TECHNICAL REPORT

ISO/IEC TR 19782

First edition
2006-06-01

Information technology — Automatic identification and data capture techniques — Effects of gloss and low substrate opacity on reading of bar code symbols

Technologies de l'information — Techniques d'identification automatique et de capture des données — Effets de la brillance et de la faible opacité du substrat sur la lecture des symboles de code à barres

Reference number
ISO/IEC TR 19782:2006(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

Page

Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of the joint technical committee is to prepare International Standards. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

In exceptional circumstances, the joint technical committee may propose the publication of a Technical Report of one of the following types:

— type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;

— type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;

— type 3, when the joint technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

ISO/IEC TR 19782, which is a Technical Report of type 3, was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 31, *Automatic identification and data capture techniques*.

Introduction

Users of bar code systems have experienced problems with poor read rates. These read rate problems can sometimes be attributed to spectral gloss from either the substrate or the image or both.

In many bar code applications, the position and orientation of the scanner relative to the bar code symbol can be directly controlled by the operator. In these applications, the presentation of the bar code symbol to the reader will usually be manipulated by the operator to achieve optimal performance. However, in bar code applications using fixed position automated reading systems, the ability to control bar code symbol presentation to the reader and achieve optimised performance is diminished.

Due to the very high volume of bar code marked items in today's supply chain, even a small reduction in read rate can represent significant logistics problems.

Traditional gloss measurements are made at the angle that maximises specular reflection and do not provide results that can be used to predict performance at other angles. Moreover, many laser scanners use a retro-collective optical system that would correspond to a gloss meter using a zero degree angle of incidence, which is not commonly available.

Present international bar code quality standards, such as ISO/IEC 15416, do not factor the impact of gloss from either the bar code image or substrate into quality grade ratings. Thus a Grade "4" label may be high gloss or low gloss. Low gloss labels and images tend to work well in all scanning systems, while high gloss labels and images may not. In the absence of industry specifications, users have no convenient reference to use when requesting suppliers to provide labels that will work well in their systems. This Technical Report provides a method for the measurement of gloss that will permit users to judge if the bar code symbol and substrate are suitably matched for the reading system used in their application.

Low opacity of the substrate can degrade system performance because it may reduce the apparent contrast of the bar code symbol. This Technical Report therefore provides means for measuring the substrate opacity.

The test method described in this Technical Report provides a means for the production of reproducible measurements. In specific applications, it may be necessary to correlate these measurements to practical performance. For example, a substrate backed by dark liquid may exhibit lower opacity than when measured dry.

Information technology — Automatic identification and data capture techniques — Effects of gloss and low substrate opacity on reading of bar code symbols

1 Scope

This Technical Report gives guidelines to deal with the effects of substrate gloss and/or low opacity on the performance of bar code symbols when scanned by reading and verification systems.

This Technical Report defines methods of measurement for gloss and opacity; it identifies conditions and values that present a risk of reading problems and provides recommendations to users on the specification of substrates and the set-up of scanning systems to minimize these problems. It also addresses the relationship between verification results and read performance when either or both of the factors are present.

This document is intended for those who specify or implement labelling systems and those involved in the reading of bar code symbols on packages, components and other carriers of bar code symbols.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 19762-1, *Information technology — Automatic identification and data capture (AIDC) techniques — Harmonized vocabulary — Part 1: General terms relating to AIDC*

ISO/IEC 19762-2, *Information technology — Automatic identification and data capture (AIDC) techniques — Harmonized vocabulary — Part 2: Optically readable media (ORM)*

ISO/IEC 15415, *Information technology — Automatic identification and data capture techniques — Bar code print quality test specification — Two-dimensional symbols*

ISO/IEC 15416, *Information technology — Automatic identification and data capture techniques — Bar code print quality test specification — Linear symbols*

TAPPI T 425 om-01, *Opacity of paper (15/d geometry, illuminant A/2°, 89 % reflectance backing and paper backing)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 19762-1, ISO/IEC 19762-2 and the following apply.

3.1
coaxial
pertaining to scanning systems in which the path of illumination from the light source to the symbol and the path of collected light from the symbol are in the same axis

3.2
image
printed part of the symbol as opposed to the background ("printed" includes any method of creating a mark on the substrate)

3.3
receiver
part of the optical system that collects the reflected light, focuses it onto the photodetector and outputs an electrical signal proportional to the intensity of the light

4 Symbols and abbreviated terms

VM	Volt Meter
mW	Milliwatts
TT	Thermal Transfer
TD	Thermal Direct
λ	wavelength
CTD	Coated Thermal Direct
UNCTD	Uncoated Thermal Direct
SUB	Substrate

5 Measurement procedures

5.1 Effects of gloss and/or low opacity

5.1.1 Gloss

The performance of scanning equipment is highly dependent on the detection of adequate contrast between the image and the substrate. Performance is degraded when an image or substrate, adversely affects the Symbol Contrast due to its gloss. Note that Symbol Contrast can also be degraded by a high gloss low-opacity substrate(see 5.1.2).

In coaxial reading systems, specular reflection can cause a problem when the incident angle is close to normal with the result that the reflected light captured by the reader includes specular reflection. However, the range of angles over which significant specular reflection occurs depends on characteristics of the material, such as its gloss.

Materials with relatively high gloss will produce a higher amplitude of specular reflection over a narrower angle, compared with matte materials. Matte materials tend to produce lower amplitude of specular reflection over a wider angle.

In order for adequate contrast to be manifest, over reading angles that come close to and may even include the normal, gloss may need to be controlled on a label for both the dark and light elements of the symbol.

The intensity of specular reflection as an indicator of the effect of gloss may be measured over a range of angles and analysed as described in 5.2. There are several methods of obtaining a gloss profile. See Annex A for examples.

5.1.2 Opacity

When a bar code symbol is printed on a substrate with low opacity, symbol contrast is reduced if the material underlying the substrate is relatively darker than the substrate. Irregularities in the reflectance of the underlying material can also affect either the defects or the modulation grade of the symbol when measured according to ISO/IEC 15416 (or ISO/IEC 15415 for two-dimensional symbols).

5.2 Measurement of gloss

5.2.1 Three dimensional gloss profile

The 3-dimensional gloss profile is a plot of the amount of reflected light as a function of the angle of incidence of illumination and the detection angle (when these are varied independently). Specular reflections occur when the detection angle is equal to the angle of incidence within a range dependent on the material. For most applications a simpler 2 dimensional plot will suffice (See section 5.2.2).

5.2.2 Two dimensional gloss profile

In many applications, the profile can be expressed as a 2-dimensional plot or family of 2-dimensional plots. A 2-dimensional plot can be used if either the angle of incidence of illumination or the detection angle are not varied independently. For example, keeping the angle of incidence of illumination constant and varying the angle of detection, a 2-dimensional plot shows how wide a range of detection angle would capture specular reflection and its intensity.

As another example of a useful 2-dimensional plot, corresponding to a coaxial scanning system, the detection angle could be maintained equal to the angle of incidence while both are varied simultaneously by tilting the target surface (See example Figure A.2 produced using the set-up shown in Figure A.1).

5.2.3 Gloss profile measurement methods

The measurement of gloss profile is influenced by the angle over which the reflected light is collected. For measuring gloss profile this angle should be fixed and small (≤ 6°) as illustrated in Figure 1. These characteristics should be controlled for repeatable measurement.

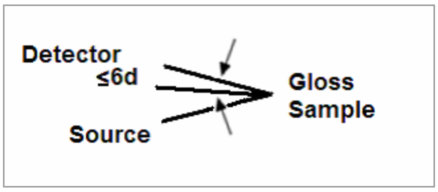

Figure 1

The measurement of gloss depends on the spot size of the incident light and the angle of collection. Gloss varies strongly with the angle of reflection of the incident light. On materials where the image becomes more reflective at or near the specular angle than the background substrate, the contrast will be measured as a negative value. For comparison in the selection of materials, it is preferable to have as small a range of angles as possible, at which the Symbol Contrast is less than 20 %.

For comparison in the selection of materials, it is possible to use from the profile the ratio of reflectance measured at 60° to reflectance measured at 90° for both the background substrate and image.

For the gloss profile, the reflectance of the substrate and of the image shall be measured over the range of 50° to 130° incident/collection angles.

From the gloss profile determine the range of angles where the Symbol Contrast is below 20% or a negative value.

For convenience of reporting, the reflectance of the substrate and of the image can be reported using incident light at 60° and at 90° (normal to the substrate) and with the collection aperture coaxial with the incident light. The reflectance measurements shall be designated as follows:

R_{90} Reflectance measured at 90°.

R_{60} Reflectance measured at 60°.

Calculate R_{60}/R_{90}

5.3 Measurement of opacity

Opacity is commonly measured in terms of transmission of light through a material. However, this is less relevant to the way bar code reading systems work than a method based on the measurement of reflectance of a substrate when it is backed alternately by light and dark underlay materials.

Measurement of opacity is made on a reflectance profile fixture with coaxial illumination and collection, at a non-specular angle such as 45 or 60 degrees. The reported measurement should include the angle of incident illumination and collection angles.

Bar code verifiers often include a reflectometer function, which can be used to measure opacity, using specified incident illumination and collection angles, such as illumination at 45° and collection at 90°. The reported measurement should include the incident and collection angles.

The preferred method for measurement of opacity on a gloss profile fixture is based on TAPPI standard T 425 om-01. In this methodology reflectance of the sample is measured first with a light backing (The reflectance of which is denoted here as RBL) and the measurement repeated with a dark backing (the reflectance of which is denoted here as RBD). The reflectance values specified in TAPPI T 425 om-01 for the two backing materials are:

RBL = 89% and RBD <= 0,5%.

For the purposes of this report the following tolerances are allowable:

RBL = 89% °± 3% and RBD =0,5% +1% -0,5%

Let RL and RD be the resulting measurements on the light and dark backings respectively. The opacity is then expressed as the ratio of RD to RL, as a percentage.

$$\text{Opacity} = 100(RD/RL)$$

Higher first pass read rates are typically achieved on printed bar code symbols as the substrate opacity is increased.

See Annex C for an example of the test set-up for the measurement of opacity.

6 Test reports

6.1 Test report for gloss

The test report shall contain the following :

— Ratio of R_{60} to R_{90} for background substrate as determined according to 5.2.3.

— Ratio of R_{60} to R_{90} for image as determined according to 5.2.3.

— Gloss profile plot as determined according to 5.2.3.

— The range of angles over which the difference in reflectance between the background substrate and image is less than 20% or negative, as shown by the gloss profile plot.

6.2 Test report for opacity

The test report shall contain the following :

— The opacity value as determined according to 5.3.

— Incident and collection angles.

— The actual measured reflectance values of the substrate, on the light and dark underlays respectively.

— The normalised reflectance values of the substrate, on the light and dark underlays respectively.

— The measured reflectance values of the light and dark underlays.

7 Impact of gloss and opacity effects on verification

This clause describes how verification results may be affected by glossy surfaces of substrates and inks.

ISO/IEC 15416 specifies an optical geometry for the verification of linear symbols that is intended to minimise the effects of specular reflection, with incident light at 45° and collection at 90°. ISO/IEC 15415 specifies a similar optical geometry for the assessment of two-dimensional symbols, but also provides for alternative angles of incident light (30° and diffuse lighting at a near-90° angle) intended to optimise contrast on direct marked surfaces.

When using 45° and 30° incident light geometries, the gloss of the substrate or ink will have the effect of reducing R_{max} and/or R_{min}, and symbol contrast, because the light reflected from a glossy material will have a lower diffuse component than that from a more matte surface. The result may be sufficient to make the substrate appear dark to the photodetector and result in an unacceptable quality grade. A glossy ink on a matte substrate will, however, yield increased symbol contrast. These effects tend to correlate well with the expected reading performance when the scanner illumination is not close to the normal to the symbol.

In the case of the near-90° illumination geometry a glossy substrate or, worse, a glossy dark image, will give a very high reflectance value (as illustrated in the examples of gloss profiles in Annex A) and the resulting symbol quality grade will not be a reliable indicator of scanning performance with other geometries. However, ISO/IEC 15415 requires the optical geometry to match the expected scanning conditions and it is improbable that a near-90° illumination angle would be specified by an application for reading symbols on high-gloss surfaces or marked with high-gloss characteristics. Such materials would best be read (and verified) with illumination at an angle significantly less than 90°.

The opacity of the substrate, together with the reflectance of the underlying material, will also influence measurements of R_{max} and. to a somewhat lesser extent, R_{min}. Where there is a risk that show-through of the package contents or other underlay may lead to reading problems, it is appropriate to follow the guidelines in ISO/IEC 15416. This is accomplished by measuring reflectance values of the symbol with both a dark and a light underlay (the reflectance values of which are specified slightly less closely than those in 5.3 of this Technical Report) and taking the worst-case values.

Annex A
(informative)

Example of gloss measurement technique

A.1 General description of set-up

This Annex describes an example of a test set-up that has been used for creating gloss profiles.

The measurement technique involves a continuous profiling of reflectance from the surface of the media by projecting a single beam of coherent laser light (λ = 665 nm) from a laser scan engine. The scan engine is modified so that there is no movement of the beam. It is important to ensure that the test set up is constructed to conform to laser safety requirements.

A mirror is mounted on the sample holder [5] in the position in which a sample to be measured is mounted. Laser output [1] is set at 500 mw. The reflected energy is measured via a meter [2] connected to the detector. Output from the detector [6] is directed to a chart recorder and plotted with measurement angle on the x-axis and detector voltage on the y-axis.

The projected beam strikes a mirror surface mounted on the sample holder [5]. The detector [6] collects light reflected from the mirror surface. The beam is adjusted so that the maximum signal is returned to the detector when the beam is normal to the surface of the mirror. This maximum voltage is taken as the 100% reflectance value.

Media under test, mounted on a flat card, is secured to the sample holder [5] via a magnet. Detector voltage is recorded as the sample holder [5] is rotated counter clockwise at 1 degree per second starting at 45° to the beam of the laser. The reflectance profile is complete when the sample holder [5] has rotated 90° from the start position.

Components of test fixture:

1. Volt meter measuring voltage to laser.
2. Volt meter measuring voltage to detector.
3. Power supply for laser.
4. Power supply for motor rotating sample holder.
5. Sample holder with protractor scale and pointer.
6. Laser housing (containing laser and detector) positioned on mount with levelling screws.

A.2 Test fixture

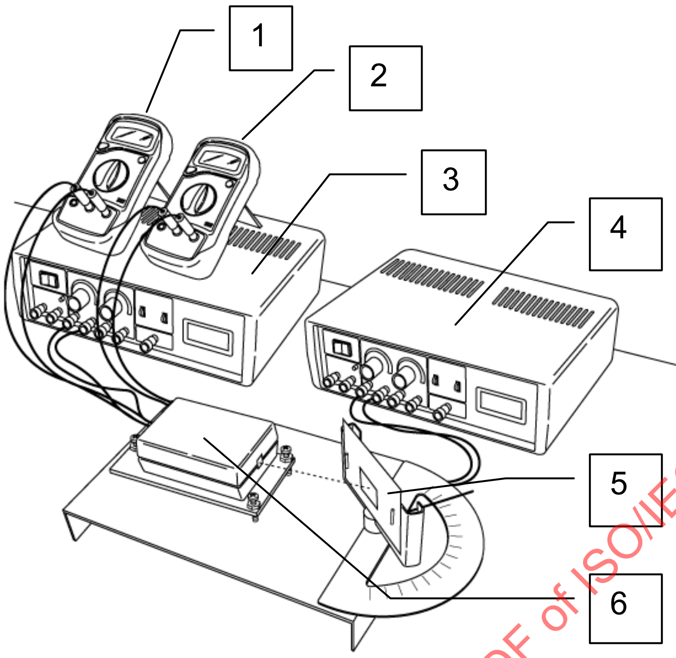

Figure A.1 — Example of instrumentation set-up

Figure A.1 shows a drawing of an example test fixture equipped with a motor that rotates a target plate through various angles, while a recorder plots the reflectance signal from a laser based scanner.

A.3 Example profiles – substrate and image

Figure A.3 illustrates a gloss profile showing original and attenuated scaling of reflectance values at angles between 50° and 130°.

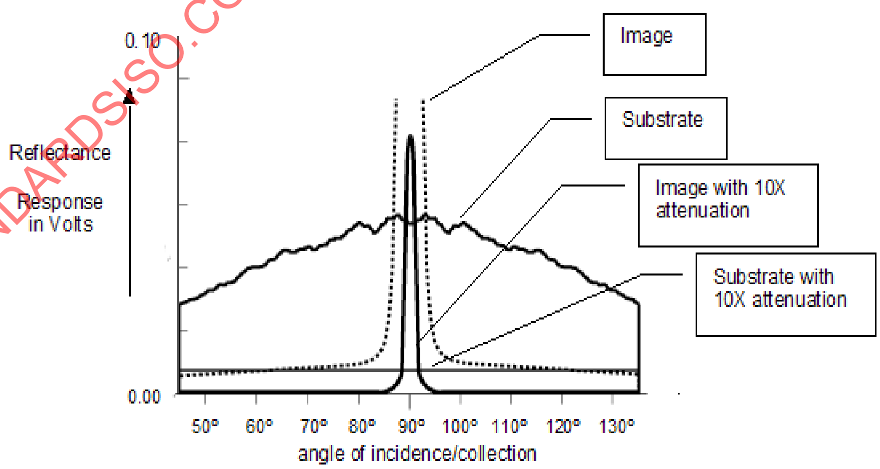

Figure A.2 — Gloss profile (original and attenuated)

Figure A.2 shows the reflected signals from substrate and from image both at the original scale and with a factor of 10X attenuation of the output signal for both the substrate and image. Signal attenuation enables observation of the large signal from the image area as the angle approaches the specular angle, in this case 90°. The black reflection peaks at over 100 times normal amplitude.

The signal from the substrate area is shown as a solid line, and that from the image area is shown as the dotted line. Angles from 45° to 135° are included in this profile.

It is clear that the contrast available at the usual scanning angles around 60° is sufficient, while the high level of specular reflection from the gloss of the imaged area makes reading in the 90° area impossible.

Figure A.3 shows the gloss profile from a matte substrate.

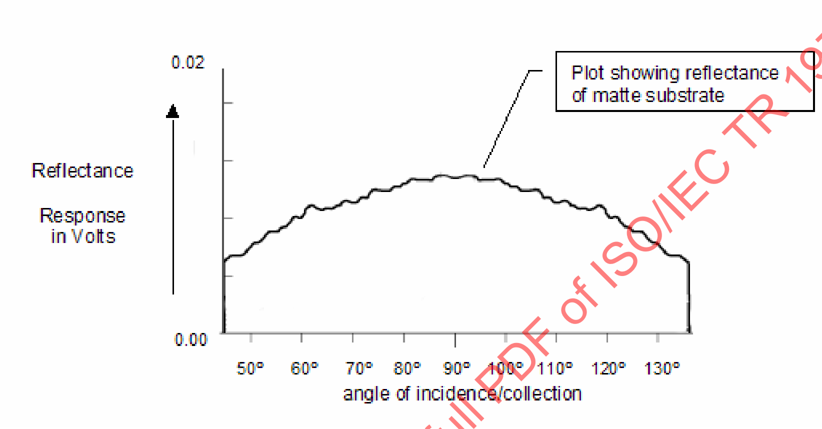

Figure A.3 — Plot of the reflected light signal from a normal matte substrate

As can be seen, although there is some increase in the reflectance as the illumination/collection angle progressively approaches the normal, there is not the sharp peak that a glossy substrate would exhibit.

Figure A.4 shows the plot of the reflectance profile from a glossy thermal transfer bar code image. The signal peaks, going off scale, as the profile approaches the specular angle.

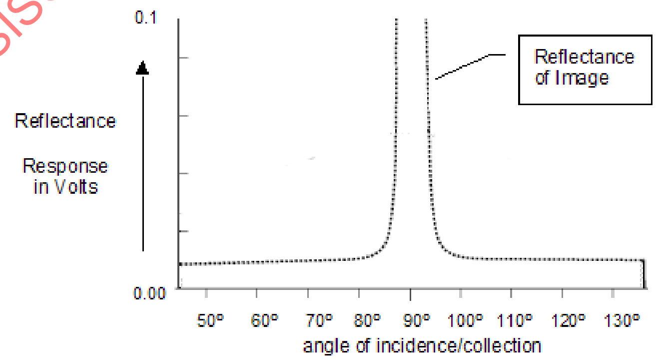

Figure A.4 — Gloss profile from a glossy thermal transfer bar code image

Figure A.5 shows the result of combining the gloss profiles of the matte substrate and thermal transfer bar code image.

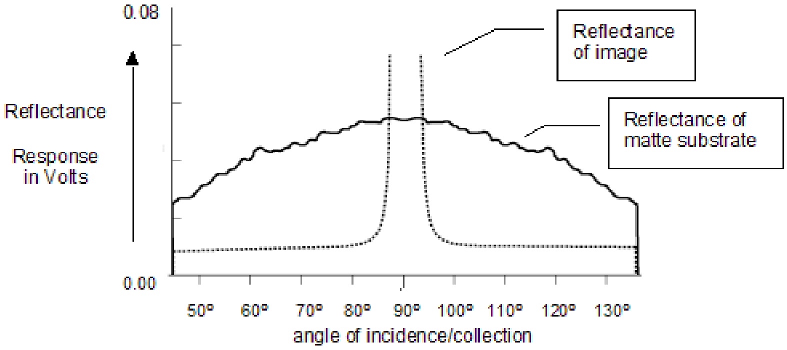

Figure A.5 — Example combined profile – matte substrate and glossy image

Figure A.6 shows the profile for a matte substrate and a signal attenuated high gloss image.

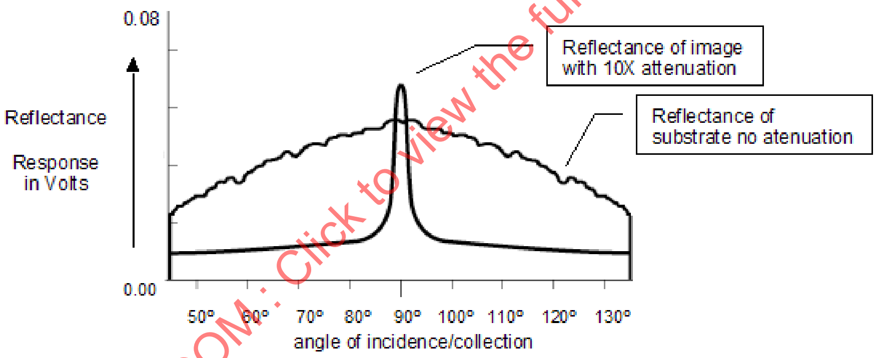

Figure A.6 — Example profile – matte substrate and high gloss image

The profile in Figure A.6 was obtained from the coated substrate paper (A.3) with a glossy transfer ribbon (A.5) used for printing the black areas. The black signal peaks at the spectral angle. As a result, the scannability of a bar code printed on this substrate with a gloss ribbon will be decreased when viewed at the spectral angles.

Figure A.7 illustrates the profiles from a glossy substrate (solid line) combined with the gloss profile from a standard wax ribbon (dotted line) measured at 20°. This condition results in negative signal differential between the background and image at the specular angle and reduces image scannability under some conditions.

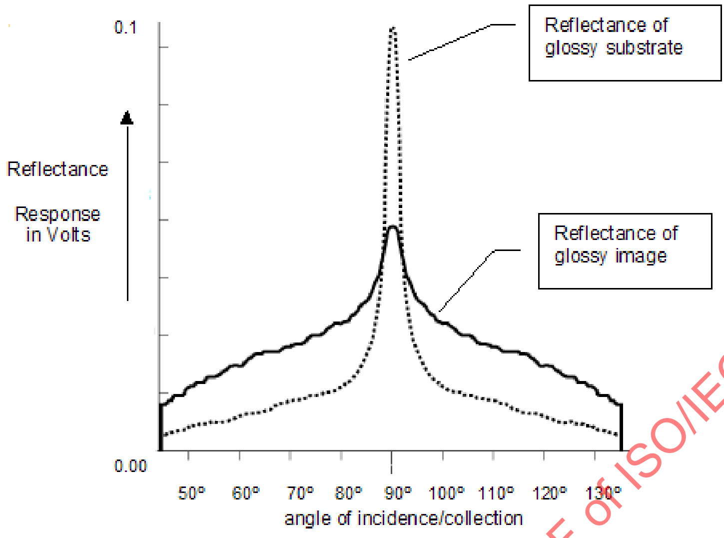

Figure A.7 — Example profile – glossy substrate and glossy image

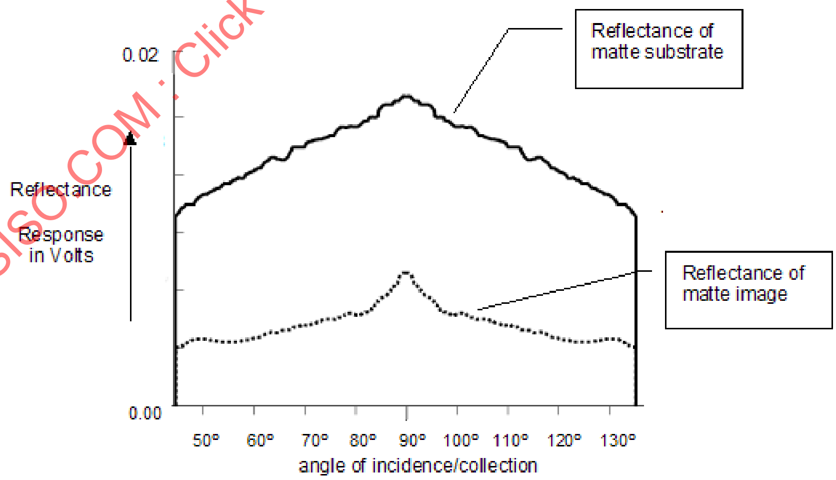

Figure A.8 — Example profile – matte substrate and matte image

Figure A.8 illustrates the gloss profile from one type of commercial matte finish thermal direct substrate. The matte finish of this stock yields a grade 3 or higher bar code symbol contrast grade (i.e. a minimum of 40% symbol contrast) at all scanning angles. This is not necessarily true with all thermal direct or thermal transfer stocks, as seen in Figure A.7 Figure A.9 illustrates a high gloss substrate, printed with a glossy wax ribbon where the gloss of the ink is reduced by applying a matte tape overlay.

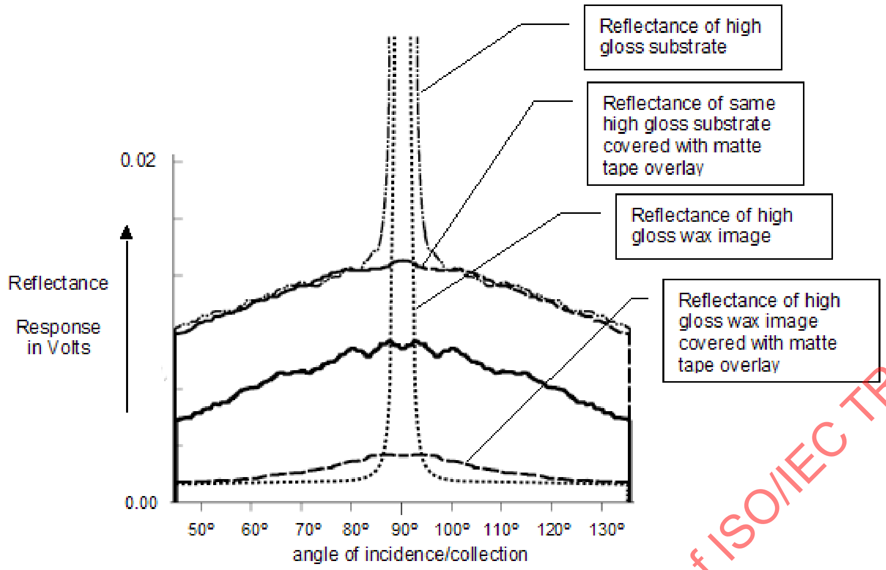

Figure A.9 — Example profile – reducing high gloss with matte overlay

There are other methods for providing a non-specular matte surface for gloss labels, as an example, Figure A.9 shows a high gloss label profile from 45° to 135°, including the off-scale signal near the specular angle of 90°. The dark dashed curve is the light reflectance and the light dotted line is the dark reflectance, at normal gain settings.

After application of the clear matte finish pressure sensitive tape, no significant gloss specular component remains.

The two plots at the top of the chart represent the light background. The off-scale plot represents the background before application of the matte tape.

The two plots at the bottom of the chart represent the black imaged area. The off-scale plot represents the image before application of the matte tape.

A.4 Comparison of TAPPI T 425 Gloss measurements with gloss profile measurements

Table A.1 — Sample gloss measurements vs. profile

Type[a]	Sample	TAPPI Image T 653 om-98 20° *	Gloss Profile Image (mv) 60°	Gloss Profile Image (mv) 90°	TAPPI Substrate T 653 om-98 20° *	Gloss Profile Substrate (mv) 60°	Gloss Profile Substrate (mv) 90°
TD	Type B	4.93	8.5	43.5	5.53	21.4	34.0
TD	Type A	0.94	6.2	12.0	4.34	21.4	28.0
TT	CTD Substrate/ Resin Ribbon	47.56	2.0	215.0	4.81	19.5	23.0
TT	CTD Substrate/ Resin Ribbon #2	46.37	2.4	220.0	4.81	21.0	25.0
TT	CTD Substrate/ Matte Ribbon	4.67	2.7	17.0	4.81	20.5	25.0
TT	Synthetic Label / Resin Ribbon	12.18	7.5	41.6	96.3	6.0	41.5

[a] TD = Thermal Direct; TT = Thermal Transfer

* Technidyne Gloss Meter

Table A.1 contains the reflectance signals at 60° and 90° of a number of papers and ribbons, as well as the gloss readings on these samples measured with a commercial gloss meter reading 20° gloss values.

The 20° gloss values (which would be shown as 70° under the convention adopted in this Technical Report) are more appropriate than the other TAPPI standard of 75° (i.e. 15° for this Report) as the bar code scanning process is usually much closer to the 20° angle. While there is general correlation of the reflection signal size with these gloss readings, measurement by the TAPPI method does not yield adequate results for bar code quality specification purposes.