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**Decorative metallic coatings for radio wave transmissive application products —  
Designation and characterization method**

*Revêtements métalliques décoratifs pour les produits d'application transmettant les ondes  
radio — Désignation et méthode de caractérisation*

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## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part-1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part-2 (see [www.iso.org/directives](http://www.iso.org/directives)).

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This document was prepared by Technical Committee ISO/TC 107, *Metallic and inorganic coatings*, Subcommittee SC 9, *Physical vapour deposition coatings*. ~~It is a minor revision and the updates include the titles of Table 4 and Table 5, as well as the position shifts of circles in Figure B.6.~~

~~This second edition cancels and replaces the first edition (ISO 5154:2022), of which it constitutes a minor revision. The changes are as follows:~~

- ~~— updated titles of Table 4 and Table 5;~~
- ~~— updated the position shifts of circles in Figure B.6.~~

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## Introduction

This document was developed to provide the designation of the characteristics of the decorative metallic coatings for radio wave transmissive application products, in response to worldwide demand for the standardization of such products. This document was also developed to specify the standard method to quantitatively characterize the decorative parts with the metallic coatings that both have the low transmission loss of radio wave and the metallic appearance.

One of the typical applications of the radio wave transmissive application products is the metallized plastic emblem and other decorative exterior parts for automobiles. These parts are placed in front of the millimetre wave radar transmitter-receivers of the collision prevention system. A typical example of these parts has the low transmission loss of the specific radio wave lower than 2,5 dB and the bright metallic appearance with lightness of 70 or higher. Low transmission loss is consistent with metallic appearance by forming a discontinuous structure of metallic coatings. An example of the discontinuous coating is the sputter-deposited film of low melting point metals such as indium having island structure.

This document specifies the designation and the characterization methods of the decorative metallic coatings of the products for radio wave transmissive application. The designation consists of the transmission loss of the radio wave, the frequency band of the radio wave under consideration, the lightness and hue of the parts, as well as the main material and manufacturing process of metallic coatings. The characterization methods consist of the determination of the transmission loss of radio wave with specific frequency band and the evaluation of lightness and hue which represent the colour and appearance.

Examples of measurement results of the radio wave transmission loss and the colour characteristics are described in Annex A and Annex B, respectively. The information in annexes is for the convenience of users and does not constitute an endorsement by ISO.

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## Decorative metallic coatings for radio wave transmissive application products — Designation and characterization method

### 1 Scope

This document specifies the designation and the characterization methods of the decorative metallic coatings of the products for radio wave transmissive application. The designation consists of the transmission loss of the radio wave, the frequency band of the radio wave under consideration, the lightness and hue of the parts, as well as the main material and manufacturing process of metallic coatings. The characterization methods consist of the determination of the transmission loss of radio wave with specific frequency band and the evaluation of lightness and hue which represent the colour and appearance.

### 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 2080, *Metallic and other inorganic coatings — Surface treatment, metallic and other inorganic coatings — Vocabulary*

ISO 4519, *Electrodeposited metallic coatings and related finishes — Sampling procedures for inspection by attributes*

ISO/CIE 11664-4, *Colorimetry — Part 4: CIE 1976 L\*a\*b\* colour space*

ISO 16348, *Metallic and other inorganic coatings — Definitions and conventions concerning appearance*

IEC 60050, *The international electrotechnical vocabulary*

IEC 62431, *Measurement Methods for Reflectivity of Electromagnetic Wave Absorbers in Millimetre Wave Frequency*

CIE S 017, *International Lighting Vocabulary*

JIS Z 8721, *Specification of colours according to their three attributes*

ASTM-D 1535, *Standard Practice for Specifying Color by the Munsell System*

### 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 2080, ISO 16348, IEC 60050 and CIE S 017 [and the following](#) apply.

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ISO and IEC maintain ~~terminological~~terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at <https://www.iso.org/obp><https://www.iso.org/obp>

— IEC Electropedia: available at <https://www.electropedia.org/><https://www.electropedia.org/>

### 3.1

#### VNA

##### vector network analyser

instrument to measure the transfer and/or impedance characteristics, that is, both magnitude and phase changes, of a linear network, device, or material through stimulus response testing over a given frequency range

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### 3.2

#### TRL calibration method

thru-reflect-line calibration method

one of the calibration methods to fix the systematic errors with the network analyser measurements using a zero-length "thru", a longer "thru" (called "line"), and high-reflect standards

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### 3.3

#### skin depth

depth at which the current density in a conducting material is reduced to 1/e times the surface current density, at a given frequency

### 3.4

#### SCI

##### specular component include

type of colour measurements including both specular and diffused reflected light

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### 3.5

#### SCE

##### specular component exclude

type of colour measurements excluding any specular reflected light

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## 4 Designation

### 4.1 General

A designation consists of the following:

- the letters, "StM", as the elementary symbol indicating that the decorative metallic coating has ability for radio wave transmittance and metallic appearance;
- a letter indicating the frequency band classification;
- the letter "T" and a number giving the transmission loss followed by a solidus (/);
- the letter "L" and a number indicating the lightness;
- letters indicating the hue followed by a solidus (/);
- an elemental symbol of the main component element of coatings followed by a solidus (/);



g) letters indicating the manufacturing method of coatings.

## 4.2 Elementary symbol

The elementary symbol, StM, shall indicate that the decorative metallic coating has ability for radio wave transmittance and metallic appearance.

## 4.3 Transmission loss of radio wave

The following letters and numbers designate the frequency band of the radio wave under consideration and the transmission loss due to reflection and absorption.

### 4.3.1 Frequency classification

The letters shown in Table 1 designate the frequency bands of the radio wave under consideration.

**Table 1 — Designation of frequency bands of radio wave**

Designation	Frequency band of the radio wave under consideration <sup>a</sup>	Band name <sup>b</sup>
	Hz	
A	$18 \times 10^9$ to $26,5 \times 10^9$	K
B	$26,5 \times 10^9$ to $40 \times 10^9$	Ka
C	$50 \times 10^9$ to $75 \times 10^9$	V
D	$75 \times 10^9$ to $110 \times 10^9$	W
E	$110 \times 10^9$ to $170 \times 10^9$	D
F	$170 \times 10^9$ to $260 \times 10^9$	H
G	$300 \times 10^9$ to $500 \times 10^9$	-

<sup>a</sup>—Lower limit exclusive, upper limit inclusive.

<sup>b</sup>—The band names of specific frequencies are given in Reference [1].

### 4.3.2 Transmission loss of radio wave

The letter "T" and a number designate the transmission loss of the radio wave due to reflection and absorption as shown in Table 2.

**Table 2 — Designation of transmission loss**

Designation	Transmission loss <sup>a</sup>
	dB
T0,1	0,1 or below
Tx (x = 0,2 to 2,4)	x
T2,5	2,5 or above

<sup>a</sup>—Transmission loss shall be rounded off to one decimal place.

## 4.4 Lightness and hue

The following letters and numbers designate the lightness and hue angle that specify the colour and appearance.

4.4.1 Lightness

The letter "L" and a number designate the lightness as shown in Table 3.

Table 3 — Designation of lightness

Designation	Lightness <sup>a</sup>
L100	100 or above
$L_n$ ( $n = 99$ to $41$ )	$n$
L40	40 or below

<sup>a</sup>—Lightness shall be rounded off to integer.

4.4.2 Hue

The letter(s) shown in Table 4 designate the hue.

Table 4 — Designation of hue

Designation	Hue angle <sup>a</sup> deg	Description of colour name
Chroma of between 3,0 and 5,0		
R	3 - 36	Red
YR	36 - 75	Yellow red
Y	75 - 103	Yellow
GY	103 - 148	Green yellow
G	148 - 186	Green
BG	186 - 225	Blue green
B	225 - 266	Blue
PB	266 - 302	Purple blue
P	302 - 332	Purple
RP	332 - 0	Red purple
RP	0 - 3	Red purple
Chroma of between 0,8 and 3,0		
R	0 - 55	Red
Y	55 to 120	Yellow
G	120 to 205	Green
B	205 to 285	Blue
P	285 to 350	Purple
R	350 to 360	Red
Chroma of 0,8 or below		
N		Achromatic colour

<sup>a</sup>—Lower limit exclusive, upper limit inclusive.

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#### 4.5 Main component element of coating

An elemental symbol designates the main component element of the decorative metallic coating.

#### 4.6 Manufacturing method

The symbols shown in Table 5 designate the manufacturing methods of the decorative metallic coating.

**Table 5 — Designation of manufacturing method**

Designation	Manufacturing method
Ve	Vacuum evaporation
Sp	Sputtering
Ep	Electroplating or Electroless plating <sup>a</sup>
OP	Other process

<sup>a</sup>— Electroless plating includes autocatalytic plating and immersion coating (see ISO 2080).

#### 4.7 Example of designation

Decorative metallic coatings for radio wave transmissive application products for W band radio wave (75 GHz to 110 GHz) with transmission loss of T0,4 level, having the appearance with the lightness of 90 and the hue of BG (blue green), with the main material of chromium coated by sputtering process would have the following designation:

EXAMPLE StM D T0,4 / L90 BG/ Cr/ Sp+

### 5 Characterization

#### 5.1 Transmission loss of radio wave

The transmission loss of the specific radio wave frequency band due to the reflection and adsorption shall be determined in accordance with IEC 62431.

#### 5.2 Lightness and hue

The definition of the parameters in CIELAB 1976 colour space, that is, lightness,  $L^*$ , chroma,  $C^*$ , and chromaticities,  $a^*$ , and  $b^*$ , are given in ISO/CIE 11664-4. These parameters shall be determined in accordance with ISO/CIE 11664-4. Hue angles shall be calculated from  $L^*$ ,  $a^*$ , and  $b^*$  values determined in accordance with ISO/CIE 11664-4.

Colour names shall be determined from hue angles in accordance with Munsell colour system (10-hue) shown in JIS Z 8721 and ASTM D 1535 for the products with  $C^*$  above 0,8. The colour name of the products with  $C^*$  of 0,8 or below shall be defined as achromatic colour.

#### 5.3 Sampling

The sampling shall be carried out in accordance with ISO 4519. The samples of which sizes are fit to the characterization devices may be used. The samples for characterization shall have the same materials and the same coating configurations as the products.

## Annex A (informative)

### Transmission loss measurement

#### A.1 Principle

This annex describes an example of measurement method and some examples of measurement results of the radio wave transmission loss of decorative metallic coatings for radio wave transmissive application products. A free-space measurement method for microwave and millimetre-wave is described. This annex also shows the measurement results of the decorative indium and chromium coatings by the free-space measurement method. These coatings are typically used for the radio wave transmissive applications such as the automobile exterior parts placed in front of the millimetre wave radar transmitter-receivers of the collision prevention system.

#### A.2 Sample and measurement method

##### A.2.1 Sample

Multi layered structured samples as shown in Figure A.1, of which structure is similar to the decorative metallic coatings of radio wave transmissive parts used in exteriors of automobiles, were prepared. Samples having the same structure were also used in the colour measurements shown in Annex B. Detailed information of metallic coatings in these samples are listed in Table A.1.

Thickness of the metallic coatings was determined on the basis of the skin depth of radio waves in order that small transmission loss due to the absorption can be expected. The calculated skin depths of indium and chromium at 110 GHz are 620 nm and 763 nm, respectively. Discontinuous metallic coatings were also formed to lessen the transmission loss. Discontinuous metallic coatings, that is, island-structured indium or micro-cracked chromium, were prepared by sputtering or vacuum evaporation methods.

The island-structured indium coatings are widely used in the emblem and other decorative exterior parts of automobiles in the market, to obtain both the low transmission loss of radio waves and bright metallic appearance. Micro-cracked chromium coatings are expected to exhibit both the low transmission loss of radio waves and valued appearance similar to the bright electroplated chromium coatings.

Five samples of chromium coatings and four samples of indium coatings shown in Table A.1, which are expected to have different radio wave transmissive characteristics, were manufactured by sputtering or vacuum evaporation with different process parameters.

NOTE Skin depth is a function of electrical conductivity and permeability of the material and radio wave frequency. Skin depth is smaller at higher frequency. Calculated skin depths at 110 GHz, that is, at the highest frequency under consideration, are the smallest ones.