SAE The Engineering Society For Advancing Mobility Land Sea Air and Space® INTERNATIONAL
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SURFACE VEHICLE RECOMMENDED PRACTICE

Submitted for recognition as an American National Standard

SAE J449a

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Superseding J449 JAN53

(R) SURFACE TEXTURE CONTROL

Foreword—This Document has also changed to reflect the new SAE Technical Standards Board Format.

1. Scope—SAE J448, Surface Texture, has been set up for precision reference specimens using a controlled surface profile to obtain reproducible roughness values. These specimens are for instrument calibration. Appropriate symbols for roughness, waviness, and lay have also been standardized (ASA B46.1-1962 and SAE J448).

For production control, especially from one geographical location to another, means are required to facilitate the inspection of surface characteristics called for by specifications which include not only roughness but profile waviness and lay. In order to integrate the requirements of the designer with the actual production of surfaces, a second grade of control standards must be adopted which will be functional in nature for the specific product being manufactured. These control standards may be Calibrated Pilot Specimens (actual parts with satisfactory texture) or Roughness Comparison Specimens (ASA B46.1-1962). This SAE Recommended Practice describes the usage of these control standards.

2. References

2.1 Applicable Publications—The following publications form a part of the specification to the extent specified herein. Unless otherwise indicated the lastest revision of SAE publications shall apply.

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J448—Surface Texture
SAE Aerospace-Automotive Drawing Standards

2.1.2 OTHER PUBLICATION

ASA B46.1-1962

3. ***Roughness Comparison Specimens*****—**In order to comply with a specific type of lay with required roughness and waviness values, a number of roughness machined comparison specimens are available commercially. These specimens are intended to have the appearance and feel of typical machine surfaces and are made to cover both a range of roughness and a variety of methods of surface preparation.

Roughness comparison specimens are well adapted for use by designers and draftsmen to relate numerical specifications of surface roughness and lay to general experience of appearance and texture of machined surfaces. They may also be used for visual and tactual comparison with production surfaces. Care should be taken when comparing specimens that the effect of shape, curvature, material, lay, and spectral characteristics do not produce misleading results. Samples of specific parts are usually the best control specimens.

4. ***Designation of Surface Texture*****—**Surface texture should be specified for production parts only on those surfaces which must be under functional control. For all other surfaces the finish resulting from the machining method required to obtain dimensional accuracy is generally satisfactory, unless the appearance of the surface is of prime concern.

The recommended degree of functional roughness, direction of lay, and waviness for any specific surface cannot be accurately foretold because of many factors influencing optimum performance in any one application. The choice of surface characteristics will be determined by such factors as loading, speed and direction of movement, physical characteristics of both materials in contact, type and amount of lubrication, contaminants, and temperature.

The primary reasons for designation of surface finish control are to improve performance, increase service life, or reduce cost. The required data for this control comes from past experience of field service or experimental results. All significant variables should be considered when establishing test methods and analyzing results.

Under conditions of complete lubrication, it would appear axiomatic that the finer the surface roughness with complete lubrication, the more efficient will be the performance. Most new moving parts do not attain a condition of complete lubrication due to imperfect geometry and running clearances, and they must therefore wear-in by actual removal of metal. In certain instances, experience may indicate that a specific degree of roughness or a specific degree of lay is necessary to accommodate this wear-in process which lessens the change of galling, seizure, or excessive wear.

The surface chosen for a specific application will be determined by its required function and a compromise made between sufficient roughness to allow proper wearing-in and resulting smoothness for expected service life. In certain cases, a roughness number in itself may not adequately define the character of the surface found by experience to give the best results. Special reference samples may be made to give manufacturing, inspection, and engineering samples for comparison with the manufactured parts. In general, with lower dimensional tolerances and better manufacturing practices, with adequate lubrication and compatible surfaces, finer finishes would be expected to give optimum results. Frequently, cases where surfaces are not compatible, such as hardened parts running together, a certain degree of roughness or character of surface may assist lubrication in obtaining satisfactory wear-in. However, where hardened parts run against soft materials, the hardened parts must have a fine finish to avoid distress on the soft parts.

Typical normal ranges of surface roughness applications on functional parts are shown in Figure 1. Specific applications may require finer or coarse roughness values than those indicated, especially for gears and bearings.

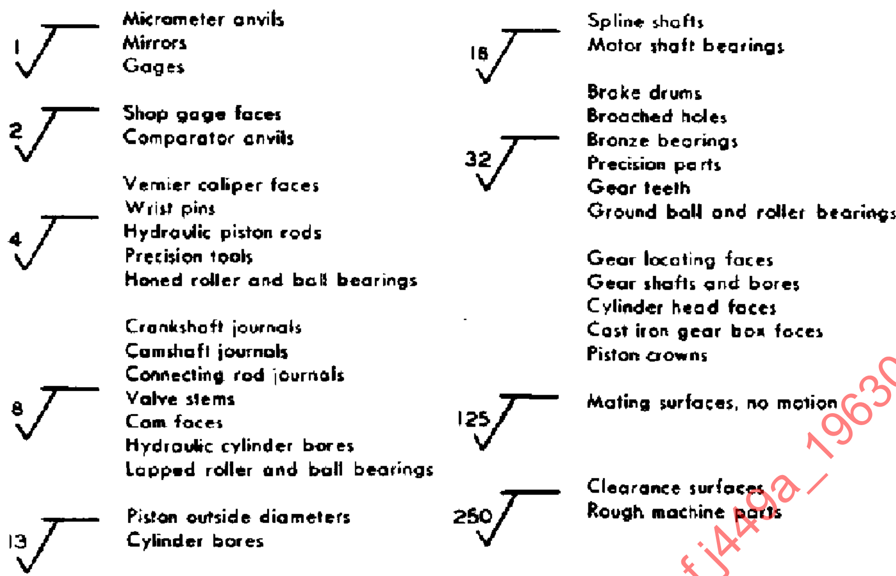

FIGURE 1—TYPICAL VALUES OF SURFACE ROUGHNESS FINISHES

The designation of surface texture requirements on drawings should conform with SAE J448, and with the Surface Texture section of the SAE Aerospace-Automotive Drawing Standards. The designer should be sure that those surfaces calling for control are of sufficient importance to warrant the expenditure of time and money necessary for this control. Profuse and loose usage of controlled finishes, where not essential, detracts from the emphasis that should be given to important surfaces. Where properly used, designation and control of a surface in accordance with SAE J448, can eliminate such confusion and many rejects.

5. ***Production of Required Surface Texture***—Unless service or experimental results have indicated that only one process method will give completely satisfactory performance, the method of machining to obtain the desired finish should be left to the discretion of the processing shop supervisory staff. They will have more intimate knowledge of the desirable machines to produce economical parts under required schedules. It is important, therefore, that production engineers and master mechanics become thoroughly familiar with surface texture as defined and rated by SAE J448.

Figure 2 is a reproduction from the section on Surface Texture in the SAE Aerospace-Automotive Drawing Standards, and it shows typical surface roughness values obtained by various production methods. This chart indicates surface roughness values up to 2000 Mu in., although in automotive practice controlled surfaces rarely exceed 100 Mu in. roughness. Fine surface finishes may require more operations and greater care in production; but if quantities are large, special tooling with honing, lapping, or high speed grinding can produce better finishes more economically than with older methods of production.

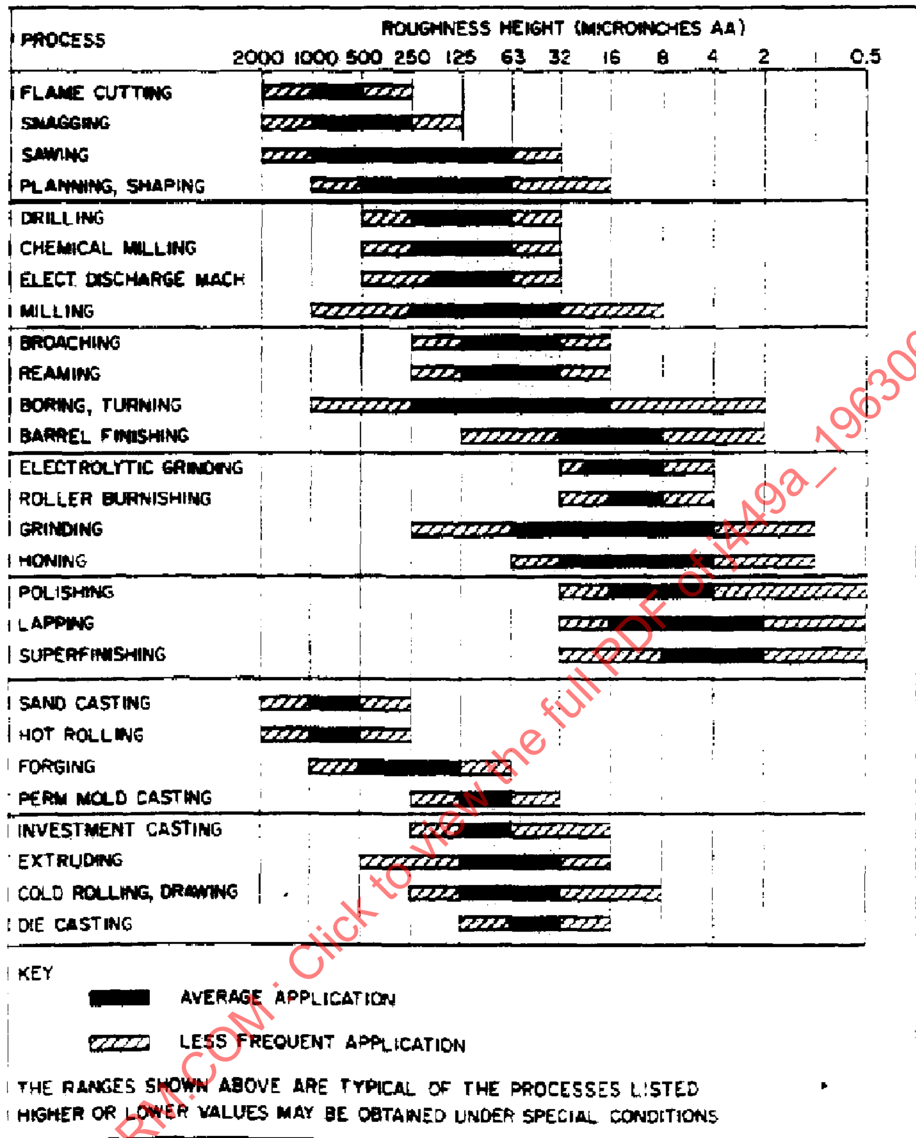

FIGURE 2—SURFACE ROUGHNESS AVAILABLE BY COMMON PRODUCTION METHODS

6. ***Inspection and Control***—A specific surface roughness depends on reproducible production techniques. The surface in question may be inspected by use of instruments or by visual or tactual comparison. Instruments should be calibrated by use of precision reference specimens. Approved pilot specimens or replicas may be used for comparison with the surface in question. Instruments may be used as a final check of the pilot specimen with the production machined surface. Roughness comparison specimens may be used for visual or tactual control but are not recommended for instrument comparison with manufactured part.

Production machined surfaces are composed of irregular peaks and valleys having a variety of grooves, angles, and variable roughness widths. The precision reference specimens have uniform roughness heights, groove angles, widths. Instruments readings will, therefore, reflect the effect of the irregular production surface character so that the readings will be relative rather than absolute.

The geometry of the precision reference specimens being uniform, instruments may be checked for worn or chipped stylus points by a comparison of corrected readings for two widely separated reference surfaces. The correction factors and methods of checking instrument accuracy are available in the literature accompanying the reference specimens. These factors are required because of the specific stylus tip radius used on the instrument. It is impossible to contact the bottom of the grooves, so this factor is comparatively small for coarse surfaces but large for fine ones.

Readings of stylus tip instruments are also affected by the roughness width because of low and high frequency response limits beyond which the instrument will not give reliable readings. In some instances the roughness width or wave length will be specified on the drawing, therefore requiring that the instrument have a definite width cutoff value. If no width is specified, it is necessary that the frequency response of the instrument does not limit its sensitivity to any significant roughness of the surface to be inspected; that is, that the significant roughness width is not greater or smaller than the instrument is capable of measuring and that the frequency response is correct for the roughness width range being measured. Technical data on roughness width cutoff of instruments is available from the various instrument manufacturers.

When continuously averaging stylus type instruments are used, the length of trace (sampling length) used should be not less than 20 times the roughness width cutoff value. For instruments having meters which indicate integrated roughness over a fixed length of trace, the sampling length shall preferably be at least five times the roughness width cutoff value.

Where the continuously-averaging type instrument is used, it is not necessary for the traversing length to be traversed 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. For this type of operation, the minimum length of travel shall be not less than five times the roughness-width cutoff. Where surfaces are not large enough to permit the recommended minimum traversing length, the readings may not be the actual roughness of a surface but may be useful for comparative purposes.

For proper surface control of production parts, the process should be completely specified and should include depth of cut, cutting speed, feed, grit size, lubricant, and so forth. Selection of process methods should be based on surface inspection of production specimens. Production may be controlled at the machine by visual, tactual, or instrument comparison of production pieces with sample specimens. If control is required at more than one station, sample specimens may be cut into the required number of pieces; or if a large quantity is required, electroformed or plastic reference specimens may be satisfactorily employed in many instances.

Final inspection of the production pieces may be by visual, tactual, or instrument comparison with the sample specimen or by instrument comparison with the precision reference specimen depending on the roughness variation allowed and on past experience with surfaces for a similar function. For disputed surfaces, instruments calibrated with the precision reference specimens should be used. A 100% inspection for all parts is necessary only for highly critical surfaces where failure to meet the surface requirements might result in costly delays. Normal sampling inspection should prove adequate for most production parts.

The thoroughness of surface roughness inspection should depend on the judgment of the inspector. He should take into account the roughness value tolerances allowed and the physical proportions of the surface.

Instrument readings are subject to the skill of interpretation of the inspector. Readings of stylus tip instruments fluctuate because of the roughness irregularities of a machined surface. All meters are damped to minimize acute fluctuations; nevertheless, extremely high and low momentary readings do occur. The reading which should be recorded as representing the roughness value of the surface should be a mean reading around which the needle tends to dwell or fluctuate under a small amplitude. Occasional extreme fluctuations represent flaws or defects rather than average surface conditions and should not be used in determining average roughness. If in the opinion of the inspector, the extreme fluctuations are too frequent, indicating excessive lack of uniformity in the surface, the manufacturing cause, such as loading of cutting edges, overheating, too rapid feeds, should be investigated.