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Fine ceramics (advanced ceramics, advanced technical ceramics) — Classification system

Céramiques techniques — Système de classification

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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

International Standard ISO 15165 was prepared by Technical Committee ISO/TC 206, *Fine ceramics*.

Annexes A, B and D form a normative part of this International Standard. Annexes C and E are for information only.

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Introduction

The detail of the classification system has been developed by international collaboration under the auspices of VAMAS Technical Working Area 14, and with support from the Commission of the European Communities, ASTM Institute of Standards Research and the Japan Fine Ceramics Association. Its construction has followed an international survey of requirements amongst manufacturing and user industries [1], discussions at an international workshop at Ispra, Italy, June 1990 [2], a consultant's study [3], and a final report of the work of VAMAS TWA14 [4].

The use of this International Standard has been reviewed by VAMAS TWA14 in an international project to test and demonstrate it. Based on the findings of this work, modifications agreed by VAMAS have been made to the original VAMAS Report [4].

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Fine ceramics (advanced ceramics, advanced technical ceramics) — Classification system

1 Scope

This International Standard describes a system by which fine ceramics (advanced ceramics, advanced technical ceramics) (see clause 3) may be classified. The system has been devised to cover all types of fine ceramics in the form of inorganic precursors for ceramic powder production, powders, granular forms, fibres, whiskers, platelets, single crystals, consolidated polycrystalline ceramics, amorphous (glassy) and composite materials and components in block, thin film and coating forms. The structure of the classification is coded to be machine readable.

The classification system does not cover:

- a) elemental carbon, except for specific ceramic forms such as diamond, vitreous carbon or chemical vapour deposited (CVD) graphite;
- b) elemental silicon, elemental germanium and other elemental or compound semi-metallic substances other than when they form an integral component of or precursor for fine ceramics;
- c) traditional ceramics based on clay, including:
 - 1) whitewares (e.g. tableware and fine porcelain);
 - 2) sanitary wares;
 - 3) floor and wall tiles;
 - 4) building ceramics (e.g. bricks and pipes);
- d) unshaped and shaped refractories for tonnage applications.

This International Standard does not specifically cover hardmetal (cemented carbide) products, or products which are mainly glassy, but the system can, in principle, be extended to cover such products. Its mode of use will be determined by the objective behind its use. It is not the purpose of this International Standard to define how the system shall be used, but examples are given of how it might be used. The user is able to define the coding combination and the level of detail to suit a particular purpose. This International Standard provides only a flexible framework and a recommended international coding system within which this might be done.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

IEC 60672-2, *Ceramic and glass insulating materials — Part 2: Methods of test*

IEC 60672-3, *Ceramic and glass insulating materials — Part 3: Specifications for individual materials*

3 Terms and definitions

For the purposes of this International Standard, the following terms and definitions apply.

3.1

fine ceramic (advanced ceramic, advanced technical ceramic)

highly engineered, high-performance, predominantly non-metallic, inorganic, ceramic material having specific functional attributes

NOTE Other terms which in whole or in part cover the scope of the above expression are in common use. The above term is the preferred one in all circumstances.

3.2

classification field

set of categories related to one independent aspect or feature of the classification

3.3

classification element

single category in a classification field

3.4

code

alphanumeric string with a prescribed definition in terms of material attributes

3.5

coding element

part of the alphanumeric code from one classification field

4 Objectives

This International Standard provides a framework wherein fine ceramic (advanced ceramic, advanced technical ceramic) products and materials can be classified for a variety of purposes including commercial statistics, market surveys, materials identification, coding and data bases.

The present range of products that is encompassed by the term “fine ceramics” or its synonyms “advanced ceramics” or “advanced technical ceramics”, or others, is enormous in breadth and complex in chemical character, form and property attributes. Normally there are close interlinks between these factors. It has therefore been impossible to devise a single hierarchical system, such as that used in IEC 60672-3 for electrotechnical ceramics for insulators or that in the Harmonised Commodity Description and Coding System for goods or derivatives thereof. The system developed and incorporated into this International Standard is novel in many respects in order to encompass all foreseen requirements and purposes, and all raw and manufactured materials and applications, i.e. it has great flexibility.

For these purposes, an adequate classification of the diversity of materials and products in various stages of manufacture may require the linking of chemical composition, form, processing method, material properties and applications in any required combination. The system described in this International Standard has the capability of classifying fine (advanced, advanced technical) ceramics by any combination of these fields in any sequence for any desired purpose. The fields are described individually in the following sections. Annexes A, B, C and D provide a coding method for each classification field of the system.

The user should select from the classification fields those relevant to his requirement, and place these in an order prescribed for the particular purpose. Some possible combinations are described in clause 6.

5 Individual classification fields

5.1 Introduction

Since the intention is to provide a means of classifying any combination of fields in any sequence appropriate to user needs, each field is separately identified by a unique initial letter code:

- **A** = application
- **C** = chemical character
- **P** = processing methods
- **D** = property characteristic or data

The form of the product is closely related to chemical character and is incorporated into the chemistry code. If appropriate, additional classification fields may be added in the same way. In each case these should be identifiable in a coding string by a unique initial letter code.

For the purposes of computer recognition, a strict sequence of classification elements is not required, but for other purposes, such as manual preparation of trade statistics or material specifications, the sequence of classification elements should be chosen and fixed as preferred.

In the following description of code structures, the variable characters used in the code are:

- **X** = any appropriate single capital letter coding character
- **n** = any appropriate single numeric coding character

5.2 Classification field for application type

The initial character to denote the start of the "Application" string is "**A**". This is followed by a three-digit number code as listed in annex A for the application areas. In the list, applications are initially separated into a hierarchical series of areas by the principal functions of the product as defined by:

- **electrical insulation**, i.e. insulators for a wide variety of purposes;
- **electronic/ionic conduction**, i.e. electronic or ionic conductors for heating or functional purposes;
- **mechanical functions**, including wear, at or near room temperature;
- **thermal and thermomechanical functions**, where dimensional stability at raised temperature, heat insulation, heat conduction or resistance to thermal shock are the principal functions, and where additionally mechanical loads may be applied;
- **nuclear functions**, where the component plays either an active or a passive nuclear role;
- **optical functions**, where the component plays a functional role as an optical element in reflection, refraction, transmission or absorption of electromagnetic radiation;
- **chemical functions**, including biomedical, where the component is employed for handling melts, chemicals, solutions or atmospheres because of its resistance to attack by them and, in the case of biomedical materials, a degree of bio-compatibility;
- **magnetic functions**, where the component possesses properties allowing a functional magnetic role;
- **powder functions**, where the fine ceramic is supplied in powder or granule form for use as such.

The first digit of the three-digit code is given as above by the principal physical function. The subsequent digits are non-hierarchical, and follow the listing given in annex A. To aid the identification of codes, an alphabetical index is also given. Figure 1 shows a flow diagram for the selection of application codes.

It may not always be possible to assign a particular product to one of the listed codes. In such a case, the code representing “**Other functions**” shall be employed, either within each of the above areas as appropriate, or failing this under codes 980-999.

If the product needs to be classified as having a general applicability to a range of unspecified applications, the general “**unspecified**” code (generally of form An00, except A400, but including A950) at the beginning of each group shall be used.

EXAMPLES

Resistor cores	code A144
Wear resisting pads for slideways	code A326
Rubber dipping formers	code A820

5.3 Classification field for chemical character

5.3.1 The initial identifier indicating “chemical character” is “**C**”. Because the chemical character of fine ceramics (advanced ceramics, advanced technical ceramics) can be complex, a flexible method of classification has been devised. The one or two alphabetical characters that follow the initial “**C**” indicate the form in which the chemical species exists (precursor, powder, solid ceramic, etc.). The following alphanumeric string indicates the species and, optionally, the amount of it present, the relationship of a second species to the first (e.g. physical or chemical admixture), etc. Details of the categories, their code letters and their uses are given in annex B.

Two formats of this string are given:

- a **short format**, intended for broad description of chemical character of common types of powder or ceramic material;
- a **long format**, when more detailed chemical information is required, such as the individual chemical components present and optionally their mass fractions.

5.3.2 The choice of whether to use the short-format or the long-format code is subject to agreement between parties. However, it should be noted that converting from the short-format to the long-format code or *vice versa* is not straightforward since the respective codings have different bases. Consequently, once a choice has been made it should be adhered to.

NOTE The short-format code is most appropriate for dealing with commercial products, sales statistics or inventories where the distinction between products is based primarily on overall chemical type, without the need to define the composition in detail. The long-format code is most appropriate for use where the precise chemical make-up of the product needs to be identified, e.g. in data banks or in recording manufacturing processes.

5.3.3 The **short-format** code is a four-digit number (nnnn) in the range 5001 to 9999 found in annex B. This is appended directly without punctuation to the chemical character identifier (C) and the form identifier (XX) to form a code:

CXXnnnn

This code is used with the appropriate form identifiers for all types of ceramic precursor and product. The classification code is terminated either by no further characters, or by one of the initial characters **A**, **P** or **D** (or additional defined initial classification field codes) indicating the start of another classification field.

EXAMPLES

Dense high-alumina ceramic, 95 % alumina	CKB5040
Open porous calcium aluminosilicate ceramic (anorthite, e.g. metallurgical filter material)	CKG5555
Separated and floated whiskers of alpha silicon carbide	CWE6260
An open porous 2D woven silicon carbide fibre reinforced silicon carbide	CKT6320

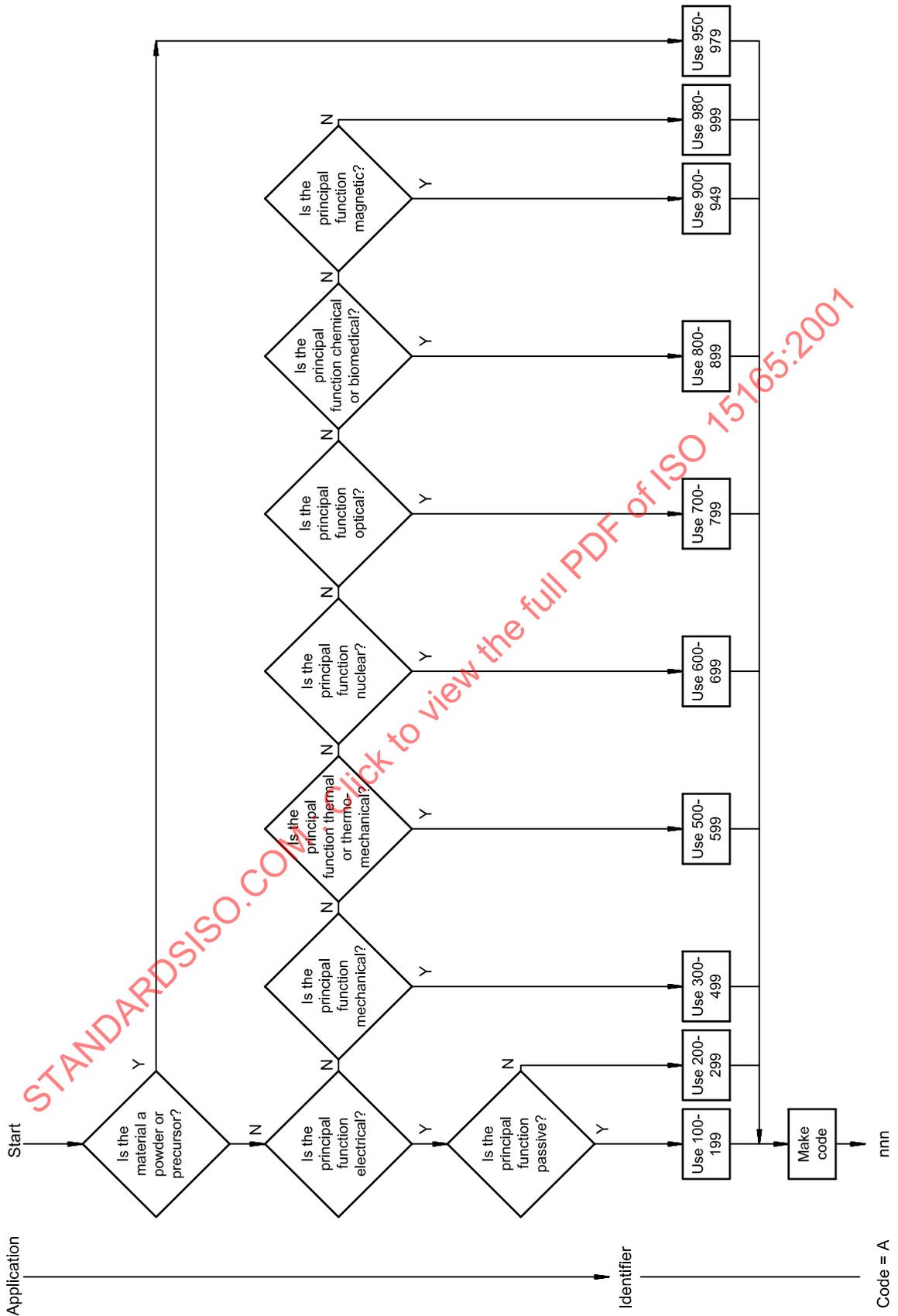


Figure 1 — Flow diagram showing the selection of codes for application

5.3.4 The **long-format** code is constructed as shown in Table 1. Chemical species codes are selected from code numbers 0001 to 4999 given in annex B. The sequence of “form” plus “chemical code” plus optional “amount” string may be repeated as few or as many times as is required to define the product in the detail required.

Important aspects to note are:

- 1) The code may be developed in the detail required to classify the product for the objective in mind.
- 2) Compositional detail may be appended if appropriate to end-use requirements. Two options are available; see Table 1 for two options, either an additional code number or a supplementary statement.
- 3) The minimum classification long-format code is “form” plus one identified chemical compound; all information beyond this point is non-mandatory.
- 4) The classification code is terminated either by no further characters, or by one of the initial characters A, P or D (or additional defined initial classification field codes) indicating the start of another classification field.
- 5) Effective use of the long-format code requires detailed knowledge of the formulation and microstructure of the product.

A flow diagram indicating the decision route to the identification and selection of codes is shown in Figure 2. The following examples indicate the flexibility of use of the classification code in any appropriate way, while remaining uniquely machine readable.

EXAMPLE 1

Alumina ceramic with 15 % by weight of unstabilized zirconia as a separate phase. Using Option 1 for the composition gives (written with spaces for clarity):

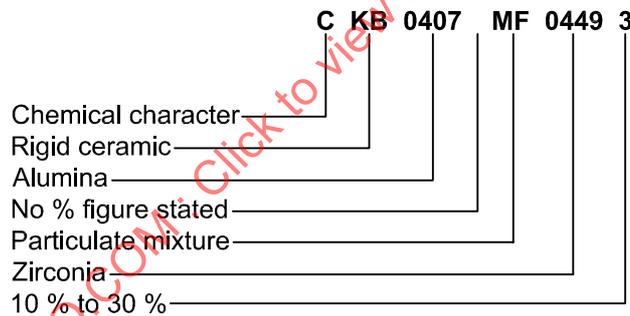


Table 1 — Construction of the long-format chemical character code

Code element	Description	
C	Chemical character code string identifier	
XX	One or two-letter code indicating the overall "form" of the product	
nnnn	Four-digit chemical character code from the numerical range 0001 to 4999 (see annex B)	
Optional n	<p>Option 1: coding element for indicating "amount" of the species nnnn in the product expressed as mass percentage, according to the following code:</p> <p>1 ≤ 1 % 2 > 1 % to 10 % 3 > 10 % to 30 % 4 > 30 % to 50 % 5 > 50 % to 70 % 6 > 70 % to 90 % 7 > 90 % to 99 % 8 > 99 %</p> <p>If the value is undefined or undefinable, this character is omitted.</p>	<p>Option 2: If the precise composition in percentage or parts per million terms is to be expressed, the figure is placed in parentheses (..) after the species code, percentage being indicated by a following letter "C" and parts per million by a following letter "M".</p> <p>The figure may be preceded by "<" or ">" to signify less than or more than a given amount, respectively.</p>
XX (**)	Two letters indicating how a second species is mixed in relation to the first when in the same form of product, e.g. for a specified second component in a two-species powder or ceramic, or an impurity.	
nnnn	Four-digit chemical character code for the second species.	
n	<p>Option 1</p> <p>Optional single digit coding percentage, by mass, of second species as defined above.</p>	<p>Option 2</p> <p>Optional supplementary statement coding quantity, by mass, of second species, as defined above.</p>
(**) The sequence is repeated from (**) for third and subsequent species as necessary.		

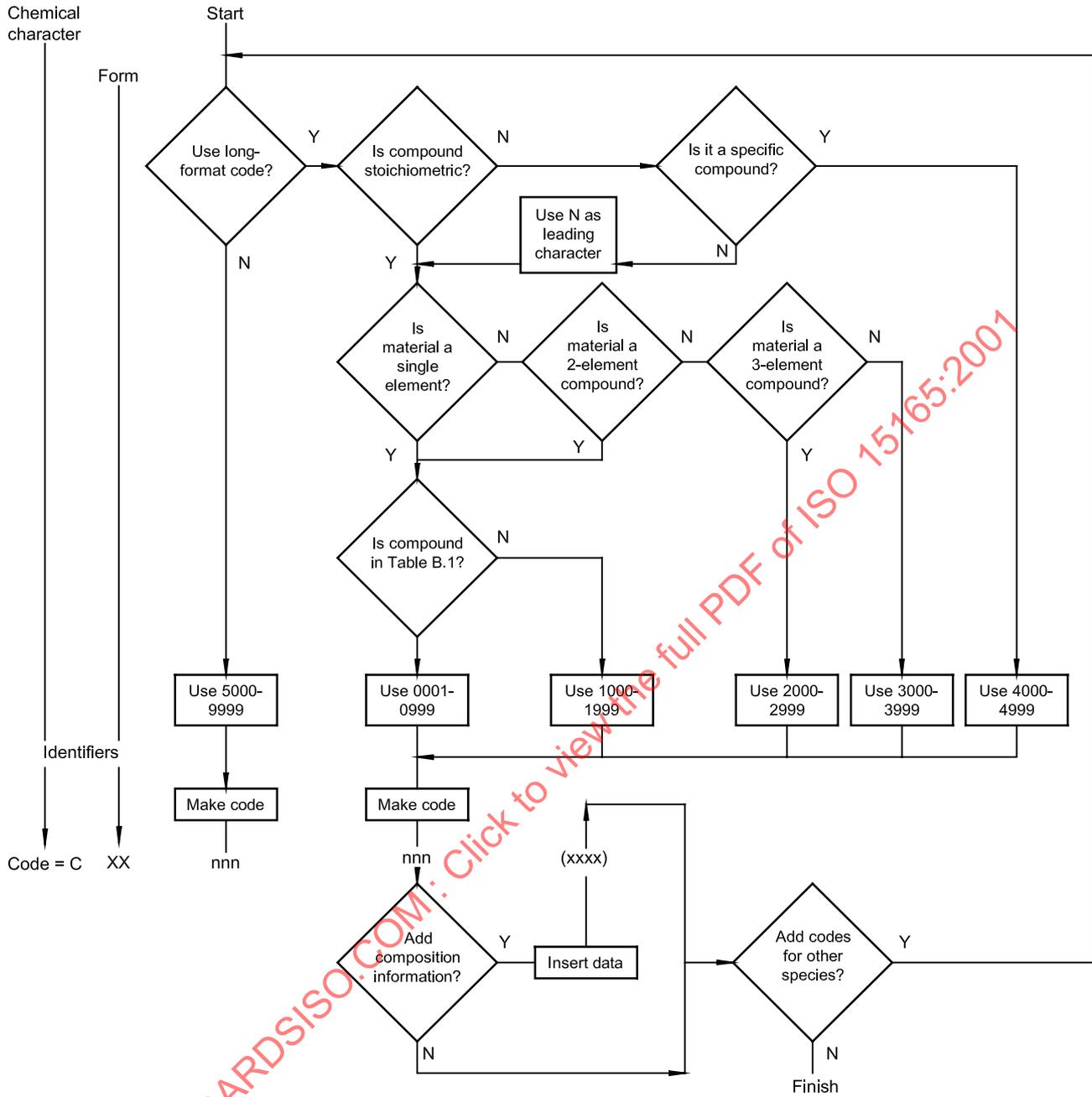
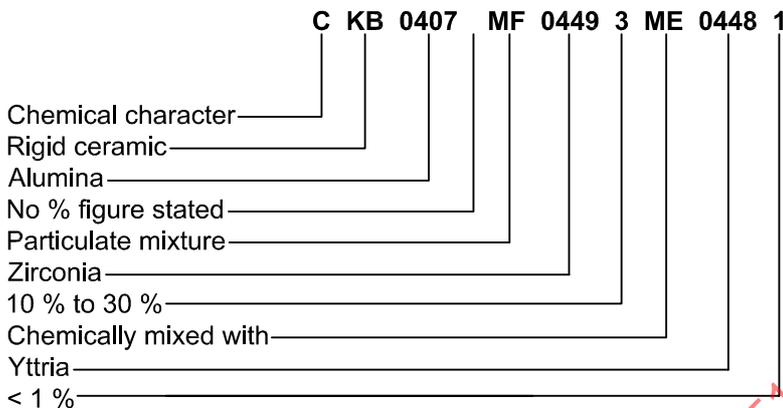


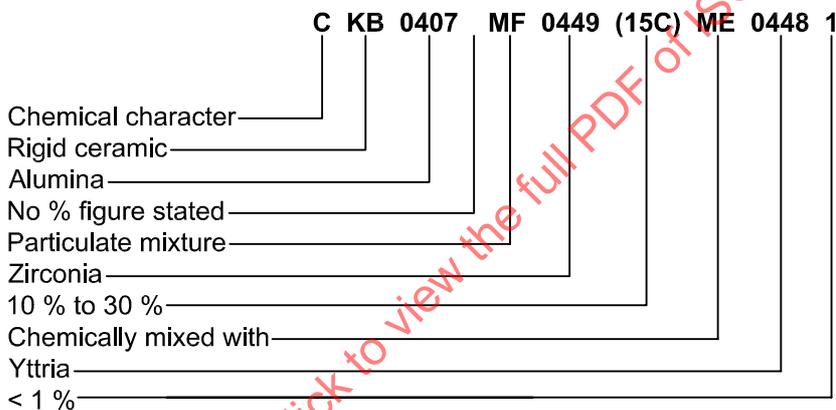
Figure 2 — Flow diagram for selection of codes representing chemical character

EXAMPLE 2

Alumina ceramic with 15 % by weight of yttria stabilized zirconia as separate phase, yttria content in the zirconia not defined but less than 1 % by weight overall. Using **Option 1** for bands of composition gives (written with spaces for clarity):

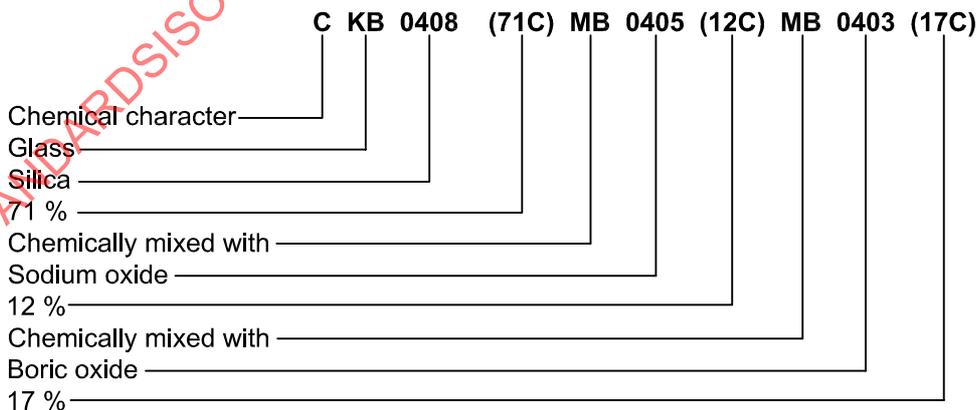


Option 2 defining the zirconia content at 15 % gives (written with spaces for clarity):



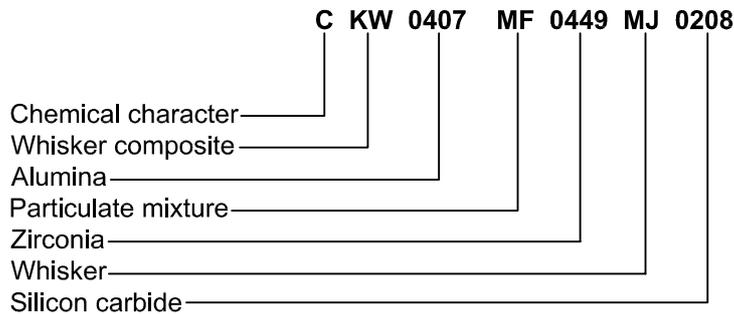
EXAMPLE 3

Sodium borosilicate glass of defined composition 71 % SiO₂, 12 % Na₂O, 17 % B₂O₃, using **Option 2** for exact percentages gives (written with spaces for clarity):



EXAMPLE 4

Silicon carbide whisker-reinforced alumina/unstabilized zirconia with unspecified composition. The compositional definition option is not invoked, and gives (written with spaces for clarity):



For this particular case with unspecified percentages, the short form CKW5190 could be used with equal value.

NOTE It may not always be possible to assign a particular product to one of the listed codes. In such a case, the code or codes representing "Other" chemical species should be used, either within a chemical group for the long-form code [e.g. "Other chromites" (2119)] or within a generic ceramic type for the short-form code [e.g. "Other glass-ceramics" (9999)].

5.4 Classification field for processing

In cases where the method of processing the ceramic needs to be identified as part of the overall code string, for example in internal inventories or data bases, this can be performed using a simple string. The initial letter is P, followed by three digits selected from the listing given in annex C, i.e.:

Pnnn

This can be repeated as many times as is required to define adequately the process or processing route adopted. For example, the processing code for a ceramic body might have the appearance:

P203P302P403P502P804

indicating that a chemically precipitated powder (P203) was used, which was spray dried (P302) prior to isostatic pressing (P403), followed by sintering in air (P502). The component was then surface ground (P804).

5.5 Classification field for property characteristics or data

5.5.1 Many ceramic products are developed for specific property attributes appropriate to particular end uses. If it is required to provide a classification element to define the "properties" or "characteristics", this is done using a code with an initial letter "D" (data), followed by a string of 3 to 6 numerical characters defined according to the matrix in annex E. The first numerical character defines the property class, and the second the property type within that class. Where appropriate, details of the properties are coded in subsequent numerical characters.

A flow diagram for the selection of property data codes is shown in Figure 3.

NOTE It is envisaged that property classification elements could be expanded into a more-detailed data base when this is desired, the other classification elements being employed to define uniquely the chemical character, applications and any other feature of the material or component.

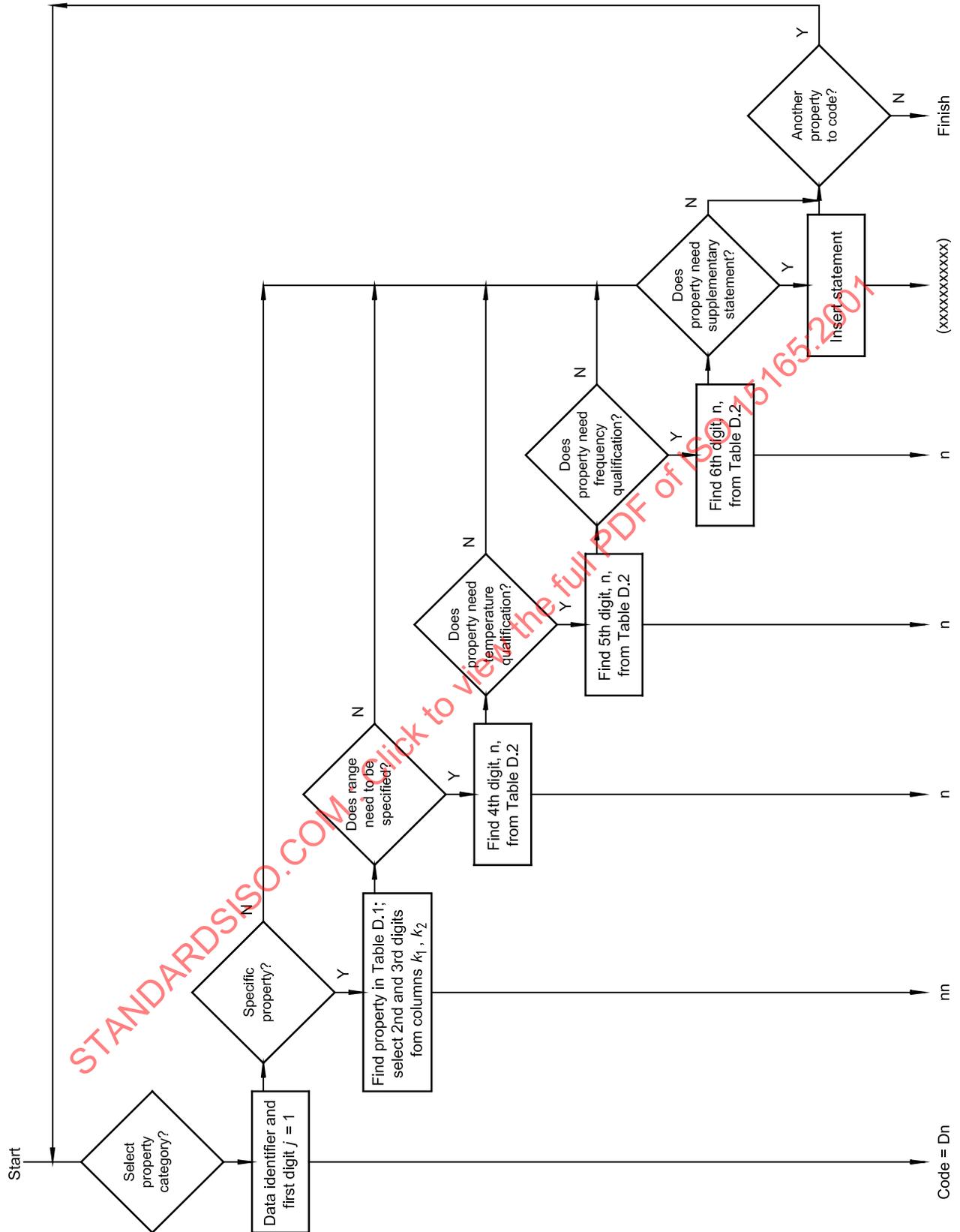


Figure 3 — Flow diagram for the selection of codes representing data

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5.5.2 For cases in which one or more properties are seen to be of relevance in the classification of a ceramic product, but where it is **either**

- adequate to indicate simply this fact, **or**
- where it is not possible to ascribe a numerical value because there are no standardized procedures for giving single-valued data, **or**
- there are no standardized or recognized test methods

the code is limited to the first three numerical characters. The citing of property characteristics in this manner shall be taken to imply that the property is important for the function of the material, either by design of the material or by the application for which it is intended.

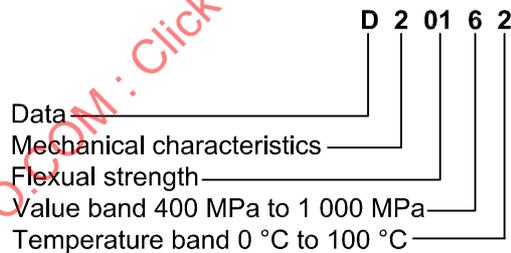
EXAMPLES

An acid-resistant material	D802
An electro-optic material	D617
A material designed for (unspecified) thermal shock resistance	D303

5.5.3 Where it is appropriate to use **numerical property values**, properties are divided into numerical bands of values as determined by a specified test method. The appropriate band can be selected using the fourth numerical character. When desirable or appropriate, the property band may be qualified by use of a fifth numerical character indicating the **temperature range** in which the property has a value in the selected band. With particular reference to electrical properties, a sixth numerical character may be selected to indicate the **frequency range** relevant to the property data. The frequency character shall always be used in conjunction with the temperature character to avoid ambiguity.

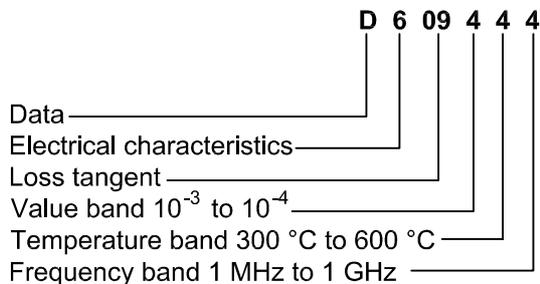
EXAMPLE 1

A material with room-temperature flexural strength of 600 MPa:



EXAMPLE 2

An electrical insulator with loss tangent 5×10^{-4} at 400 °C and 10 MHz:



5.5.4 If more than one property characteristic is required, the code D is repeated, i.e.:

DnnnDnnnnnnDnnn

represents three property features of particular relevance. These coding elements can be placed in any sequence without change of meaning.

EXAMPLE

A material with thermal conductivity $40 \text{ W m}^{-1} \text{ K}^{-1}$, dielectric loss tangent 5×10^{-4} at 10 MHz and flexural strength 600 MPa, all at $400 \text{ }^\circ\text{C}$:

D20164D609444D30154

The first two elements in this example are taken from the previous examples for single elements, and the third signifies the thermal conductivity classification.

5.5.5 Optionally, a “**supplementary statement**” may be added to the classification code in order to indicate the test method being used, a test method parameter, or other relevant attribute, e.g. colour. The supplementary statement is enclosed in parentheses (..) and immediately follows the Dnnnnnn code.

EXAMPLE

Taking the previous example and adding the test methods and the colour of the product gives:

D20164(ISO 14704, 4-point bending, 40 mm span)D609444(IEC 60672)D30154(EN 821-2 and specific heat) D403(white)

5.6 Other classification fields

While not a defined part of this International Standard, additional classification fields may be used for further features associated with a product as required by the application of the classification. If it is desired to include such information, the classification fields should be constructed as agreed tables of codes in the form:

Xnnn

where **X** is a unique and unambiguously identifiable initial classification field character, and **nnn** is a three-digit code from an agreed table. In this form, the additional classification elements remain unique and machine readable.

Examples of attributes which could be coded in this way include:

- date of coding
- manufacturer's name
- country of origin

6 Construction of a complete classification code

The classification method described above may be used to assemble a code of any length to any level of detail appropriate to the end-use requirements. By using unique letter identifiers at the start of each classification element an individual element is easily identifiable in the combined code, which can then be constructed in any appropriate order of classification fields.

The complete code comprises the individual coding elements in any agreed order, and shall be written as a continuous string of characters with no gaps or punctuation.

It is the purpose of this International Standard to provide only a framework for classification rather than to prescribe exact formats of codes for specific end functions. The system is sufficiently flexible to cover many envisaged purposes by the appropriate agreed methods of selecting and ordering the coding elements. However, it is recommended that unless otherwise required, the short format chemistry code is used.

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The following examples are given to illustrate the potential applications.

EXAMPLE 1 To survey markets or to compile trade statistics for fine ceramics, a trade organization might require compilation of sales data by its members by classifying their products according to the criterion:

application + short-form chemical character

The classification code would appear as:

AnnnCXXnnnn

where XX defines the form of the product of interest, and nnnn is a short form code for a particular chemistry category. Trade returns could be demanded labelled in this way. Thus, reduced titania threadguides would be coded:

A402CKB6441

EXAMPLE 2 A research organization wishes to construct a data base based on brochures for commercially available materials. The chemical character is the principal identifier, and the available information from manufacturers on chemical character and principle property data might be converted into a machine readable code:

CXXnnnnDnnnDnnnDnnnn.....

In this case the application may not be relevant, while the data elements are key items allowing differentiation between products. As many data elements as needed may be added in the data string. Alternatively, the chemical character string alone could be used to head a purpose-built detailed property data base. For example, a 95 % alumina ceramic used as an electrical insulator with the property data defined in 5.5.3 above would be coded:

CKB5040D20162D609444

EXAMPLE 3 An organization requires a ceramic material with specific property attributes for a particular application. The chemical character is not important. The product could be characterized using the code:

AnnnDnnnDnnnnnnDnnnnDnnnn.....

where the data classification field is used to identify the broad property requirements. This code could be used to search a data base; e.g. a rotating shaft seal for a chemical plant pump requiring high strength (> 200 MPa, room temperature implied), sliding wear resistance, acid resistance and resistance to water quench thermal shock to 300 °C could be searched for using the code:

A371D2015D702D802D3033

Annex A (normative)

Application classification field

A.1 Introduction

This field is uniquely identified by the initial letter **A**.

The classification list for applications of fine ceramics (advanced ceramics, advanced technical ceramics) is given below. The list is composed of a hierarchy of application types grouped as given below.

To assist in the identification of the appropriate class and code as determined by its principal function, an alphabetical index follows the hierarchical listing.

NOTE Since the application range for fine ceramic (advanced ceramic, advanced technical ceramic) products is widening rapidly, this list may not include recently developed applications. Where there is any doubt, until the classification is updated, the most appropriate "other" identification should be used.

Code No.	Application type
100-199	Passive electrical applications
200-299	Active electrical applications
300-499	Mechanical applications
500-599	Thermal and thermomechanical applications
600-699	Nuclear applications
700-799	Optical applications.
800-899	Chemical applications, including biomedical applications
900-949	Magnetic applications
950-979	Ceramic powder applications
980-999	Other applications

In cases where a material needs to be described as having a general field of application, e.g. unspecified mechanical applications, the **unspecified** or **general** code given at the head of each sublist shall be used. In cases where the application is specified, but not explicitly listed, the "**other**" code given at the end of the relevant sublist shall be used.

Some applications may appear not to fall uniquely into a single category listed above by virtue of using several advantageous features. An example would be a rotating shaft seal for a chemical plant pump. This performs a mechanical function in a chemical environment and is listed under mechanical applications. The rule shall be used such that the application is coded under the general heading which is most appropriate to its field of use. An index is provided to assist location in the list.

A.2 Classes of applications

100-199 Passive electrical applications

100 Unspecified or general passive electrical applications

Power insulators

- 101 Structural electrical power insulators
 - 102 Small low-tension electrical insulators (e.g. stand-off insulators, bus bar supports, terminal blocks)
 - 103 Spark plug insulators
 - 104 Igniter insulators
 - 105 Glow plug insulators
 - 106 Eyelets and cable cleats
 - 107 Bushes, sleeves, ≤ 200 °C
 - 108 Bushes, sleeves, > 200 °C
 - 109 Aerial insulators
 - 110 Low power coil formers
 - 111 High power coil formers
 - 112 Precision coil formers
 - 113 Coil formers for high frequency applications
 - 114 Coil formers for high temperature applications
 - 115 Low power fuse bodies
 - 116 High power fuse bodies
 - 117 Vacuum envelopes
 - 118 Vacuum leadthroughs
 - 119 Electrical insulators for use in vacuum
- 120 Other electrical components for use in vacuum
- 121 Thermostat bases and assemblies
 - 122 Cartridge heater supports and assemblies
 - 123 Moulded insulators
 - 124 Moulded insulators with metal parts
- 139 Other power electrical insulators

Insulators for electronics

- 140 Substrates for electronic components, monolithic, including pin-grid arrays
 - 141 Multilayer interconnects for electronic circuits, including pin-grid arrays
 - 142 Heat sinks
 - 143 Power semiconductor housings
 - 144 Resistor cores
- 169 Other insulators for electronics

Microwave insulators

- 170 Radomes and missile nosecones
- 171 Windows for use in microwave devices
- 172 Absorbers and attenuators for microwave devices
- 173 Phase shifters for use in microwave devices

179 Other applications in microwave devices

199 Other passive electrical applications

200-299 Active electrical applications

200 Unspecified or general active electrical applications

Ohmic electrical conductors

- 201 Ohmic heating elements
- 202 High frequency susceptors
- 203 Electrodes
- 204 Igniters, jet engine
- 205 Thermionic emitting cathodes
- 206 Semiconducting devices for IC handling

219 Other ohmic electrical conducting applications

Ionic conductors

- 220 Battery electrolytes
- 221 Fuel cell electrolytes
- 222 Gas detectors
- 223 Exhaust oxygen sensors
- 224 Molten metal oxygen sensors

229 Other ionic conducting applications

Capacitor applications

- 230 Monolithic single-layer capacitors
- 231 Multilayer chip capacitors

239 Other capacitors

Non-ohmic electrical conductors

- 240 Varistors
- 241 Thermistors
- 242 Attenuators
- 243 Applications based on superconducting ceramic components

249 Other non-ohmic electrical conductors

Piezoelectric applications

- 250 Microphone membranes, including telephone handsets
- 251 Loudspeaker membranes, including telephone handsets
- 252 Other buzzers and vibrators
- 253 Force, pressure and acceleration transducers
- 254 Sonar emitters and detectors
- 255 Impact igniters
- 256 Mechanical actuators
- 257 Motor elements
- 258 Ink-jet printer heads
- 259 Resonators
- 260 Hydrophones

- 269 Other piezoelectric devices

- 270 Electrostrictive devices

- 280 Pyroelectric devices

- 299 Other functional electrical devices

300-499 Mechanical applications

- 300 Unspecified or general mechanical applications

Milling and crushing machinery

- 301 Mill bodies and mill linings
- 302 Milling media
- 303 Other mill parts
- 304 Pestle and mortar linings for grinding soft materials
- 305 Pestle and mortar linings for grinding hard materials

- 309 Other milling or crushing applications

Agricultural applications

- 310 Agricultural implements for soil working
- 311 Agricultural pulverizing nozzles

- 319 Other agricultural applications

Wear resistant facings for plant and machinery

- 320 Shot blast nozzles
- 321 Pipelines and cyclones
- 322 Chute linings
- 323 Food processing applications
- 324 Mould and die liners
- 325 Crushing rolls
- 326 Slideways, wear resisting pads

- 327 Forming rolls
- 328 Gear wheels

- 329 Other wear resistant facings

Ballistic applications

- 330 Ballistic armour
- 331 Ballistic projectiles

- 339 Other ballistic applications

Material cutting applications

- 340 Indexable cutting tools
- 341 Machine tool parts
- 343 Inserts for rock drilling
- 344 Paper, tape cutting knives
- 345 Domestic knives
- 346 Scissors and shears
- 347 Tool dressing components

- 359 Other material cutting applications

Material shaping applications

- 360 Cold die parts
- 361 Extrusion and drawing dies
- 362 Wire drawing cones
- 363 Dies for hot processes
- 364 Stamping dies and roller dies

- 369 Other material shaping applications

Pump applications

- 370 Vanes and impellers for pumps
- 371 Rotating shaft seals (stationary or rotating components)
- 372 Hydraulic plungers and cylinders
- 373 Pump bearing sleeves
- 374 Pump shafts
- 375 Pump housings

- 379 Other pump applications

Valve and tap (faucet) applications

- 380 Tap (faucet) valve faces, single lever action
- 381 Tap (faucet) valve faces, multiple lever action
- 382 Tap (faucet) valves, for water, other
- 383 Pneumatic valves

- 399 Other valve facings for non-corroding liquids

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Guides for thread, paper, tape, wire, etc.

- 400 Thread-spinning nozzles
- 401 Friction discs for thread texturing
- 402 Thread guides
- 403 Guides, runners for paper handling
- 404 Applications in printer heads
- 405 Guides and other components for magnetic tape transport
- 406 Printing rollers
- 407 Wire guides

- 419 Other thread, paper, tape or wire guide applications

Bearing applications

- 420 Plain bearing sets
- 421 Roller bearing sets
- 422 Precision balls for bearings
- 423 Precision rollers for bearings
- 424 Thrust bearing sets

- 439 Other bearing applications

Precision jigs and metrological devices

- 440 Sizing rings
- 441 Gauge blocks
- 442 Jigs
- 443 Vee blocks
- 444 Surface plates and angle plates

- 459 Other precision tooling applications

Sports goods

- 460 Shoe studs
- 461 Golf-club inserts
- 462 Fishing rod ring liners
- 463 Ice-skate blades

- 469 Other applications in sports goods

Personal Applications

- 470 Watch cases
- 471 Jewellery

- 479 Other personal applications

- 499 Other mechanical applications

500-599 Thermal and thermomechanical applications

500 Unspecified or general thermal or thermomechanical applications

Temperature resistant electrical applications

501 Thermocouple insulators and sheaths
 502 Coiled wire heating element supports
 503 Supports for rod heating elements
 504 Insulators for lamp elements
 505 Resistance thermometer element bases
 506 Lamp holders

509 Other temperature resistant electrical applications

High-temperature materials processing applications

510 Applications in hot metal immersion probes, including ferrules
 511 Muffle tubes for furnaces
 512 Saggars for material processing
 513 Kiln furniture (ware support) for high temperature processing
 514 Pins for refractory insulation
 515 Furnace rollers, runners and guides
 516 Burner parts
 517 High duty heat exchangers
 518 Low duty heat exchangers
 519 High temperature gas valves
 520 Weld pool rings
 521 Gas and plasma welding nozzles
 522 Welding jigs
 523 Casting tubes for molten metals
 524 Shell moulds
 525 Casting cores
 526 Filters for liquid metals
 527 Break rings for the continuous casting process
 528 Crucibles for metal melting and handling
 529 Other liquid metal handling applications

530 Kiln furniture for electronic materials processing

539 Other high-temperature materials processing applications

Aerospace applications

540 Rocket nozzles
 541 Ablation shields
 542 Jet engine petals/nozzles
 543 Brake discs

549 Other aerospace applications

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Domestic applications

- 550 Domestic cooker tops
- 551 Cookery ware

- 559 Other domestic applications

Reciprocating engine applications

- 560 Cylinder blocks
- 561 Pistons and piston crowns
- 562 Fuel injector nozzles
- 563 Pre-combustion chambers
- 564 Piston pins
- 565 Valves and valve seats
- 566 Cam followers
- 567 Cylinder liners
- 568 Exhaust port liners
- 569 Exhaust pipe liners
- 570 Turbocharger rotors
- 571 Turbocharger stators
- 572 Turbocharger housing
- 573 Fuel injection pins
- 574 Diesel particulate filters

NOTE See code 843 for vehicle exhaust catalyst supports.

- 579 Other reciprocating engine applications

Applications in turbine engines

- 580 Rotors and blades
- 581 Stators
- 582 Combustion chambers
- 583 Fuel injectors
- 584 Regenerators and heat exchanger components
- 585 Thermal barrier coating of metallic components
- 586 Shrouds and shroud components
- 587 Scrolls and scroll components
- 588 Seals and seal components
- 589 Other gas turbine applications

- 599 Other thermal and thermomechanical applications

600-699 Nuclear applications

- 600 Unspecified or general nuclear applications

- 601 Nuclear fuel elements
- 602 Element separators in nuclear applications
- 603 Moderators in nuclear applications

699 Other nuclear applications

700-799 Optical applications

700 Unspecified or general optical applications

Reflective applications

701 Telescope mirrors

702 Synchrotron mirrors

709 Other reflective applications

Non-optical structural components for optical systems

710 Optical benches

711 Ferrules for fibre optics

719 Other structural components for optical applications

Laser components

720 Laser waveguides

721 Laser rods

729 Other components for lasers

Optical window applications

730 Windows for optical wavelengths

731 Windows for infrared wavelengths

739 Other optical window applications

Lamp envelopes

740 High power lamp envelopes

741 Envelopes for high-pressure sodium vapour lamps

749 Other lamp envelopes

Active optical components

750 Optical modulators

751 Luminescent/fluorescent articles

759 Other active optical components

799 Other optical applications

800-899 Chemical and biomedical applications

800 Unspecified or general chemical or biomedical applications

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Laboratory chemical equipment

- 801 Crucibles and boats for laboratory use
- 802 Funnels for laboratory use
- 803 Filter media for laboratory use

- 809 Other laboratory chemical ware applications

Chemical plant applications

- 810 Tower packing in large scale chemical plant
- 811 Vessels and pipes in large scale chemical plant
- 812 Floats and tubes in large scale chemical plant
- 813 Ball valves in large scale chemical plant
- 814 Flowmeter applications
- 815 Gas percolation elements

- 819 Other chemical plant applications

Chemical moulding parts

- 820 Rubber dipping formers

- 829 Other chemical moulding components

Filter bodies and materials

- 830 Filter elements for liquid media, monolithic
- 831 Filter elements for gaseous media, monolithic
- 832 Ceramic filter membranes

- 839 Other filter applications

NOTE Filters for molten metals are coded 526.

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- 840 Ceramic catalysts
- 841 Catalyst supports, granular
- 842 Catalyst supports, plate
- 843 Catalyst supports, monolithic honeycomb, including vehicle exhaust and combustion applications

- 849 Other applications in catalysis

Components for coating processes

- 851 Sputtering targets
- 852 Evaporator boats for metal coating

- 859 Other coating process components

Biomedical applications

- 861 Bone and joint replacement components

- 862 Dental implants
- 863 Vascular biomedical implants
- 864 Dental brackets
- 865 Dental prosthetic crowns

- 869 Other specified biomedical applications

Biochemical applications

- 871 Antibacterial filter applications
- 872 Slow-release drug supports

- 889 Other specified biochemical applications

- 899 Other chemical and biomedical applications

900-949 Magnetic applications

- 900 Unspecified or general magnetic applications

- 901 Cores for loudspeakers and microphones
- 902 Components for transducers
- 903 Components for microwave devices
- 904 Components for coils
- 905 Components for yokes
- 906 Components in flyback transformers
- 907 Components for data recording heads
- 908 Non-magnetic components for data recording heads
- 909 Magnets for motors

- 949 Other magnetic applications

950-979 Ceramic powder applications

- 950 Ceramic powders for unspecified or general applications

Powders for ceramic manufacture

- 951 Ceramic powders for ceramic manufacture – as-manufactured
- 952 Ceramic powders for ceramic manufacture – mixed and/or with binders (ready to use)
- 953 Ceramic powders for the manufacture of adhesives or cements

Powders used as such without alteration

- 954 Ceramic powders for thermal insulation
- 955 Ceramic powders for electrical insulation
- 956 Ceramic powders for heat-treatment beds or furnace insulation
- 957 Ceramic powders for use as abrasives, including blasting grits, lapping or grinding grits and polishing powders
- 958 Ceramic powders for use as reference materials

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Powders used for surface coatings

- 959 Ceramic powders for flame spraying or plasma spraying
- 960 Ceramic powders for lubricating coating purposes
- 961 Ceramic powders for luminescent coatings
- 962 Ceramic powders for colours, glazes or enamels on ceramic, glass or metal articles

Powders used as fillers in other materials

- 963 Ceramic powders for fillers in polymers
- 964 Ceramic powders for fillers in adhesives or potting compounds
- 965 Ceramic powders for fillers in greases or pastes
- 966 Ceramic powders for the active component in magnetic media

- 979 Other specified applications for ceramic powders

980-999 Other applications

NOTE 980-998 are reserved for future classifiable applications not falling under previous classes. At present none is specifically identified, and the number 999 should be used.

- 999 Other applications

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Annex B (normative)

Chemical character descriptor field

B.1 Introduction

This field contains information relating to the **chemical character** and **form**, and is uniquely identified by the initial letter **C**.

Due to the relatively complex chemical character of fine ceramics (advanced ceramics, advanced technical ceramics) and the likelihood of the presence of a number of compounds and forms, this part of the classification system is required to be particularly versatile. The chemical character code contains at least three essential items of information in the following order:

- a) the initial identifier letter **C**;
- b) the overall form of the item, i.e. powder, fibre, monolithic, etc., expressed as one or two upper case letters;
- c) a numerical identification of the chemical formulation (of the major constituent at least) either by a long-format code or a short-format code (see B.2).

Additional classification items may be included in the long-format coding string to identify the purity of the major component, and the form and chemical character of second or minor constituents. In these cases, the form descriptors also act as separators between related compounds.

B.2 Chemical formulation format selection

The decision on selection of a long-format or short-format code depends on the purpose for which the system is being used, and shall be subject to agreement between parties.

The **long-format** code is appropriate for situations in which it is desired to define the product closely in terms of several chemical species and the manner and/or quantity in which they are physically or chemically present in the material in question. Examples include detailed technical data bases, research and development inventories, manufacturing trials.

The **short-format** code is appropriate for situations in which it is desired only to define the product as being one of a group or class commonly referred to by a chemical name, e.g. cordierite, but where a narrower classification concerning its make-up, proportions of chemical species present and the physical or chemical arrangement of them, is not required. Examples include commercial product listings, trade statistics, internal inventories, etc.

NOTE 1 Whichever format is chosen, this four-digit code system provides sufficient space for the materials of more complex composition which are in current usage and will allow additions of items which may warrant inclusion in the future.

NOTE 2 The two coding forms offer the possibility of identifying a product either by a combination of simple compound codes or by a single four-digit code representing a material group. Unfortunately, it is not possible to avoid using different numerical code constructions for these two formats without losing a great deal of flexibility in use. There is therefore no direct general logic link between the two formats for any product. However, it is possible to create such links if required for specific material types, e.g. a range of long-format codes might be represented by a single short-format code. If both formats are to be used in parallel for a particular application, links between the formats must be specifically created in order to ensure correct identification of the materials.

B.3 Form descriptors

B.3.1 The Form descriptors, which also act as separators in the chemical character coding, are given in the following list.

B = Precursor

BG = gas

BL = liquid

BS = solid

E = Powder

EE = conventional

EF = powder coated with an inorganic material

EG = powder coated with an organic material

EH = spray dried powder granules

EJ = mechanically granulated powder

EK = partly consolidated ceramic/preform/green shape

EL = unfired ceramic-loaded green tape or foil

EM = ceramic powder loaded metal body

EQ = ceramic powder loaded polymer body

ER = ceramic powder loaded paste

NOTE Codes EM to ER are intended for use with products in their final use condition, not as intermediaries to the production of other materials.

W = Whisker

WB = whisker mat

WE = floated/sized whiskers

WM = ceramic whisker loaded metal body

WQ = ceramic whisker loaded polymer body

WR = ceramic whisker loaded paste

F = Fibres

FS = short thin fibres

FL = single long thin (continuous) fibres

FF = filament (thick fibres)

FT = long fibre tows

FW = woven fibre mat

FP = pre-preg

FB = blanket

FV = rigid pressed or vacuum formed preform or board

FM = ceramic fibre loaded metal body

FQ = ceramic fibre loaded polymer body

FR = ceramic rods in a polymer body

FW = ceramic fibre loaded paste

J = Platelets

H = Hollow spheres

S = Single crystal

K = Rigid ceramic body

KB = solid glass, glass-ceramic or polycrystalline ceramic object (no deliberate porosity)

KE = 3D closed cellular ceramic

KF = 2D (e.g. honeycomb) cellular ceramic

KG = open porous ceramic

KH = graded density (open porous) ceramic

KJ = functionally graded ceramic

KK = coated ceramic

KL = surface treated or surface modified ceramic

KM = multilayer composite ceramic

KS = unidirectional (1D) ceramic matrix long-fibre composite

KT = bidirectional (2D) ceramic matrix long-fibre composite (including woven fibres)

KU = multidirectional (3D and higher) ceramic matrix long-fibre composite (including knitted fibres)

KV = short (chopped) fibre ceramic matrix composites

KW = ceramic matrix whisker-containing composite

KX = ceramic matrix platelet-containing composite

KY = ceramic with moulded-in metal or ceramic parts (prior to consolidation)

KZ = ceramic containing dispersed metal particles

L = Ceramic coating

LB = thin (< 20 µm) coating

LE = thick (≥ 20 µm) coating

LF = cementitious material for joining

The following codes are used exclusively with the **long-format code only** to define how individually identified species are incorporated into the material:

M = Mixture (used for second and subsequent species to indicate relationship to first species)

MB = chemical mixture of a second or subsequent species with the previous one(s) to indicate a compound or solid solution not specifically listed in the chemical character listing given in B.5 (e.g. a solid solution of magnesium dititanate and aluminium titanate, or a glass) – the code indicates that the following numerical code element refers to a declared second additional compound chemically combined with the previous one

ME = physical or chemical mixture of a second or subsequent deliberate minor or trace addition to the previously defined compound (e.g. MgO in alumina or B in SiC), the exact form or nature of which is not specifically identified

MF = physically discrete particulate mixture of a second or subsequent species with the previous one(s) (e.g. a second distinct individual discontinuous crystalline phase, a second powder intermixed with a first) – this code indicates that the following numerical code element refers to a declared additional compound in a physically separate form from the previous one

MG = physically discrete, nominally continuous second phase in a material comprising principally the previously cited phases

MH = the following species is in the form of discrete fibres

MJ = the following species is in the form of discrete whiskers

MK = the following species is in the form of discrete platelets

ML = the following species is in the form of a coating on the previous species

MM = the following species is used in chemically altering the surface of a material relative to its bulk

MS = the following species is used as a distinct layer in a layer composite

B.3.2 The following code construction rules apply:

- a) When describing ceramic matrix composite materials, the matrix phase(s) must be defined first.
- b) All particulate-containing ceramic bodies, including metal and ceramic particles, where the particles form a discrete second phase which might be considered to strengthen or toughen the matrix, are described by codes KB – KZ according to the form of the product. There is no separate code for ceramic particulate reinforcement, which should be coded using KB.

B.4 Four-digit codes for other compounds and defined product types

B.4.1 For long-format codes

The four digits in the chemical character code will identify the item as belonging to one of the specific listed types. The listing is arranged according to the following hierarchy:

0000 - 0999 Elements and simple ceramic compounds described as oxides, nitrides, carbides, etc.

1000 - 1999	Binary stoichiometric compounds and compositions not directly available from the matrix.
2000 - 2999	Tertiary stoichiometric compounds
3000 - 3999	Other stoichiometric compounds
4000 - 4999	Non-stoichiometric compounds

Codes in the range 0000 to 0999 are listed in matrix form in Table B.1. For specific chemical compounds which are not available from the above matrix, a four-digit code in the range 1000 to 4999 is specified in the following clause.

The following general rules shall be followed:

- 1) For precursors and powders of high purity or where purity may need to be defined, four-digit codes shall be used from the range 0001 - 4999.
- 2) For ceramics, glasses or glass-ceramics where detailed composition in chemical component form is to be identified, four-digit codes from the range 0001 - 4999 shall be used in combination optionally with codes for the amounts present and with the relational form of the secondary components using the mixture codes (see B.5).
- 3) If a compound does not appear with the appropriate valency in Table B.1, it is necessary either to treat this as an appropriate mixture of the cited compounds, or as an "other" compound. Example: Fe_3O_4 can be taken as an equimolar chemical mixture of FeO and Fe_2O_3 , or can be coded as "other" (0400).
- 4) If an element cited, e.g., in a chemical analysis, does not appear in Table B.1, the code for "other" shall be used; e.g. nitrogen: 0400, fluorine: 0500.
- 5) Complex organic compounds are currently outside the scope of the classification system.

B.4.2 For short-format codes

Specific material types or compositions are coded 5000 to 9999, and are included in order to provide simple identifiable codes for complex materials in common usage where full chemical identification is either impractical or undesirable.

B.5 Long-format codes

B.5.1 Four-digit codes for simple chemical compounds

Table B.1 gives a four-digit code to be used for the description of chemical components of precursors, powders, and ceramic products where composition in simple chemical compound form is to be described. The Table lists the most common elements, including those of variable valency, and nine commonly-met simple anions. Individual codes are obtained by combining the cationic species of appropriate valency from the list on the left hand side of the table with the required anion given at the top of the table. Each combination of cation and anion is identified by a unique number. The four-digit codes are arranged according to the following hierarchy:

Code No.	Anion
0001 – 0099	(Element alone)
0101 – 0199	Boride
0201 – 0299	Carbide
0301 – 0399	Nitride
0401 – 0499	Oxide

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0501 – 0599	Fluoride
0601 – 0699	Silicide
0701 – 0799	Phosphide
0801 – 0899	Sulphide
0901 – 0999	Iodide

In the majority of cases requiring classification by detailed chemical character, it will be possible to describe a fine ceramic material in terms of these codes. However, the list is not exclusive, and the element description “other” may be used for metallic species not appearing in Table B.1. For single-species anions not appearing in the table, refer to four-digit codes 1000 – 1999 (see B.5.2), for two-species of anion see codes 2000 – 2999 (see B.5.3), and for more complex compounds see 3000 – 3999 (see B.5.4).

It is apparent from the matrix of codes for simple binary compounds that many of the possible code numbers will rarely be used, indeed several of the codes are redundant through impossible combinations, e.g. carbon carbide, or through thermodynamic considerations (instability).

For atomic species which exist with more than one valency, separate rows are provided in the matrix for each valency state. In this way the matrix can provide codes which differentiate between the states, e.g. CeO_2 and Ce_2O_3 , or FeO and Fe_2O_3 . In some cases, the use of simple valencies is not possible. In such cases the formula is quoted after the code number in Table B.1, but would not be used in the code. In other cases, a series of two or more compounds may be formed from the same species. This classification does not attempt to separate them with individual codes, but represents them either in the form A_xB_y or in the form AB_y .

If the component is not normally solid at ambient temperature, this is noted in the matrix table as (g) for gaseous or (l) for liquid. If the chemical normally has water of crystallisation which would be removed in forming a ceramic product, this is indicated by (h) (= hydrated).

Substoichiometry of compounds is accommodated in one of two ways:

- 1) By the inclusion of a leading character (N = Non-stoichiometric) in the code. “N” does not appear as a character in the form descriptor, and therefore would not be confused with data in that field. The code for a non-stoichiometric titanium dioxide for example would be:

N0420

- 2) As a designated item in the code band 4000 - 4999 (see B.5.5).

In cases where impurities are required to be coded, but there is no code for the impurity in Table B.1, e.g. oxygen specified as an impurity in AlN, for coding purposes the impurity should be considered as a relevant compound (e.g. Al_2O_3 in AlN), or alternatively, should be specifically indicated in a supplementary statement to the code.

EXAMPLE An aluminium nitride containing 2 % by mass of oxygen has the equivalent amount of alumina (Al_2O_3) of:

$$2\% \times \frac{\text{M.W. of } \text{Al}_2\text{O}_3}{\text{M.W. of } \text{O}_3} = 2 \times \frac{101,6}{48,0} = 4,2\%$$

where M.W. is the molecular weight. The product could then be coded:

CKB0307ME0407(4.2C)

where the code ME has been used to indicate that the Al_2O_3 (0407) has an unknown spatial relationship (ME) to the AlN (0307).

Table B.1 — Four-digit chemical character codes for elements and simple compounds

Element (valency)	Element alone	Boride	Carbide	Nitride	Oxide	Fluoride	Silicide	Phosphide	Sulphide	Iodide
Li	0001	0101 Li _x B _y	0201 Li ₂ C ₂	0301	0401	0501	0601	0701	0801	0901
Be	0002	0102 Be _x B _y	0202 Be ₂ C	0302	0402	0502	x	x	0802 BeS	0902
B	0003	x	0203 B _x C _y	0303	0403	0503 (g)	0603 B _x Si	0703	0803	0903
C	0004	x	x	x	0404 CO _x (g)	0504	x	x	0804 C _x S	0904
Na	0005	0105 NaB _y	0205 Na ₂ C ₂	0305	0405	0505	x	0705	0805Na _x S _y	0905
Mg	0006	0106 MgB _{2,4}	0206	0306	0406	0506	0606Mg _x Si _y	x	0806	0906
Al	0007	0107 Al _x B _y	0207	0307	0407	0507	x	0707	0807	0907
Si	0008	0108 Si _x B _y	0208	0308	0408	0508 (g)	x	x	0808 Si _x S _y	0908
P(1)	x	x	x	x	x	x	x	x	x	x
P(3)	x	0110 PB ₆	x	x	0410	0510 (g)	x	x	x	0910 PI ₃
P(5)	0011	x	x	0311	0411	0511 (g)	x	x	0811 P _x S _y	x
S(2)	x	x	0212	x	0412 S ₂ O ₃	x	x	x	x	x
S(4)	0013	x	x	0313S ₄ N ₄	0413 SO ₂	0513 (g)	x	x	x	x
S(6)	x	0114 B ₁₂ S ₂	x	x	0414 SO ₃	0514 (g)	x	x	x	x
K	0015	0115 KB ₆	0215 KC ₈	x	0415	0515	x	x	0815 K _x S _y	0915
Ca	0016	0116 CaB ₆	0216 CaC ₂	0316	0416	0516	0616 CaSi ₂	0716Ca ₃ P ₂	0816 CaS	0916
Sc	0017	0117 ScB _{2,12}	0217 Sc _x C _y	0317	0417	0517	0617	x	0817 Sc _x S _y	x
Ti(2)	x	x	x	x	0418	x	0618	x	0818 TiS	x
Ti(3)	x	x	x	0319	0419	0519	0619	0719Ti ₃ P	0819 Ti ₂ S ₃	0919
Ti(4)	0020	0120 TiB ₂	0220 TiC	x	0420	0520	0620	x	0820 TiS ₂	0920
V(2)	x	x	0221 V ₂ C	x	0421	x	0621 V ₂ Si	x	0821 VS	x
V(3)	x	x	0222 V ₄ C ₃	0322	0422	0522	0622 V ₃ Si	x	0822 V ₂ S ₃	0922 (h)
V(4)	x	x	0223 VC	x	0423	0523	x	0723V ₃ P	x	x
V(5)	0024	0124 V _x B _y	0224 V _x C _y	x	0424	0524	0624 VSi ₂	0724 VP	0824 V ₂ S ₅	x
Cr(2)	x	x	x	x	0425	0525	x	x	0825	0925
Cr(3)	0026	x	0226 Cr ₃ C ₂	0326 CrN	0426	0526	0626	0726 CrP	0826	x
Cr(6)	x	0127 Cr _x B _y	x	x	0427	x	x	x	0827 Cr ₃ S ₄	x
Mn(2)	0028	x	x	x	0428	0528 MnF ₂	0628 MnSi	0728 MnP	0828 MnS	0928
Mn(4)	x	0129 Mn _x B _y	0229 Mn _x C _y	x	0429	0529 MnF ₃	0629MnSi ₂	0729Mn ₃ P ₂	0829 MnS ₂	x
Mn(7)	x	x	x	0330 Mn ₂ N	0430	x	x	x	x	x
Fe(2)	0031	0131 Fe ₂ B	0231 Fe ₃ C	x	0431	0531	0631 FeSi _x	0731 Fe ₂ P	0831 FeS	0931
Fe(3)	x	0132 FeB	0232 Fe ₂ C ₃	0332	0432	0532	x	0732 Fe ₃ P	0832 Fe ₂ S ₃	x
Co(2)	0033	0133 Co _x B	x	x	0433	0533 (h)	0633 CoSi	0733 Co ₂ P	0833 CoS	0933
Co(3)	x	x	x	0334	0434	0534	0634 CoSi ₂	x	0834 Co ₂ S ₃	x
Ni	0035	0135 Ni _x B _y	0235 Ni ₃ C	0335	0435 NiO _x	0535	0635 Ni _x Si _y	0735 Ni ₃ P	0835 NiS _x	0935
Cu(1)	x	x	x	x	0436	0536	x	0736 Cu ₃ P	0836 Cu ₂ S	0936
Cu(2)	0037	0137Cu _x B _y	x	x	0437	0537 (h)	0637	0737 Cu ₃ P ₂	0837 CuS	x
Zn	0038	0138 ZnB ₂	x	x	0438	0538	x	0738 Zn ₃ P ₂	0838	0938
Ga	0039	x	x	x	0439	0539	x	0739	0839 Ga _x S _y	0939
Ge(2)	x	x	x	x	x	0540	x	0740 GeP	0840 GeS	0940

Table B.1 (continued)

Element (valency)	Element alone	Boride	Carbide	Nitride	Oxide	Fluoride	Silicide	Phosphide	Sulphide	Iodide
Ge(4)	0041	x	x	x	0441	0541	0641 Si _x Ge _y	x	0841 GeS ₂	0941
As(3)	x	x	x	x	0442	0542 (g)	0642	x	0842	0942
As(5)	0043	0143	x	x	0443	0543 (g)	0643	0743	0843	0943
Se(4)	x	x	x	x	0444	0544	x	x	0844 SeS	0944
Se(6)	0045	x	x	x	x	0545	x	x	0845 SeS ₂	0945 Se ₂ I ₂
Rb	0046	x	0246	x	0446 Rb _x O _y	0546	x	0746	0846 Rb _x S _y	0946
Sr	0047	0147 SrB ₆	0247 SrC ₂	x	0447	0547	x	0747	0847	0947
Y	0048	0148 YB _{4,6}	0248	0348	0448	0548 (h)	0648	0748	0848	0948
Zr	0049	0149 ZrB ₂	0249	0349	0449	0549	0649	0749	0849	0949
Nb(3)	0050	0150 Nb ₃ B ₂	0250	0350	0450 NbO	x	x	x	x	x
Nb(5)	0051	0151 NbB ₂	0251 NbC	x	0451	0551	x	0751 NbP	x	x
Mo(3)	0052	x	0252 Mo ₂ C	0352	0452	x	x	0752 MoP	x	x
Mo(6)	x	0153 MoB ₂	x	x	0453	0553 MoF ₆	0653 MoSi ₂	0753 MoP ₂	0853 Mo _x S _y	0953 MoI ₆
Ru(3)	x	x	x	x	0454	0554	x	x	x	x
Ru(4)	x	x	x	x	0455	0555	x	x	x	x
Ru(6)	0056	0156 Ru _x B _y	x	x	0456 RuO ₄	0556 RuF ₅	0656 RuSi	x	0856 RuS ₂	0956 RuI
Rh	0057	0157 Rh _x B _y	x	x	0457 Rh _x O _y	0557	x	0757	0857 Rh _x S _y	x
Pd	0058	0158 Pd _x B _y	x	x	0458 Pd _x O _y	0558 Pd _x F _y	0658 Pd ₂ Si	x	0858 Pd _x S _y	0958
Ag	0059	x	x	x	0459 AgO	0559 Ag _x F	0659	x	0859 Ag _x S	0959
Cd	0060	x	x	x	0460	0560	x	x	0860	0960
In	0061	x	x	x	0461 In _x O _y	0561	0661	0761 InP	0861 In _x S _y	0961 InI _x
Sn(2)	x	x	x	x	0462	0562	x	0762 Sn _x P _y	0862	0962
Sn(4)	0063	x	x	x	0463	0563	0663 SnSi	x	0863	0963
Sb(3)	x	x	x	x	0464	0564	x	x	0864	0964
Sb(5)	0065	x	x	x	0465	0565 (l)	x	x	0865	0965
Te(4)	x	x	x	x	0466	0566	x	x	866 TeS ₂	0966
Te(6)	0067	x	x	x	0467	0567	x	x	x	0967
Cs	0068	x	0268 CsC ₈	x	0468 Cs _x O _y	0568	x	x	868 CsS _x	0968
Ba	0069	0169 BaB ₆	x	x	0469	0569	x	x	869 BaS	0969(h)
La	0070	0170 LaB _{4,6}	0270 LaC ₂	0370	0470	0570	0670	0770	870	0970
Ce(3)	x	0171 CeB ₆	0271 Ce ₂ C ₃	x	0471	0571	x	0771	871 Ce ₂ S ₃	x
Ce(4)	0072	0172 CeB ₄	0272 CeC ₂	0372	0472	0572 (h)	0672 CeSi ₂	x	x	0972 (h)
Pr	0073	0173 PrB _{4,6}	0273 Pr _x C _y	0373	0473 Pr _x O _y	0573	0673	x	873 Pr ₂ S ₃	x
Nd(3)	0074	0174 NdB ₆	0274 Nd ₂ C ₃	0374	0474	0574	0674 Nd ₂ Si ₃	0774	874 Nd ₂ S ₃	0974
Nd(4)	x	0175 NdB ₄	0275 NdC ₂	x	x	x	0675 Nd ₃ Si ₄	x	x	x
Sm	0076	0176 SmB _{4,6}	0276 Sm _x C _y	0376	0476	0576	0676	0776	876	0976
Eu	0077	0177 EuB _{4,6}	0277 Eu _x C _y	0377	0477	x	x	x	877 EuS	x
Gd	0078	0178 GdB _{4,6}	0278 Gd _x C _y	x	0478	0578	0678 GdSi ₂	0778	878 Gd ₂ S ₃	x
Dy	0079	0179 DyB _{4,6}	0279 Dy _x C _y	0379	0479	x	0679	0779	879	x
Ho	0080	0180 HoB _{4,6}	0280 Ho _x C _y	0380	0480	x	x	x	x	x
Er	0081	0181 ErB _{4,6}	0281 Er _x C _y	0381	0481	x	0681	0781	x	x
Yb	0082	0182 YbB _{4,6}	0282 Yb _x C _y	0382	0482	0582	x	0782	882	x
Hf	0083	0183 HfB ₂	0283 HfC	0383	0483	x	0683	0783 HfP	x	x
Ta(4)	x	x	0284 TaC	0384	0484	x	0684 Ta ₂ Si	x	884 TaS ₂	x
Ta(5)	0085	0185 TaB ₂	x	0385	0485	0585	0685 TaSi ₂	0785 TaP	x	x

Table B.1 (continued)

Element (valency)	Element alone	Boride	Carbide	Nitride	Oxide	Fluoride	Silicide	Phosphide	Sulphide	Iodide
W(4)	x	x	0286 W ₂ C	0386 W ₂ N	0486 WO ₂	x	0686 WSi _x	0786 WP	886 WS	0986 WI ₂
W(6)	0087	0187 W _x B _y	0287 WC	0387 WN	0487 WO ₃	0587 (g)	x	0787 WP ₂	887 WS ₂	0987 WI ₄
Re	0088	0188 Re _x B _y	x	x	0488 Re _x O _y	0588 ReF _{4,6}	x	x	x	x
Ir	0089	0189 Ir _x B _y	x	x	0489 Ir _x O _y	0589 IrF ₆	0689	x	889 IrS _x	0989 IrI _x
Pt	0090	0190 PtB	x	x	0490 Pt _x O _y	x	0690	x	890 PtS _x	0990 PtI _{2,4}
Au	0091	0191 Au _x B _y	x	x	0491 Au _x O _y	x	x	0791	891	0991
Tl	0092	x	x	0392 TlN ₃	0492 Tl _x O _y	0592 TlF _{1,3}	x	x	892 Tl _x S _y	0992 Tl _x I _y
Pb(2)	x	x	x	x	0493 PbO	0593	x	x	893 PbS	0993 Pbl
Pb(4)	0094	x	x	x	0494 PbO ₂	x	x	x	x	0994 Pbl ₂
Bi	0095	x	x	x	0495	0595	x	x	895 Bi ₂ S ₃	0995
Th	0096	0196 ThB ₆	0296 ThC ₂	0396	0496	0596	x	0796	896	0996
U(3)	x	x	x	x	0497 U ₃ O ₈	x	0697 U ₃ Si	x	897 U ₂ S ₃	0997
U(4)	0098	x	0298 d-UC	x	0498 UO ₂	0598	0698 U ₃ Si ₂	0798 U ₃ P ₄	898 US ₂	0998
U(6)	x	0199 U _x B _y	0299 UC ₂	0399	0499 UO ₃	0599 (g)	x	x	x	0999
Other	0000	0100	0200	0300	0400	0500	0600	0700	0800	0900

Key:
g = normally gaseous
l = normally liquid
h = normally with water of crystallization
x = does not exist, or not appropriate
A_xB_y: there may be several distinct compounds with various values of x and y; some may not be truly stoichiometric
The existence of more than one distinct compound with a single code is indicated by the use of a “;” within the subscript “y”.

B.5.2 Codes for two-component stoichiometric species, long-format codes 1000 - 1999

The following grouping is used:

1000 – 1099	Aluminides
1100 – 1199	Antimonides
1200 – 1299	Arsenides
1300 – 1399	Bromides
1400 – 1499	Chlorides
1500 – 1599	Hydrides
1600 – 1699	Selenides
1700 – 1799	Tellurides
1800 – 1999	Binary components with other radicals

Individual classified components are:

1000	Nickel aluminide
1099	Other aluminides
1100	Indium antimonide
1101	Lead antimonide
1102	Nickel antimonide

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1103	Potassium antimonide
1104	Sodium antimonide
1199	Other antimonides
1200	Cadmium arsenide
1201	Copper arsenide
1202	Indium arsenide
1203	Nickel arsenide
1299	Other arsenides
1300	Beryllium bromide
1301	Boron bromide
1302	Cadmium bromide
1303	Indium bromide
1304	Lithium bromide
1305	Nickel bromide
1306	Silicon bromide
1399	Other bromides
1400	Boron trichloride
1401	Calcium chloride
1402	Cerium chloride
1403	Chromium chloride
1404	Indium chloride
1405	Lithium chloride
1406	Magnesium chloride
1407	Nickel chloride
1408	Potassium chloride
1409	Silicon chloride
1499	Other chlorides
1500	Boron hydride
1501	Lithium hydride
1502	Silicon hydride
1503	Titanium hydride
1599	Other hydrides
1600	Copper selenide
1601	Indium selenide
1602	Zinc selenide
1699	Other selenides
1700	Indium telluride
1701	Lead telluride
1799	Other tellurides
1999	Other binary stoichiometric compounds

B.5.3 Codes for three-component stoichiometric compounds, long-format codes 2000 - 2999

This classification is divided into the following alphabetical hierarchy:

2000 – 2049	Aluminates
2050 – 2099	Borates
2100 – 2109	Cerates
2110 – 2119	Chromites
2120 – 2149	Cuprates
2150 – 2199	Ferrites
2200 – 2249	Ferrates
2250 – 2299	Germanates
2300 – 2349	Manganates
2350 – 2399	Niobates
2400 - 2449	Phosphates
2450 – 2549	Silicates
2550 – 2599	Stannates
2600 – 2649	Sulfates
2650 – 2749	Titanates
2750 – 2799	Tungstates
2800 – 2849	Vanadates
2850 – 2899	Zirconates
2900 – 2999	Other three-component species

Individual classified compounds are:

2000	Barium aluminate
2001	Beryllium aluminate
2002	Calcium aluminate
2003	Lithium aluminate
2004	Magnesium aluminate
2005	Potassium aluminate
2006	Sodium aluminate
2007	Zinc aluminate
2049	Other aluminates
2050	Aluminium borate
2051	Lithium borate
2052	Potassium borate
2053	Sodium borate
2054	Zinc borate
2099	Other borates
2100	Strontium cerate
2109	Other cerates
2110	Lanthanum chromite
2119	Other chromates or chromites

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2120	Aluminium cuprate
2121	Barium cuprate
2122	Lanthanum cuprate
2123	Neodymium cuprate
2124	Praseodymium cuprate
2149	Other cuprates
2150	Calcium ferrite
2151	Cobalt ferrite
2152	Lead ferrite
2153	Magnesium ferrite
2154	Manganese ferrite
2155	Nickel ferrite
2156	Sodium ferrite
2157	Zinc ferrite
2199	Other ferrites
2200	Copper ferrate
2201	Nickel ferrate
2202	Zinc ferrate
2249	Other ferrates
2250	Lithium germanate
2251	Potassium germanate
2252	Sodium germanate
2299	Other germanates
2300	Barium manganate
2301	Nickel manganate
2349	Other manganates
2350	Lead niobate
2351	Lithium niobate
2399	Other niobates
2400	Aluminium phosphate
2401	Cadmium phosphate
2402	Calcium phosphate
2403	Lead phosphate
2404	Lithium phosphate
2405	Magnesium phosphate
2406	Manganese phosphate
2407	Potassium phosphate
2408	Sodium phosphate
2409	Zinc phosphate
2410	Zirconyl phosphate
2449	Other phosphates
2450	Aluminium silicate
2451	Barium silicate

2452	Beryllium silicate (beryl)
2453	Cadmium silicate
2454	Calcium silicate
2455	Cobalt silicate
2456	Iron silicate
2457	Lead silicate
2458	Lithium silicate
2459	Magnesium silicate (MgSiO_3 , enstatite)
2460	Magnesium silicate ($2\text{MgO}\cdot\text{SiO}_2$, forsterite)
2461	Potassium silicate
2462	Sodium silicate
2463	Zinc silicate (willemite)
2464	Zirconium silicate (zircon)
2549	Other silicates
2550	Indium stannate
2599	Other stannates
2600	Barium sulphate
2601	Calcium sulphate
2649	Other sulphates
2650	Aluminium titanate
2651	Barium titanate
2652	Calcium titanate
2653	Iron titanate
2654	Lead titanate
2655	Lithium titanate
2656	Magnesium titanate
2657	Manganese titanate
2658	Potassium titanate
2659	Sodium titanate
2660	Strontium titanate
2749	Other titanates
2750	Calcium tungstate
2751	Cerium tungstate
2752	Iron tungstate
2753	Lead tungstate
2754	Lithium tungstate
2755	Potassium tungstate
2756	Sodium tungstate
2799	Other tungstates
2800	Iron vanadate
2849	Other vanadates
2850	Calcium zirconate
2851	Lead zirconate
2852	Lithium zirconate

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2853	Magnesium zirconate
2854	Titanium zirconate
2899	Other zirconates
2999	Other three-component stoichiometric compounds

B.5.4 Codes for other stoichiometric compounds, long-format codes 3000 - 3999

There is a wide variety of materials falling into this category, so only a broad hierarchy can be defined:

3000 – 3399	Oxide based compounds
3400 – 3699	Non-oxide based compounds
3700 – 3999	Mixed oxide/non-oxide based compounds

Individual classified compounds are:

3000	Aluminium zirconium silicate
3001	Antimony sulfur iodide
3002	Barium aluminium silicate
3003	Barium magnesium aluminium silicate (barium osumilite)
3004	Bismuth strontium calcium copper oxide
3006	Calcium aluminium silicate
3007	Calcium magnesium silicate
3008	Calcium strontium barium zirconate
3011	Lead fluorosilicate
3012	Lead lanthanum zirconate titanate
3013	Lead magnesium tungstate
3014	Lead nickel tungstate
3016	Lead zirconate titanate
3017	Lithium aluminium silicate
3019	Lithium cadmium silicate
3020	Lithium zinc silicate
3022	Magnesium aluminium silicate (cordierite)
3023	Manganese copper ferrite
3024	Manganese magnesium ferrite
3025	Manganese magnesium zinc ferrite
3026	Manganese zinc ferrite
3027	Nickel zinc ferrite
3028	Potassium aluminium silicate (feldspar)

3030	Sodium aluminium silicate (feldspar)
3032	Sodium zirconium aluminate
3033	Ytterbium barium titanate
3034	Yttrium aluminium silicate
3035	Yttrium barium copper oxide
3036	Yttrium iron silicate
3399	Other complex oxide compounds
3400	Titanium carbonitride
3449	Other carbonitrides
3700	Aluminium oxynitride (Alon)
3701	Silicon oxynitride
3702	Silicon aluminium oxynitride
3749	Other oxynitrides
3801	Silicon oxycarbide
3849	Other oxycarbides
3899	Other complex non-oxide compounds
3999	Other mixed oxide/non-oxide based compounds

B.5.5 Codes for non-stoichiometric compounds, long-format codes 4000 - 4999

The four-digit numeric codes in the range 4000 - 4999 defining the chemical character are given in the following list:

4999	Other non-stoichiometric compounds
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NOTE In the formulation of this International Standard, no specific instances of non-stoichiometric compounds requiring a separate code have been identified. This situation will be revised in accordance with user demand.

B.6 Codes for defined product types, short-format codes 5000 - 9999

The four-digit numeric codes in the range 5000 - 9999 defining the chemical character are obtained from the following list in alphabetical order of the first metallic species by which the product is normally known from its chemical formula.

NOTE 1 There may be occasions when there is no preferred name; e.g., yttrium aluminate and aluminium yttrate are equal names for yttrium aluminium garnet (YAG). In such cases it is recommended to search the coding list for both names. If neither is found, use the "other" classification for the principal metal species appearing highest in the alphabetical list, in this case under aluminium.

NOTE 2 To aid identification of materials described by mineral or other non-chemical names, porcelains may be found under aluminosilicates; mica-based products will be found under aluminosilicates; cordierites will be found under magnesium aluminosilicates; steatites and forsterites will be found under magnesium silicates; apatite based materials may be found under phosphates.

NOTE 3 For materials which contain component A distributed in a matrix of B, e.g. $\text{Al}_2\text{O}_3/\text{ZrO}_2$, when specifically coded these can be found grouped with materials of type A.

5000 – 5359 Materials based on aluminium

5000 Aluminium based materials, not otherwise specified

5001 – 5099 Materials based on alumina (aluminium oxide)

5001 Aluminas, dense, based on alpha-alumina, not otherwise specified

5002 Al_2O_3 materials - ultra high purity (> 99,99 %)

5005 Al_2O_3 materials - extreme high purity (> 99,8 % to 99,99 %)

5010 Al_2O_3 materials - very high purity (> 99,5 % to 99,8 %)

5020 Al_2O_3 materials - high purity (> 99 % to 99,5 %, including IEC 60672 Group C 799)

5030 Al_2O_3 materials - technical (> 96,5 % to 99 % alumina, including IEC 60672 Groups C 530, C 795)

5040 Al_2O_3 materials - technical (> 94 % to 96,5 % alumina, including IEC 60672 Groups C 530, C 786, C 795)

5041 with CaO/SiO_2 additive

5042 with $\text{MgO}/\text{CaO}/\text{SiO}_2$ additive

5043 with MnO/TiO_2 additive

5049 with other specified additives

5050 Al_2O_3 materials - technical (> 90 % to 94 % alumina, including IEC 60672 Group C 786)

5051 with CaO/SiO_2 additive

5052 with $\text{MgO}/\text{CaO}/\text{SiO}_2$ additive

5053 with MnO/TiO_2 additive

5059 with other specified additives

5060 Al_2O_3 materials - technical (> 80 % to 90 % alumina, including IEC 60672 Groups C 780, C 786)

5061 with CaO/SiO_2 additive

5062 with $\text{MgO}/\text{CaO}/\text{SiO}_2$ additive

5063 with MnO/TiO_2 additive

5069 with other specified additives

5070 Al_2O_3 materials - $\leq 80\%$ alumina

5080 $\text{Al}_2\text{O}_3/\text{ZrO}_2$ materials

5090 $\text{Al}_2\text{O}_3/\text{SiC}$ materials

5099 Other specified alpha- Al_2O_3 based dense materials

5101 – 5149 Other forms of alumina

5101 Gamma alumina

5102 Delta alumina

5103 Alpha alumina (other than dense forms)

5110 Tabular alumina

5120 Sapphire

5121 Ruby

5130 Sodium b-alumina

5149 Other specified types of alumina

5150 – 5199 Alumina matrix composite materials

5150 Alumina matrix composites not otherwise specified

5151 containing SiC long fibres

- 5159 containing other fibres
- 5160 containing SiC whiskers
- 5169 containing other whiskers
- 5170 containing SiC platelets
- 5179 containing other platelets
- 5180 containing SiC particulates
- 5181 containing TiC particulates
- 5189 containing other particulates
- 5190 containing SiC whiskers and ZrO₂ particulates
- 5199 Other alumina matrix composites containing a specified second phase

5200 – 5209 *Aluminium nitrides*

- 5200 Aluminium nitride not otherwise specified
- 5201 High-purity aluminium nitride materials
- 5205 Aluminium nitride based materials (99 % \geq AlN \geq 50 %)
- 5209 Other specified aluminium nitrides

5210 – 5219 *Aluminium oxynitrides*

- 5210 Aluminium oxynitride, not otherwise specified
- 5211 Optical grade aluminium oxynitride
- 5215 Aluminium nitride polytypoids (e.g. 15R)
- 5219 Other specified aluminium oxynitrides

5220 – 5349 *Aluminosilicate based materials*

- 5220 Aluminosilicate materials not otherwise specified

5221 – 5239 *Refractory forms of aluminosilicates (including IEC 60672 Group C 500)*

- 5221 Refractory aluminosilicates, not otherwise specified
- 5222 Fused mullite
- 5223 Calcined mullite
- 5224 Molochnite based
- 5225 Sillimanite based
- 5226 Kyanite based
- 5227 Andalusite based
- 5228 Pyrophyllite based
- 5230 High-purity sintered mullite
- 5231 Mullite/zirconia ceramics
- 5232 Mullite ceramics (including IEC 60672 Group C 600)
- 5239 Other specified mullite based materials

5310 – 5339 *Non-refractory aluminosilicates (alkali porcelains)*

- 5310 Non-refractory aluminosilicates, not otherwise specified
- 5311 Siliceous alkali porcelain materials (including IEC 60672 Group C 110)
- 5312 Siliceous alkali porcelain materials, pressed (including IEC 60672 Group C 111)
- 5320 Siliceous alkali porcelain materials (aluminous porcelain, typically 30 % to 50 % Al₂O₃), high strength (including IEC 60672 Group C 120)
- 5330 Siliceous alkali porcelain materials (aluminous porcelain, typically 50 % to 80 % Al₂O₃), high strength (including IEC 60672 Group C 130)
- 5339 Other specified siliceous alkali porcelain materials

5340 – 5344 *Mica based materials*

- 5340 Mica based materials, not otherwise specified
- 5341 Natural mica based materials
- 5342 Fluorine substituted mica based materials
- 5344 Other specified mica based materials

- 5349 Other specified aluminosilicate based materials

5350 – 5355 *Aluminium titanate based materials*

- 5350 Aluminium titanate not otherwise specified
- 5351 Stoichiometric aluminium titanate
- 5352 Stabilized aluminium titanate ceramic body or raw material
- 5355 Other specified mixed aluminium titanate based materials

- 5359 Other specified aluminium based ceramics

5360 Antimony based materials

5380 – 5449 Barium based materials

- 5380 Barium based materials not otherwise specified
- 5381 Barium carbonate based materials
- 5390 Barium silicate based materials
- 5395 Barium aluminosilicate based materials (celsian)
- 5400 Barium titanate based materials
- 5440 Barium fluoride based materials
- 5449 Other specified barium based materials

5450 – 5489 Beryllium based materials

- 5450 Beryllium based materials not otherwise specified
- 5451 Beryllia (including IEC 60672 Group C 810)
- 5460 Beryllia/SiC composites
- 5469 Other beryllia based materials
- 5470 Beryllium boride based materials
- 5489 Other specified beryllium based materials

5490 – 5499 Bismuth based materials

- 5490 Bismuth based materials not otherwise specified
- 5491 Bismuth oxide based materials
- 5495 Bismuth calcium strontium copper oxide materials
- 5499 Other specified bismuth based materials

5500 – 5529 Boron carbide based materials

- 5500 Boron nitrides not otherwise specified
- 5501 Boron carbide materials
- 5520 Boron carbide/titanium diboride composites
- 5521 Boron carbide/alumina materials
- 5529 Other specified boron carbides

5530 – 5549 Boron nitride based materials

- 5530 Boron nitrides not otherwise specified
- 5531 Boron nitride, hexagonal type
- 5539 Boron nitride, cubic type
- 5540 Boron nitride/titanium diboride composites
- 5549 Other specified boron nitrides

5550 – 5579 Calcium based materials

- 5550 Calcium based materials not otherwise specified
- 5551 Calcium oxide based materials
- 5552 Calcium silicate based materials
- 5555 Calcium aluminosilicate based materials
- 5560 Calcium magnesium silicate based materials
- 5565 Calcium zirconium silicate based materials
- 5569 Other specified calcium oxide based materials

- 5570 Calcium fluoride based materials
- 5579 Other specified calcium based materials

5580 – 5599 Carbon based materials

- 5580 Carbon based materials not otherwise specified
- 5581 Diamond single crystals
- 5582 Diamond based composites
- 5583 Diamond-like films
- 5585 CVD graphite
- 5590 Vitreous carbon
- 5595 Fullerenes
- 5599 Other specified carbon based materials

5600 – 5609 Cerium based materials

- 5600 Cerium based materials not otherwise specified
- 5601 Cerium oxide based materials
- 5605 Cerium sulphide based materials
- 5609 Other specified cerium based materials

5610 – 5619 Chromium based materials

- 5610 Chromium based materials not otherwise specified
- 5611 Chromia (Cr₂O₃) based materials
- 5619 Other specified chromium based materials

5620 Cobalt based materials**5630 – 5639 Copper based materials**

- 5630 Copper based materials not otherwise specified
- 5631 Copper oxide based materials
- 5639 Other copper based materials

5640 Dysprosium based materials

5650 Erbium based materials

5660 Europium based materials

5670 – 5679 Gadolinium based materials

- 5670 Gadolinium based materials not otherwise specified
- 5671 Gadolinium iron garnet materials
- 5679 Other specified gadolinium based materials

5680 Gallium based materials

5690 Germanium based materials

5700 – 5709 Hafnium based materials

- 5700 Hafnium based materials not otherwise specified
- 5701 Hafnium oxide based materials
- 5705 Hafnium carbide based materials
- 5709 Other specified hafnium based materials

5710 – 5749 Iron based materials

- 5710 Iron based materials not otherwise specified
- 5711 Iron oxide based materials
- 5720 Iron silicate based materials
- 5730 Iron chromate based materials
- 5740 Iron sulfide based materials
- 5749 Other specified iron based materials

5750 Lanthanum based materials

5760 – 5829 Lead based materials

- 5760 Lead based materials not otherwise specified
- 5761 Lead oxide based materials
- 5770 Lead monosilicate based materials
- 5780 Lead bisilicate materials
- 5790 Lead titanate based materials
- 5800 Lead zirconate based materials
- 5810 Lead niobate based materials
- 5820 Lead lithium niobate materials
- 5829 Other specified lead based materials

5830 – 5899 Lithium based materials

- 5830 Lithium based materials not otherwise specified
- 5831 Petalite based materials
- 5835 Spodumene based materials
- 5840 Eucryptite based materials
- 5859 Other specified lithium aluminium silicate based materials

- 5860 Lithium aluminate based materials
- 5870 Lithium titanate based materials
- 5880 Lithium zirconate based materials
- 5899 Other specified lithium based materials

5900 – 6099 Magnesium based materials

5900 Magnesium based materials not otherwise specified

5901 – 5919 Materials based on magnesia (magnesium oxide)

- 5901 Magnesia materials, not otherwise specified
- 5902 Sintered magnesia, high purity, dense
- 5903 Sintered magnesia, porous, crushable (including IEC 60672 Group C 820)
- 5904 Silicate bonded dense magnesia
- 5905 Fused magnesia
- 5910 Dolomite based materials (MgO/CaO)
- 5919 Other specified magnesium oxide based materials

5920 – 5949 Magnesium aluminate based materials

- 5920 Spinel materials, not otherwise specified
- 5921 Transparent spinel ceramics
- 5922 Technical grade spinel ceramics
- 5930 Fused spinel
- 5935 Calcined spinel
- 5949 Other specified magnesium aluminate based materials

5950 – 5999 Magnesium aluminium silicate materials

- 5950 Magnesium aluminium silicate materials, not otherwise specified
- 5951 Magnesium aluminium silicates (cordierite and cordierite composites), > 95 % cordierite (including IEC 60672 Group C 500)
- 5952 > 70 % to 95 % cordierite (including IEC 60672 Group C 500)
- 5953 ≤ 70 % cordierite (secondary phases unspecified) (including IEC 60672 Group C 500)
- 5970 Cordierite/mullite composites
- 5999 Other specified cordierite based materials

6000 – 6049 Magnesium silicate based materials

- 6000 Steatite based materials, including IEC 60672 Group C210
- 6001 Steatite based materials, including IEC 60672 Group C220
- 6002 Steatite based materials, including IEC 60672 Group C221
- 6003 Steatite based materials, porous, including IEC 60672 Group C230
- 6010 Forsterite based materials, including IEC 60672 Group C250
- 6011 Forsterite based materials, porous, including IEC 60672 Group C240
- 6049 Other specified magnesium silicate based materials

6080 Magnesium fluoride based materials

6099 Other specified magnesium based materials

6100 Molybdenum based materials

6101 Molybdenum disilicide ceramics

6110 Neodymium made materials**6120 – 6139 Nickel based materials**

6120 Nickel based materials not otherwise specified

- 6121 Nickel oxide based materials
- 6130 Nickel ferrite based materials
- 6139 Other specified nickel based materials

6140 Niobium based materials

6150 – 6159 Phosphate and apatite based materials

- 6150 Phosphate based ceramics not otherwise specified
- 6151 Hydroxyapatite
- 6152 Fluorapatite
- 6159 Other specified phosphate based materials

6160 – 6169 Potassium based materials

- 6160 Potassium based ceramics not otherwise specified
- 6161 Potassium silicate based materials
- 6162 Potassium silicon fluoride based materials
- 6169 Other specified potassium based materials

6170 Samarium based materials

6180 Scandium based materials

6200 – 6369 Silicon based materials

- 6200 Silicon based ceramics not otherwise specified

6201 – 6239 Silicon dioxide (silica) based materials

- 6201 Silicon dioxide materials, not otherwise specified
- 6202 Fused quartz
- 6203 Fused, vitreous silica
- 6210 Sintered fused silica
- 6220 Quartz crystal
- 6239 Other specified silica based materials

6250 – 6329 Silicon carbide based materials

- 6250 Silicon carbide materials not otherwise specified
- 6260 Alpha silicon carbide (including powders and consolidated materials)
- 6262 Alpha silicon carbide/titanium nitride composite materials
- 6270 Beta silicon carbide (including powders and consolidated ceramics)
- 6280 Reaction bonded silicon carbide (with free silicon)
- 6285 Siliconized silicon carbide (infiltrated after sintering)
- 6290 CVD silicon carbide
- 6300 Silicon nitride bonded silicon carbide materials
- 6301 Silicon oxynitride bonded silicon carbide materials
- 6309 Other specified silicon carbide based materials

- 6310 Si-C-O-N fibres
- 6311 Si-Ti-C-O-N fibres
- 6319 Other specified silicon carbide based fibres

- 6320 Silicon carbide fibre reinforced silicon carbide
- 6329 Other specified silicon carbide fibre reinforced materials

6330 – 6359 Silicon nitride based materials

- 6330 Silicon nitride materials not otherwise specified
- 6331 Alpha silicon nitride
- 6332 Beta silicon nitride
- 6335 Porous (reaction bonded) silicon nitride
- 6340 Dense silicon nitride, no additives
- 6345 Dense silicon nitrides, with additives, including sintered silicon nitrides
- 6350 Dense beta-sialon based materials
- 6351 Dense beta-sialon/titanium nitride based materials
- 6352 Dense alpha-sialon based materials
- 6355 Silicon oxynitride based materials
- 6358 CVD silicon nitride materials
- 6359 Other specified silicon nitride materials

- 6369 Other specified silicon based materials

6370 – 6399 Sodium based materials

- 6370 Sodium based materials not otherwise specified
- 6371 Sodium aluminate based materials
- 6380 Sodium orthosilicate based materials
- 6381 Sodium metasilicate based materials
- 6390 Sodium silicon fluoride materials
- 6399 Other specified sodium based materials

6400 – 6419 Strontium based materials

- 6400 Strontium based materials not otherwise specified
- 6401 Strontium cerate based materials
- 6410 Strontium titanate based materials
- 6419 Other specified strontium based materials

6420 – 6429 Thorium based materials

- 6420 Thorium based materials not otherwise specified
- 6420 Thorium oxide based materials
- 6429 Other specified thorium based materials

6430 Tin oxide based materials

6440 – 6489 Titanium based materials

- 6440 Titanium based materials not otherwise specified
- 6441 Titania (TiO₂) materials (fully oxidized)
- 6442 Reduced titania materials
- 6449 Other specified titania based materials
- 6450 Titanium carbide based materials
- 6460 Titanium nitride based materials
- 6470 Titanium diboride based materials

6489 Other specified titanium based materials

6490 – 6509 Tungsten based materials

- 6490 Tungsten based materials not otherwise specified
- 6491 Tungsten oxide based materials
- 6500 Tungsten carbide based materials
- 6509 Other specified tungsten based materials

6510 – 6519 Uranium based materials

- 6510 Uranium based materials not otherwise specified
- 6511 Uranium oxide based materials
- 6512 Uranium carbide based materials
- 6519 Other specified uranium based materials

6520 Vanadium based materials

6530 – 6579 Yttrium based materials

- 6530 Yttrium based materials not otherwise specified
- 6531 Yttrium oxide based materials
- 6540 Yttrium aluminium garnet based materials
- 6550 Yttrium iron garnet based materials
- 6570 Yttrium barium copper oxide based materials
- 6579 Other specified yttrium based materials

6580 – 6609 Zinc based materials

- 6580 Zinc based materials not otherwise specified
- 6581 Bismuth doped zinc oxide materials
- 6582 Rare earth doped zinc oxide materials
- 6590 Zinc silicate (willemitite) based materials
- 6600 Zinc zirconium silicate based materials
- 6609 Other specified zinc based materials

6620 – 6799 Zirconium based materials

6620 Zirconium based materials not otherwise specified

6621 – 6699 Zirconium oxide based materials

6621 Monoclinic zirconia (unstabilized, normally only as a powder)

6630 – 6639 Stabilized zirconias (containing principally the cubic phase and containing stabilizers)

- 6630 Fully stabilized with MgO
- 6631 Fully stabilized with CaO (including IEC 60672 Group C 830)
- 6632 Fully stabilized with Y_2O_3
- 6635 Fully stabilized with mixed MgO/CaO/ Y_2O_3 stabilizer
- 6639 Other specified fully stabilized materials

6640 – 6644 Partially stabilized zirconia (normally of mixed phase and containing stabilizers)

- 6640 Partially stabilized with MgO (containing principally cubic and monoclinic phases)
- 6641 Partially stabilized with CaO (containing principally cubic and monoclinic phases)
- 6643 Partially stabilized with unspecified or other specified stabilizers (containing principally cubic and monoclinic phases)

6644 partially stabilized with MgO (transformation toughened type containing principally cubic and tetragonal phases)

6645 – 6656 *TZP type containing principally the tetragonal phase*

6645 Y₂O₃-stabilized (Y-tetragonal zirconia polycrystal (TZP) type)

6650 CeO₂-stabilized (Ce-TZP)

6655 TZP stabilized with unspecified or mixed or other specified stabilizers)

6656 TZP containing Al₂O₃ reinforcement

6699 Other specified zirconium oxide based materials

6700 – 6799 *Other zirconium based materials*

6700 Zirconium silicate based materials (zircon)

6720 Zirconium spinel based materials

6740 Zirconium carbide based materials

6750 Zirconium diboride based materials

6799 Other specified zirconium based materials

8000 – 8999 Glass materials (see under silica materials above for vitreous silica)

8000 Glass materials not otherwise specified

8110 Soda-lime-silica (annealed, including IEC 60672 Group G 110)

8120 Soda-lime-silica (thermally toughened, including IEC 60672 Group G 120)

8200 Borosilicate, chemically resistant (including IEC 60672 Group G 200)

8310 Borosilicate, electrically resistant, low loss (including IEC 60672 Group G 310)

8400 Alumina-lime-silica (including IEC 60672 Group G 400)

8500 Lead oxide alkali silica (including IEC 60672 Group G 500)

8600 Baria alkali silica (including IEC 60672 Group G 600)

8700 Lead zinc borate

8800 Alumino-borate based glasses

8999 Other specified glasses

9000 – 9499 Glass-ceramic materials

9000 Glass-ceramic materials not otherwise specified

9001 Lithium aluminosilicate type

9010 Magnesium aluminosilicate type

9020 Lithium zinc silicate type

9499 Other specified glass-ceramics

9500 – 9999 Pre-ceramic precursors

9500 Pre-ceramics precursors, not otherwise specified

9501 – 9510 *Naturally occurring precursors*

9501 Organic precursors

9502 Inorganic precursors

9503 Organo-metallic precursors

9511 – 9520 *Synthetic precursors*

9511 Organic precursors

9512 Inorganic precursors

9513 Metallic precursors

9514 Organometallic precursors

Annex C (informative)

Processing classification field

C.1 Introduction

The information contained in this field relates to the identification of important aspects of the processing route applied to the product; e.g., aspects that might be used to distinguish one product from another. This classification has value in identifying processing methods for the purposes of inventories, for product labelling, or for describing materials used for scientific research.

NOTE Detailed information on processing may not be available for commercial products, and thus the effective use of this coding field may be limited.

C.2 Coding structure

This field is uniquely defined by the initial letter **P**.

The coding for this descriptor should contain the letter **P** followed by a three-digit number unique to each processing aspect, i.e.:

Pnnn

Since a number of aspects of processing might require classification, the overall code is built up from a sequence of individual Processing codes:

PnnnPnnnPnnnPnnn.....

written without gaps or punctuation.

C.3 Processing code classification

The following list gives a listing of the processing codes:

Preparation/manufacture of precursors

- 101 Preparation of solid pre-ceramic precursors
- 102 Manufacture of gaseous pre-ceramic precursors
- 103 Manufacture of sol/gel pre-ceramic precursors
- 104 Manufacture of other pre-ceramic precursors
- 199 Other methods for the manufacture of precursors

Manufacture of powders

- 201 Manufacture of powders by calcining/milling
- 202 Manufacture of powders by fusion/crushing/milling
- 203 Manufacture of powders by chemical precipitation
- 204 Manufacture of powders by gas-phase reaction
- 205 Manufacture of powders by flame pyrolysis
- 206 Manufacture of powders by sol/gel techniques

- 210 Manufacture of fibres or whiskers
- 299 Other methods for the manufacture of powders

Processing of powders, etc.

- 301 Powder in the as-manufactured condition
- 302 Granulation by spray drying
- 303 Granulation by melt spraying
- 304 Freeze-drying of powders
- 305 Powder formed by filter pressing/granulation
- 306 Milling of powders
- 307 Granulation by tumbling
- 308 Drying
- 309 Calcining
- 310 Granulation using a fluidized bed
- 311 Slurry formation
- 399 Other processing methods for powders

Powder compaction/shaping processes

- 401 Uniaxial pressing of powder
- 402 Green-state processing, e.g. machining or assembly of green parts
- 403 Isostatic pressing of powder
- 404 Unassisted slip casting
- 405 Pressure slip casting
- 406 Tape casting
- 407 Injection moulding
- 408 Low-pressure injection moulding
- 409 Compression moulding
- 410 Roll compaction
- 411 Extrusion (ram, auger)
- 412 Electrophoretically deposited
- 413 Dough kneading/moulding
- 414 Freeze casting
- 415 Direct coagulation casting
- 416 Thixotropic/vibratory casting
- 417 Gel casting
- 418 Drying of green bodies
- 419 Forming of filament/fibre materials, including weaving
- 499 Other green forming processes

Consolidation of powders

- 501 Consolidation by non-air atmospheric pressure sintering
- 502 Consolidation by air atmosphere ambient pressure sintering
- 503 Consolidation by non-air non-ambient pressure sintering (including gas-pressure sintering)
- 504 Vacuum sintering
- 505 Gas pressure sintering
- 506 Sinter-HIP
- 507 Encapsulated HIPing
- 508 HIPing after conventional sintering
- 509 Uniaxial hot pressing

- 510 Self-sustained high-temperature synthesis
- 511 Liquid-phase reaction bonding
- 512 Gas-phase reaction bonding
- 513 Chemical vapour deposition
- 514 Chemical vapour infiltration (bonding)
- 515 Plasma/flame spraying
- 516 Controlled interface reaction
- 517 Chemical bonding
- 518 Sol-gel consolidation techniques
- 519 Microwave assisted sintering
- 520 Reaction sintering
- 521 Pre-firing/binder removal
- 599 Other consolidation processes

Production of coatings

- 601 CVD coating processes
- 602 PVD coating processes
- 603 Ion plating coating processes
- 605 Sol-gel coating processes
- 606 Sputter coating processes
- 607 Plasma spraying
- 608 Flame spraying
- 699 Other coating processes

Direct forming

- 701 Melt forming, including crystal growth
- 702 Vapour forming
- 799 Other direct forming processes

Post-consolidation processes

- 801 As-manufactured, i.e. no further processing
- 802 Rumbling/vibro-milling surfaces
- 803 Abrading surfaces
- 804 Machining/grinding surfaces (fixed grit)
- 805 Lapping surfaces (loose grit)
- 806 Polishing surfaces
- 807 Machining and refiring
- 808 Glazing
- 809 Drilling
- 810 Metallizing
- 811 Brazing surfaces
- 812 Adhesive bonding
- 813 Joining by glass bonding
- 814 Joining by thermal diffusion bonding
- 815 Cutting (sawing, slicing, dicing)
- 816 Heat treatment
- 817 Engraving
- 818 Laser scribing, drilling or marking
- 819 Chemical etching