

Paints and varnishes — Determination of hiding power —

Part 1: Kubelka-Munk method for white and light-coloured paints

This European Standard EN ISO 6504-1:2006 has the status of a
British Standard

ICS 87.040

National foreword

This British Standard was published by BSI. It is the UK implementation of EN ISO 6504-1:2006. It is identical with ISO 6504-1:1983 “*Paints and varnishes — Determination of hiding power — Part 1: Kubelka-Munk method for white and light-coloured paints*”, published by the International Organization for Standardization (ISO).

The UK participation in its preparation was entrusted to Technical Committee STI/10, Test methods for paints.

A list of organizations represented on this committee can be obtained on request to its secretary.

It has been assumed in the drafting of this standard that it will be used and applied by those who are appropriately qualified and experienced, and for whose guidance it has been prepared.

ISO 3905 has not been implemented as a British Standard because the Technical Committee responsible considers it to be inferior to ISO 3906 which has been implemented as BS 3900-D6. Reference to ISO 3905 is for information purposes only and therefore the validity of this standard is not affected.

NOTE *Textual error.* When adopting the text of this International Standard, the textual error given below was discovered. It has been marked in the text by an asterisk and the error has been reported to ISO in a proposal to amend the text of the standard.

In 7.2.2.1, last line, replace “plate” by “film”.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot of itself confer immunity from legal obligations.

This British Standard, having been prepared under the direction of the Pigments, Paints and Varnishes Standards Committee, was published under the authority of the Board of BSI and comes into effect on 30 December 1983

© BSI 2007

The Committees responsible for this British Standard are shown in the Introduction to BS 3900 issued separately. The following BSI references relate to the work on this standard:
Committee reference PVC/10
Draft for comment 81/51820 DC

Amendments issued since publication

| Amd. No. | Date | Comments |
|----------|------------------|---|
| 16876 | 28 February 2007 | Renumbers the BS as BS EN ISO 6504-1:2006 |
| | | |
| | | |
| | | |

ISBN 0 580 13623 X

Contents

| | Page |
|--|------|
| 0 Introduction | 1 |
| 1 Scope and field of application | 1 |
| 2 References | 1 |
| 3 Principle | 1 |
| 4 Kubelka-Munk equations | 1 |
| 5 Apparatus and materials | 2 |
| 6 Sampling | 3 |
| 7 Procedure | 3 |
| 8 Expression of results | 4 |
| 9 Precision | 4 |
| 10 Test report | 4 |
| <hr/> | |
| Annex A Graphs for determination of St from R_B and R_∞ | 5 |
| Annex B Table of values of reflectivity R_∞ and factor α | 5 |
| Annex C Examples of the calculation of hiding power from measurements of R_B and R_∞ | 6 |
| <hr/> | |
| Figure 1 — Index graph for determination of St from values of R_B and R_∞ | 8 |
| Figure 2 — Values of St for the ranges $0,87 \leq R_B \leq 0,94$ $0,88 \leq R_\infty \leq 0,98$ | 9 |
| Figure 3 — Values of St for the ranges $0,86 \leq R_B \leq 0,93$ $0,87 \leq R_\infty \leq 0,98$ | 10 |
| Figure 4 — Values of St for the ranges $0,79 \leq R_B \leq 0,86$ $0,80 \leq R_\infty \leq 0,86$ | 11 |
| Figure 5 — Values of St for the ranges $0,84 \leq R_B \leq 0,91$ $0,85 \leq R_\infty \leq 0,98$ | 12 |
| Figure 6 — Values of St for the ranges $0,77 \leq R_B \leq 0,84$ $0,78 \leq R_\infty \leq 0,89$ | 13 |
| Figure 7 — Values of St for the ranges $0,70 \leq R_B \leq 0,77$ $0,71 \leq R_\infty \leq 0,77$ | 14 |
| Figure 8 — Values of St for the ranges $0,79 \leq R_B \leq 0,86$ $0,82 \leq R_\infty \leq 0,98$ | 15 |
| Figure 9 — Values of St for the ranges $0,72 \leq R_B \leq 0,79$ $0,73 \leq R_\infty \leq 0,89$ | 16 |
| Figure 10 — Values of St for the ranges $0,65 \leq R_B \leq 0,72$ $0,66 \leq R_\infty \leq 0,75$ | 17 |
| Figure 11 — Values of St for the ranges $0,58 \leq R_B \leq 0,65$ $0,59 \leq R_\infty \leq 0,66$ | 18 |
| Figure 12 — Values of St for the ranges $0,73 \leq R_B \leq 0,80$ $0,78 \leq R_\infty \leq 0,98$ | 19 |

| | Page |
|--|------|
| Figure 13 — Values of St for the ranges $0,66 \leq R_B \leq 0,73$ $0,68 \leq R_\infty \leq 0,98$ | 20 |
| Figure 14 — Values of St for the ranges $0,59 \leq R_B \leq 0,66$ $0,60 \leq R_\infty \leq 0,85$ | 21 |
| Figure 15 — Values of St for the ranges $0,52 \leq R_B \leq 0,59$ $0,53 \leq R_\infty \leq 0,65$ | 22 |
| Figure 16 — Values of St for the ranges $0,45 \leq R_B \leq 0,52$ $0,46 \leq R_\infty \leq 0,54$ | 23 |
| Figure 17 — Values of St for the ranges $0,38 \leq R_B \leq 0,45$ $0,39 \leq R_\infty \leq 0,46$ | 24 |
| Figure 18 — Values of St for the ranges $0,61 \leq R_B \leq 0,68$ $0,75 \leq R_\infty \leq 0,98$ and $0,47 \leq R_B \leq 0,50$ $0,70 \leq R_\infty \leq 0,98$ | 25 |
| Figure 19 — Values of St for the ranges $0,54 \leq R_B \leq 0,61$ $0,59 \leq R_\infty \leq 0,98$ | 26 |
| Figure 20 — Values of St for the ranges $0,47 \leq R_B \leq 0,54$ $0,49 \leq R_\infty \leq 0,98$ | 27 |
| Figure 21 — Values of St for the ranges $0,40 \leq R_B \leq 0,47$ $0,41 \leq R_\infty \leq 0,64$ | 28 |
| Figure 22 — Values of St for the ranges $0,33 \leq R_B \leq 0,40$ $0,34 \leq R_\infty \leq 0,46$ | 29 |
| Figure 23 — Values of St for the ranges $0,40 \leq R_B \leq 0,47$ $0,48 \leq R_\infty \leq 0,98$ | 30 |
| Figure 24 — Values of St for the ranges $0,33 \leq R_B \leq 0,40$ $0,36 \leq R_\infty \leq 0,98$ | 31 |

EUROPEAN STANDARD

EN ISO 6504-1

NORME EUROPÉENNE

EUROPÄISCHE NORM

February 2006

ICS 87.040

English Version

**Paints and varnishes - Determination of hiding power - Part 1:
Kubelka-Munk method for white and light-coloured paints (ISO
6504-1:1983)**

Peintures et vernis - Détermination du pouvoir masquant -
Partie 1: Méthode de Kubelka-Munk pour les peintures
blanches et les peintures claires (ISO 6504-1:1983)

Beschichtungsstoffe - Bestimmung des Deckvermögens -
Teil 1: Verfahren nach Kubelka-Munk für weiße und helle
Beschichtungsstoffe (ISO 6504-1:1983)

This European Standard was approved by CEN on 16 January 2006.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.



EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: rue de Stassart, 36 B-1050 Brussels

Foreword

The text of ISO 6504-1:1983 has been prepared by Technical Committee ISO/TC 35 "Paints and varnishes" of the International Organization for Standardization (ISO) and has been taken over as EN ISO 6504-1:2006 by Technical Committee CEN/TC 139 "Paints and varnishes", the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by August 2006, and conflicting national standards shall be withdrawn at the latest by August 2006.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

Endorsement notice

The text of ISO 6504-1:1983 has been approved by CEN as EN ISO 6504-1:2006 without any modifications.

Paints and varnishes — Determination of hiding power — Part 1 : Kubelka-Munk method for white and light-coloured paints

0 Introduction

This International Standard is one of a series of standards dealing with the testing and sampling of paints, varnishes and related products.

ISO 3905 and ISO 3906 specify methods for determining the contrast ratio of paints at a fixed spreading rate, by applying paint films to black and white charts and to polyester film respectively. They depend on the observation that there is a linear relationship between contrast ratio and reciprocal film thickness, at least over a limited range of film thickness.

Hiding power of paints is generally defined as the spreading rate required to give a contrast ratio of 98 %. To determine this by the methods specified in ISO 3905 and ISO 3906 would be time-consuming and require considerable extrapolation which often exceeds the limit of linearity of the relationship between contrast ratio and spreading rate. Therefore, this method for the determination of hiding power, involving the Kubelka-Munk (K-M) equations which relate scattering and absorption coefficients to optical properties, has also been standardized.

1 Scope and field of application

This International Standard specifies a method to be used for determining the hiding power (spreading rate necessary to give a contrast ratio of 98 %) of white or light-coloured paints. It is restricted to paint films having the tri-stimulus value of $Y \geq 70$. It is not applicable to fluorescent or metallic paints.

2 References

ISO 1512, *Paints and varnishes — Sampling*.

ISO 1513, *Paints and varnishes — Examination and preparation of samples for testing*.

ISO 1515, *Paints and varnishes — Determination of volatile and non-volatile matter*.

ISO 2808, *Paints and varnishes — Determination of film thickness*.¹⁾

ISO 2811, *Paints and varnishes — Determination of density*.

ISO 3905, *Paints and varnishes — Determination of contrast ratio (opacity) of light-coloured paints at a fixed spreading rate (using black and white charts)*.

ISO 3906, *Paints and varnishes — Determination of contrast ratio (opacity) of light-coloured paints at a fixed spreading rate (using polyester film)*.

3 Principle

The method is based on the Kubelka and Munk equations relating the scattering and absorption coefficients of pigmented films to their colour and opacity.

For the determination of hiding power, both the reflectance (R_B) of a paint film of thickness t on a black background and the reflectivity (R_∞) are required for introduction into the Kubelka-Munk equations (clause 4).

4 Kubelka-Munk equations

The Kubelka-Munk (K-M) equations required are

$$a = \frac{1}{2} \left(R_\infty + \frac{1}{R_\infty} \right) \quad \dots (1)$$

$$b = a - R_\infty \quad \dots (2)$$

$$R_B = \frac{1}{a + b \coth bSt} \quad \dots (3)$$

$$R = \frac{1 - R_g (a - b \coth bSt)}{a + b \coth bSt - R_g} \quad \dots (4)$$

where

R_∞ is the reflectivity, i.e. the reflectance of a paint film of such thickness that further increase in thickness gives no further change in reflectance;

R_B is the reflectance of a paint film of thickness t applied over a black background;

R is the reflectance of a paint film of thickness t applied over a white background of defined reflectance R_g (for this method, $R_g = 0,80$);

S is the scattering coefficient per micrometre (μm^{-1});

t is the thickness, in micrometres, of the paint film.

When using equations (1) to (4) with this method, the measured CIE tristimulus values Y divided by 100 are inserted for R , R_B and R_∞ , respectively.

1) At present at the stage of draft. (Revision of ISO 2808-1974.)

The hiding power $V_{0,98}$ is the spreading rate necessary to give a contrast ratio (R_B/R) of 0,98, and is determined via the equivalent film thickness $t_{0,98}$ according to the equation

$$V = \frac{1\,000}{t}$$

where

V is the hiding power, in square metres per litre;

t is the thickness, in micrometres, of the wet paint film.

From equations (3) and (4), when the contrast ratio (R_B/R) is equal to 0,98

$$\frac{a - 0,8 + b \coth bSt_{0,98}}{[a + b \coth bSt_{0,98}] \{1 - 0,8 [a - b \coth bSt_{0,98}]\}} = 0,98$$

or, after rearrangement

$$t_{0,98} = \frac{1}{bS} \operatorname{arcoth} \left(\frac{0,02 + \sqrt{D}}{1,568 b} \right) \quad \dots (5)$$

where

$$D = 3,136 a [1 - 0,98 (1 - 0,8 a)] - 2,508 4$$

and

$$V = \frac{1\,000}{t} = \frac{1\,000 bS}{\operatorname{arcoth} \left(\frac{0,02 + \sqrt{D}}{1,568 b} \right)} = \alpha S \quad \dots (6)$$

NOTE — If $y = \coth x$, $x = \operatorname{arcoth} y$.

It can be seen that for constant values of R_g (0,80) and contrast ratio (0,98), factor α is a function of R_∞ .

The scattering coefficient S is determined from a rearrangement of equation (3), the values of a and b being known by calculation from equations (1) and (2) respectively, as follows :

$$St = \frac{1}{b} \operatorname{arcoth} \left(\frac{1 - aR_B}{bR_B} \right) \quad \dots (7)$$

To simplify the calculations, graphs are available for the determination of the product St from measured values of R_B and R_∞ .

The scattering coefficient S is calculated by dividing St by the film thickness t , and $V_{0,98}$ is obtained from equations (5) and (6). A table of values of α for various values of R_∞ simplifies the calculation.

NOTE — Suitable tables and graphs are referred to in DIN 53 162 and in ASTM D 2805. The table in annex B is taken, with modifications, from ASTM D 2805 and the graphs are from *Official Digest* 35, 464, p.1871 (1963).

5 Apparatus and materials

5.1 Substrates

5.1.1 Determination of R_B

5.1.1.1 Glass plates, black, plane, polished, not less than 6 mm thick and of dimensions at least 200 mm × 200 mm,

or

5.1.1.2 Polyester film, clear, untreated, transparent, of uniform thickness between 30 and 100 μm, and of dimensions at least 100 mm × 150 mm, together with a glass plate as specified in 5.1.1.1.

NOTE — Commercially available polyester sheet has been found to be satisfactory.

5.1.2 Determination of R_∞

5.1.2.1 Smooth surfaced paper charts, readily wetted by, but impervious to, solvent and water-thinned paints, and similar in reflectance to the paint to be tested.

Suitable chart colours are grey for paints of low reflectivity and white for paints of high reflectivity. Alternatively, ceramic tiles or glass may be used.

5.2 Film applicators

A series of film applicators giving films of uniform thickness within the range 40 to 150 μm is required. For application to glass, bar applicators are suitable. For application to polyester film or paper charts, wirewound applicators are more suitable.

The film laid down shall be at least 150 mm wide (using glass) or 70 mm wide (using polyester film) to cover areas, at a uniform thickness, of at least 100 mm × 125 mm or 60 mm × 60 mm respectively. The application of uniform films is facilitated by the use of automatic applicators, which are recommended.

5.3 Reflectometer

A photoelectric instrument is required, giving an indicated reading proportional to the intensity of light reflected from the surface under test to an accuracy of 0,1 % of full scale deflection, and having a spectral response approximating to the product of the relative spectral energy distribution of CIE illuminant D 65 and the colour matching function $\bar{y}(\lambda)$ of the CIE standard observer.

NOTES

1 It is recognized that the relative geometrical arrangement of the illuminating beam and the light detector can affect the measurement of reflectance, but it is considered that variations arising from this factor in commercial reflectometers should be considerably less than the figures for reproducibility stated in clause 9. In the event of dispute, 8°/diffuse geometry, without gloss trap, should be used.

2 For other than reference purposes, illuminant C may be used.

5.4 Template

A rectangular metal template with minimum dimensions of 100 mm × 125 mm is required for films applied to black glass. For films on polyester film, a metal template or die stamp with minimum dimensions of 60 mm × 60 mm is required.

6 Sampling

Take a representative sample of the product to be tested as described in ISO 1512.

Examine and prepare the sample for testing as described in ISO 1513.

7 Procedure

7.1 Determination of R_{∞}

Apply a few millilitres of the paint sample in a line across one end of a paper substrate and spread it immediately by drawing down a suitable applicator at a steady rate so as to give a uniform film thickness. Repeat the operation so as to provide uniform films having dry film thicknesses of about 75, 100, 125 and 150 μm . Dry the coatings as described in 7.2.1.3. Measure the reflectance of each coating at four positions on each coated paper. Record the value of reflectance which is independent of the film thickness as the reflectivity R_{∞} .

NOTE — If the reflectance is still increasing when the film thickness reaches 150 μm , further coats should be applied until a constant reflectance is obtained.

7.2 Determination of R_B

7.2.1 Preparation of test films

Apply a film thickness that will give a dry film having a reflectance at least 0,02 lower than the reflectivity R_{∞} of the paint sample.

7.2.1.1 Method using polyester film

Prepare the polyester film (5.1.1.2) for coating by either

- a) spreading it on a black glass plate (5.1.1.1) which has first been moistened with just sufficient white spirit (a few drops), to hold the film in position by surface tension. Ensure that none of the liquid wets the upper surface of the film and that no air bubbles are trapped under it;

or, if wirewound applicators are to be used

- b) by fixing the polyester film at one end and laying it over a flat rubber block.

Apply a few millilitres of the paint sample, according to the film thickness required, in a line across one end of the polyester film and spread it immediately by drawing down a suitable applicator at a steady rate to give a uniform film thickness. Prepare a total of four films in this way.

7.2.1.2 Method using black glass plates

Apply a few millilitres of the paint sample in a line across one end of a black glass plate (5.1.1.1) and spread it immediately by drawing down a suitable applicator at a steady rate to give a uniform film thickness. Repeat the application with different black glass plates (5.1.1.1) until four uniform films of approximately the same thickness have been prepared.

7.2.1.3 Drying and conditioning

With the coated substrates in a horizontal position, dry the paint by the appropriate procedure for the type of paint or as agreed between the parties. Maintain the dried test films at a temperature of 23 ± 2 °C in a dust-free atmosphere having a relative humidity of 50 ± 5 % for at least 24 h, but not more than 168 h, before carrying out the reflectance measurements.

7.2.2 Measurement of reflectance R_B

NOTE — Variation in readings is likely to be the result of non-uniform application of the paint film and is dependent on the techniques used. If the precision (clause 9) is not obtained, the technique should be re-examined.

7.2.2.1 Method using polyester film

Fix the coated polyester films over a black glass plate, introducing a few drops of white spirit between the underside of the film and the glass to ensure optical contact. Measure the reflectance of the test films at a minimum of four positions and calculate the mean reflectance R_B of each coated plate. *

7.2.2.2 Method using black glass plates

Measure the reflectance R_B directly by means of the reflectometer (5.3), taking readings at a minimum of four positions on each coated plate, avoiding its edges, and calculate the mean reflectance R_B of each coated plate.

7.3 Determination of film thickness

NOTE — The method using polyester film (7.3.1) is preferred. Other methods for measuring wet film thickness, based on those given in ISO 2808, may also be found to be suitable.

7.3.1 Method using polyester film

By means of the metal template and a sharp knife or precision die stamp, cut equal areas of dimensions at least 60 mm × 60 mm from the centres of the coated polyester films.

Weigh the detached pieces to the nearest 0,1 mg. Remove the paint film by the use of a solvent which has been found to have no effect on the dry mass of the polyester film, and, after thorough drying, reweigh the film. Record the mass m of the paint film, i.e. the difference in mass between the coated and uncoated polyester film, and repeat the procedure with the other three films tested.

NOTE — If difficulty is experienced in removing the paint film with solvent, an approximation to the dry film mass may be obtained from the difference in mass between coated and uncoated polyester films of the same area.

7.3.2 Method using black glass plates

Cover the area of the film previously used for the measurement of reflectance R_B with the metal template (5.4), ensuring that the template is not within 20 mm of any edge of the film. Scrape away and discard the excess film around the template using a fresh razor blade in a holder. Remove the template and scrape the remaining film from the substrate on to a tared weighing dish. Manipulate the razor blade at all times so that the blade is almost flat on the glass and cannot nick or scratch the glass substrate. Record the mass m , to the nearest 0,1 mg, and repeat the procedure with the other three films tested.

8 Expression of results

8.1 Calculation of wet film thickness

Calculate the wet film thickness of each of the four films, from the equation

$$t = \frac{m}{A \times \rho \times NV} \times 10^8$$

where

m is the mass, in grams, of the paint film;

A is the area, in square millimetres, of the template;

ρ is the density, in grams per millilitre, of the paint, determined by the method specified in ISO 2811;

NV is the non-volatile matter content, expressed as a percentage by mass, of the paint, determined by the method specified in ISO 1515;

t is the wet film thickness, in micrometres.

8.2 Calculation of hiding power

Calculate the hiding power, $V_{0,98}$, using the equations given in clause 4, from the measured values of R_B and t for each film, and from the mean value of R_∞ .

Examples of the calculations, using both the table and graphs and directly from the equations, are given in annex C.

9 Precision

The precision of the method, as obtained by statistical examination of interlaboratory test results, is as follows.

9.1 Repeatability (r)

The value below which the absolute difference between two single test results on identical material, obtained by one operator in one laboratory using the same equipment within a short interval of time using the standardized test method, may be expected to lie with a 95 % probability, is 2 %.

9.2 Reproducibility (R)

The value below which the absolute difference between two single test results on identical material, obtained by operators in different laboratories, using the standardized test method, may be expected to lie with a 95 % probability, is 6 %.

10 Test report

The test report shall contain at least the following information :

- a) the type and identification of the paint under test;
- b) a reference to this International Standard (ISO 6504/1);
- c) the result of the test;
- d) the paint density and the non-volatile matter content, expressed as a percentage by mass, used in the calculation of the test result;
- e) the drying time (and/or stoving conditions);
- f) whether black glass plates or polyester film were used as the substrate;
- g) any deviation, by agreement or otherwise, from the procedure specified;
- h) the date of the test.

Annex A

Graphs for determination of St from R_B and R_∞

After determination of the values of R_B for each film and the mean value of R_∞ , refer to the graph in figure 1 to ascertain which of the larger scale graphs is appropriate. (This is indicated by the encircled number.)

In each of the graphs, St is plotted against R_B for a range of values of R_∞ , which are recorded on each curve. An example of the use of these graphs is given in annex C.

Annex B

Table of values of reflectivity R_∞ and factor α

| R_∞ | Factor α | R_∞ | Factor α | R_∞ | Factor α | R_∞ | Factor α |
|------------|-----------------|------------|-----------------|------------|-----------------|------------|-----------------|
| 0,125 | 1 352,1 | 0,455 | 391,3 | 0,630 | 249,4 | 0,805 | 151,4 |
| 0,150 | 1 153,1 | 0,460 | 386,3 | 0,635 | 246,2 | 0,810 | 149,0 |
| 0,175 | 1 006,5 | 0,465 | 381,2 | 0,640 | 243,0 | 0,815 | 146,6 |
| 0,200 | 893,1 | 0,470 | 376,3 | 0,645 | 239,8 | 0,820 | 144,1 |
| 0,225 | 802,3 | 0,475 | 371,4 | 0,650 | 236,6 | 0,825 | 141,9 |
| 0,250 | 727,6 | 0,480 | 366,7 | 0,655 | 233,5 | 0,830 | 139,5 |
| 0,275 | 664,8 | 0,485 | 361,9 | 0,660 | 230,5 | 0,835 | 137,2 |
| 0,300 | 611,0 | 0,490 | 357,3 | 0,665 | 227,4 | 0,840 | 135,0 |
| 0,310 | 591,6 | 0,495 | 352,7 | 0,670 | 224,3 | 0,845 | 132,7 |
| 0,320 | 573,2 | 0,500 | 348,3 | 0,675 | 221,3 | 0,850 | 130,4 |
| 0,330 | 555,2 | 0,505 | 343,8 | 0,680 | 218,4 | 0,855 | 128,2 |
| 0,335 | 546,8 | 0,510 | 339,4 | 0,685 | 215,4 | 0,860 | 126,0 |
| 0,340 | 538,8 | 0,515 | 335,1 | 0,690 | 212,5 | 0,865 | 123,8 |
| 0,345 | 530,9 | 0,520 | 330,8 | 0,695 | 209,6 | 0,870 | 121,7 |
| 0,350 | 523,2 | 0,525 | 326,7 | 0,700 | 206,7 | 0,875 | 119,6 |
| 0,355 | 515,5 | 0,530 | 322,5 | 0,705 | 203,8 | 0,880 | 117,4 |
| 0,360 | 508,0 | 0,535 | 318,4 | 0,710 | 201,0 | 0,885 | 115,4 |
| 0,365 | 500,7 | 0,540 | 314,4 | 0,715 | 198,2 | 0,890 | 113,3 |
| 0,370 | 493,5 | 0,545 | 310,5 | 0,720 | 195,3 | 0,895 | 111,3 |
| 0,375 | 486,6 | 0,550 | 306,5 | 0,725 | 192,6 | 0,900 | 109,4 |
| 0,380 | 479,7 | 0,555 | 302,6 | 0,730 | 189,9 | 0,905 | 107,5 |
| 0,385 | 473,0 | 0,560 | 298,9 | 0,735 | 187,2 | 0,910 | 105,5 |
| 0,390 | 466,4 | 0,565 | 295,0 | 0,740 | 184,6 | 0,915 | 103,7 |
| 0,395 | 459,9 | 0,570 | 291,2 | 0,745 | 181,8 | 0,920 | 101,9 |
| 0,400 | 453,6 | 0,575 | 287,5 | 0,750 | 179,2 | 0,925 | 100,2 |
| 0,405 | 447,4 | 0,580 | 283,8 | 0,755 | 176,6 | 0,930 | 98,5 |
| 0,410 | 441,4 | 0,585 | 280,3 | 0,760 | 174,0 | 0,935 | 96,9 |
| 0,415 | 435,4 | 0,590 | 276,7 | 0,765 | 171,4 | 0,940 | 95,4 |
| 0,420 | 429,5 | 0,595 | 273,2 | 0,770 | 168,8 | 0,945 | 93,9 |
| 0,425 | 423,4 | 0,600 | 269,6 | 0,775 | 166,3 | 0,950 | 92,5 |
| 0,430 | 418,0 | 0,605 | 266,2 | 0,780 | 163,8 | 0,955 | 91,3 |
| 0,435 | 412,6 | 0,610 | 262,8 | 0,785 | 161,2 | 0,960 | 90,0 |
| 0,440 | 407,1 | 0,615 | 259,4 | 0,790 | 158,7 | 0,965 | 88,9 |
| 0,445 | 401,8 | 0,620 | 256,0 | 0,795 | 156,3 | 0,970 | 88,0 |
| 0,450 | 396,5 | 0,625 | 252,7 | 0,800 | 153,9 | 0,975 | 87,2 |

Annex C

Examples of the calculation of hiding power from measurements of R_B and R_∞

C.1 Determination of the scattering coefficient, S

C.1.1 Determine St from the appropriate graph relating R_B , R_∞ and St . For example, for a white paint with $R_B = 0,78$ and $R_\infty = 0,92$, reference to the graph in figure 1 indicates that the large scale graph required is that in figure 12. The intersection of the relevant lines gives $St = 3,70$.

C.1.2 Divide St by t (for example $18,7 \mu\text{m}$; the scattering coefficient, S , is thus $0,198 \mu\text{m}^{-1}$).

C.2 Determination of hiding power, V

C.2.1 Refer to the table in annex B to obtain the value of α for the determined value of R_∞ . For $R_\infty = 0,92$, $\alpha = 101,9$. Therefore,

$$V = \alpha S = 20,2 \text{ m}^2/\text{l}$$

C.2.2 If tables and graphs are not available, the calculations may be carried out as follows.

C.2.2.1 Determine a and b from R_∞ , using equations (1) and (2), as follows :

$$a = \frac{1}{2} \left(R_\infty + \frac{1}{R_\infty} \right) = \frac{1}{2} (0,92 + 1,086 96) = 1,003 48$$

$$b = a - R_\infty = 1,003 48 - 0,92 = 0,083 48$$

C.2.2.2 Determine S from R_B and R_∞ , using equation (7), as follows

$$\begin{aligned} St &= \frac{1}{b} \operatorname{arccoth} \left(\frac{1 - aR_B}{bR_B} \right) \\ &= \frac{1}{0,083 48} \operatorname{arccoth} \left[\frac{1 - (1,003 48 \times 0,78)}{0,083 48 \times 0,78} \right] \\ &= \frac{1}{0,083 48} \operatorname{arccoth} \left(\frac{0,217 29}{0,065 11} \right) \\ &= \frac{1}{0,083 48} \operatorname{arccoth} 3,337 2 \\ &= \frac{0,309 1}{0,083 48} = 3,703 \end{aligned}$$

Using the value of t taken for the example in C.1.2, i.e. $18,7 \mu\text{m}$,

$$S = \frac{3,703}{18,7} = 0,198 \mu\text{m}^{-1}$$

as in C.1.2.

C.2.2.3 Determine $t_{0,98}$ using equation (5), as follows

$$t_{0,98} = \frac{1}{0,083\ 48 \times 0,198} \operatorname{arccoth} \left(\frac{0,02 + \sqrt{D}}{1,568 \times 0,083\ 48} \right)$$

Calculate D as follows

$$\begin{aligned} D &= 3,136 \times 1,003\ 48 \times \{ 1 - 0,98 [1 - (0,8 \times 1,003\ 48)] \} - 2,508\ 4 \\ &= 0,030\ 3 \end{aligned}$$

Therefore

$$\sqrt{D} = 0,174\ 1$$

and

$$\begin{aligned} t_{0,98} &= \frac{1}{0,016\ 53} \operatorname{arccoth} \left(\frac{0,02 + 0,174\ 1}{1,568 \times 0,083\ 48} \right) = \frac{\operatorname{arccoth}\ 1,483}{0,016\ 53} \\ &= \frac{0,818}{0,016\ 53} = 49,48\ \mu\text{m} \end{aligned}$$

C.2.2.4 Determine V using equation (6), as follows

$$V = \frac{1\ 000}{49,48} = 20,2\ \text{m}^2/\text{l}$$

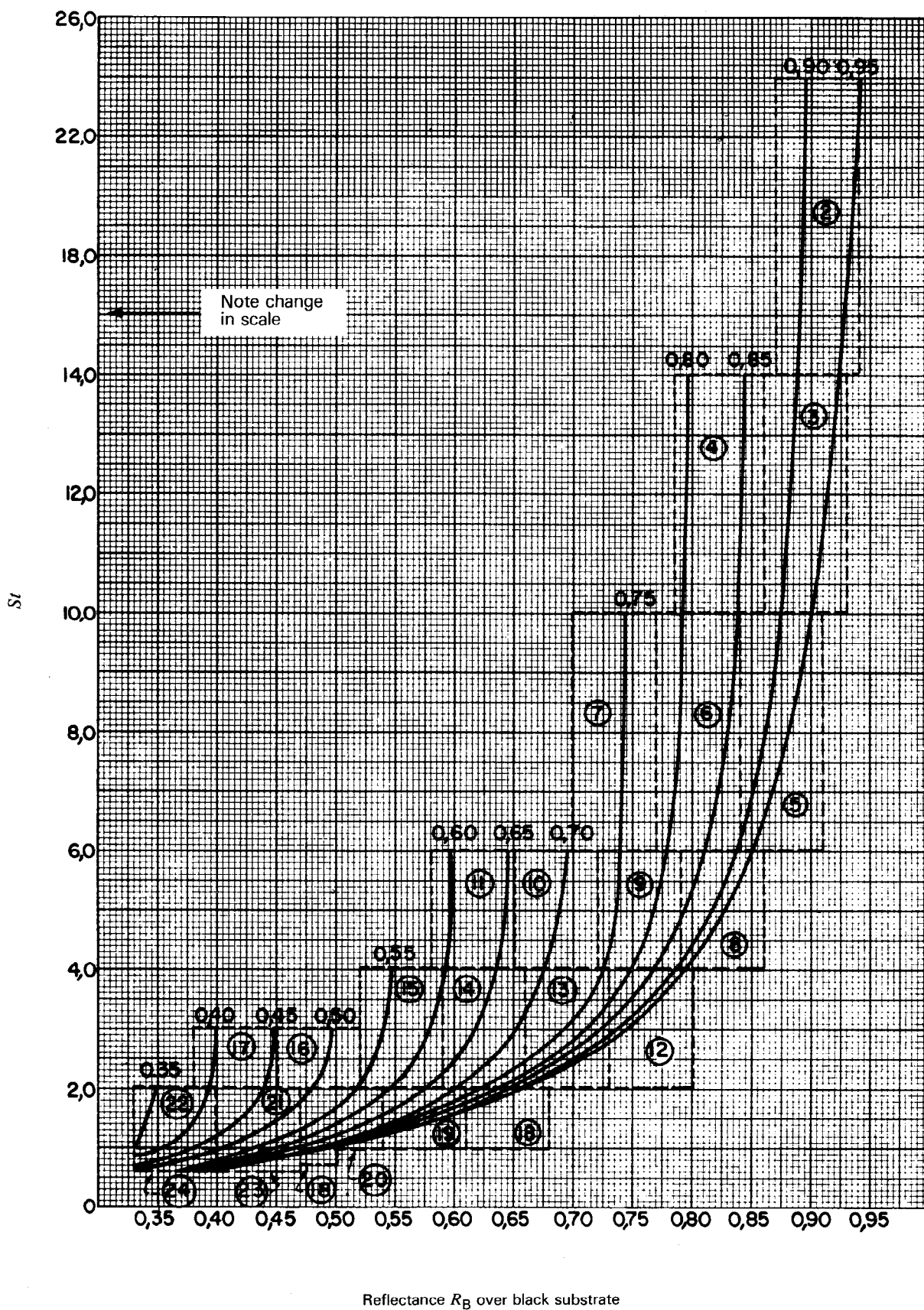


Figure 1 — Index graph for determination of S_t from values of R_B and R_∞

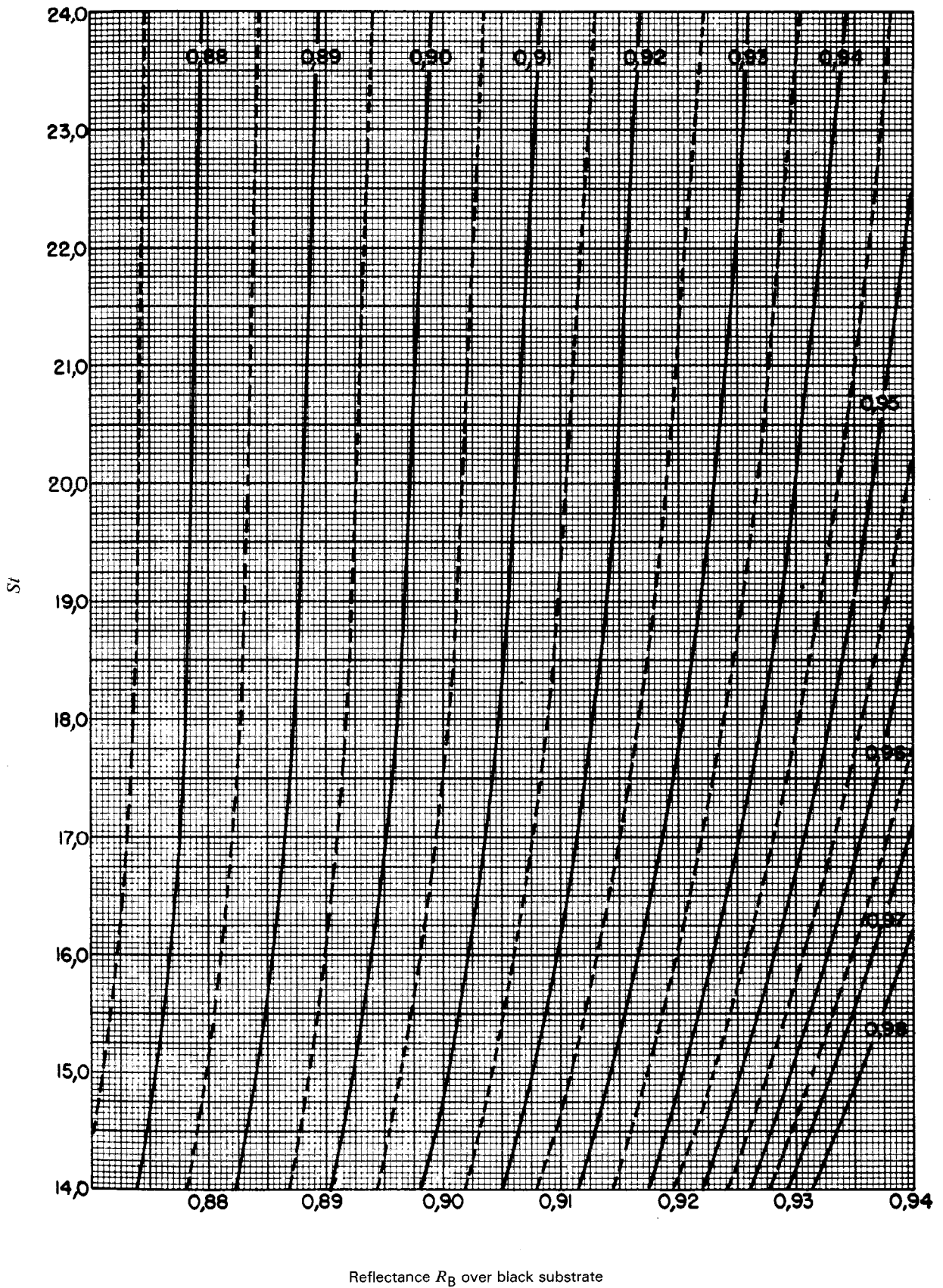


Figure 2 — Values of St for the ranges
 $0.87 \leq R_B \leq 0.94$
 $0.88 \leq R_\infty \leq 0.98$

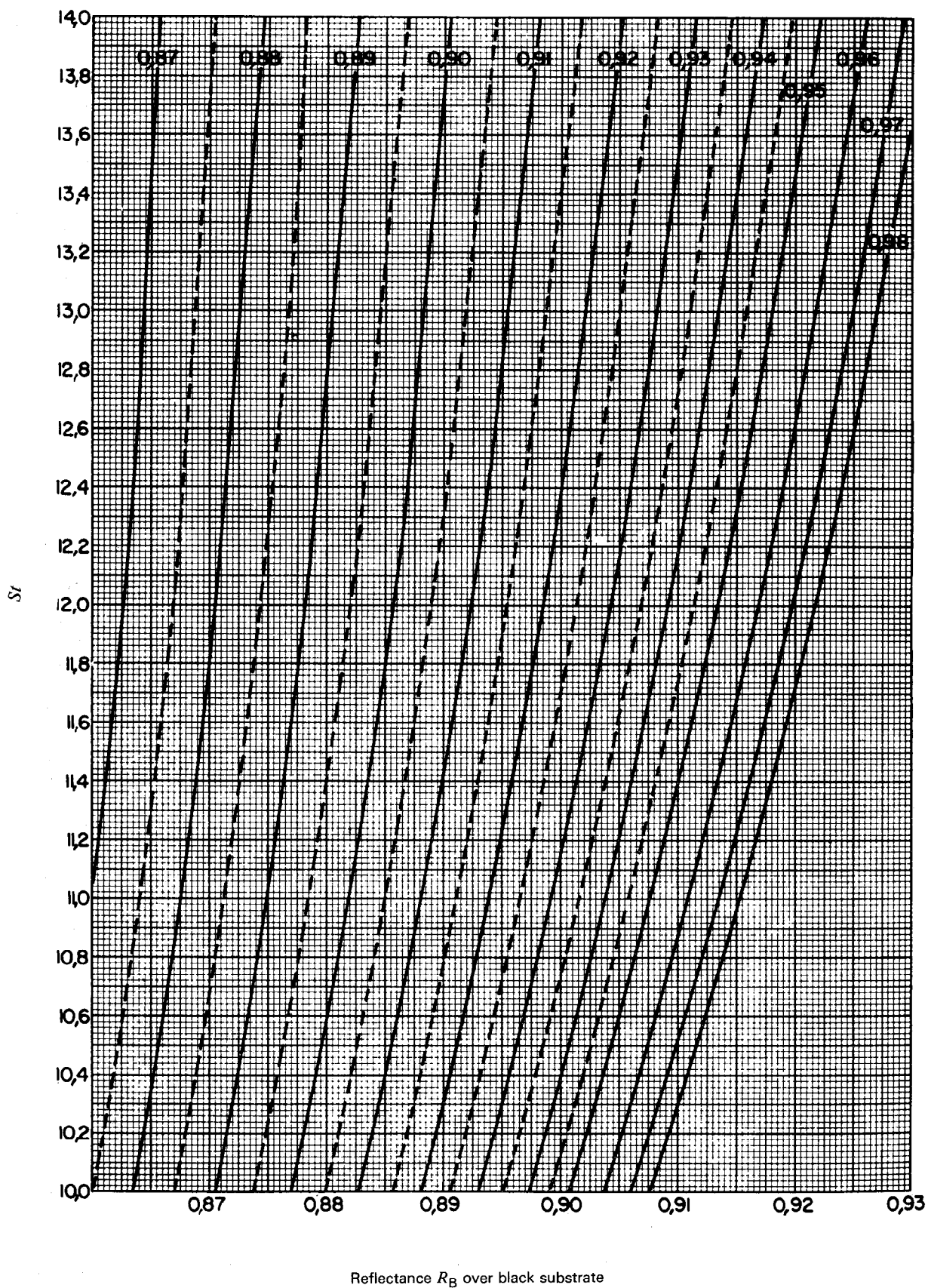


Figure 3 — Values of St for the ranges
 $0.86 \leq R_B \leq 0.93$
 $0.87 \leq R_\infty \leq 0.98$

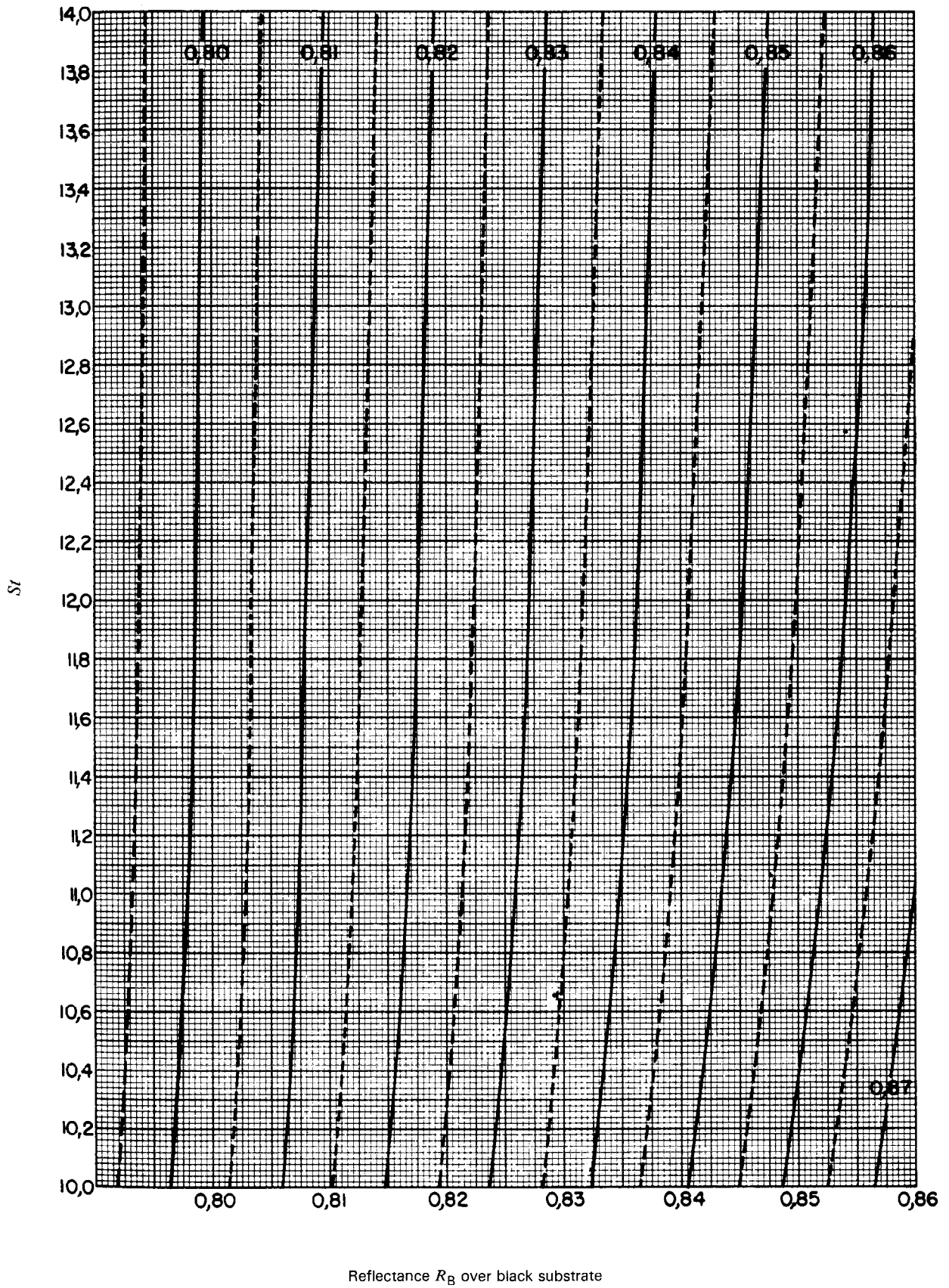


Figure 4 – Values of S_T for the ranges
 $0,79 \leq R_B \leq 0,86$
 $0,80 \leq R_\infty \leq 0,86$

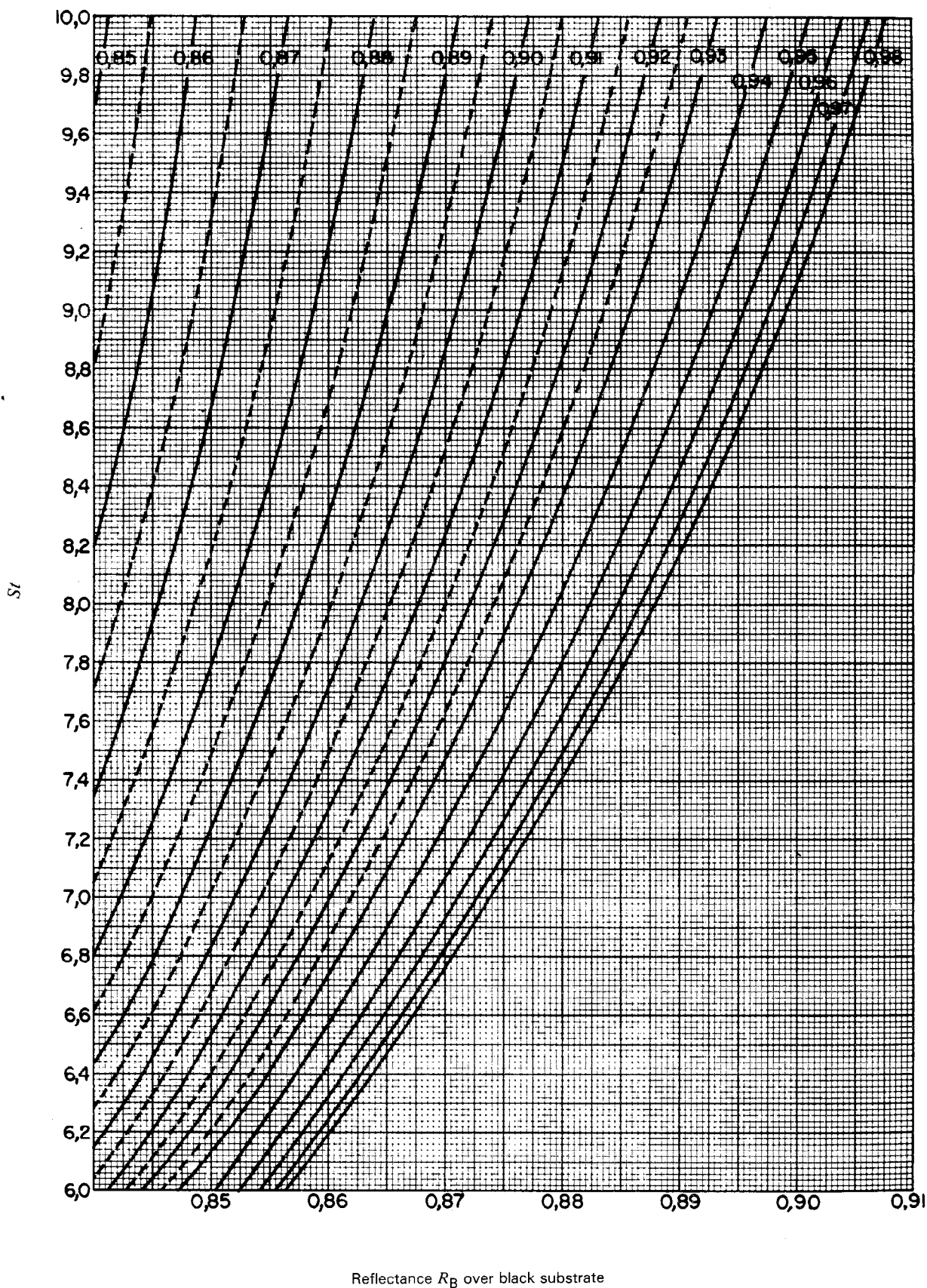


Figure 5 — Values of St for the ranges
 $0,84 \leq R_B \leq 0,91$
 $0,85 \leq R_\infty \leq 0,98$

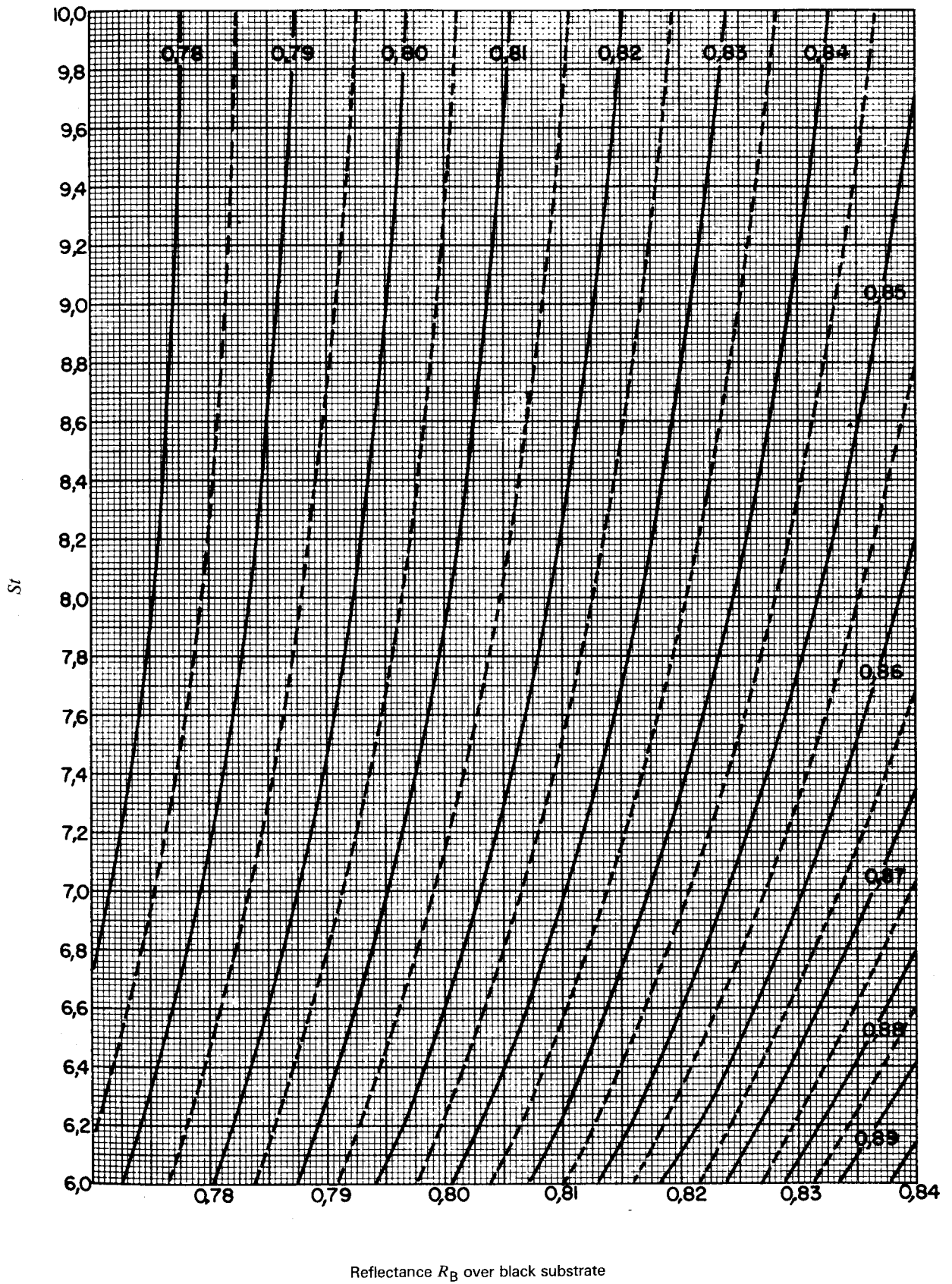


Figure 6 — Values of S_r for the ranges
 $0.77 < R_B < 0.84$
 $0.78 < R_\infty < 0.89$

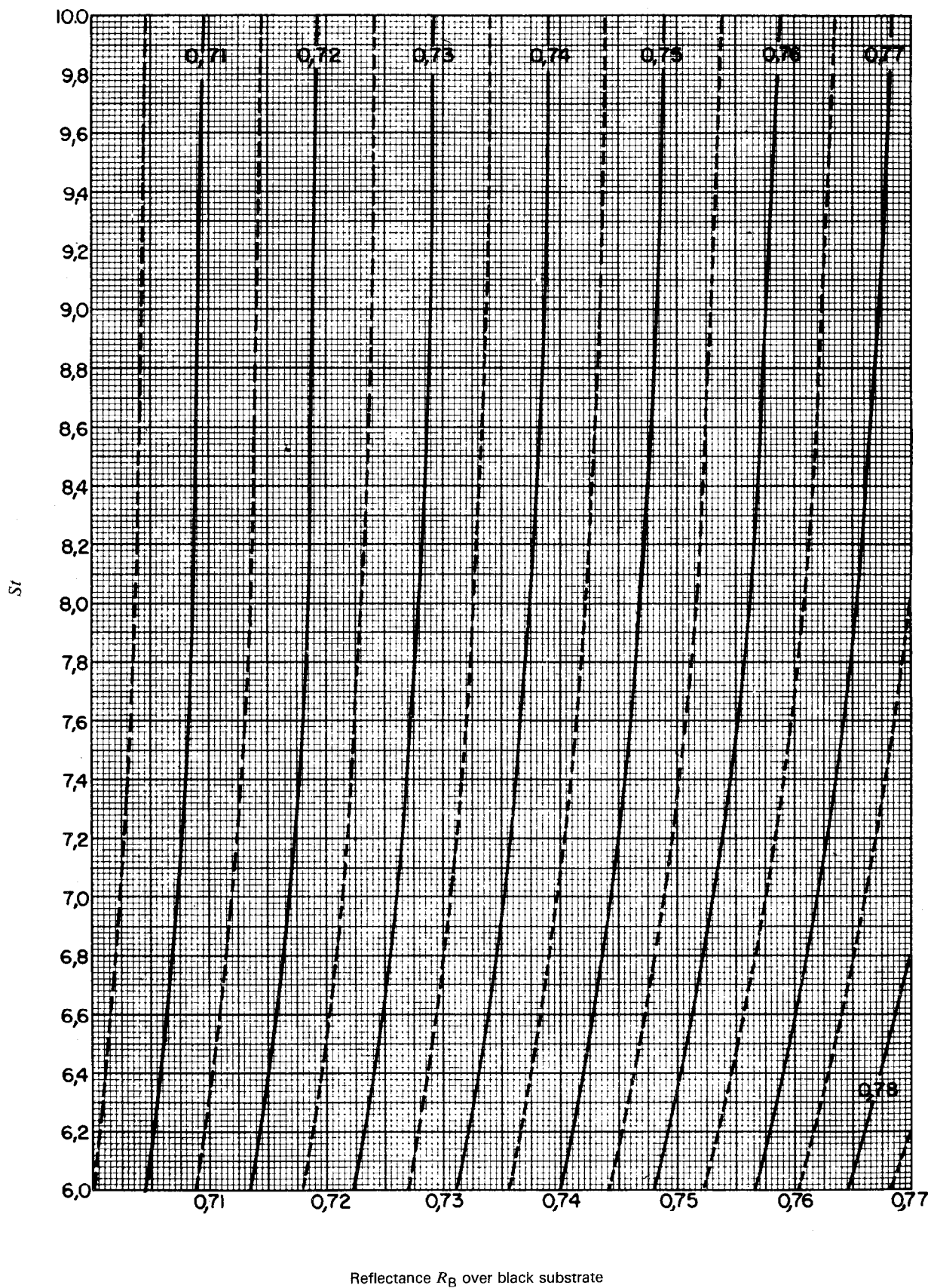


Figure 7 – Values of S_I for the ranges
 $0,70 < R_B < 0,77$
 $0,71 < R_\infty < 0,77$

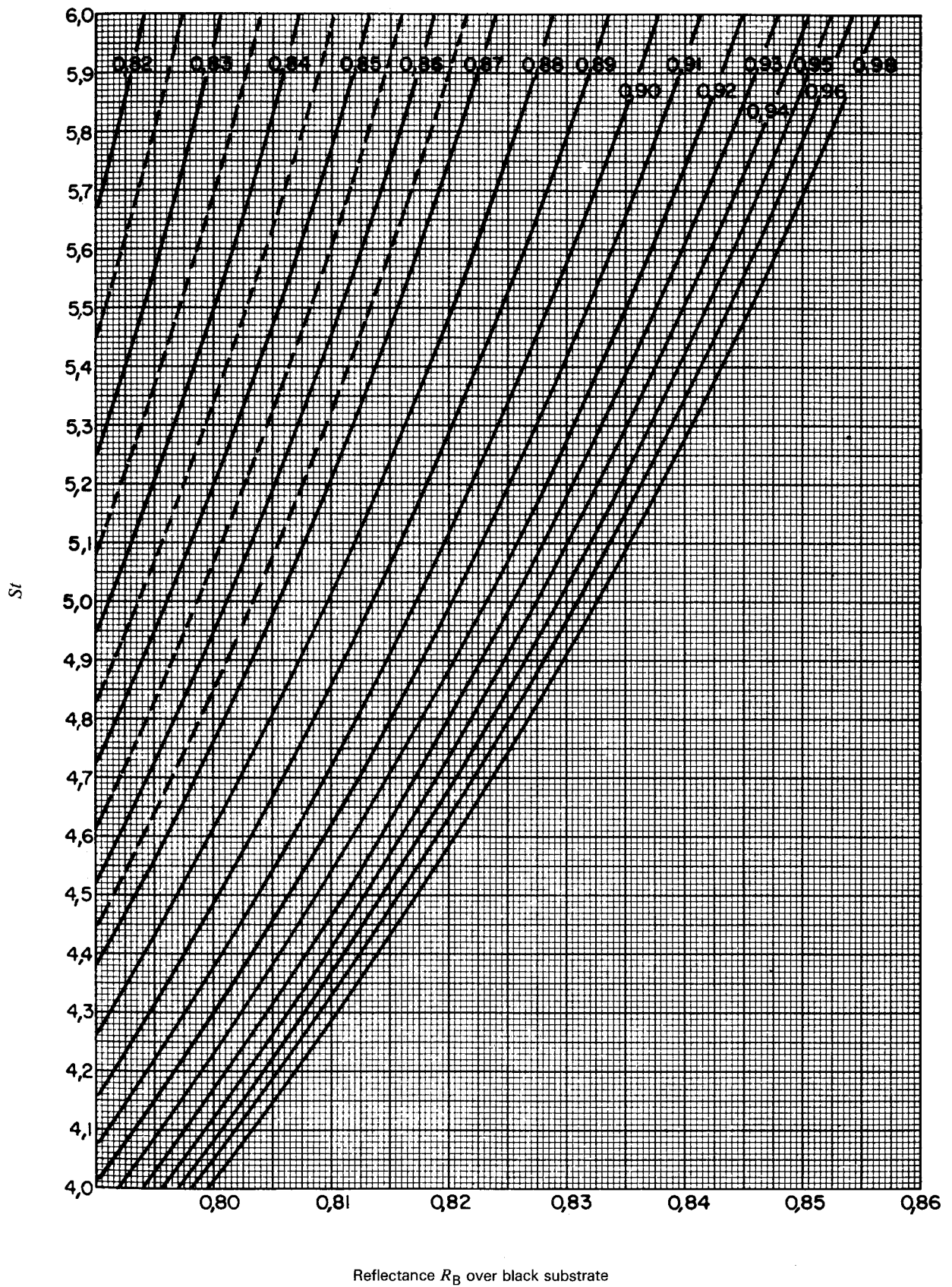


Figure 8 – Values of Sr for the ranges
 $0.79 \leq R_B \leq 0.86$
 $0.82 \leq R_\infty \leq 0.98$

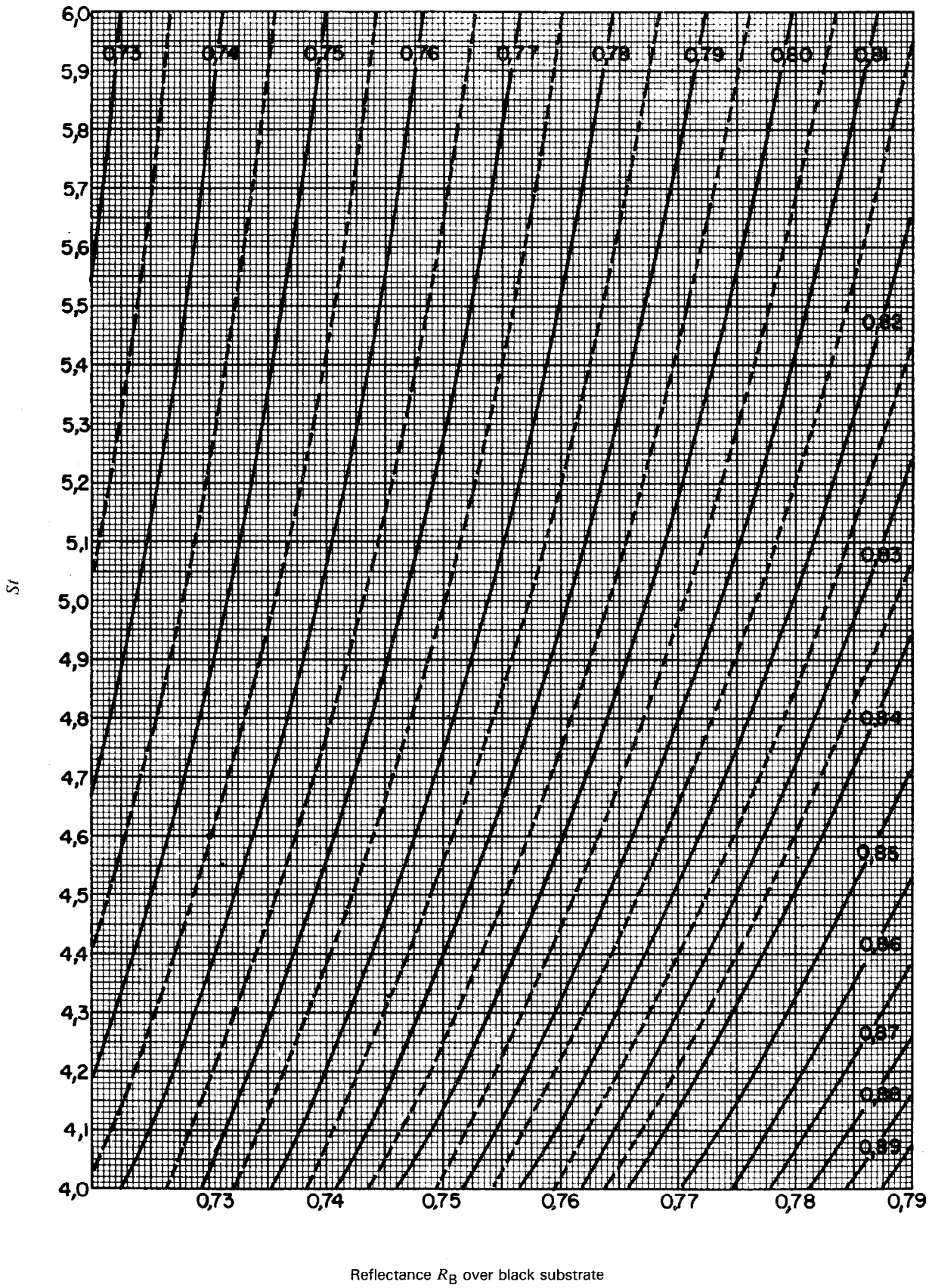


Figure 9 – Values of S_T for the ranges
 $0,72 \leq R_B \leq 0,79$
 $0,73 \leq R_\infty \leq 0,89$

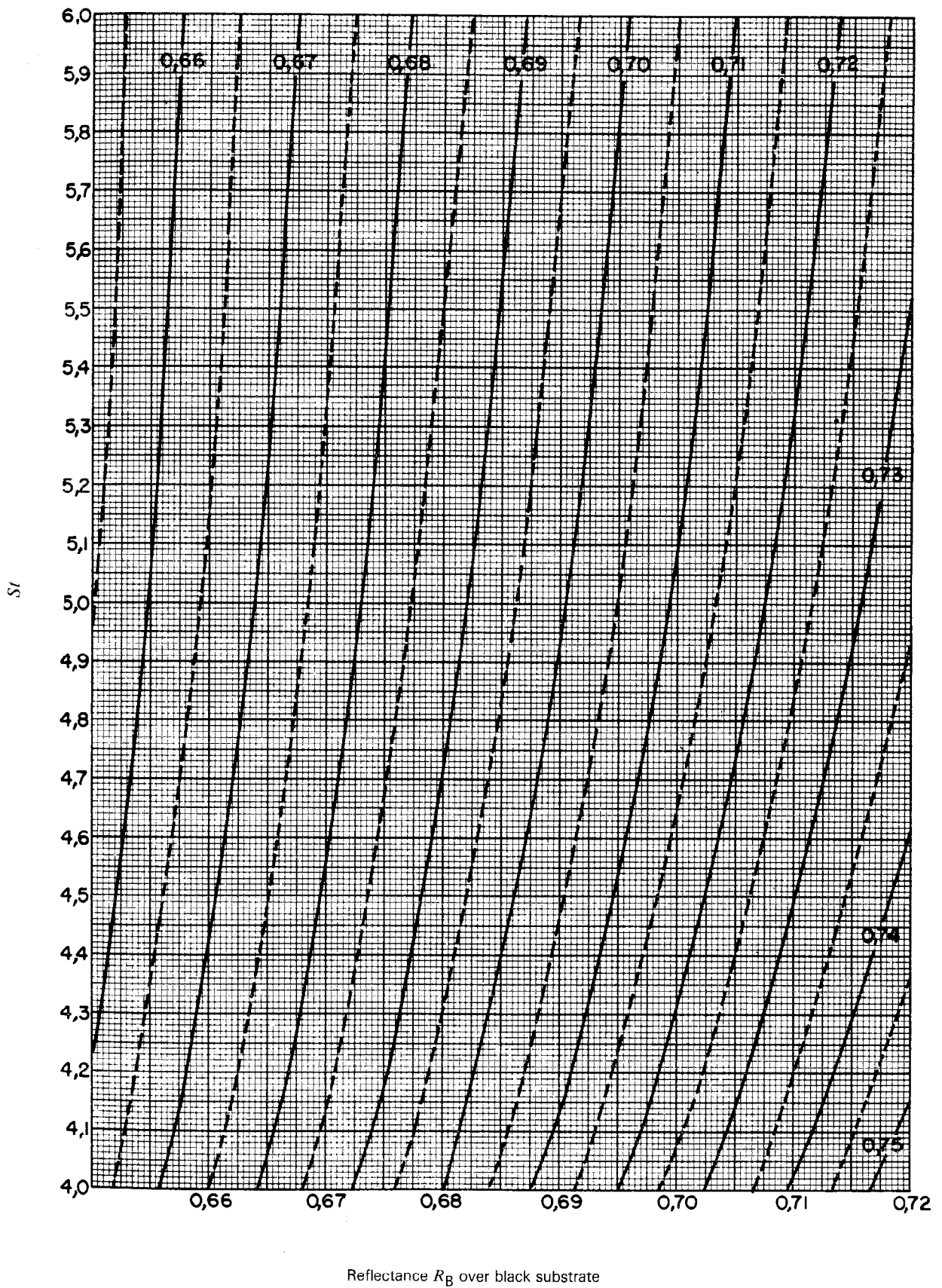
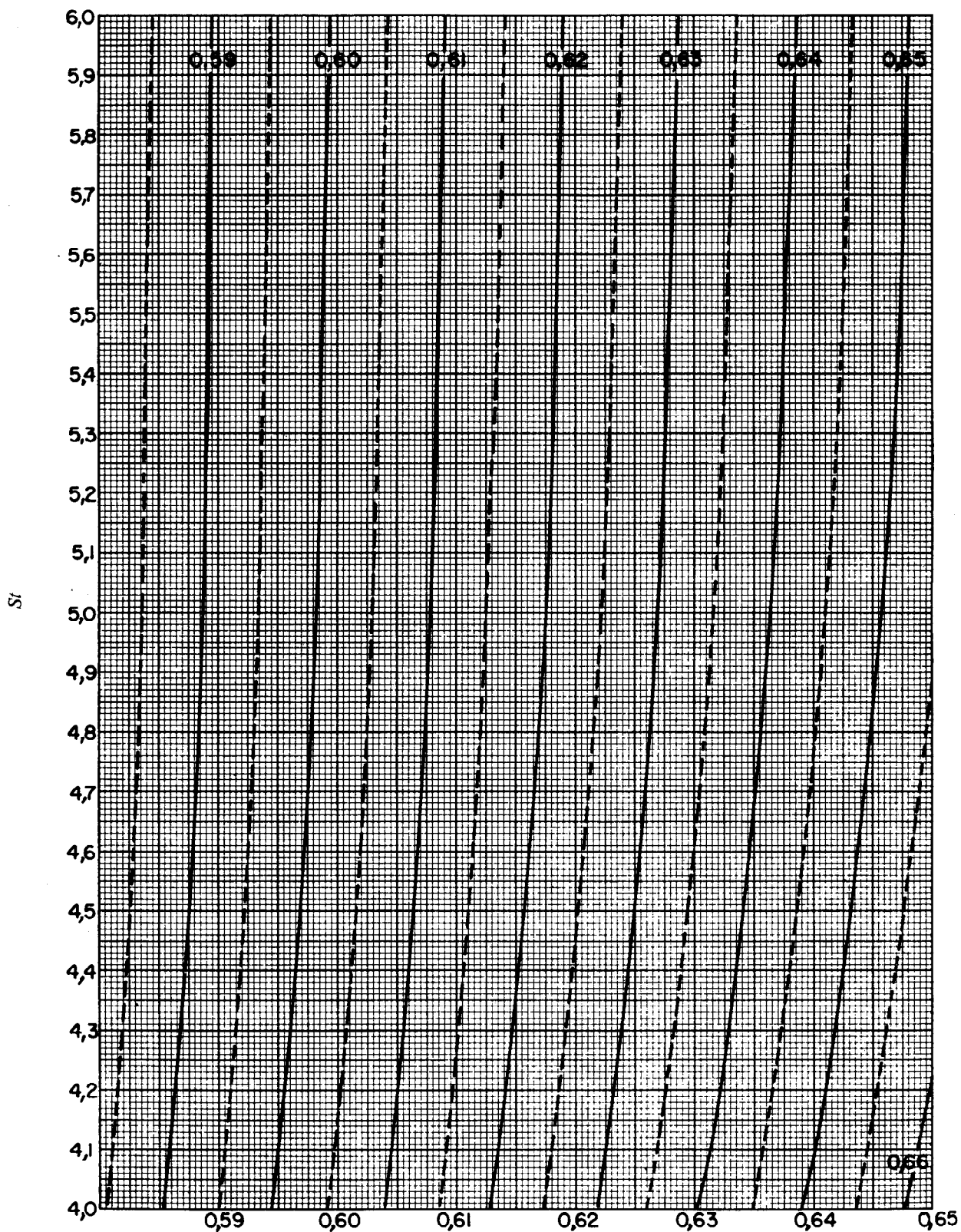


Figure 10 — Values of S_i for the ranges
 $0,65 \leq R_B \leq 0,72$
 $0,66 \leq R_\infty \leq 0,75$



Reflectance R_B over black substrate

Figure 11 — Values of S_t for the ranges
 $0,58 \leq R_B \leq 0,65$
 $0,59 \leq R_\infty \leq 0,66$

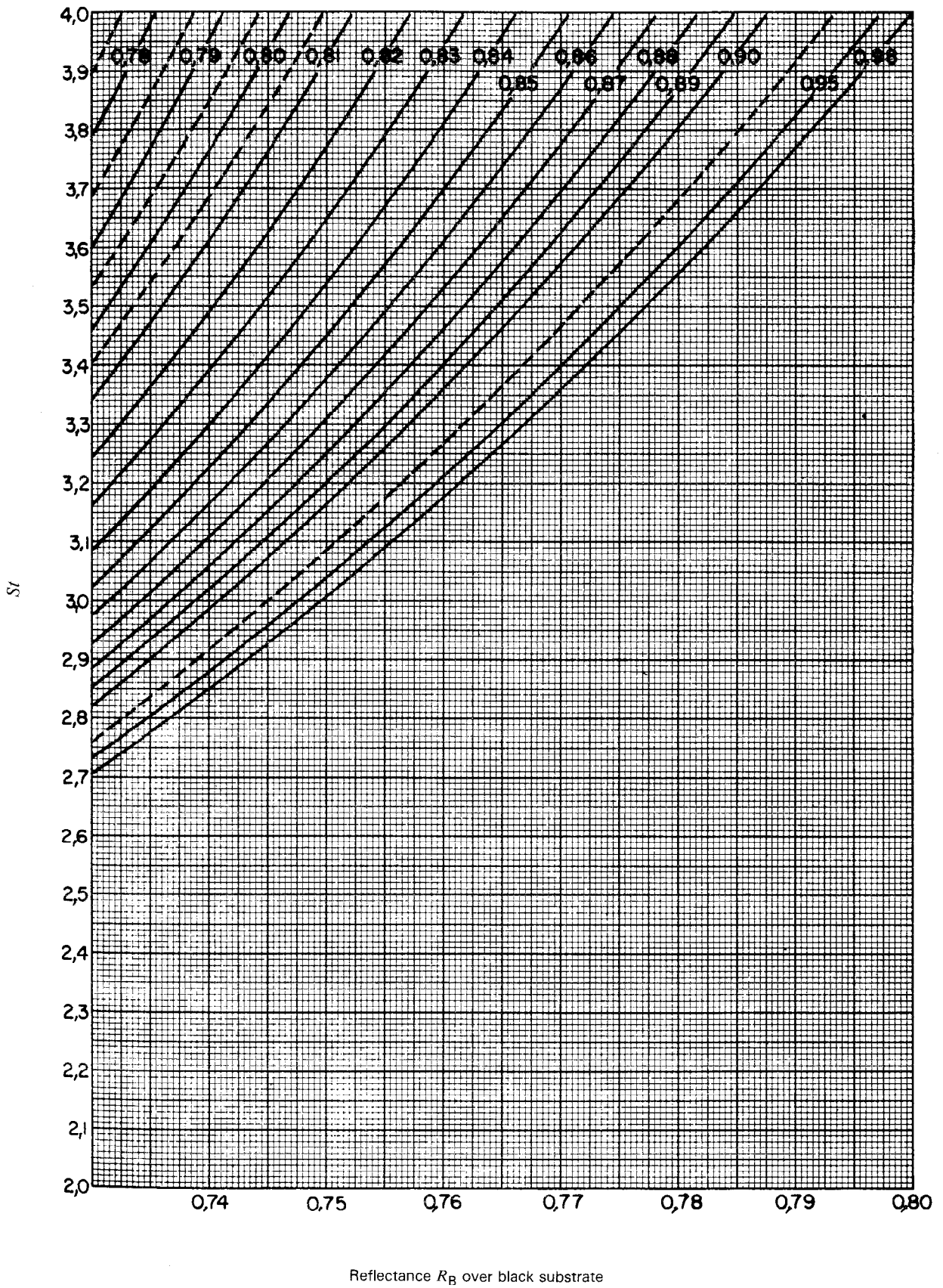


Figure 12 — Values of S_f for the ranges
 $0,73 \leq R_B \leq 0,80$
 $0,78 \leq R_\infty \leq 0,98$

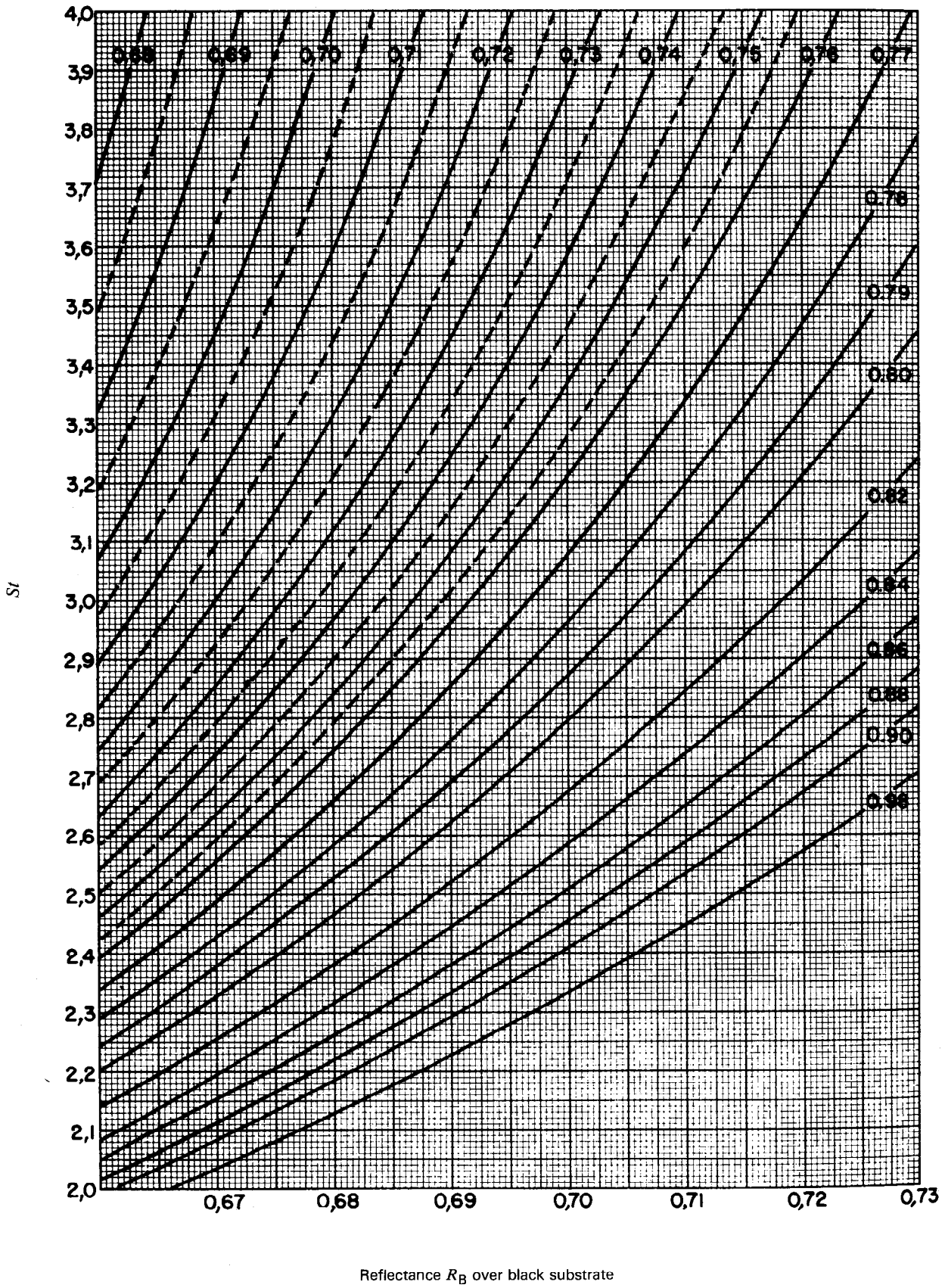


Figure 13 — Values of S_t for the ranges
 $0,66 \leq R_B \leq 0,73$
 $0,68 \leq R_\infty \leq 0,98$

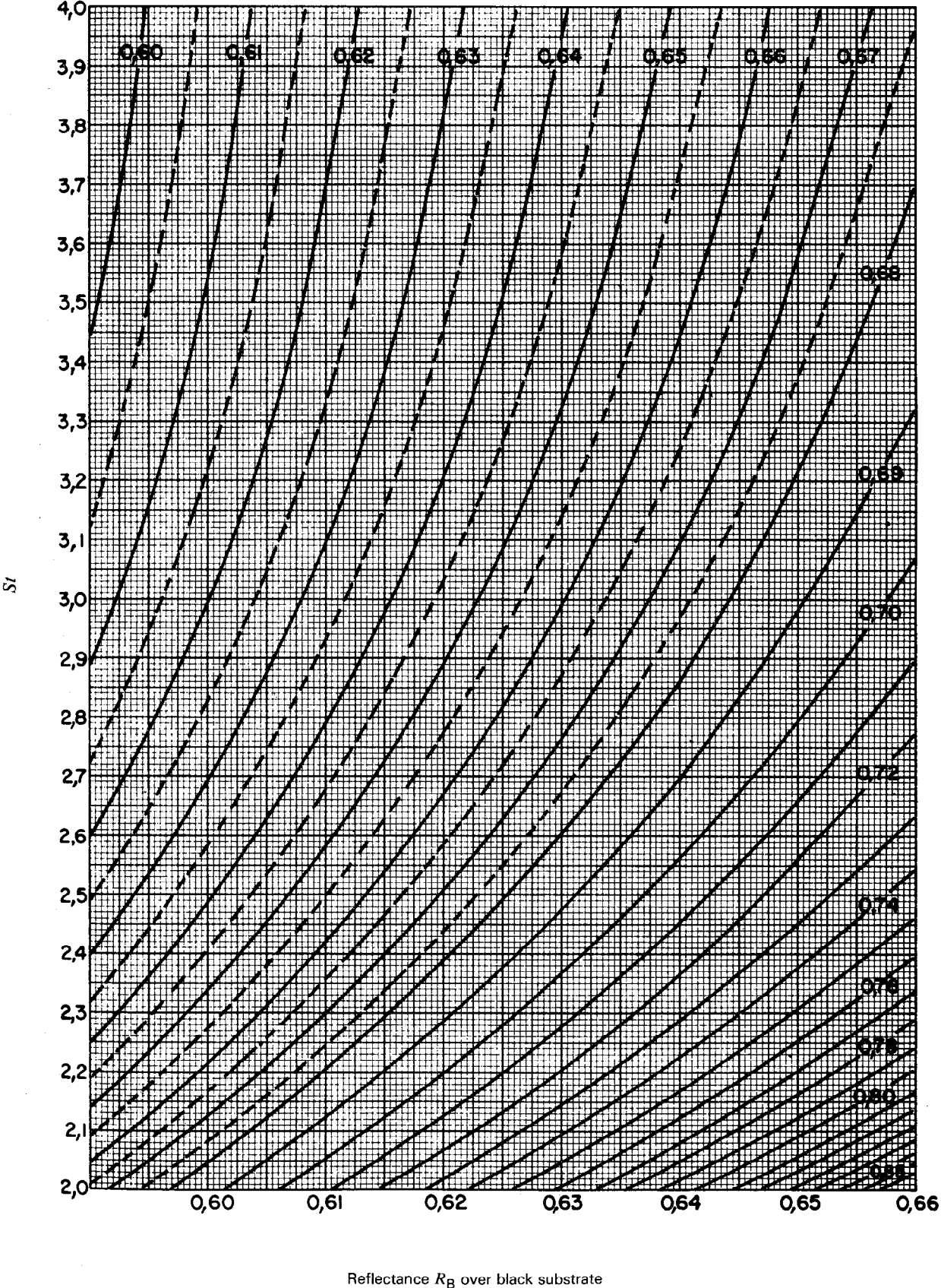


Figure 14 — Values of S_t for the ranges
 $0.59 \leq R_B \leq 0.66$
 $0.60 \leq R_\infty \leq 0.85$

Licensed copy: Lee Shau Kee Library, HKUST, Version correct as of 03/01/2015, (c) The British Standards Institution 2013

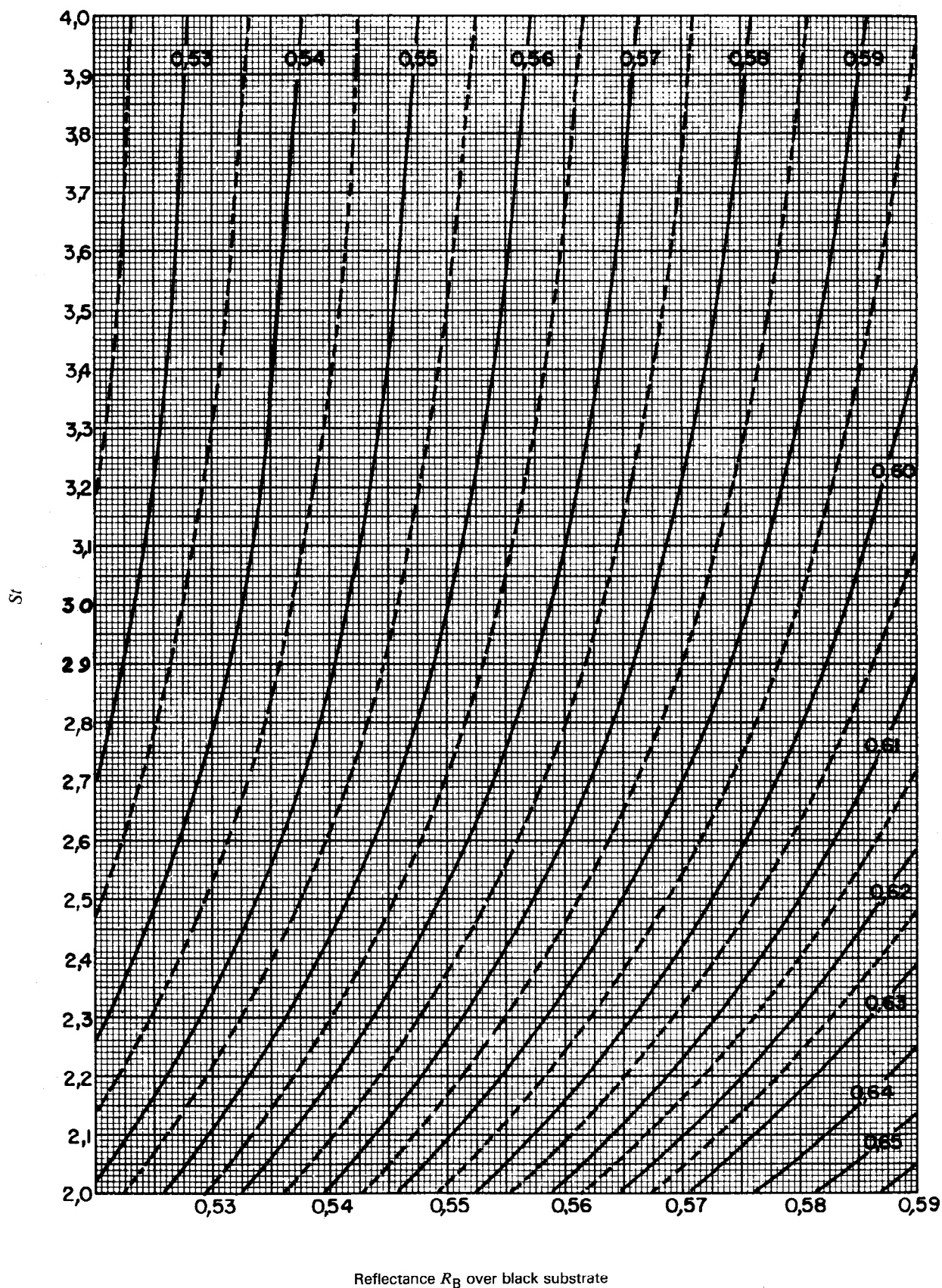
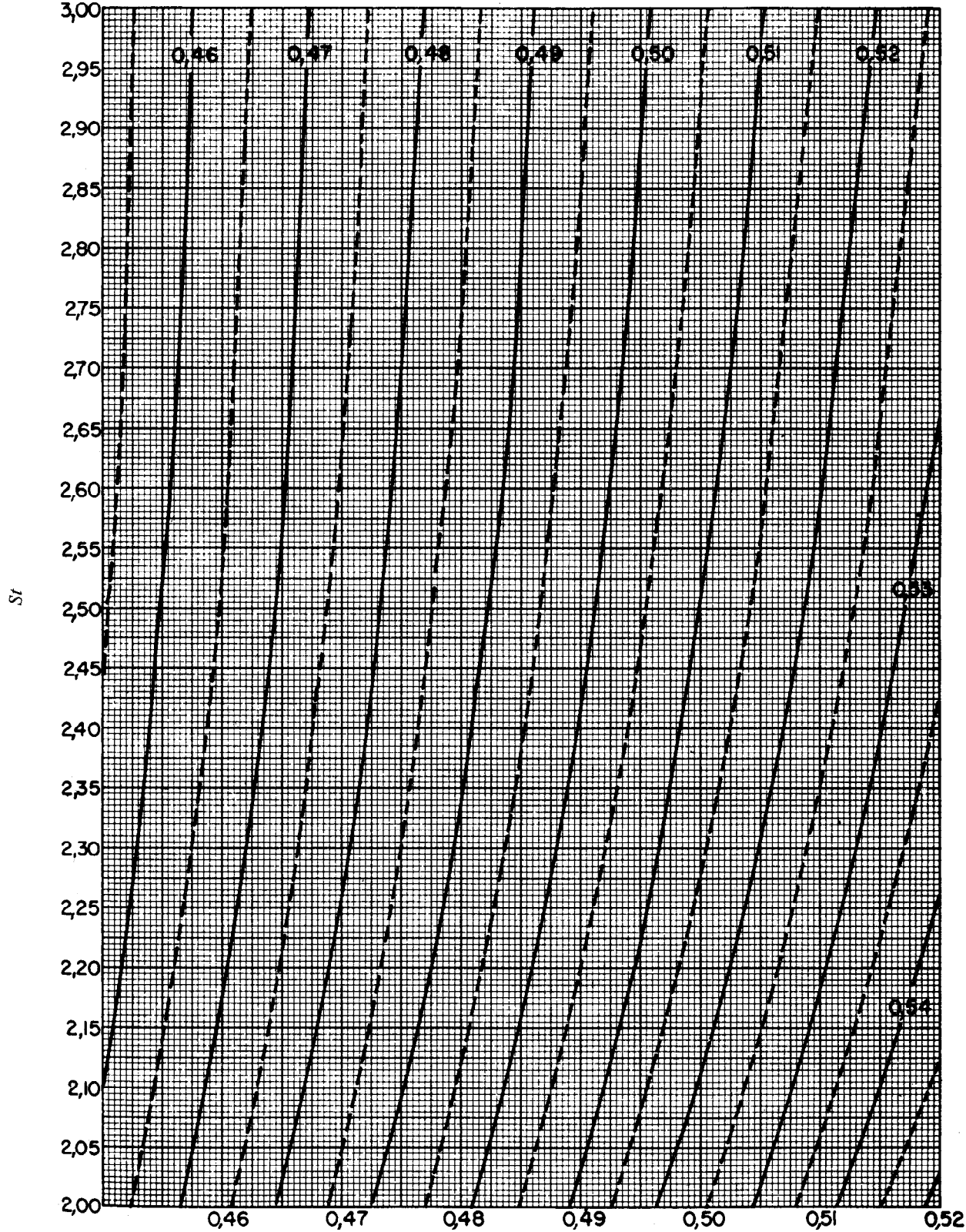


Figure 15 – Values of S_T for the ranges
 $0.52 < R_B < 0.59$
 $0.53 < R_\infty < 0.65$



Reflectance R_B over black substrate

Figure 16 — Values of S_t for the ranges
 $0.45 \leq R_B \leq 0.52$
 $0.46 \leq R_\infty \leq 0.54$

Licensed copy: Lee Shau Kee Library, HKUST, Version correct as of 03/01/2015, (c) The British Standards Institution 2013

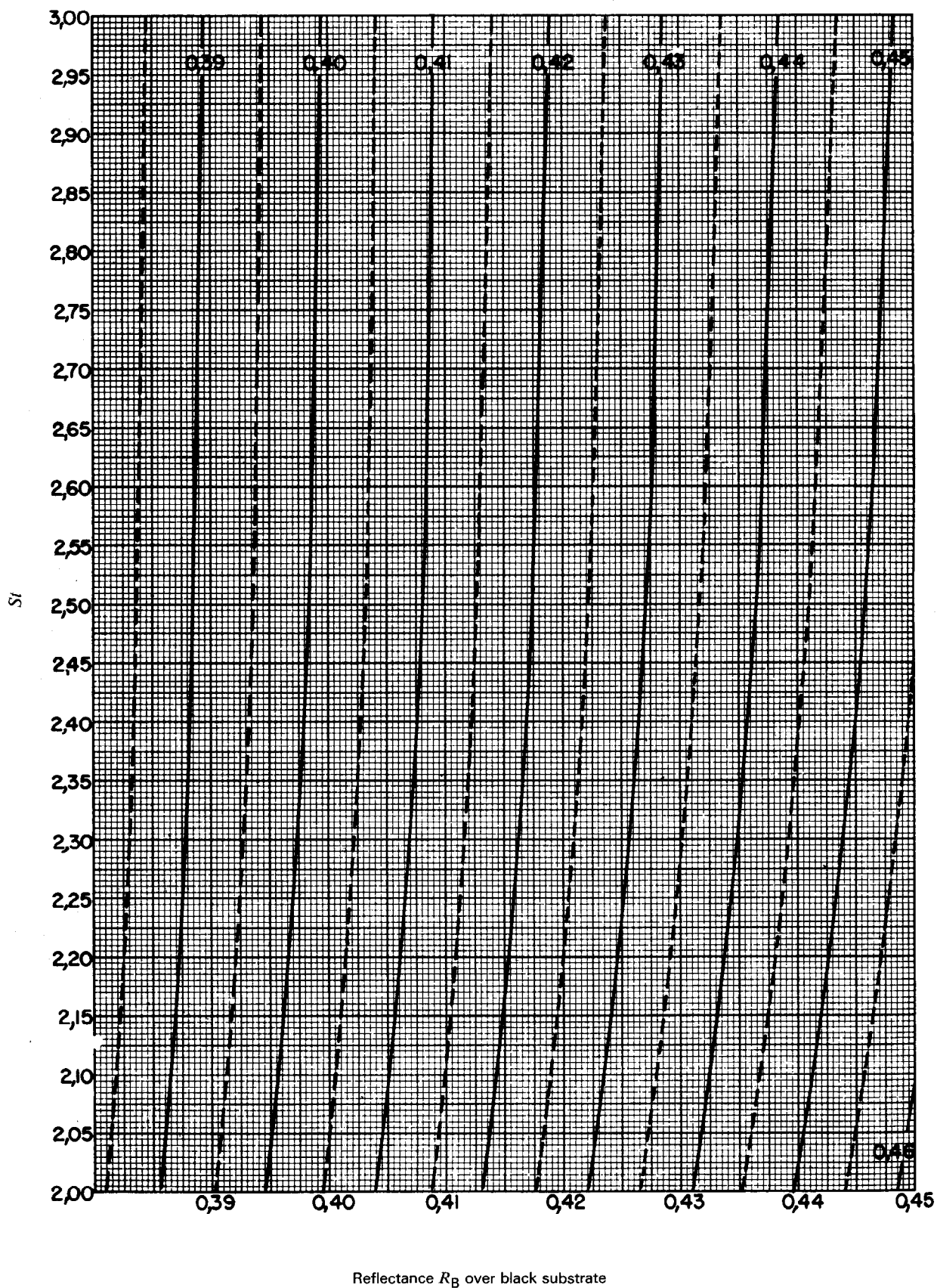


Figure 17 — Values of St for the ranges
 $0,38 \leq R_B \leq 0,45$
 $0,39 \leq R_\infty \leq 0,46$

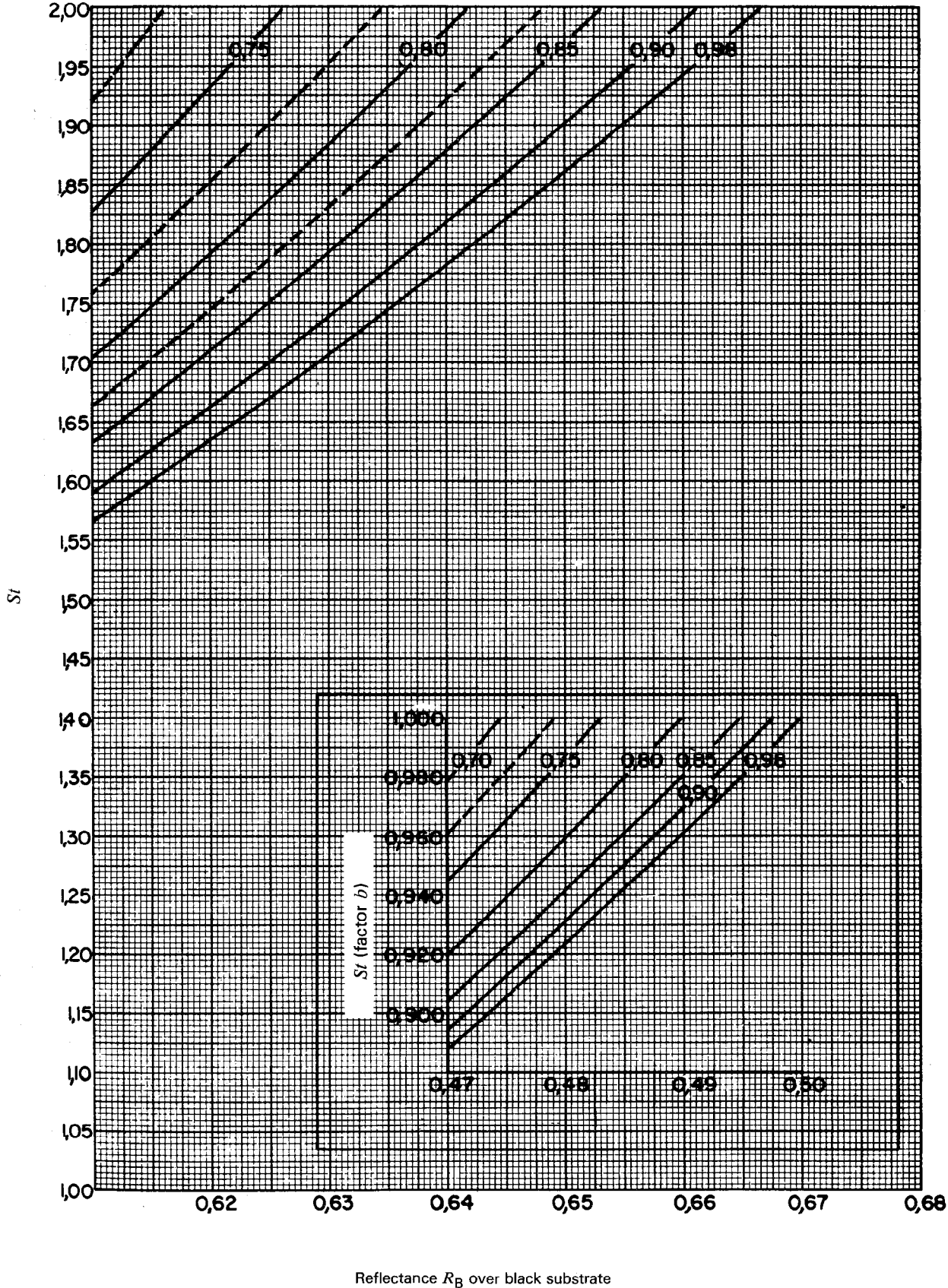


Figure 18 — Values of St for the ranges
 $0.61 \leq R_B \leq 0.68$ and $0.47 \leq R_B \leq 0.50$
 $0.75 \leq R_\infty \leq 0.98$ and $0.70 \leq R_\infty \leq 0.98$

Licensed copy: Lee Shau Kee Library, HKUST, Version correct as of 03/01/2015, (c) The British Standards Institution 2013

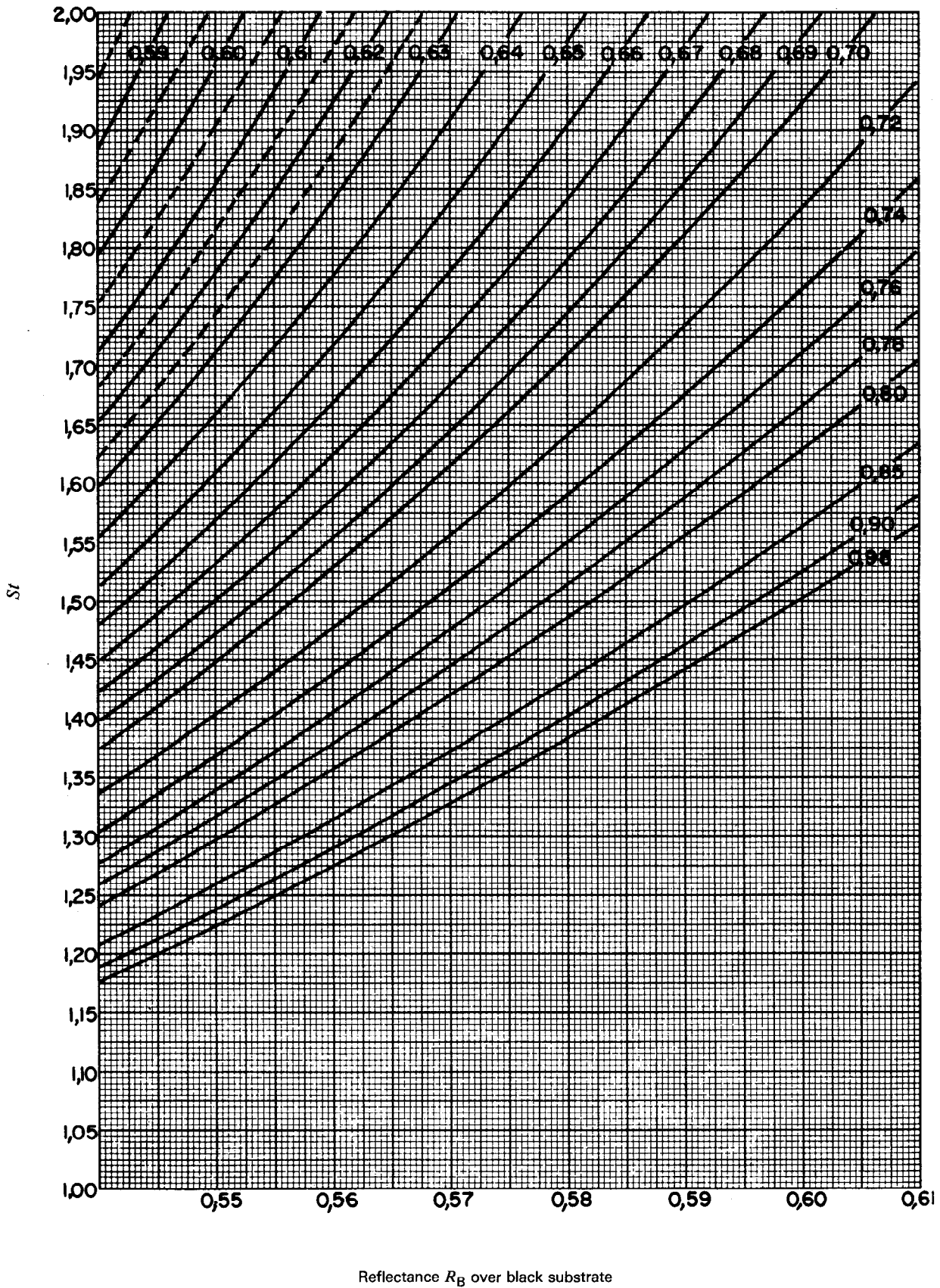


Figure 19 — Values of St for the ranges
 $0.54 \leq R_B \leq 0.61$
 $0.59 \leq R_\infty \leq 0.98$

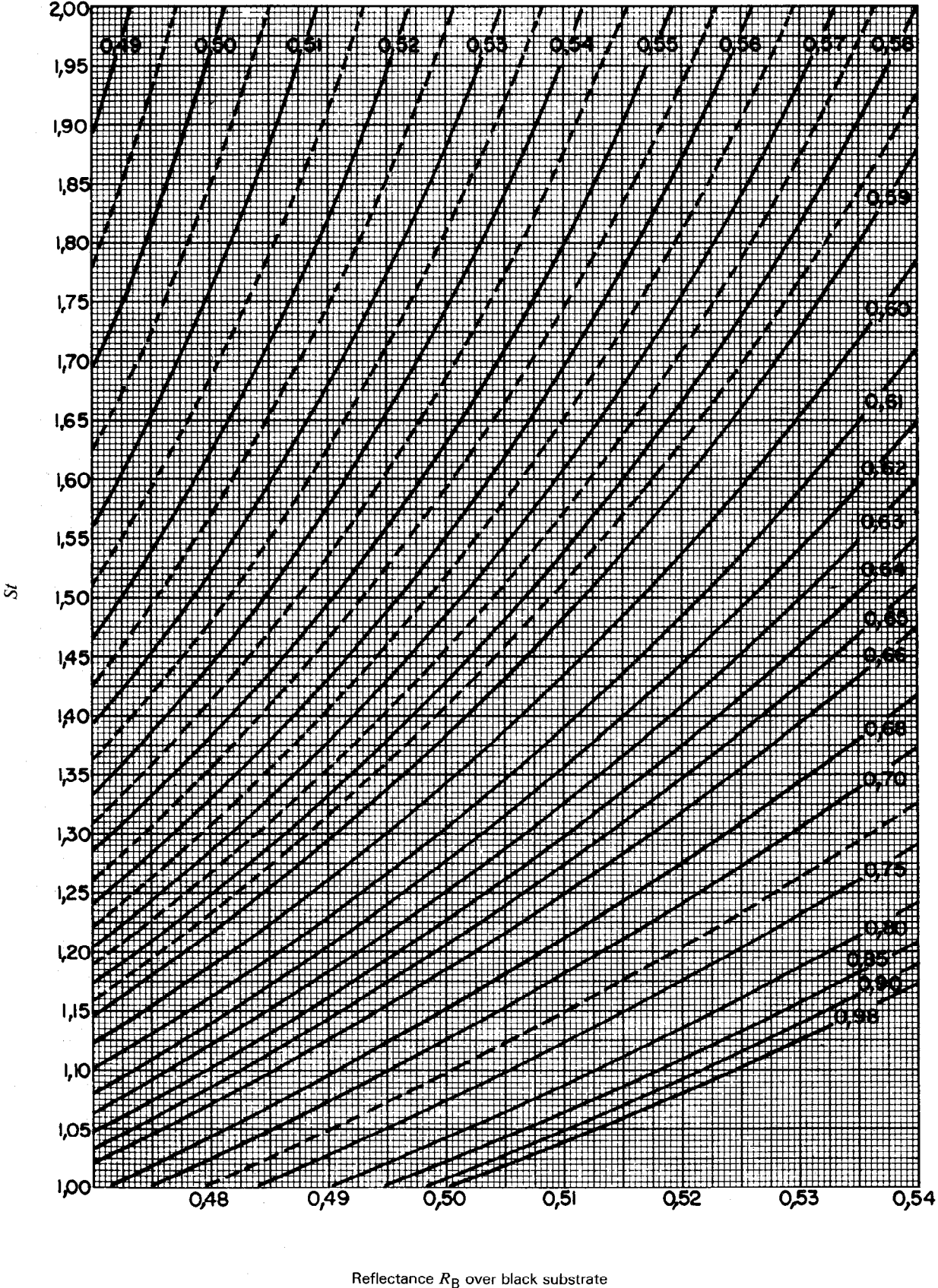


Figure 20 – Values of S_t for the ranges
 $0.47 \leq R_B \leq 0.54$
 $0.49 \leq R_\infty \leq 0.98$

Licensed copy: Lee Shau Kee Library, HKUST, Version correct as of 03/01/2015, (c) The British Standards Institution 2013

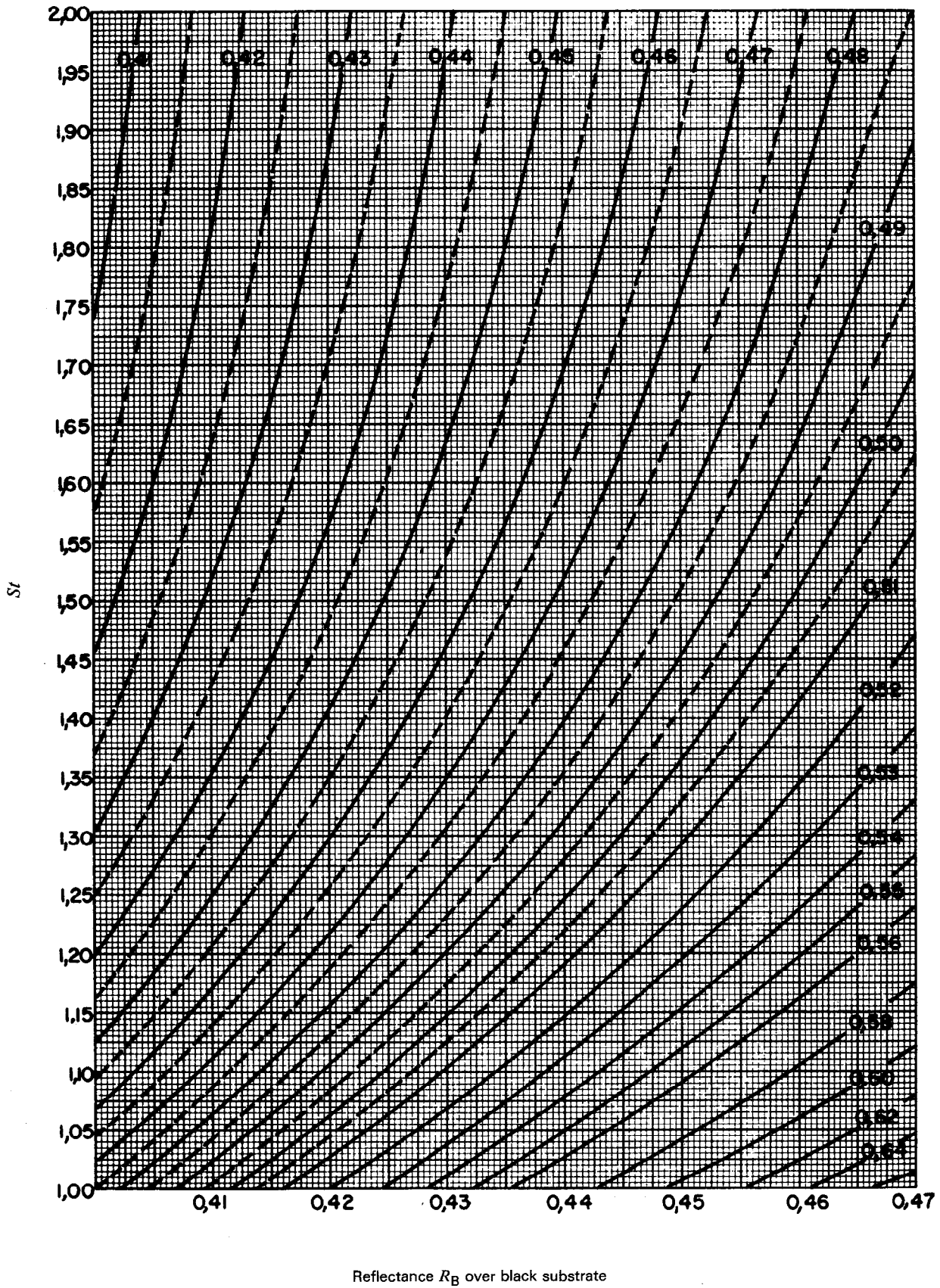


Figure 21 — Values of St for the ranges
 $0,40 \leq R_B \leq 0,47$
 $0,41 \leq R_\infty \leq 0,64$

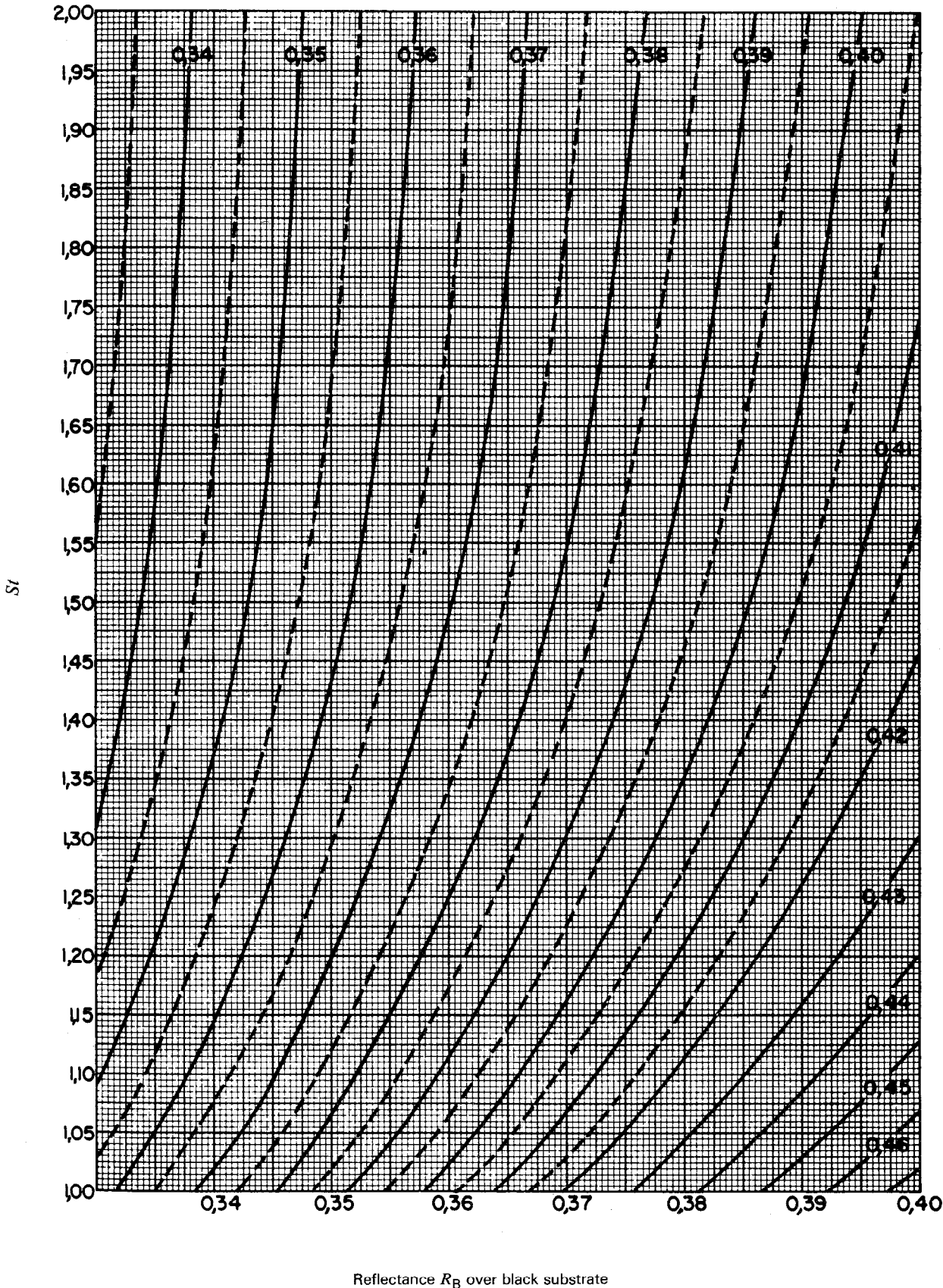


Figure 22 — Values of S_l for the ranges
 $0,33 \leq R_B \leq 0,40$
 $0,34 \leq R_\infty \leq 0,46$

Licensed copy: Lee Shau Kee Library, HKUST, Version correct as of 03/01/2015, (c) The British Standards Institution 2013

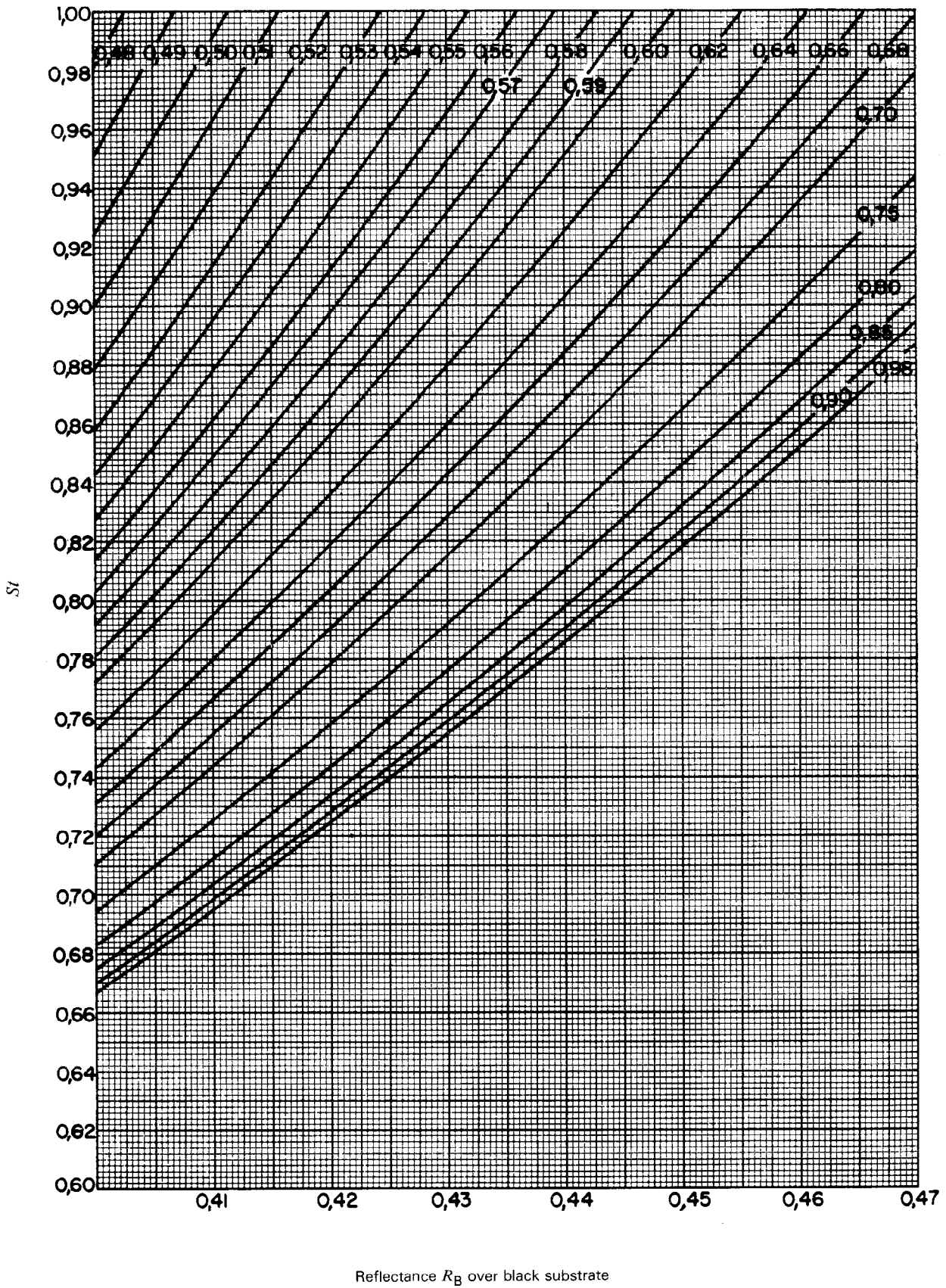


Figure 23 — Values of S_T for the ranges
 $0.40 \leq R_B \leq 0.47$
 $0.48 \leq R_\infty \leq 0.98$

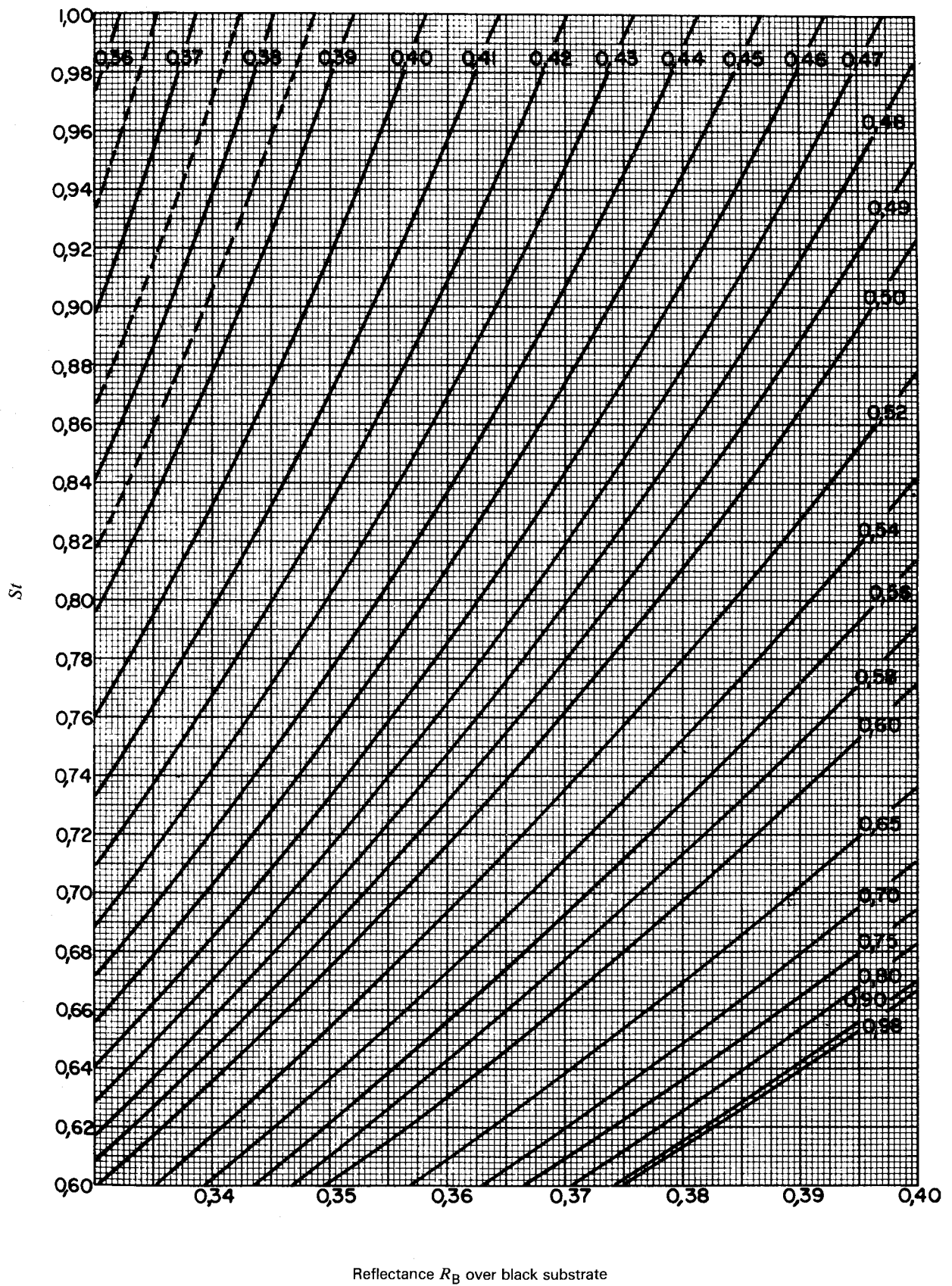


Figure 24 — Values of S_I for the ranges
 $0,33 < R_B < 0,40$
 $0,36 < R_\infty < 0,98$

BSI — British Standards Institution

BSI is the independent national body responsible for preparing British Standards. It presents the UK view on standards in Europe and at the international level. It is incorporated by Royal Charter.

Revisions

British Standards are updated by amendment or revision. Users of British Standards should make sure that they possess the latest amendments or editions.

It is the constant aim of BSI to improve the quality of our products and services. We would be grateful if anyone finding an inaccuracy or ambiguity while using this British Standard would inform the Secretary of the technical committee responsible, the identity of which can be found on the inside front cover.
Tel: +44 (0)20 8996 9000. Fax: +44 (0)20 8996 7400.

BSI offers members an individual updating service called PLUS which ensures that subscribers automatically receive the latest editions of standards.

Buying standards

Orders for all BSI, international and foreign standards publications should be addressed to Customer Services. Tel: +44 (0)20 8996 9001.
Fax: +44 (0)20 8996 7001. Email: orders@bsi-global.com. Standards are also available from the BSI website at <http://www.bsi-global.com>.

In response to orders for international standards, it is BSI policy to supply the BSI implementation of those that have been published as British Standards, unless otherwise requested.

Information on standards

BSI provides a wide range of information on national, European and international standards through its Library and its Technical Help to Exporters Service. Various BSI electronic information services are also available which give details on all its products and services. Contact the Information Centre.
Tel: +44 (0)20 8996 7111. Fax: +44 (0)20 8996 7048. Email: info@bsi-global.com.

Subscribing members of BSI are kept up to date with standards developments and receive substantial discounts on the purchase price of standards. For details of these and other benefits contact Membership Administration.
Tel: +44 (0)20 8996 7002. Fax: +44 (0)20 8996 7001.
Email: membership@bsi-global.com.

Information regarding online access to British Standards via British Standards Online can be found at <http://www.bsi-global.com/bsonline>.

Further information about BSI is available on the BSI website at <http://www.bsi-global.com>.

Copyright

Copyright subsists in all BSI publications. BSI also holds the copyright, in the UK, of the publications of the international standardization bodies. Except as permitted under the Copyright, Designs and Patents Act 1988 no extract may be reproduced, stored in a retrieval system or transmitted in any form or by any means – electronic, photocopying, recording or otherwise – without prior written permission from BSI.

This does not preclude the free use, in the course of implementing the standard, of necessary details such as symbols, and size, type or grade designations. If these details are to be used for any other purpose than implementation then the prior written permission of BSI must be obtained.

Details and advice can be obtained from the Copyright & Licensing Manager.
Tel: +44 (0)20 8996 7070. Fax: +44 (0)20 8996 7553.
Email: copyright@bsi-global.com.