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WATERTOWN ARSENAL
PRODUCTION DEPARTMENT

GUN DIVISION
REPORT NO. WGD-5

DTIC
JUN 17 1981

Standards For Gun Tube Drawings

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BY

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DATE 1 January 1944

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6 STANDARDS FOR GUN TUBE DRAWINGS,

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Approved:
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14 Report No.
WGD-5 ✓

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STANDARDS FOR GUN TUBE DRAWINGS

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Section A. INTRODUCTION

This set of standards is prepared so that there will be on record a listing of the gun tube drawings required and the details pertaining to each, so that a uniform practice can be followed in their preparation.

It is visualized that the standard drawings will cover practically all cases; however, there may be some instances that will not fall within their scope (e.g., - when rough castings are shipped, a special drawing will be needed to cover exactly the details as may be specified in the production order). The requirement for special drawings should be taken up with the Gun Division.

Section B. STANDARD DRAWING TITLES

The first line of all drawing titles will start with the words, "Tube for" to be followed in sequence by caliber of the tube and the model. The method of manufacture at Watertown Arsenal (CW - Cold Work, HS - High Strength) will be shown in parentheses after the word "tube", as:

TUBE (CW) FOR 105 MM HCWITZER M2A1

TUBE (HS) FOR 76 MM GUN M1A1

The second line of all drawing titles will identify the Standard Drawing and will designate the stage of manufacture. "Standard Process Drawings" will show the casting in various stages of production and will carry local "J" drawing numbers. "Standard Shipping Drawings" will show only the details of the tube as shipped from Watertown Arsenal and will carry Ordnance Office drawing numbers. The types of Standard Drawings required for each method of manufacture are listed below. Specific titles and a description of each drawing are detailed in Section "D".

- a. Tubes processed through cold work after heat treatment in the rough condition will require the preparation of Process Drawings Types I, II, III and IV, and Shipping Drawing Type VII.
- b. Tubes processed through cold work after heat treatment in the rough machined condition will require the preparation of Process Drawings Types I, V, III and IV, and Shipping Drawing Type VII.
- c. Tubes heat treated to strength (not cold-worked) will require the preparation of Process Drawings Types I and VI, and Shipping Drawing Type VIII.

A listing of Standard Drawings by type follows for reference, and a sample layout of a Type V drawing is included at the end of Section "D".

<u>DRG. TYPE</u>	<u>TITLE</u>
I	<u>Rough Casting</u>
II	<u>Rough Casting at Heat Treat Size and Details of Testing</u>
III	<u>Machined Preparatory to Cold Working 6% † 2%</u>
IV	<u>Cold Worked 6% † 2% Preparatory to Finish Machining</u>
V	<u>Rough Machined to Heat Treat Size and Details of Testing</u>
VI	<u>Rough Machined to Heat Treat Size, Details of Testing and Shipping Size</u>
VII	<u>Cold Worked Casting Preparatory to Finish Machining</u>
VIII	<u>Rough Machined Casting Preparatory to Finish Machining</u>

Section C. GENERAL PROCEDURE FOR ALL STANDARD DRAWINGS

- a. All tube drawings will be made on "D" size sheets. The original tracing of all drawings will be retained at this Arsenal. Copies of Shipping Drawings will be generally the only prints to leave the Arsenal and these will carry Ordnance Office numbers as well as the reference "As Produced at Watertown Arsenal" to distinguish practice from that of other establishments.
- b. Physical property requirements of any production order for tubes will be entered on Shipping Drawings and on only those Process Drawings which show the tube at Heat Treat size (Types II, V and VI). In addition, these Process Drawings will carry the local restriction:
- "Variation in Yield Strength from breech to muzzle of any one tube shall not exceed 15,000 psi."
- c. Breech end of tube will be shown on left hand side of drawing.
- d. In cases where the casting is machined before heat treatment, shoulders and breaks in taper will be located 1/2" away from the corresponding point in either the "Finished Tube" or the "Before Cold Work" tube as the case may be.
- e. When the casting is machined before heat treatment, all shoulders will be machined to approximately 30° from horizontal. The length (not degrees) of the shoulder will be shown to the nearest sixteenth inch (but never less than 1/2") with the standard tolerance of plus 1/4".
- f. The following general rule for locating length dimensions on the drawing will be observed whenever possible:

"Dimensions established prior to the specific stage of processing shown by the drawing will be entered above the tube; dimensions showing the tube as released to the next operation will be entered below the tube."

For example, for HS tubes, the "Rough Casting" drawing shows the cold casting length above the tube and the length as released from the Foundry below the tube. The subsequent Process Drawing, "Rough Machined to Heat Treat Size," shows the latter length (and details of machining) above the tube, and the details of testing and the length after test below the tube. Likewise, for CW tubes, the discards after cold work are shown above the tube, and the shipping length below the tube.

g. Tapers will be stated on all drawings with the notation "(Reference)".

h. Desired allowance for test metal (unless otherwise specified by Gun Division).

a. First test after heat treatment:

Breech discard	2"
Breech disc	1" *
Muzzle discard	2"
Muzzle disc	1" *
Total	<u>6"</u>

*One inch, based on 3/4" disc and two 1/8" saw cuts.

b. Additional allowance for reheat-treatment and second test:

Same discards and discs as above = 6" additional.

c. Additional spare test metal to allow farther for a retest at each end.

Discs without discards = 2" additional.

Total Test Metal = 14" divided equally with 7" on each end.

Note: When cross section is so small that transverse bars cannot be obtained, the 3/4" discs must be increased to 3" slugs to provide for longitudinal test bars. 3/4" discs are satisfactory even in small sections if Brinell hardness is used for acceptance.

- i. Except for tubes heat treated as a rough casting, test metal will be straight turned (not a continuation of a taper) and will be shown dotted.
- j. Test discs will be shown shaded.
- k. Tensile test bars will be of the .357" shoulder type and will be located in both the breech and muzzle discs at a position tangent to the finished caliber diameter. Two bars will be shown in each disc, being located at the 6 and 12 o'clock positions. Positions at which the two sides of the suspension loops are welded are designated as 3 and 9 o'clock. The detail of testing will be positioned in the lower left corner of the drawing whenever possible.
- l. Charpy bars are not sufficiently well standardized at the time of this writing to include full detail. In general, it is expected that they will be of the V-notch type with the notch at the bore side and the center line of the bar tangent to the midwall diameter of the heat treat dimensions. Charpy bars will likely be located at 3 and 9 o'clock positions in both breech and muzzle discs.
- m. In the following discussion, certain allowances are cited for "building up" the finished tube to the "Before Cold Work" and the "Heat Treat Size" dimensions. These apply to guns of the medium standard sizes (75 mm to 105 mm). For either smaller or larger sizes, allowances for finish boring and turning, straightness, test metal, etc., may be necessarily decreased or increased to meet particular requirements.

Section B. ADDITIONAL PROCEDURE FOR SPECIFIC STANDARD DRAWINGS

The following titles and comments refer to drawings as indexed in Section "B". For discussion purposes, it is assumed that the mold layout for a particular tube has been completed and, necessarily, the centrifugal casting design has been established. The comments are to assist the draftsman in preparing Process and Shipping drawings which will show all necessary dimensions, tolerances, weights, etc., without complicating any particular drawing with redundant detail.

Title:

Process Drawing Type I

"ROUGH CASTING"

Description:

- a. Show dimensions of the cold casting. These can be obtained from the mold layout. Tolerances will not be shown for either diameters or lengths. All dimensions will be approximate, i.e. shown to the nearest 1/4" on length and 0.1" on diameter.
- b. State maximum allowable hole size.
- c. Show size of breech and muzzle Foundry discards. If Foundry macro discs are taken, they will be obtained from within the discard material. Foundry discs will not be shown on the drawing.
- d. Show length of casting as released from the Foundry to the Heat Treat Section.
- e. Show:

"Estimated Average Weight at Full Length", and

"Estimated Average Weight After Discard"

The Gun Division will advise the average hole size to be used in calculating weights.

Title:

Process Drawing Type II

"ROUGH CASTING AT HEAT TREAT SIZE AND DETAILS OF TESTING"

Description:

- a. Show dimensions of the rough casting as released from the Foundry to the Heat Treat Section. These will be obtained from the "Rough Casting" drawing. Tolerances will not be shown for either diameters or lengths. All dimensions will be approximate, i.e. shown to the nearest 1/4" on length and 0.1" on diameter.
- b. State maximum allowable hole size.
- c. Make reference to drawing number of suspension loop near muzzle of tube.
- d. Show first set of discards and discs.
- e. Show cross section of both breech and muzzle discs with details of test bar location.
- f. Show note "For Additional Details of Testing see Drawing J-52-30471."
- g. Show the physical property specifications and cite authority for their use.
- h. Show as an "arrowed" dimension:

"Desired Length After Heat Treatment and Test"

This is the length required for the Lo-Swing lathe and will be $3\frac{1}{2}$ " over Before Cold Work length.

- i. Show the following lengths in the notes:

1.) "Minimum Length After Heat Treatment and Test"

This is Before Cold Work length plus 1/2" facing allowance. (CW guns can be salvaged at lengths below this by means of collars. Such practice is not recognized on drawings).

2.) "Desired Length Before Cold Work"

- j. Show:

"Estimated Average Weight for Heat Treatment"

This will coincide generally with the "Estimated Average Weight After Discard" shown on the Rough Casting drawing.

k. No comment will be made as to straightness of the casting.

Title:

Process Drawing Type III

"MACHINED PREPARATORY TO COLD WORKING 6% \pm 2%"

Description:

a. Show dimensions of the casting at the Before Cold Work size. Generally, the cold work design and both Before and After Cold Work dimensions will be prepared from the Finished Tube drawing (ballistic size) by personnel of the Cold Work Section with consideration for the following accepted practices:

- 1.) A minimum of 0.3" on both outside and inside diameters is allowed for finish machining to ballistic size. The machining tolerance for outside diameters is $\pm .015$ " and for the bore and packing chamber diameters $\pm .008$ ".
- 2.) A 1/4" fillet is shown at the ends of all bore surfaces.
- 3.) The tube is designed with a minimum number of tapers.
- 4.) Tapers are kept between .005 and .020 inches per inch on the diameter.
- 5.) Shoulders are eliminated if possible.
- 6.) Generally, 1" is allowed on each end (2" total) for facing the cold worked casting to Finished Tube length. Approximately 5" additional length is allowed on each end (10" total) for seal support. The machining tolerance for length dimensions is as follows:

Overall length = $\pm .03$ "

Outside lengths to shoulders and breaks
on taper = $\pm .02$ "

Inside lengths of packing chamber = $\pm .10$ "

b. Dimensions for machining to Before Cold Work size are shown above the tube with all length dimensions referred to the extreme breach of the casting.

c. State:

"Pressure to Cold Work 6% = (P.F.) x Yield Stress"

substituting for the term (P.F.) the maximum Pressure Factor of the tube.

d. Show weight of the tube.

e. State:

Maximum Bore Runout = .030".

Maximum O.D. Runout = .030".

Title:

Process Drawing Type IV

"COLD WORKED 6% \pm 2% PREPARATORY TO FINISH MACHINING"

Description:

- a. Show dimensions of the casting at the After Cold Work size. The After Cold Work dimensions will be calculated from the cold work design by personnel of the Cold Work Section, with maximum and minimum values determined from the following general equation, where:

BCW = Before Cold Working

ACW = After Cold Working

$$\text{Diameter}_{ACW} = \text{Diameter}_{BCW} \pm \text{Machining Tolerance}_{BCW} \pm \text{Expansion during Cold Working (Nominal 5\% at Bore)} \pm \text{Expansion for Cold Working Tolerance (2\% at Bore)}$$

Solving the equation with plus values for both Machining and Cold Working tolerances will yield maximum diameters after cold working; solving with minus values will yield minimum diameters. Both values are shown to the nearest .01" for all shipping dimensions.

- b. Length of After Cold Work breech and muzzle discards (seal supports) are shown above the tube as an absolute figure without tolerance. Show:

"Shipping Length"

as an "arrowed" dimension below the tube with length dimensions referred to the new breech (established by removing the breech discard). The length tolerance for shipping dimensions is plus .25".

- c. State:

"Minimum Acceptable Cold Working Pressure =

(P.F. x Y.S.) P.S.I."

substituting for the term (P.F. x Y.S.) the product of the maximum Pressure Factor of the tube and the minimum allowed Yield Strength of the specifications.

d. Show:

"Maximum Weight For Shipment"

e. State:

Maximum Bore Runout = .060"
Maximum O.D. Runout = .060"

Title:

Process Drawing Type V

"ROUGH MACHINED TO HEAT TREAT SIZE AND DETAILS OF TESTING"

Description:

- a. Show dimensions of the rough machined casting at Heat Treat size with facing, chucking and test metal allowances. The Before Cold Work size will be used as the basis for layout.
- 1.) The basic outside diameters will be $5/8$ " larger than the Before Cold Work size diameters with a machining tolerance of minus $1/8$ ". Decimal values will be increased arbitrarily to the next sixteenth inch.
 - 2.) The basic bore diameter will be essentially $1/2$ " smaller than the Before Cold Work bore size, but should be modified to fit standard boring tools. Machining tolerance for the bore diameter will be plus $1/16$ ".
 - 3.) Allow $1/4$ " on each end ($1/2$ " total) for facing the heat-treated casting to Before Cold Work length.
 - 4.) Allow 3" on the muzzle end for Lo-Swing lathe chuck-hold.
 - 5.) Allow 7" on each end (14" total) for test metal.
 - 6.) The machining tolerance for length dimensions will be plus $1/4$ ".

- b. Show dimensions for machining to Heat Treat size above the tube with all length dimensions (except muzzle test metal) referred to the extreme breech of the casting. Show:

"Desired Length After Heat Treatment and Test"

as an "arrowed" dimension below the tube with length dimensions referred to the new breech (established by removing all breech and test metal). This is the length required for the Lo-Swing lathe and will be $3\frac{1}{2}$ " over Before Cold Work length.

- c. Show the following lengths in the notes:

- 1.) "Minimum Length After Heat Treatment and Test"

This is Before Cold Work length plus 1/2" facing allowance. (SW tubes can be salvaged at lengths below this by means of collars. Such practice is not recognized on drawings).

2.) "Desired Length Before Cold Work".

- d. Make reference to drawing number of suspension loop near muzzle of tube.
- e. Show location of first set of discards and discs.
- f. Show cross section of both breech and muzzle discs with details of test bars.
- g. Show note "For Additional Details of Testing see Dwg. J-52-30471".
- h. Show the physical property specifications and cite authority for their use.
- i. Show:

"Maximum Weight For Heat Treatment"

- j. No comment will be made regarding bore and O.D. runouts.

Title:

Process Drawing Type VI

"ROUGH MACHINED TO HEAT TREAT SIZE, DETAILS OF TESTING AND SHIPPING SIZE"

Description:

- a. Show dimensions of the rough machined casting at Heat Treat size with facing and test metal allowances. The Finished Tube (ballistic size) will be used as the basis for layout.
- 1.) The basic outside diameters will be $9/16$ " larger than the Finished Tube diameters with a machining tolerance of minus $1/16$ ". Decimal values will be increased arbitrarily to the next sixteenth inch.
 - 2.) The basic bore diameter will be essentially $1/2$ " smaller than the finished caliber bore, but should be modified to fit standard boring tools. Machining tolerance for the bore diameter will be plus $1/16$ ".
 - 3.) Allow 1" on each end (2" total) for facing the heat-treated casting to Finished Tube length.
 - 4.) Allow 7" on each end (14" total) for test metal.
 - 5.) The machining tolerance for length dimensions will be plus $1/4$ ".

If the rough casting to be used is longer than required by Items 3 and 4, the Gun Division will be consulted as to the proper distribution of the excess metal. This will apply particularly when tubes are to be machined from castings designed for a larger caliber gun.

- b. Show dimensions for machining to Heat Treat size above the tube with all length dimensions (except muzzle test metal) referred to the extreme breech of the casting.
Show:

"Shipping Length"

as an "arrowed" dimension below the tube with length dimensions referred to the new breech (established by removing all breech end test metal). This is .2" over Finished Tube length.

- c. Make reference to drawing number of suspension loop near muzzle of tube.

- d. Show location of first set of discards and discs.
- e. Show cross section of both breech and muzzle discs with details of test bars.
- f. Show note "For Additional Details of Testing see Dwg. J-52-32471".
- g. Show the physical property specifications and cite authority for their use.
- h. Show:
- "Maximum Weight For Heat Treatment", and
- "Maximum Weight For Shipment"
- i. State:
- Maximum Bore Runout = .075"
- Maximum O.D. Runout = .075"

Title:

Shipping Drawing Type VII

"COLD WORKED CASTING PREPARATORY TO FINISH MACHINING"

Description:

a. Show dimensions of the cold-worked casting at Shipping size. This drawing will be essentially the same as the No. IV drawing "Cold Worked 6% \pm 2% Preparatory to Finish Machining", with the title modified to include the word "Casting" and with the omission of all process details as After Cold Work discards and local processing notes.

- 1.) Show all length dimensions above the tube with a tolerance of plus .25". These will be identical with the shipping dimensions shown below the tube in the Type IV drawing.
- 2.) Outside and bore diameters will be based on maximum and minimum values shown on the Type IV drawing, but will be revised to include an additional process tolerance equal to the last term of the general equation, viz:

$$\begin{aligned} \text{Shipping Diameter} = & \text{Diameter}_{\text{BCW}} \pm \text{Machining} \\ & \text{Tolerance}_{\text{BCW}} \pm \text{Expansion} \\ & \text{during Cold Working (Nominal 6\% at Bore)} \pm \text{Twice the} \\ & \text{Expansion for Cold Working} \\ & \text{Tolerance (2\% at Bore)}. \end{aligned}$$

bore diameters will be shown as the minimum value to the nearest .01" with a plus tolerance. Outside diameters will be shown as the maximum value to the nearest .01" with a minus tolerance. The tolerance in all cases will be the difference between maximum and minimum diameters at any point.

b. Show physical property specifications with the note:

"Before Cold Working"

and cite authority for their use.

c. As the third line of the title, state:

"As Produced at Watertown Arsenal"

d. Show:

"Maximum Weight For Shipment"

e. State:

Maximum Bore Runout = .060"

Maximum O.D. Runout = .060"

f. State:

Inspection Note

Tubes designated "Irregular" may be shipped with underturned areas, but in no case smaller than the Finished (Ballistic) Tube diameter plus .150".

The value .150" is an arbitrary minimum and may be increased as required for particular circumstances.

Title:

Shipping Drawing Type VIII

"ROUGH MACHINED CASTING PREPARATORY TO FINISH MACHINING"

Description:

- a. Show dimensions of the rough-machined heat-treated casting at Shipping size. This drawing will be essentially the same as the Type VI drawing, "Rough Machined to Heat Treat Size, Details of Testing and Shipping Size", with the title modified to include the word "Casting" and with the omission of all process detail as suspension loop reference, test metal, test layout, etc.
- 1.) Show all length dimensions above the tube with a tolerance of plus 1/4". These will be identical with the shipping dimensions shown below the tube in the Type VI drawing.
 - 2.) Basic outside and bore diameters and tolerances will be identical with the dimensions shown in the Type VI drawing.
- b. Show the physical property specifications and cite authority for their use. Do not include local process restrictions or locally imposed impact or hardness specifications.
- c. As the third line of the title, state:
- "As Produced At Watertown Arsenal"
- and assign an Ordnance Office drawing number.
- d. Show:
- "Maximum Weight For Shipment"
- e. State:
- Maximum Bore Runout = .075"
- Maximum O.D. Runout = .075"
- f. This drawing will compare with the "Rough Machined Forging" and "Upset Seamless Tubing" drawings issued by Watervliet Arsenal for manufacture of a particular Finished Tube, except to show Watertown Arsenal's practice as to tolerances and straightness.

