

LOAN COPY
INFORMATION CENTRE
STANDARDS AUSTRALIA

Dup. WITHDRAWN:
19990701

AS 2536—1982
UDC 621.9.015:620.179.118

Australian Standard 2536—1982

SURFACE TEXTURE



STANDARDS ASSOCIATION OF AUSTRALIA
Incorporated by Royal Charter



This Australian standard was prepared by Committee ME/27, Engineering Tolerance Systems, Metrology and Surface Quality. It was approved on behalf of the Council of the Standards Association of Australia on 10 March 1982 and published on 19 July 1982.

The following interests were represented on the committee responsible for the preparation of this standard:

Bureau of Steel Manufacturers of Australia
Confederation of Australian Industry
CSIRO, Division of Applied Physics
CSIRO, Division of Manufacturing Technology
Department of Defence
Department of Industry and Commerce
Department of Technical and Further Education, N.S.W.
Federal Chamber of Automotive Industries
Institution of Engineers Australia
Institution of Production Engineers
Institute of Technology, S.A.
Metal Trades Industry Association of Australia
Queensland Institute of Technology
Railways of Australia Committee
Royal Melbourne Institute of Technology
Society of Manufacturing Engineers
State Rail Authority, N.S.W.
University of New South Wales
University of Queensland

To keep abreast of progress in industry, Australian standards are subject to continuous review and are kept up-to-date by the issue of amendments or new editions as necessary. It is important therefore that standards users ensure that their standards are up-to-date. Full details of all SAA publications will be found in the Annual List of Australian Standards; these details are supplemented by listings in the SAA monthly journal 'The Australian Standard'. Information on the Annual List and 'The Australian Standard' may be obtained from any sales office of the Association, where details are also available of the current status of individual standards. Suggestions for improvements to published standards, addressed to the head office of the Association, are welcomed.

This standard was issued in draft form for comment as DR 81060.

AUSTRALIAN STANDARD

SURFACE TEXTURE

AS 2536—1982

First published 1982

PUBLISHED BY THE STANDARDS ASSOCIATION OF AUSTRALIA
STANDARDS HOUSE, 80 ARTHUR ST, NORTH SYDNEY, N.S.W.



ISBN 0 7262 2554 1

16 11 12

PREFACE

This standard was prepared by the Association's Committee on Engineering Tolerance Systems, Metrology and Surface Texture. It is intended to provide a comprehensive treatment of the topography of surfaces insofar as is practical having regard to the state of current knowledge.

The standard includes material related to the specifying and measuring of surface roughness together with information on instrument requirements, surface roughness comparison specimens, and calibration specimens. In order to promote as wide an understanding of the subject as possible, appendices give discursive material on the use of stylus instruments, the specification and production of surface texture, and the calibration of stylus instruments, and include an extensive bibliography (including standards) of selected works on surface texture.

The term 'cut-off' has been used in preference to 'sampling length' in this standard, both in geometrical definitions of parameters and also in those definitions which are principally related to electrical instrumentation. This has been done to avoid the major confusion that comes about because of the statistical term 'sampling'. Cut-off and sampling length are interpreted identically in this standard. Current practice in standards of a number of countries, including those of the International Organization for Standardization (ISO), is to use both these terms which leads to confusion and difficulties in interpretation.

Possibly the two most important aspects related to the specifying, producing and controlling of surface roughness are: first, typical roughness values (R_a) which may be associated with ordinary materials, using common production processes; and, secondly, the typical relationship of surface roughness values (R_a) to production time, employing commonly-used machine tools and processes. Both of the foregoing are useful tools when the cost effectiveness of a process or design is being evaluated. Material on these two aspects is given in Table 3.1 and Fig. B1 respectively.

In the preparation of this standard the confusion that could result from the specification of an unrestricted range of complex parameters was very much in mind. It is generally accepted, however, that to specify a single parameter, R_a , together with the process is no longer sufficient to meet all the needs of industry and that an extended group of parameters needs formal definition. Although the number of parameters defined in this standard has been increased above that in the present Australian standard (AS 1965), only parameters which have achieved a high degree of acceptance by the major industrial nations and ISO have been included in the formal part. The large number of parameters and functions referred to in Appendix D have been included as reference material to aid in interpreting manufacturing specifications originating outside Australia and a fuller understanding of the subject.

Wherever possible the work of ISO/TC 57 has been taken into account in the preparation of this standard. This standard therefore has been based on and is in agreement with the following ISO standards:

ISO/468	Surface Roughness
ISO/2632	Roughness Comparison Specimens Part 1: Turned, ground, bored, milled, shaped and planed Part 2: Spark-eroded, shot-blasted, grit-blasted and polished Part 3: Cast surfaces
ISO/3274	Instruments for the measurement of surface roughness by the profile method—Contact (stylus) instruments of consecutive profile transformation—Contact profile meters, system M.
ISO/4287/1	Surface Roughness Terminology Part 1: Surface and its parameters

The following overseas standards were also taken into account:

BS 1134	Method for the Assessment of Surface Texture Part 1: Method and instrumentation Part 2: General information and guidance
ANSI B46.1	Surface Texture, Surface Roughness, Waviness and Lay
ANSI Y14.36	Engineering Drawings and Related Documentation and Practices—Surface Texture Symbols

Acknowledgement is made to BSI for material from BS 1134 used in this standard.

© Copyright — STANDARDS ASSOCIATION OF AUSTRALIA 1982

Users of standards are reminded that copyright subsists in all SAA publications. No part of this publication may be reproduced, stored in a retrieval system in any form or transmitted by any means without prior permission in writing of the Standards Association of Australia.

CONTENTS

	<i>Page</i>		<i>Page</i>
FOREWORD.....	5	2.5 Graphical Determination of R_a Values	12
SECTION 1. SCOPE AND DEFINITIONS		3.1 Surface Texture Symbols and Construction	13
1.1 Scope	6	3.2 Symbols for Lay	15
1.2 Definitions	6	4.1 Transmission Characteristics	19
1.3 Referenced Documents	7	4.2 Stylus Tip Radii	20
SECTION 2. SURFACE TEXTURE PARAMETERS		4.3 Stylus Acting Midway Between Two Skids	20
2.1 General	8	A1 Effects of Various Cut-offs	24
2.2 Surface Roughness Parameters	8	A2 Relationship of Stylus Point to the Actual Profile of the Surface	26
2.3 Waviness Parameters	8	A3 Behaviour of the Stylus when Traversing Ridges and Grooves	26
2.4 Graphical Determination of Surface Roughness Parameters.....	8	A4 Relationship of Skid to Wavelength of Texture	26
SECTION 3. SPECIFYING SURFACE TEXTURE		A5 A Surface Texture Representing the Combined Effects of Several Causes	28
3.1 General	13	A6 Effect of Different Horizontal Magnifications	28
3.2 Lay	13	A7 Various Profiles Having the Same Height of Departure From the Nominal Profile	29
3.3 Flaws	13	A8 Various Profiles Having the Same Spacing and Same Average Height	29
3.4 Production Process	13	B1 Typical Relationship of Surface Roughness to Production Time for Commonly-used Tools and Processes	32
3.5 Surface Texture Symbols	13	C1 Schmalz Profile Microscope	36
3.6 Waviness Height	17	C2 Interference Microscope Systems	37
3.7 Surface Roughness	17	C3 2-beam Interferogram With Superimposed Stylus Profile Record	38
SECTION 4. MEASURING INSTRUMENT REQUIREMENTS		C4 3-dimensional Plot of Scanned Surface....	38
4.1 General	18	D1 Amplitude Density Function (ADF)	42
4.2 Measuring Traverse Length	18	D2 Relation of Parameters to the Amplitude Density Function (ADF)	43
4.3 Transmission Characteristics	18	D3 Example of Negative Skewness	43
4.4 Stylus	20	D4 Kurtosis	43
4.5 Skid	21	D5 Examples of Profiles and their Auto-correlation Functions	45
4.6 Profile Recorder	21	D6 Examples of Profiles and Their Amplitude Spectra	46
4.7 Instrument Accuracy	21	E1 Calibration of Recorder Using Gauge Blocks Directly (Suitable for Lower Magnifications Needing Steps not less than $5\mu\text{m}$)	49
4.8 Calibration	21	E2 Calibration of Recorder Using Gauge Block Steps Scaled Down by Lever	50
SECTION 5. SURFACE ROUGHNESS COMPARISON SPECIMENS		F1 Reference Lines (A) and Electrical Reference Lines (B)	52
5.1 General	22		
APPENDICES		TABLES	
A General Notes on the Use of Stylus Instruments	23	3.1 Typical Roughness Values Obtained with Ordinary Materials and Common Production Processes	16
B Specification and Production of Surface Texture	30	3.2 Preferred Maximum Waviness Height Value	17
C Methods of Measuring the Microtopography of Surfaces....	33	3.3 Preferred R_a Values	17
D Surface Topography Parameters and Functions	39	3.4 Finishing Processes and Cut-off Values Suitable for Assessing or Specifying Processes	17
E The Calibration of Stylus Instruments	48	4.1 Minimum Averaging or Measuring Traverse Lengths	18
F Method Divergence	52		
G Bibliography	53		
FIGURES			
2.1 Surface Characteristics	10		
2.2 Maximum Peak-to-valley Roughness Height	11		
2.3 Ten-point Height	11		
2.4 Bearing Length Ratio	11		

	<i>Page</i>		<i>Page</i>
4.2 Long Wavelength Transmission Characteristics—Nominal Sinusoidal Frequency Response	19	C1 Characteristics of Various Surface Examination Methods	33
4.3 Upper and Lower Limits of Transmission Characteristics	20	C2 Numerical Apertures (NA), Resolving Powers, and Useful Magnifications for a Wavelength of 556 nm	34
4.4 Maximum Static Stylus Measuring Force	21	D1 Parameters and Symbols Used in National Standards 1980	40

STANDARDS ASSOCIATION OF AUSTRALIA

Australian Standard for SURFACE TEXTURE

FOREWORD

Surface texture is normally specified in a manufacturing process to give a surface which experience has shown will have functional properties complying with a set of requirements.

The specifying of surface characteristics, unless they are essential for performance, may substantially increase production costs and will lessen the emphasis placed on the finishing of important surfaces.

In the mechanical field the specification of the process required to achieve the necessary dimensional accuracy will often be sufficient. The working surfaces on bearings, pistons, and gears are typical examples of surfaces for which optimum performance will require the control of surface characteristics following the procedures given in this standard.

Smoothness and roughness are relative—a surface may be either smooth or rough for the purpose intended—and what is smooth for one purpose may be rough for another. Many surfaces do not require any surface control. Further discussion relating to the specification and production of surface texture will be found in Appendix B.

It should be understood that ultimately, there is no such thing as a surface; there is essentially a region of transition from the bulk properties of one material to another. What is assessed as a 'surface' is dependent on the means of detection. An operational definition is also involved, and major or minor differences in the interpretation of surface topography can be expected depending on the method of detection used. It follows therefore that 'surfaces' are extremely complex, consisting mainly of randomly distributed irregularities covering a wide range of both height and spacing. There may also be a periodic component.

Surface texture is broadly defined as the topography of a surface and includes surface roughness and waviness, but excluding errors of form. To assign any single number of technical significance, to a surface, therefore requires the selection of certain features and parameters of the surface for measurement. A clear understanding of the way this selection is made, its limitations, and the method(s) of making the measurements, are necessary aids in the interpretation and measurement of surface texture, and guidance on this is given in this standard.

The accepted property used for characterizing a surface is surface roughness, because there is sufficient

knowledge of this property to enable the major parameters, constituting surface roughness to be quantified and measured in a meaningful fashion. This standard deals with all the parameters in widespread use for quantifying surface roughness. The parameter which is most often used in characterizing the roughness of a surface is the arithmetic mean deviation (R_a).

Conversely little is known practically about waviness, particularly relative to its effect on function, and waviness parameters are therefore difficult to quantify in a meaningful way. This standard includes such waviness parameters that have been found useful, and which are also included in international standards or standards of other countries.

As well as the restricted range of surface roughness and waviness parameters and a few functions such as bearing area which are defined in this standard and also standards of other countries, there are a large number of other parameters and functions which have currency in contemporary literature. A number of those will eventually be incorporated into standards and used much more frequently. In addition the range of symbols used in different countries for the same parameter is confusing and there are strong moves within ISO to unify such usage.

To further the understanding of this wider range of parameters, to clarify their meaning and also to avoid the confusion caused by the use of different symbols, Appendix D has been provided which gives this information in some detail.

The most common method of measuring surface texture is to move a sharp pointed stylus over the surface and to translate its motion perpendicular to the surface into a meter reading and/or a profile graph. There are a number of factors inherent in this process which affect the results obtained, and this standard has attempted to specify these factors in such a way that instruments of different design and construction will give the same measurement on any given surface. There are a large number of alternative techniques for examining surfaces, such as optical microscopy, light scattering and electron microscopy, which can give information on a variety of surface properties and these are discussed in some detail in Appendix C.

SECTION 1. SCOPE AND DEFINITIONS

1.1 SCOPE. This standard specifies those properties which constitute surface texture. It includes methods of assessing the properties, and requirements for measuring instruments. It deals with surface roughness and also waviness, and includes the most important parameters used in the quantitative expression of surface texture generally.

Appendices give general notes on a wider range of surface texture parameters, and describe instrument types and their usage.

1.2 DEFINITIONS. For the purpose of this standard, the following definitions apply:

1.2.1 Nominal surface (geometrical surface)—the surface specified by the design but excluding the surface texture. The errors of form defined later (see Clause 1.2.5) are deviations from the nominal surface.

1.2.2 Surface texture—the topography of a surface including roughness and waviness but excluding errors of form.

1.2.3 Surface roughness—the topography of a surface which consists of short wavelengths only. It comprises surface irregularities with relatively small spacings and usually incorporates irregularities resulting from the method of manufacture.

NOTE: There is a clear distinction between surface texture and the roughness of surfaces (see Clauses 1.2.2 and 1.2.3).

1.2.4 Waviness—the topography of a surface which consists of wavelengths of intermediate length. Waviness may result from such factors as machine or work deflection, vibration and chatter or heat treatment.

1.2.5 Errors of form—the departures from the nominal surface resulting from long wavelengths in the measured surface. Errors of form may result from the manufacturing process, thermal effects or similar causes.

1.2.6 Nominal profile (geometrical profile)—the line of intersection of a defined plane with the nominal surface.

1.2.7 Measured surface profile—the representation of a surface profile obtained by an instrument.

1.2.8 Modified profile—the line representing the profile of a surface after filtering.

1.2.9 Wavelength (λ)—for a periodic wave, the wavelength is the distance between corresponding points in two consecutive cycles of the wave.

1.2.10 Reference line—the curve or straight line defined by convention in relation to the nominal profile or other datum, which serves as a reference for the definition of parameters.

1.2.11 Electrical reference line—a line established by the filtering action of an instrument on the electrical signal which represents the measured surface profile.

1.2.12 Centreline—a reference line representing the form of the traced profile and parallel to its general direction throughout the cut-off length, such that the sums of the areas contained between it and those parts of the profile which lie on each side of it are equal.

NOTE: The centreline is defined and used for graphical convenience. When the profile has a distinct periodicity and its general direction therefore determinate, the (equal area) centreline

is unique. When the profile is irregular, the assessment of its general direction becomes uncertain over a given range. Within this range a family of 'equal area' centrelines can be drawn, one of which can be identical with the 'least squares' reference line.

1.2.13 Least squares reference line—a reference line having the form of the nominal profile within the limits of the cut-off, and placed so that within the cut-off the sum of the squares of the deviations of the profile from the reference line is a minimum.

NOTE: The least squares reference line is unique in position and direction, but its graphical determination can be laborious.

1.2.14 Profile peak—a portion of a profile lying above the reference line and between two intersections of the profile with the reference line.

1.2.15 Profile valley—a portion of a profile lying below the reference line and between two intersections of the profile with the reference line.

1.2.16 Profile peak height (Y_p)—the height of the highest point of a profile peak above the reference line.

1.2.17 Profile valley depth (Y_v)—the depth of the lowest portion of a profile valley below the reference line.

1.2.18 Local peak height (R_p)—the height of a point of maximum height on the profile above the reference line.

1.2.19 Local valley depth (R_m)—the depth of a point of maximum depth on the profile below the reference line.

1.2.20 Profile irregularity—a profile peak and the adjacent profile valley.

1.2.21 Spacing of a profile irregularity—the distance measured along the reference line which contains the profile irregularity.

1.2.22 Measuring traverse length (L)—the length of the modified surface profile used in the measurement of surface roughness parameters, or the length over which the profile is evaluated. The latter may contain one or more cut-offs.

NOTE: The terms evaluation length and assessment length are also used for this parameter.

1.2.23 Cut-off—

- the value of the wavelength, λ , defined by convention as the longest wavelength transmitted by an instrument;
- the length of equal segments into which the measured profile is divided for the purpose of making a geometric determination of surface roughness.

Sampling length—see Cut-off.

1.2.24 Lay—the direction of the predominant surface pattern ordinarily determined by the production method used.

1.2.25 Flaws—unintentional irregularities which occur at one place or at relatively infrequent or widely varying intervals on the surface. Flaws include such defects as cracks, inclusions, ridges and scratches.

1.2.26 Static measuring force—the force which the stylus exerts on the surface when not traversing the surface.