be recorded on NAVORD Form 2310F and dilations and creep shall be determined and recorded on the same form.

4.3.6.2.2.2 Abnormal dilation. - Whenever the diameter measurements reveal a dilation greater than 150 per cent of that shown on the dilation chart in the detail specification, this measurement shall be recorded on NAVORD Form 2310F. In the event prescribed pressure is reached and because of creep the dilation exceeds 150 per cent this measurement shall be recorded on NAVORD Form 2310F. On completion of stabilizing heat treatment and satisfactory application of desired pressure level the outside diameters at the proper measuring station and the bore diameters shall be measured at one-inch intervals throughout its length and recorded on NAVORD Form 2310F.

4.3.6.2.3 Remaining expansion stages. - Measurements shall be recorded after each pressure increment during the remaining expansion stages in the same manner as for the first stage of expansion. On completion of the expansion process and the release of pressure the bore diameters shall be measured at one-inch intervals throughout its length and recorded on NAVORD Form 2310E. The outside diameters shall be measured at the prescribed measuring stations and recorded on NAVORD Form

2310F, with the dilation and creep also entered. The measured overall length shall be entered on the aforementioned form. In addition, the material shall be checked for runout in accordance with the applicable drawings and documents.

4.3.6.2.4 Stabilizing heat treatment. - During the stabilizing heat treatment after radial expansion, the pyrometer readings of the furnace shall be recorded on NAVORD Form 2310 with the length of time the gun barrel was soaked at this temperature. The gun barrel shall be indicated for straightness after the aging period.

4.3.6.2.5 Re-expansion of deficient stages. - Measure the outside diameters at the prescribed measuring stations after material has been subjected to the maximum pressure obtained during the preceding attempt to expand that stage. Record these dimensions on NAVORD Form 2310F. Determine dilation. If abnormal dilation has not occurred check for additional permanent set. Repeat this process until material conforms to the conditions of 3.13.1.2.1.9.

#### 4.3.6.3 Type II Class 1 gun barrels. -

4.3.6.3.1 Prior to shrinkage. - Measure the overall length of the enveloping and enveloped cylinders. Record these measurements, names and forging numbers on NAVORD Form 2310D for both cylinders. Record the shrinkage sheet Drawing number and revision letter on the aforementioned form.

4.3.6.3.1.1 Enveloping cylinder. - Stargage the finished bore diameters at one-inch intervals throughout its length and record the measurements on NAVORD Form 2310D. Measure the distance to the bearing shoulder and record it on the above named form.

4.3.6.3.1.2 Enveloped cylinder. - Measure the outside diameters of the enveloped cylinder at one-inch intervals throughout its length in the same locations as was done for the enveloping cylinder. Subtract the enveloping cylinder diameters from the enveloped cylinder diameters. Enter the remainder as actual shrinkage on NAVORD Form 2310D. Enter from the applicable shrinkage sheet the prescribed shrinkage and allowed variation on the above mentioned form. Record the bore diameters at one-inch intervals throughout its length for the innermost cylinder in the proper column on Form 2310D. Measure the distance to bearing collar and record it on Form 2310D.

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4.3.6.3.2 After shrinkage. - Measure the enveloped and enveloping cylinders overall lengths and determine the change in length of these cylinders from before shrinkage. Enter the differences as the change in lengths for these cylinders on NAVORD Form 2310D. Determine the relationship of the breech faces of the two cylinders in order to evaluate the seating of the bearing shoulders. Stargage the bore diameters at every station stargaged prior to shrinkage. Enter these measurements on NAVORD Form 2310D in the proper columns. Subtract the final measurements from the original bore measurements and enter as compressions in the proper columns on the aforementioned forms. Obtain and record on NAVORD Form 2310 the measurements requested in paragraph 4.3 to 4.3.4 inclusive.

4.3.6.4 Type II Class 2 gun barrels. -

4.3.6.4.1 During manufacture. - Gun barrels of this class shall be measured and their dimensions recorded on NAVORD Form 2310 in accordance with paragraphs 4 through 4.3.6.3.2 in their entirety.

4.3.6.5 Type III Class 1 gun barrels. - Gun barrels of this type and class shall be inspected in accordance with the provisions of paragraphs 4 to 4.3.4 inclusive. In addition, the exterior diameters of the liner and the interior diameters of the tube shall be measured at one-inch intervals throughout their lengths and recorded on NAVORD Form 2310.

4.3.6.5.1 Type III Class 2 gun barrels. - Gun barrels of this type and class shall be inspected in accordance with paragraphs 4 to 4.3.4 inclusive and 4.3.6.3 to 4.3.6.3.2 inclusive. The liner and tube shall be measured and the dimensions recorded as specified for Type III class 1 gun barrels.

4.4 Packing and marking. - The inspector shall ascertain that all parts are properly packed, marked and identified in accordance with the detail specifications, applicable drawings, and documents of the gun barrel on order.

4.5 Tests. -

4.5.1 Unplated areas. - Suspected unplated areas which cannot be determined by visual inspection shall be tested by cleaning the areas with a solvent to remove grease and then swabbing with a solution containing 13.4 ounces per gallon of copper sulphate ( $\text{CuSO}_4 \cdot 5 \text{H}_2\text{O}$ ) and 20 drops per gallon of sulphuric acid (95 per cent). Deposits of copper indicate that the surfaces are not covered with chromium. Any copper sulphate solution remaining in the bore after the test shall be removed immediately by wiping with a wet cloth or cotton

and the bore dried. Copper deposits shall be removed from the test areas. In the event unplated areas are discovered the gun barrel shall be deplated and replated.

4.5.2 Proof tests. - Each gun barrel submitted under the conditional acceptance provisions of 4.1.1 shall be test fired at proof pressures. Proof tests shall be specified by the procuring activity and shall be conducted at a proving ground designated by this activity.

4.5.2.1 Post proof inspection and acceptance. - Each proof tested gun barrel shall be inspected in accordance with acceptance inspection procedure and classifications of defects provided by the procuring activity, or, according to such alternative acceptance inspection instructions as are provided by the procuring activity.

4.5.3 Resubmission of rejected gun barrels. - Gun barrels rejected by the post proof inspection may be reworked to correct defects and may be resubmitted for reinspection only with express approval of the procuring activity.

## 5. PREPARATION FOR DELIVERY

### 5.1 Preservation and Packaging. -

5.1.1 Level B. - Unless otherwise specified in the contract order or the individual gun barrel specification, gun barrels shall be preserved and packaged in accordance with Ordnance Publication OP 1105.

5.2 Shipping Instructions. - Unless otherwise specified in the contract, order or the individual gun barrel specification, gun barrels shall be shipped in accordance with Ordnance Publication OP 1810.

5.3 Marking. - Each gun barrel shall be marked in accordance with the requirements of MIL-STD-129. In addition each gun barrel shall be tagged and stencilled (painted) for identification. The identifying information shall consist of the mark and modification assignment, the serial number and the contract or order number.

## 6. NOTES

6.1 Intended use. - This specification, when used in conjunction with the drawings, specification and applicable

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documents of the particular gun barrel desired, contains all the information necessary to procure gun barrels for the United States Navy.

6.2 Ordering data. - Procurement documents should specify those items required by the detail specifications of the gun barrel on order. In addition, procurement documents should specify a time limitation for the replacement of rejected gun barrels. The following is a suggested schedule for this replacement:

<u>Gun Barrels</u>	<u>Time Allowed for Replacement</u>
12-Inch to 16-Inch (incl.)	1 year
6-Inch to 8-Inch (incl.)	6 months
5-Inch	4 months
4-Inch or smaller	3 months

6.3 Superseding data. - This specification supersedes that portion of Publication Op 400A (GENERAL SPECIFICATIONS FOR THE MANUFACTURE AND INSPECTION OF GUNS, GUN BARRELS, BREECH MECHANISMS AND BREECH HOUSINGS FOR THE UNITED STATES NAVY) pertaining to guns and gun barrels.

Notice: When Government drawings, specifications or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use or sell any invention that may in any way be related thereto.

Preparing activity:  
Navy - Bureau of Ordnance

Custodians:  
Navy - Bureau of Ordnance

Other Interest:  
Navy - Y, CG, MC

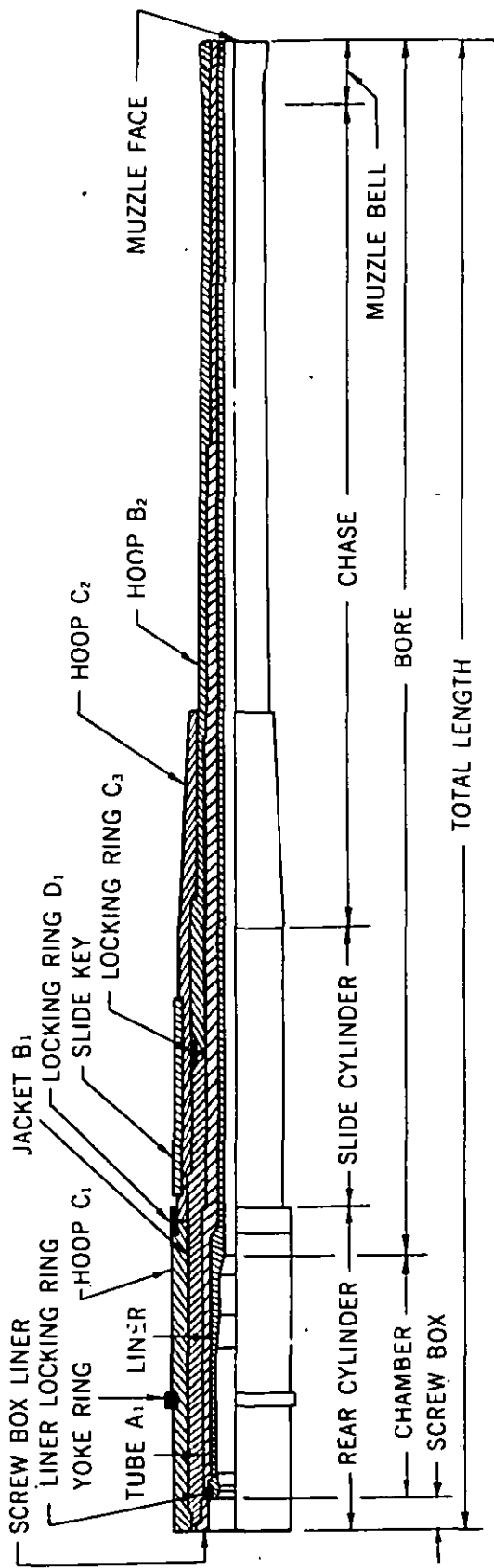


FIG. 1 BUILT UP GUN BARREL

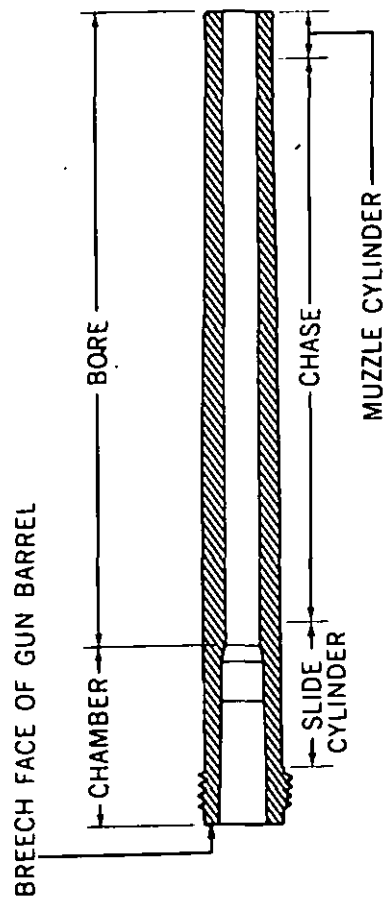


FIG. 2 MONOBLOC GUN BARREL



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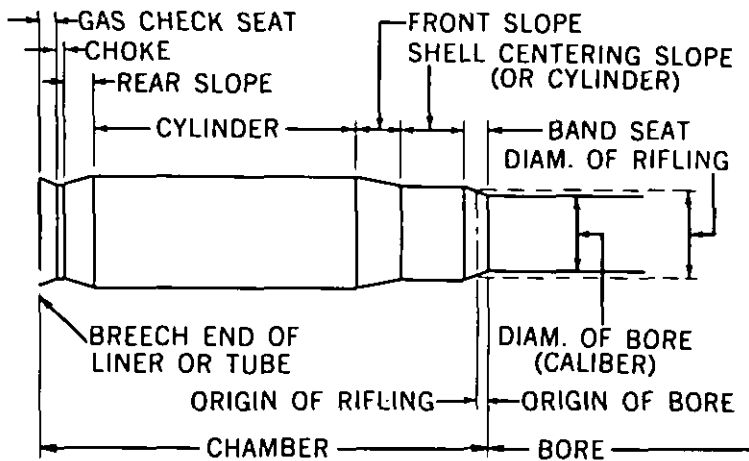


FIG. 3 CHAMBER - BAG AMMUNITION

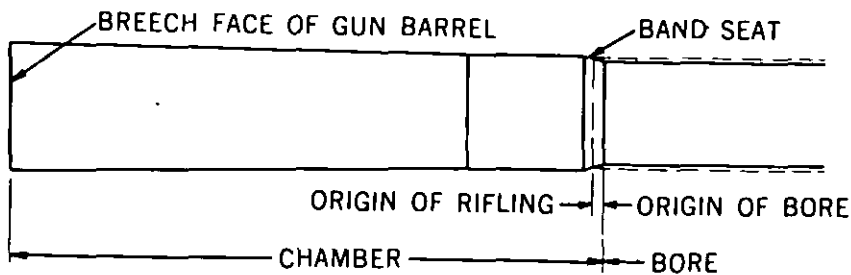


FIG. 4 CHAMBER - CASE AMMUNITION

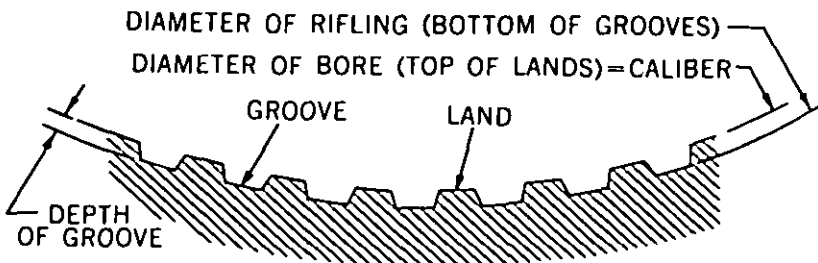


FIG. 5 RIFLING PROFILE