**MIL-STD-10A**
**Notice 2**
**25 October 1963**

**MILITARY STANDARD**

# SURFACE ROUGHNESS, WAVINESS AND LAY

Notice 1, dated 21 June 1963 which cancelled MIL-STD-10A and approved American Standards Association (ASA) B46.1—1962 Surface Texture (Surface Roughness, Waviness and Lay) for Department of Defense use, applies only to the Air Force. The Army and Navy continue to have requirements for and to use MIL-STD-10A, pending the completion of the project for coordination of the ASA standard.

**Custodians:**

Navy—Wep
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**Preparing activity:**

Navy—Wep

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MIL–STD–10A
13 October 1955

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2 August 1949



# MILITARY STANDARD

# SURFACE ROUGHNESS WAVINESS AND LAY

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# MILITARY STANDARD

# SURFACE ROUGHNESS WAVINESS AND LAY

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# OFFICE OF THE ASSISTANT SECRETARY OF DEFENSE

## WASHINGTON 25, D. C.

13 October 1955

Supply and Logistics
SURFACE ROUGHNESS, WAVINESS AND LAY
MIL-STD-10A

1. This standard has been approved by the Department of Defense for use by the Departments of the Army, the Navy, and the Air Force.

2. In accordance with established procedure, the Standardization Division has designated the Ordnance Corps, Bureau of Ordnance and the Air Force, respectively, as Army-Navy-Air Force custodians of this standard.

3. This standard is mandatory for use effective 15 April 1956 by the Departments of the Army, the Navy, and the Air Force.

4. Recommended corrections, additions, or deletions should be addressed to the Standardization Division, Office of the Assistant Secretary of Defense (Supply and Logistic), Washington 25, D. C.

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# MILITARY STANDARD

# SURFACE ROUGHNESS, WAVINESS AND LAY

## 1. GENERAL

**1.1 Purpose.** This standard establishes a uniform system for the identification and specification of the geometric irregularities of the surfaces of solid materials. It provides, through the use of symbols and numerical classifications, a means for accurately expressing surface roughness, waviness and lay requirements on drawings, in specifications, or verbally.

**1.2 Scope.** This standard covers surface irregularities with respect to their height, width, and direction. It shall replace all former practices for specifying finishes or surface conditions and shall apply to any surface of sufficient hardness to be evaluated in terms of microinches (millionths of an inch) under the provisions herein specified.

**1.3 Materials and processes.** This standard is not concerned with materials analysis, microstructure, corrosion resistance, appearance, lustre, color or like characteristics except when specified for a particular application.

**1.4 Manufacturing methods.** Surface roughness designation is not intended to be directly associated with any method of producing a surface; therefore, unless otherwise specified, the manufacturing activity may use any available manufacturing method which will produce the results desired.

**2. DEFINITIONS OF TERMS.** The terms used in this standard shall have the following meanings.

**2.1 Surface.** The surface of an object is the boundary which separates that object from another object or substance.

**2.2 Profile.** The profile is the contour of a surface in a plane perpendicular to a surface, unless some other angle is specified.

**2.3 Mean line.** A mean line is an imaginary line about which roughness height is measured, parallel to the general direction of the profile, so positioned that the sums of the areas contained between it and those parts of the profile which lie on either side of it are equal.

**2.4 Surface irregularities.** Surface irregularities are deviations from the mean line, including roughnes and waviness.

**2.5 Microinch.** A microinch is one millionth of an inch. (0.000001 inch).

**2.6 Surface roughness.** Surface roughness is relatively finely-spaced surface irregularities, the height, width, direction, and shape of which establish the predominate surface pattern. Irregularities produced by the cutting or abrading action of machine tools may be considered roughness.

**2.7 Roughness height rating.** Roughness height rating is a height rating of surface roughness over a length equal to the roughness-width cutoff obtained by averaging the microinch deviations from a mean line. This method is fully described in 5.2.2.

**2.8 Roughness-width cutoff.** Roughness-width cutoff is a unit length of the profile over which the irregularities of the surface profile are averaged to obtain the roughness height rating. (Electrical integrating instruments indicate automatically, as roughness height ratings, the mean result from several such consecutive unit lengths.) Cutoff values, in inches, are shown in table III.

**2.9 Surface roughness width.** Surface roughness width is the distance, in inches, between the successive peaks or ridges which constitute the predominate pattern of the surface roughness. Roughness-width cutoff must always be greater than the roughness width in order to obtain a true roughness height rating.

**2.10 Waviness.** Waviness is irregularities from a mean line which are of greater spacing than the roughness, as illustrated in figure 12. Waviness may result from imperfections or vibrations of machine tools, deflections, warping, etc. Surface roughness may be considered as superimposed upon a wavy surface.

**2.11 Waviness height.** The waviness height is the peak to valley height in inches, total indicator reading. See table II for recommended values.

**2.12 Lay.** Lay is the direction of the predominate surface pattern produced by tool marks or grain of the surface, ordinarily dependent upon the production method used. Lay symbols shall be as specified in table IV.

**2.13 Flaws.** Flaw are irregularities which occur at one place, or at relatively infrequent or widely varying intervals in a surface. Flaws include such defects as cracks, blowholes, checks, ridges, scratches, etc. Unless otherwise specified the effect of flaws shall not be included in the roughness height measurements.

**2.14 Contact area.** Contact area is the area of the surface required to affect contact with its component surface. Unless otherwise specified, contact area shall be equally distributed over the surface with approximate uniformity. Contact area shall be specified in the manner indicated in figure 7.

**3. SURFACE CONTROL APPLIED TO DRAWINGS.** To ensure uniform and efficient drafting practices, the application of surface roughness requirements shall be made in the manner hereinafter specified.

**3.1 Basic surface roughness symbol.** The basic symbol √ shall be used to designate surfaced roughness. Convenient proportions for the basic symbol are shown in figure 1.

3.1.1 *Extension line.* The surface roughness symbol shall be supplemented with a horizontal extension line of suitable length, as illustrated in figure 6 through 8, when requirements such as waviness height, waviness width, etc. are specified in the symbol.

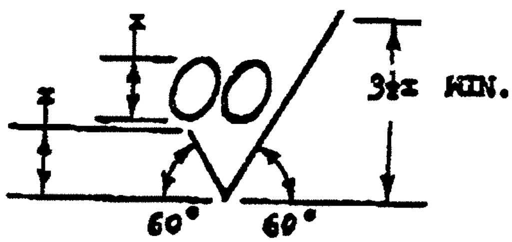



FIGURE 1. *Proportions for Basic Symbol.*

TABLE I

| Preferred Roughness Height Ratings* | | | | |
|---|---|---|---|---|
| ¼ | 2 | 16 | 125 | 1000 |
| ½ | 4 | 32 | 250 | ....... |
| 1 | 8 | 63 | 500 | ....... |

* Known also as Arithmetical Average (AA) ratings and Centre Line Average (CLA) index numbers.

TABLE II

| Waviness Height Values (Inches) | | | | | |
|---|---|---|---|---|---|
| 0.00002 | 0.00008 | 0.0003 | 0.001 | 0.005 | 0.015 |
| 0.00003 | 0.0001 | 0.0005 | 0.002 | 0.008 | 0.020 |
| 0.00005 | 0.0002 | 0.0008 | 0.003 | 0.010 | ....... |

TABLE III

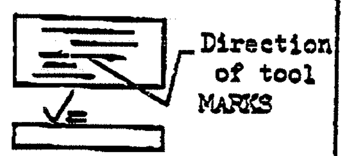
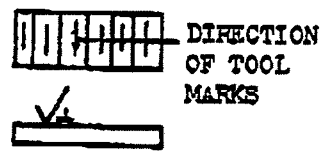
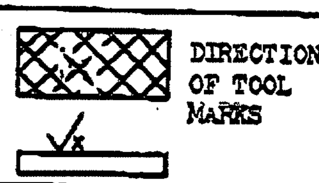
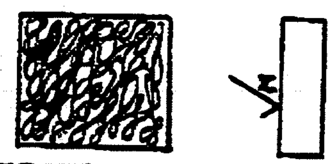
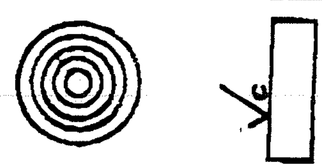
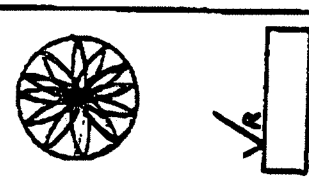
| Roughness-Width Cutoff Values (Inches) | | | | | |
|---|---|---|---|---|---|
| .003 | .010 | .030[1] | .100 | .300 | 1.000 |

[1] The .030 cutoff value shall be standard unless otherwise specified. When the .030 cutoff value applies, it need not be shown in the symbol, or specified in specifications, etc.

**3.2 Symbols indicating direction of lay.** The symbols in table IV shall be used when lay is to be specified with the symbol.

**3.3 Application of symbols and ratings.** Surface roughness, waviness and lay requirements shall be represented on drawings in the manner illustrated in figures 2 through 10. Care should be exercised to insert numerical

TABLE IV

| LAY SYMBOLS | | |
|---|---|---|
| LAY SYMBOL | DESIGNATION | EXAMPLE |
| = | Lay parallel to the boundary line representing the surface to which the symbol applies. |  |
| ⊥ | Lay perpendicular to the boundary line representing the surface to which the symbol applies. |  |
| X | Lay angular in both directions to boundary line representing the surface to which symbol applies. |  |
| M | Lay multidirectional |  |
| C | Lay approximately circular relative to the center of the surface to which the symbol applies. |  |
| R | Lay approximately radial relative to the center of the surface to which the symbol applies. |  |

values in the precise positions shown. Waviness, lay, and roughness-width cutoff, designations may, when warranted by special requirements, be specified in NOTES.

Figure 2

**Surface Roughness Symbol (Basic).**—Designation of symbol only indicates requirements governing surface irregularities detailed in NOTES.


Figure 3

**Roughness Height Rating.**—The surface roughness height, expressed by a numerical rating, placed adjacent to and at the left of long leg as shown. The specification of one number indicates the maximum permissible sustained roughness height rating. Any lesser rating shall be acceptable.


Figure 4

**Maximum and Minimum Ratings.**—Maximum and minimum roughness height ratings shall indicate permissible range. The maximum rating shall be placed above the minimum as shown.


Figure 5

**Waviness Height.**—Waviness height value, in inches, shall be placed above extension line as shown. The value shown shall indicate maximum allowable waviness height.


Figure 6

**Waviness Width.** — Waviness width value, in inches, shall be placed above the extension line at the right of the waviness height value as shown. The value shown shall indicate the maximum allowable waviness width. NOTE —This designation will not be used when percentage of contact area is specified.


Figure 7

**Contact Area.** — Minimum requirements for contact or bearing area shall be indicated by a percentage value placed above the extension line as shown. Further requirements may be controlled by NOTES.


Figure 8

**Lay.**—The lay designation is indicated by the symbol placed to the right and slightly above the point of the surface roughness symbol as shown.

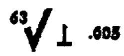



Figure 9

**Surface Roughness Width.**—The surface roughness width value, in inches, shall be placed at the right and parallel to the lay symbol as shown. The value shown shall indicate maximum allowable roughness width.


Figure 10

**Roughness-Width Cutoff.**—The roughness-width cutoff value, other than the preferred .030 cutoff value, shall be placed immediately below the extension and to the right of the long leg as shown.

**3.4 Roughness-width cutoff selection.** Tracer type instruments commonly employed for measuring surface roughness height are designed to assess only those surfaces with roughness widths less than the preselected or standard cutoff value which is established by the instrument characteristics and the speed of trace. The roughness-width cutoff of surface roughness measuring instruments is determined by the frequency response characteristics of the instruments and the speed of trace. The roughness-width cutoff of some instruments is varied by changing the frequency response by means of a switch on the instrument and on other instruments by changing the speed of trace. Instrument operating instructions should be consulted as to the proper method of securing the required roughness width-cutoff. Only approximate control of roughness-width cutoff can be obtained with hand tracing. Surface requirements for normal design applications are suitably served with the preferred .030 cutoff value, as listed in table III. In some cases, either for conversion or through necessity, it may prove beneficial to specify a different roughness-width cutoff value. For example, when controlling mating surfaces where contact is important, a greater cutoff value may prove beneficial, or, on surfaces subject to fatigue failure where irregularities of lesser width are important, a smaller cutoff value may be specified.

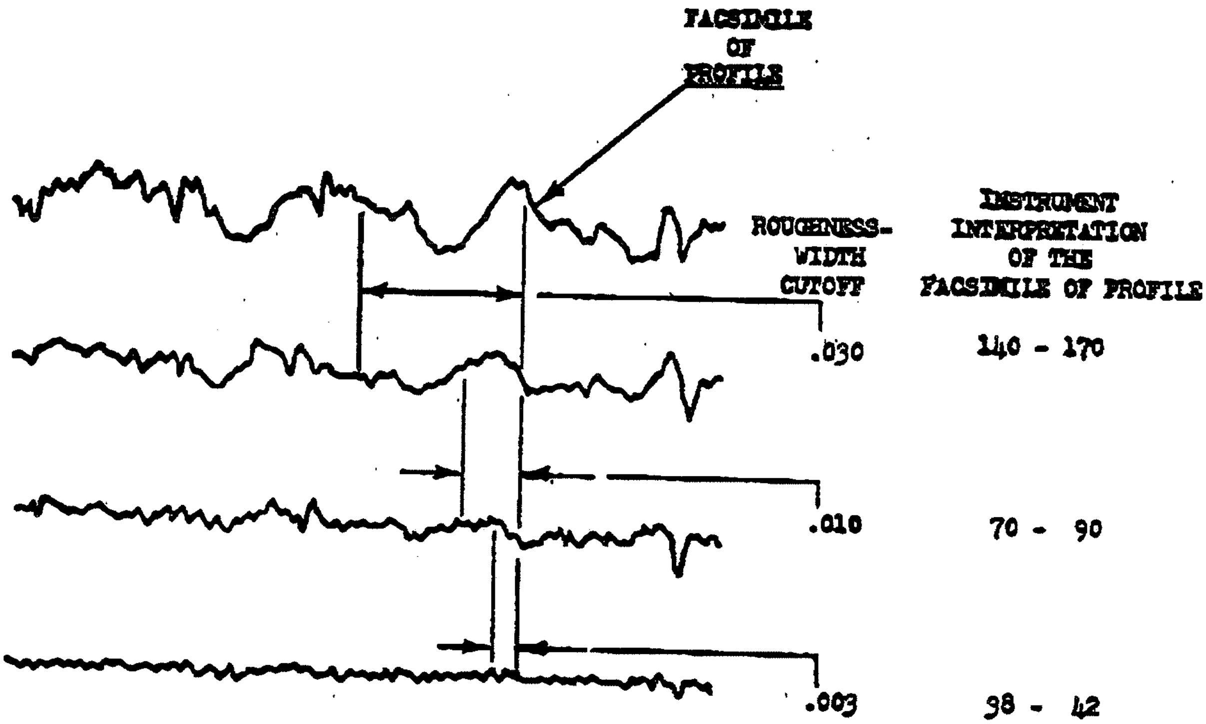


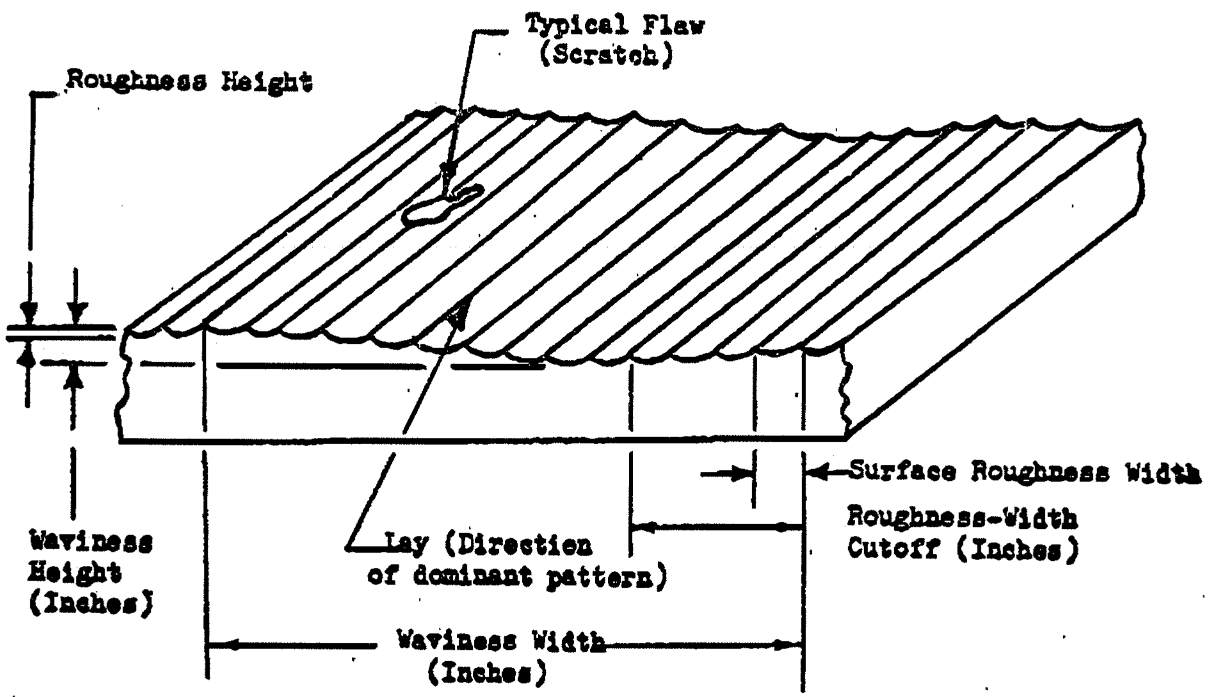

FIGURE 11. *Profile Interpretation of Roughness-Width Cutoff.*

3.4.1 *Effect of variation.* The effect of variation in roughness-width cutoff can be understood better by reference to figure 11.

The profile at the top of figure 11 is the facsimile of a surface profile having a roughness spacing of about .040 and the profiles below are the instrument interpretations of the facsimile profile with roughness-width cutoff value settings of .030, .010, and .008, respectively. It can be seen that the profile based on the .030 roughness-width cutoff includes most of the coarse irregularities and all the fine irregularities of the facsimile profile, that the profile based on the .010 roughness-width cutoff excludes the coarser irregularities but includes the fine and medium fine, and that the profile based on the .008 roughness-width cutoff includes only the very fine irregularities. In this example, the effect of reducing the roughness-width cutoff includes only the very fine irregularities. In this example, the effect of reducing the roughness-width cutoff has been to reduce the roughness height indication. However, had the facsimile profile been made up of irregularities as fine as those of the bottom profile, the roughness height indications could have been the same for all three roughness-width cutoff settings. Thus, if the roughness-width cutoff value is too small to include coarser irregularities of a surface, the measurements will not agree with those taken with a wider roughness-width cutoff. For this reason, the design engineer is cautioned to choose that roughness-width cutoff which will include all the surface irregularities which it is desired to assess.

3.5 **Symbol placement.** Symbols, basic or combined, as illustrated in figure 12, shall be applied to drawings in the manner noted in figure 13. Whenever practicable, the apex of the symbol shall be drawn touching the surface to be controlled. When this is not practical the symbol may be placed with the apex touching an extension line from the surface to which it applies. Preferably, surface control symbols should be oriented in such a manner that all symbols on horizontal lines or surfaces may be read from the bottom of the drawing and all symbols on vertical or angular lines or surfaces may be read from either the bottom or the right side of the drawing. Surface control indications for any individual surface should be in one place only and not repeated in another view or section.

3.6 **Parts finished all over, uniform roughness.** When it is required that a part is to be finished all over with a uniform degree of roughness, a NOTE on the drawing should include specification, for example, "Finish



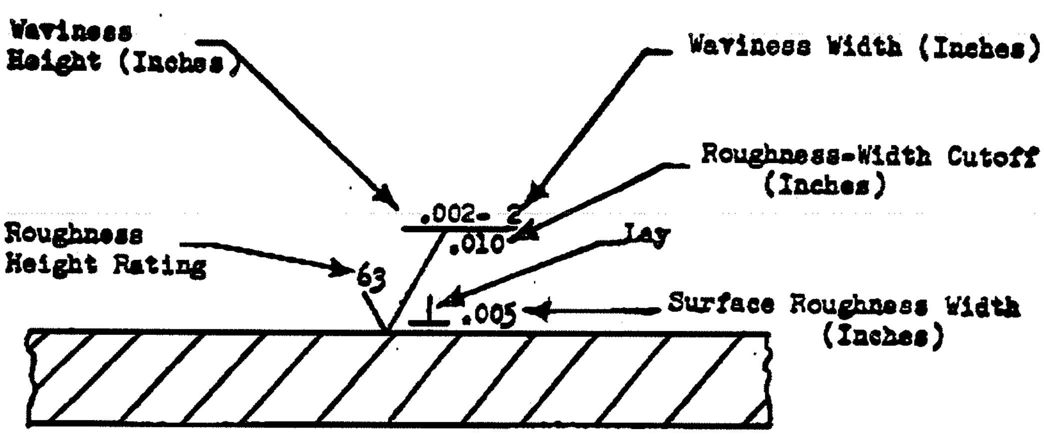




FIGURE 12. *Relation of Symbols to Surface Characteristics.*

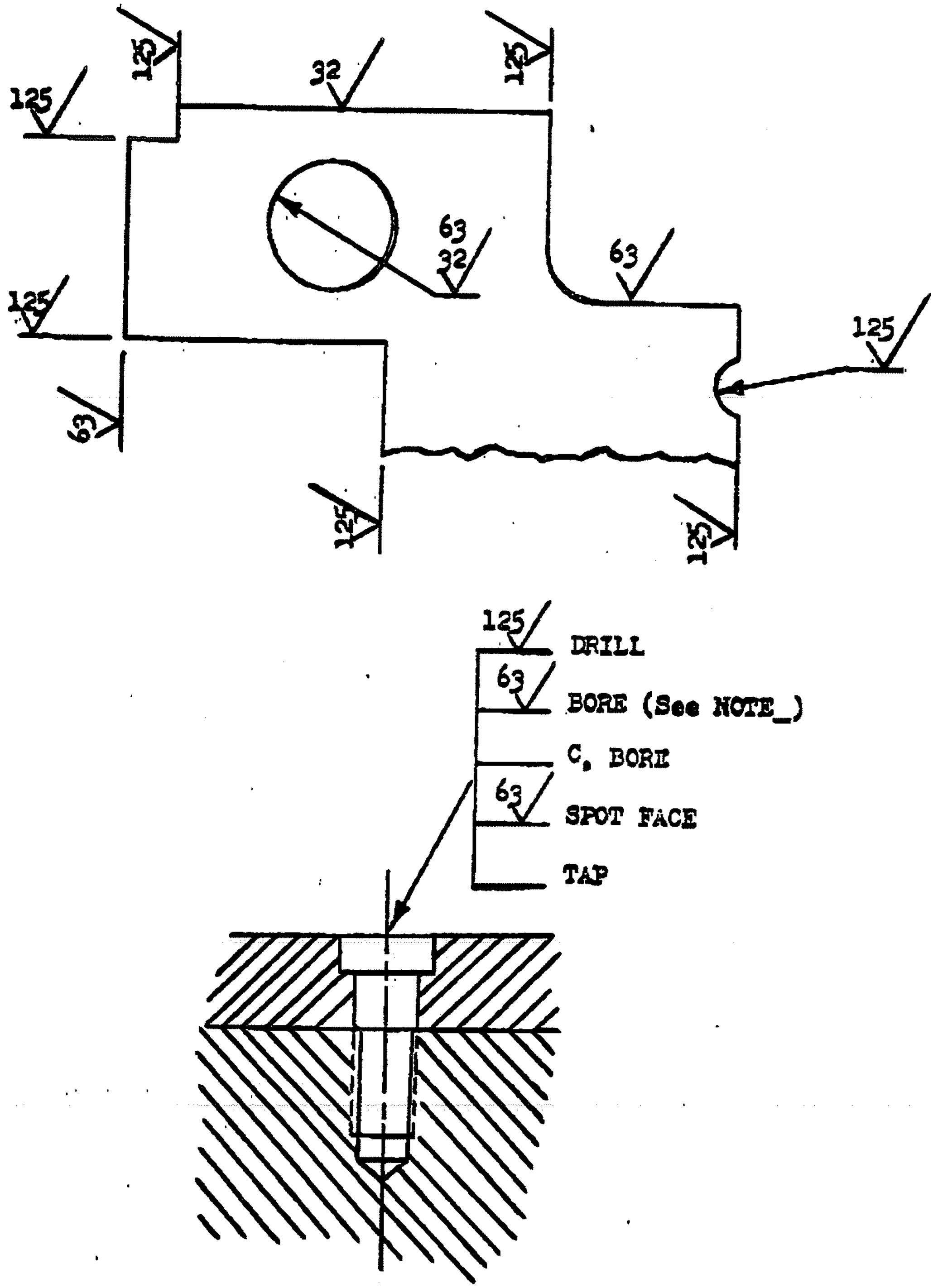



FIGURE 13. *Symbol Placement.*

all over $^{xx}\surd$"; the symbol, basic or combined, should embrace the roughness height rating. No other finish marks or symbols indicating surface control should appear on the drawing.

**3.7 Parts finished all over, varying roughness.** When it is required that a part be finished all over, but to different degrees of roughness, a NOTE on the drawing should include the specification, for example: "$^{xx}\surd$ all over except as noted", with the symbol, basic or combined, specifying the rating applicable to the greater number of surfaces of the part. Surfaces to which the predominant requirements do not apply should bear individual symbols, with their applicable ratings.

**3.8 Castings, forgings, etc., uniform roughness.** In the case of a casting, forging, piece made from bar stock, etc., in which all finished surfaces require the same degree of surface roughness, a NOTE on the drawing should include the specification, for example, "surfaces marked $\surd$ to have $^{xx}\surd$", the latter symbol, basic or combined, specifying the required rating. In such cases the symbol appearing on the various surfaces will be the basic symbol only, with the required surface specifications appearing in the NOTE.

**3.9 Castings, forgings, bar stock, etc., varying roughness.** In the case of castings, forgings, bar stock, etc., where the finished surfaces require different degrees of surface roughness, each finished surface shall bear the surface roughness symbol enclosing the roughness height rating corresponding to the allowed roughness, except that when the same roughness rating applies to a predominate number of finished surfaces a $\surd$ may be placed on each surface having the same allowed roughness and this note placed on the drawing: "Surfaces marked $\surd$ to have $^{xx}\surd$, except as noted. Cast Finish # (or rolled, drawn, etc.)." Each remaining finished surface shall be marked with the prescribed roughness symbol enclosing the allowed roughness rating, and other data as required.

**3.10 Plated or coated surfaces.** Surface roughness designations, unless otherwise specified, shall apply to the completed surface. Drawings or specifications for plated or coated parts shall definitely indicate whether the surface roughness designations apply before plating (coating), apply after plating (coating), or apply before and after plating or coating.

**3.11 Special surfaces.** Surfaces of which the required characteristics can only be obtained by operations such as lapping, scraping, honing, buffing, etc. shall have the surface roughness specified by the surface roughness symbol and the roughness height rating, followed or preceded by notation of the required operation e.g., $^{4}\surd$ Lap.

**3.12 Areas of transition.** Where the surface roughness symbol is used with a dimension it affects all surfaces defined by the dimension. Areas of transition, such as chamfers and fillets, shall conform with the roughest adjacent finished area unless otherwise indicated.

## 4. SURFACE CONTROL IN PRODUCT DESIGN

**4.1 Basis of selection.** The specification of surface roughness requirements is the responsibility of the design engineer. Selection of the proper degree of roughness, amount of waviness, and direction of lay must be derived from an analysis of the surface function. Functional aspects involved in this consideration are size and type of loading, direction and speed of movement, temperature range, lubrication, physical characteristics of materials in contact, etc. When surfaces have only minor functional duties, or when they are economically dimensioned for purposes of clearance, etc. surface roughness specifications are not necessary.

**4.2 Effect of cost.** Manufacturing costs usually increase rapidly when surfaces are required to be refined to successively greater degrees than those produced by basic machining operations normally associated with quantity production.

**4.3 Recommended ratings for standard processes.** The roughness height ratings listed in table V represent the acceptable surface qualities resulting from standard commercial manufacturing processes. These ratings are in accordance with the preferred series tabulated in table I. It should be understood, however, that the selection of roughness height ratings is based upon the requirements of the design and, when such factors as fatigue, strength, and motion are involved, the surface roughness requirements will vary for each particular application.

## 5. SURFACE MEASUREMENT

### 5.1 Traversing length.

5.1.1 *Representative sample.* To provide full readings for continuously-averaging type instruments, the traversing length used for any given measurement shall not be less than 20 times the roughness-width cutoff value. For instruments having meters which indicate integrated roughness over a fixed length of trace, the traversing length shall be at least five times the roughness-width cutoff value.

5.1.2 *Exceptions.* Where the continuously-averaging type instrument is used, it is not necessary for the traversing length to be traced continuously in one direction provided that the time required to reverse the direction of trace is short compared to the time the tracer is in motion. Where surfaces are not large enough to permit the recommended minimum traversing length, the readings shall not be assumed to be the actual roughness. Such readings may, however, be used for comparative purposes.

**5.2 Correlation of methods for determining roughness height.** The definitions and formulae herein are provided to insure an efficient change over from the RMS method formerly referenced in this standard, to the roughness height averaging method now specified. Figure 14 is used in describing each method: Y = average deviation from the mean line, y = ordinate of the curve of the profile, and l = the length over which the average is taken. A, B, C, D, etc. represent in microinches the deviations of the true surface from the mean surface at uniform intervals along the profile normal to the lay, or in the direction which gives the maximum value.

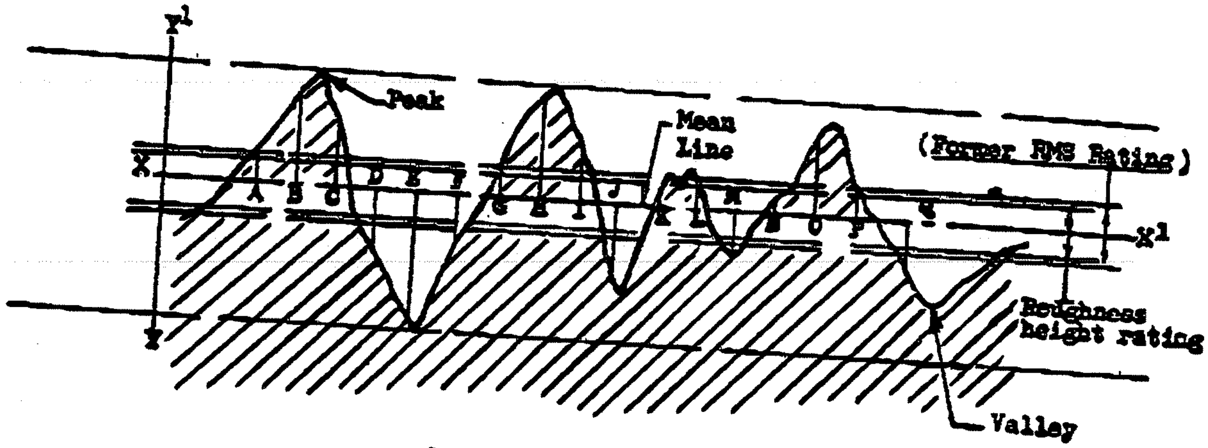



FIGURE 14. *True Surface Profile.*

5.2.1 *RMS (Root-Mean-Square) averaging method.* The former method for determining a roughness height average in RMS microinches is:

$$Y = \left[\frac{1}{l}\int_{x=0}^{x=l} Y^2\,dx\right]^{1/2}$$

An approximation of the foregoing may be obtained by extracting the square root of the sum of the squares of the "y" incruments without regard to sign divided by the number "n" of the incruments taken:

$$Y = \sqrt{\frac{A^2 + B^2 + C^2 + D^2 + \ldots}{n}}$$

5.2.2 *Roughness height averaging method.* The method required by this standard (2.7) for determining roughness height is:

Ra

$$Y = \frac{1}{l}\int_{x=0}^{x=l} |Y|\,dx$$

An approximation of the above may be obtained by adding the "y" incruments without regard to sign and dividing the sum by the number "n" of the increments taken:

$$Y = \frac{A + B + C + D + \ldots}{n}$$

5.2.3 *Conversion ratio.* Numerically, the RMS value of a profile is always greater than that obtained by the roughness height averaging method. For profiles of commonly found shapes, the ratio varies from about 1.1 to 1.3. Using a portion of the ordinates shown in figure 14, a mathematical illustration of this ratio would be:

| | |
|---|---|
| A — 16 | $A^2$ — 256 |
| B — 50 | $B^2$ — 2500 |
| C — 20 | $C^2$ — 400 |
| D — 35 | $D^2$ — 1225 |
| E — 60 | $E^2$ — 3600 |
| F — 30 | $F^2$ — 900 |
| G — 15 | $G^2$ — 225 |
| H — 50 | $H^2$ — 2500 |
| I — 25 | $I^2$ — 625 |
| J — 50 | $J^2$ — 2500 |
| K — 16 | $K^2$ — 256 |
| L — 16 | $L^2$ — 256 |
| M — 25 | $M^2$ — 625 |
| 408 | 15868 |

$$\text{Roughness Height rating} = \frac{408}{13} = 31.38$$

$$\text{RMS Average} = \sqrt{\frac{15868}{13}} = 34.94$$

5.2.4 *Effect on drawings, specifications, etc.* In normal design applications the numerical difference between the values obtained from the roughness height averaging method and the RMS method is not large enough to warrant the conversion of drawings, specifications, etc. However, on critical surfaces where slight differences in surface roughness is significant, the 11 percent conversion factor may be used.

TABLE V

| Roughness Height Rating | General Application of Roughness Height Ratings |
|---|---|
| 1000√ | Very rough, low grade surface resulting from sand casting, torch or saw cutting, chipping or rough forgings. Machine operations are not required as appearance is not objectionable. This finish, rarely specified, is suitable for unmachined clearance areas on machinery, jigs, and other rough construction items. |
| 500√ | Very rough, low grade surfaces, where smoothness is of no object, resulting from heavy cuts and coarse feeds in milling, turning, shaping, boring, and from very rough filing, rough disc grinding and snagging. This surface is suitable for clearance areas on machinery, jigs, and fixtures. This surface roughness may be obtained by natural processes of sand casting or rough forging. |
| 250√ | Coarse production surfaces, for unimportant clearance and cleanup operations, resulting from very coarse surface grind, rough file, disc grind, and from rapid feeds in turning, milling, shaping, drilling, boring, grinding, etc., where definite tool marks are not objectionable. This roughness may also be produced on the natural surfaces of forgings, permanent mold castings, extrusions and rolled surfaces. Surfaces with this roughness value can be produced very economically and is used to a great extent on parts where stress requirements, appearance, and conditions of operations and design permit. |
| 125√ | This is the roughest surface recommended for parts subject to loads, vibration, and high stress. This surface roughness is also permitted for bearing surfaces when the motion is slow and the loads are light or infrequent, but not to be specified for fast rotating shafts, axles, and parts subject to severe vibration or extreme tension. This surface is a medium, commercial machine finish in which relatively high speeds and fine feeds are used in taking light cuts with well-sharpened tools, and may be economically produced on lathes, milling machines, shapers, grinders, etc. The surface finish may also be obtained on permanent mold castings, die castings, extrusions, and rolled surfaces. |
| 63√ | A good machine finish produced under controlled production procedures using relatively high speeds and fine feeds in taking light cuts with well-sharpened cutters. This surface value may be specified where close fits are required and may be used for all stressed parts, except for fast rotating shafts, axles, and parts subject to severe vibration or extreme tension. This surface roughness is satisfactory for bearing surfaces when the motion is slow and the loads are light or infrequent. This surface roughness may also be obtained on extrusions, rolled surfaces, die castings, and permanent mold castings when rigidly controlled. |
| 32√ | A high-grade machine finish requiring close control when produced by lathes, shapers, milling machines, etc., but relatively easy to produce by centerless, cylindrical or surface grinders. This surface may be specified in parts where stress concentration is present. This surface finish is satisfactory for bearing surfaces when motion is not continuous and loads are light. When finer finishes than this are specified, production costs rise rapidly, therefore, such finishes must be analyzed carefully by the engineer or designer. Also processes such as extruding, rolling, or die casting may produce a comparable surface roughness when such processes are rigidly controlled. |
| 16√ | A high quality surface produced by fine cylindrical grinding, emery buffing, coarse honing or lapping. A surface of this value is specified where smoothness is of primary importance for proper functioning of the part, such as rapidly rotating shaft bearing, heavily loaded bearings, and extreme tension members. |

TABLE V—Continued

| Roughness Height Rating | General Application of Roughness Height Ratings |
|---|---|
| 8√ | Very fine surfaces produced by special finishing operations such as honing, lapping, or buffing. Surfaces refined to this degree are specified where packings and rings must slide across the direction of the surface grain, maintaining or withstanding pressures; the interior honed surfaces of hydraulic cylinders are an example. Finishes of this value may also be required in precision gages and instrument work, on sensitive value surfaces, or on rapidly rotating shafts and on bearings where lubrication is not dependable. |
| 4√ | Refined surfaces produced by special finishing operations such as honing, lapping, and buffing. This surface roughness value should be specified only when the requirements of design makes it mandatory as the cost of manufacturing is extremely high. Surfaces refined to this degree are required in instrument work, gage work and where packings and rings must slide across the direction of surface grain, such as on chrome plated piston rods, etc. where lubrication is not dependable. |
| 2√ 1√ 1/2√ 1/4√ | Very refined surfaces produced only by the finest of modern honing, lapping, buffing, and superfinishing equipment. These surfaces may have a satin or highly polished appearance depending on the finishing operation and material. Finishes of this type are only specified when design requirements make it mandatory as the cost of manufacturing is extremely high. Surfaces refined to this degree are specified on fine or very sensitive instrument parts or other laboratory items, and certain gage surfaces, such as on precision gage blocks. |

Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring agency or as directed by the contracting officer.

Copies of this standard for military use may be obtained as indicated in the foreword to the Index of Military Specifications and Standards.

Copies of this standard may be obtained for other than official use by individuals, firms, and contractors from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

Both the title and the identifying symbol number should be stipulated when requesting copies of Military Standards.

Custodians:

Army—Ordnance Corps
Navy—Bureau of Ordnance
Air Force

Other Interests:

Army—CEMSig
Navy–AShMCCG

# APPENDIX 1

# CONTROL OF SURFACE ROUGHNESS

*This appendix is for the purpose of adding clarification to the standard and includes no mandatory provisions.*

Smoothness and roughness are relative, i.e., surfaces may be either smooth or rough for the purpose intended; what is smooth for one purpose may be rough for another purpose.

In the mechanical field comparatively few surfaces require any control of smoothness or roughness beyond that afforded by the processes required to obtain the necessary dimensional characteristics.

Working surfaces such as bearings, pistons, and gears are typical of surfaces for which optimum performance may require control of the surface characteristics in accordance with the procedure outlined in the foregoing standard. Nonworking surfaces seldom require any surface control such as that with which this standard is concerned, the only exceptions in these instances being restrictions that may be necessary for process control and finish required for sake of appearance.

It follows from the above that surface characteristics should not be controlled on a drawing or specification unless such control is essential to appearance or mechanical performance of the product. Imposition of such restrictions when unnecessary may increase production costs and in any event will serve to lessen the emphasis on the control specified for important surfaces.

In general, working surfaces and those requiring a high degree of smoothness for sake of appearance should be controlled in accordance with the foregoing standard. There will, of course, be many exceptions where control is uneconomical and unnecessary from the standpoint of operating characteristics.

In the mechanical field roughness or smoothness is largely a result of the processing method; a machined or a ground part may be relatively smooth or relatively rough for the purpose intended; the surface obtained from casting, forging or burnishing is the result of plastic deformation; if machined or ground, lapped or honed, the surface obtained is the result of tearing action of the cutting tools or abrasive grains.

Regardless of how the surface characteristics are evolved, magnified profiles in all instances consist of a series of peaks and valleys which deviate in a more or less irregular fashion above and below a mean surface. Superimposed on these major peaks and valleys there are irregularities of lesser magnitude.

Experience has shown that the ideal surface characteristics for working surfaces may involve such operating conditions as the area in contact, the load, speed, direction of motion, type and amount of lubricant, temperature, material and physical characteristics of component parts, variations of which in any one of the conditions may require a change in the specified surface characteristics. Experimentation or experience with surfaces performing similar functions are therefore the only criteria on which selection and specification of given surface characteristics can be based.

Once the required surface characteristics have been established on the basis of experience or experimentation the requirement should be documented on the engineering drawing in accordance with the foregoing standard with detail limited to the characteristics which are definitely known to be essential to the specific application. The responsibility for making the surface is thereby transferred to the producer.

Table V shows the typical range of surface roughness values which may be obtained by various natural processes and production methods. The ability of a processing operation to produce a specific surface roughness depends on many factors. For example, in surface grinding, the final surface depends on the peripheral speed of the wheel, the speed of the traverse, the rate of feed, the grit size, bonding material and state of dress of the wheel, the amount and type of lubrication at the point of cutting, and the physical properties of the piece being ground. A small change in any of the above factors can have a marked effect on the surface produced. Therefore, the values shown in table V should be considered flexible and not hard and fast limits.

Interpretation of surface requirements as specified on the drawing is explained in detail in the foregoing standard. The standard, however, permits considerable latitude in the method or procedure for controlling production of the surfaces and establishing their conformity with the specified drawing requirements.



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