INTERNATIONAL STANDARD

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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.

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].

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 precoursor 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

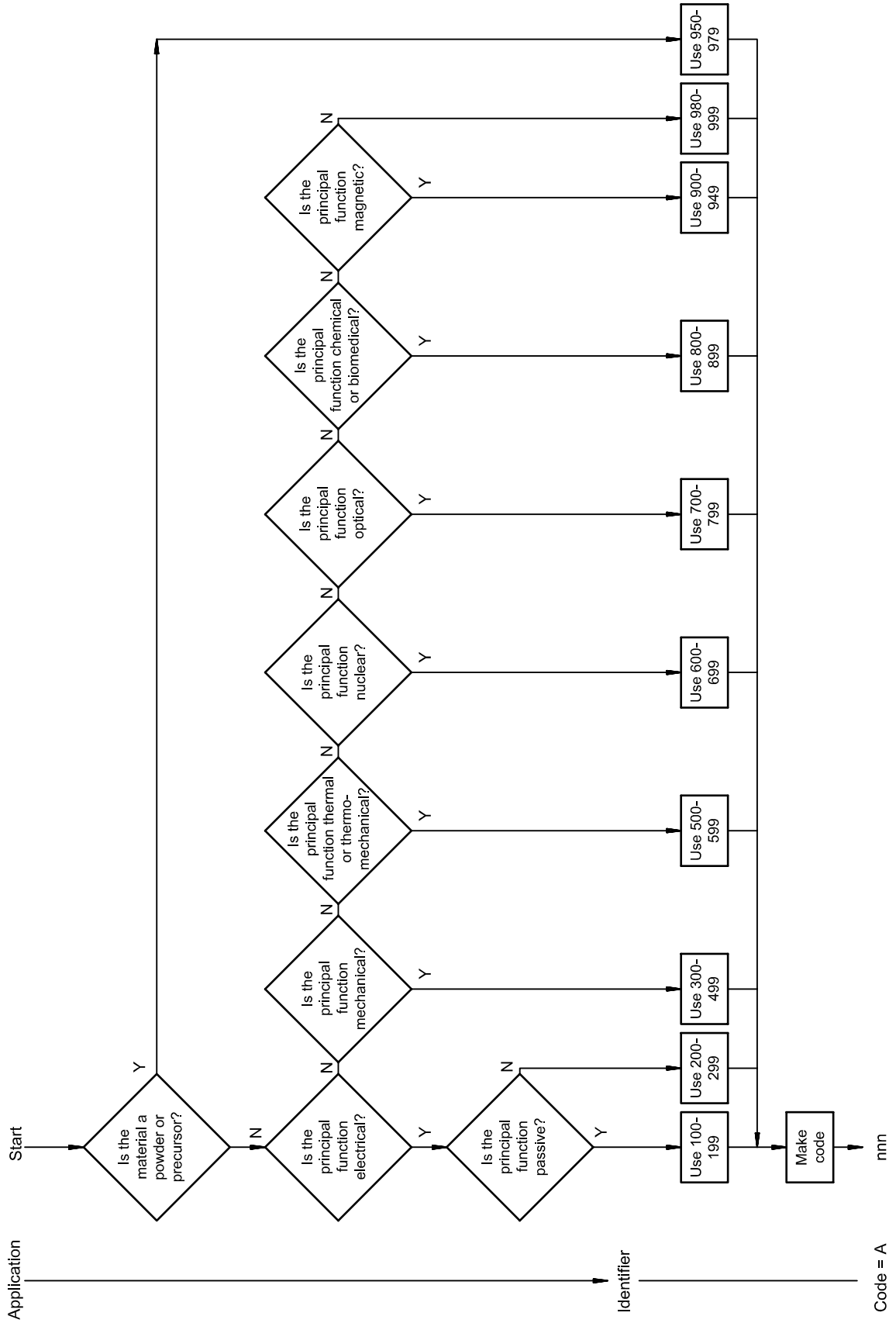


Figure 1 — Flow diagram showing the selection of codes for application

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):

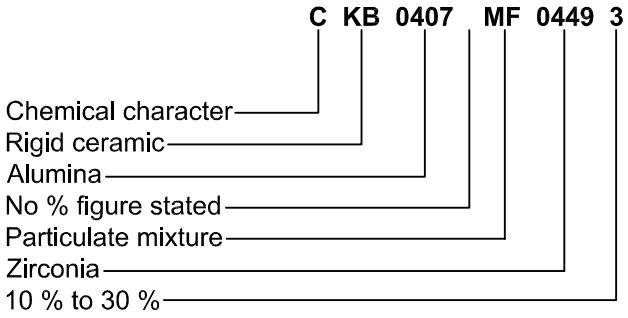


Table 1 — Construction of the long-format chemical character code

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**	**Option 1:** coding element for indicating “amount” of the species nnnn in the product expressed as mass percentage, according to the following code: 1 $\leqslant$ 1 % 2 > 1 % to10 % 3 > 10 % to 30 % 4 > 30 % to 50 % 5 > 50 % to 70 % 6 > 70 % to 90 % 7 > 90 % to 99 % 8 > 99 % If the value is undefined or undefinable, this character is omitted.	**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”. The figure may be preceded by “<” or “>” to signify less than or more than a given amount, respectively.
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	**Option 1** Optional single digit coding percentage, by mass, of second species as defined above.	**Option 2** Optional supplementary statement coding quantity, by mass, of second species, as defined above.
(**) The sequence is repeated from (**) for third and subsequent species as necessary.		

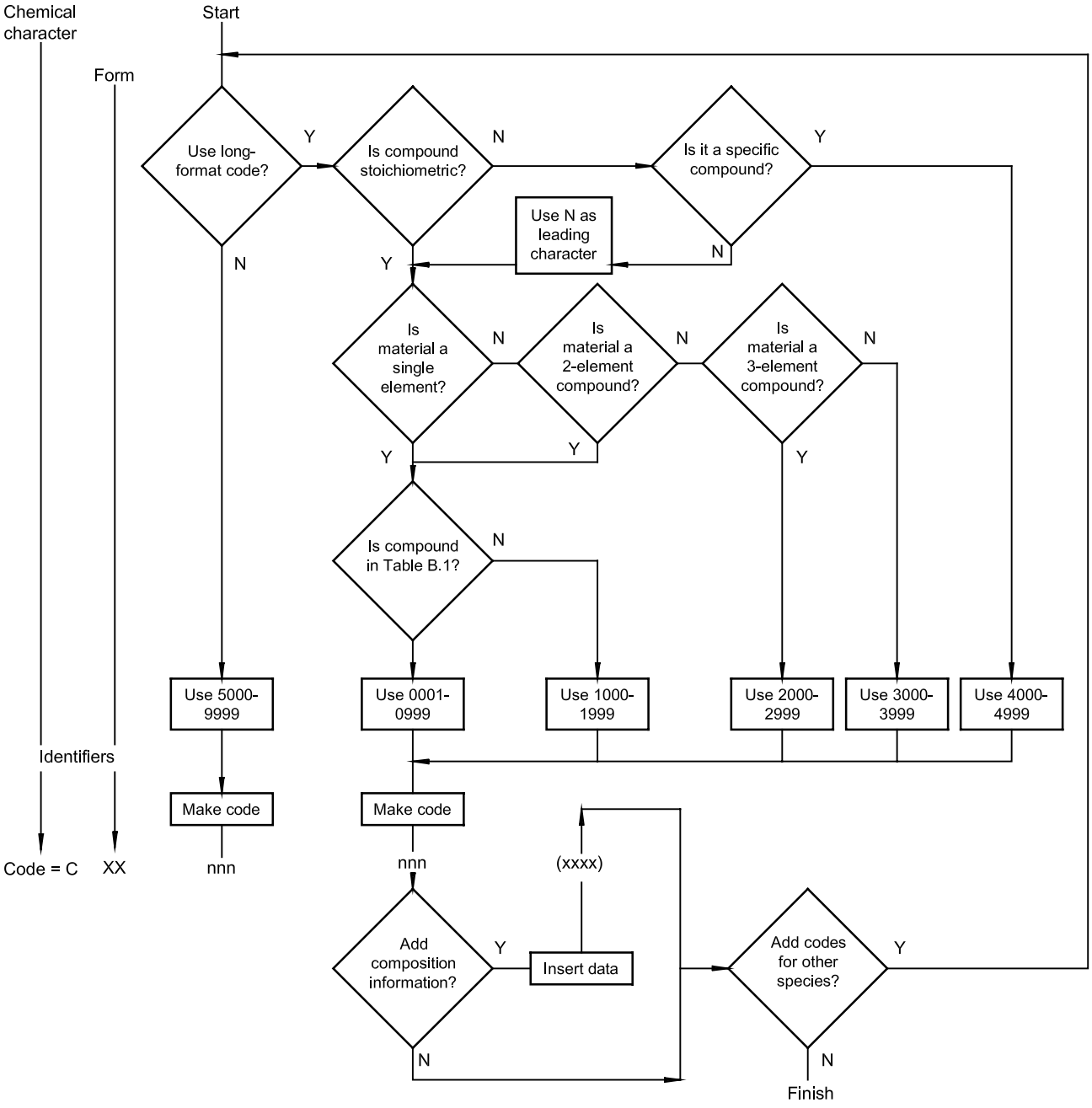
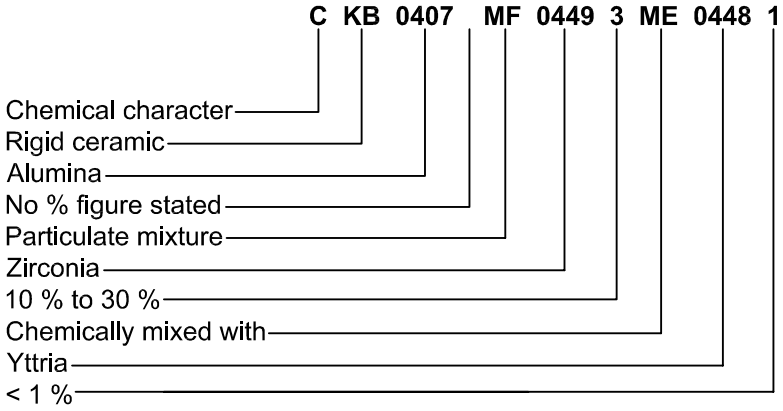


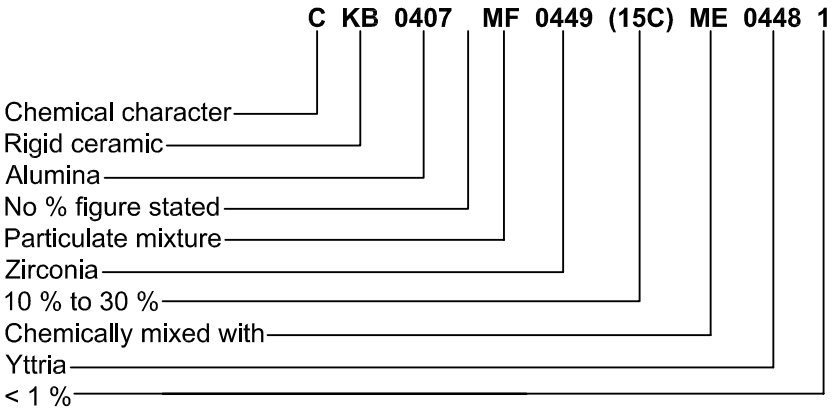
Figure 2 — Flow diagram for selection of codes representing chemical character

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):

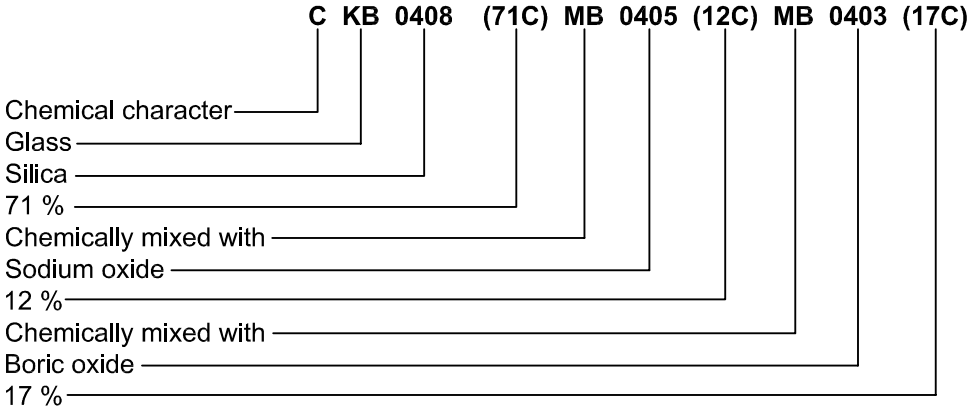


Option 2 defining the zirconia content at 15 % gives (written with spaces for clarity):



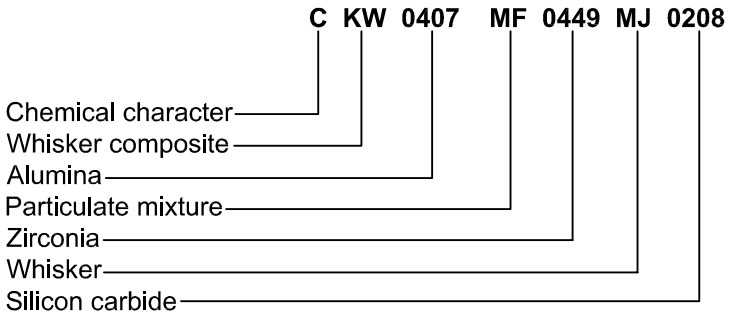
EXAMPLE 3

Sodium borosilicate glass of defined composition 71 % SiO_2, 12 % Na_2O, 17 % B_2O_3, 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.

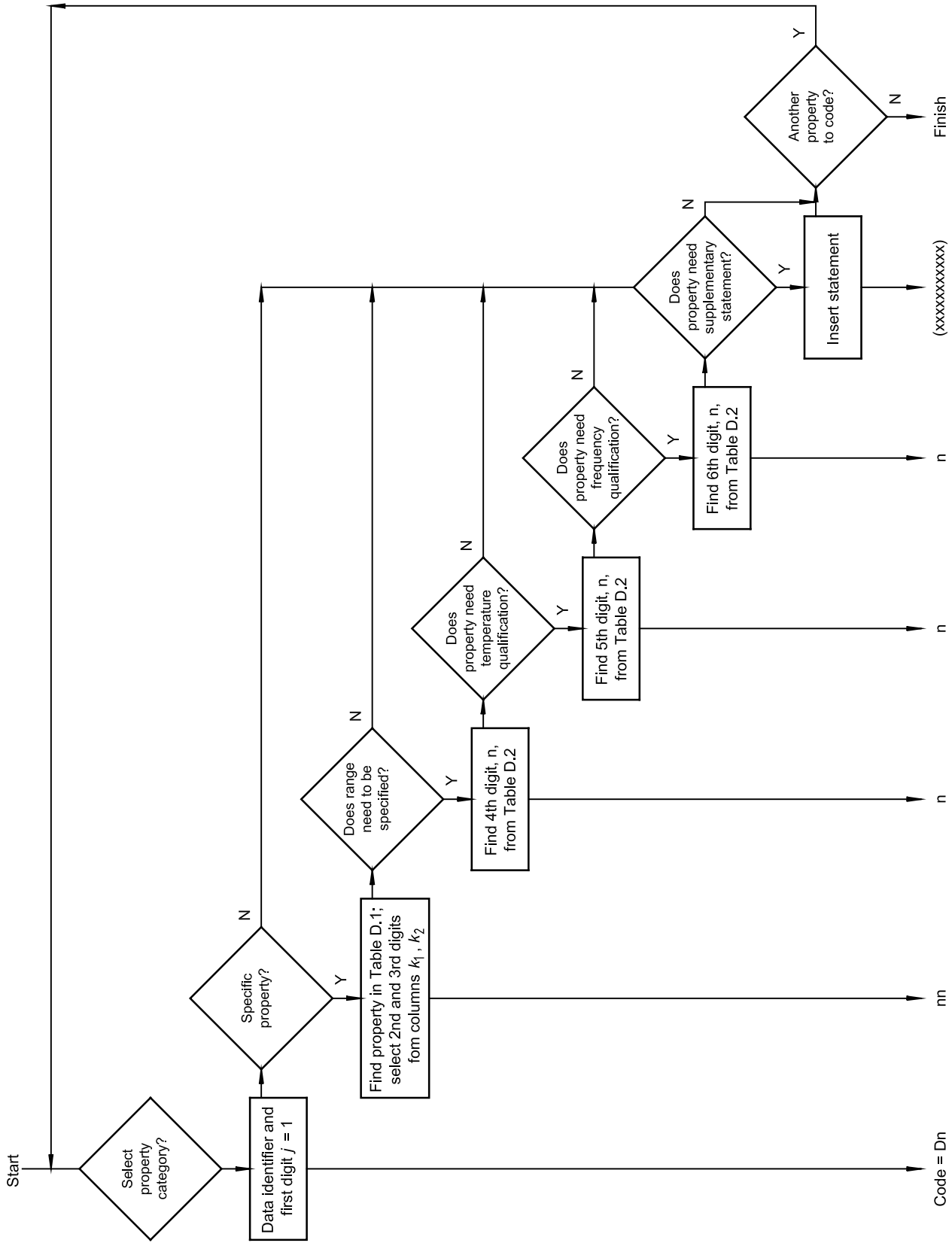


Figure 3 — Flow diagram for the selection of codes representing data

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.

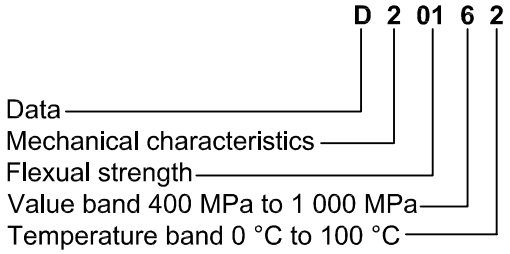
EXAMPLES

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.

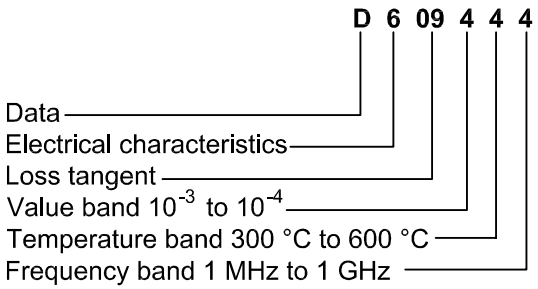
EXAMPLE 1

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



EXAMPLE 2

An electrical insulator with loss tangent 5×10^{-4} at 400 ^{o}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 W m^{-1} K^{-1}, dielectric loss tangent 5×10^{-4} at 10 MHz and flexural strength 600 MPa, all at 400 ^{o}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.

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:

CXXnnnnDnnnDnnnDnnnnn.....

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 ^{o}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, $\leqslant$ 200 ^{o}C
108 Bushes, sleeves, $>$ 200 ^{o}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

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

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

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.

Catalysts and catalyst supports

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

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

A.3 Alphabetical index for applications classification

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

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:

$$2\% \times \frac{\text{M.W. of } Al_2O_3}{\text{M.W. of } O_3} = 2 \times \frac{101,6}{48,0} = 4,2\%$$

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_xB_y	0201 Li_2C_2	0301	0401	0501	0601	0701	0801	0901
Be	0002	0102 Be_xB_y	0202 Be_2C	0302	0402	0502	x	x	0802 BeS	0902
B	0003	x	0203 B_xC_y	0303	0403	0503 (g)	0603 B_xSi	0703	0803	0903
C	0004	x	x	x	0404 CO_x(g)	0504	x	x	0804 C_xS	0904
Na	0005	0105 NaB_y	0205 Na_2C_2	0305	0405	0505	x	0705	0805Na_xS_y	0905
Mg	0006	0106 $MgB_{2;4}$	0206	0306	0406	0506	0606Mg_xSi_y	x	0806	0906
Al	0007	0107 Al_xB_y	0207	0307	0407	0507	x	0707	0807	0907
Si	0008	0108 Si_xB_y	0208	0308	0408	0508 (g)	x	x	0808 Si_xS_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_xS_y	x
S(2)	x	x	0212	x	0412 S_2O_3	x	x	x	x	x
S(4)	0013	x	x	0313S_4N_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_xS_y	0915
Ca	0016	0116 CaB_6	0216 CaC_2	0316	0416	0516	0616 $CaSi_2$	0716Ca_3P_2	0816 CaS	0916
Sc	0017	0117 $ScB_{2;12}$	0217 Sc_xC_y	0317	0417	0517	0617	x	0817 Sc_xS_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_3P	0819 Ti_2S_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_2C	x	0421	x	0621 V_2Si	x	0821 VS	x
V(3)	x	x	0222 V_4C_3	0322	0422	0522	0622 V_3Si	x	0822 V_2S_3	0922 (h)
V(4)	x	x	0223 VC	x	0423	0523	x	0723V_3P	x	x
V(5)	0024	0124 V_xB_y	0224 V_xC_y	x	0424	0524	0624 VSi_2	0724 VP	0824 V_2S_5	x
Cr(2)	x	x	x	x	0425	0525	x	x	0825	0925
Cr(3)	0026	x	0226 Cr_3C_2	0326 CrN	0426	0526	0626	0726 CrP	0826	x
Cr(6)	x	0127 Cr_xB_y	x	x	0427	x	x	x	0827 Cr_3S_4	x
Mn(2)	0028	x	x	x	0428	0528 MnF_2	0628 MnSi	0728 MnP	0828 MnS	0928
Mn(4)	x	0129 Mn_xB_y	0229 Mn_xC_y	x	0429	0529 MnF_3	0629$MnSi_2$	0729Mn_3P_2	0829 MnS_2	x
Mn(7)	x	x	x	0330 Mn_2N	0430	x	x	x	x	x
Fe(2)	0031	0131 Fe_2B	0231 Fe_3C	x	0431	0531	0631 $FeSi_x$	0731 Fe_2P	0831 FeS	0931
Fe(3)	x	0132 FeB	0232 Fe_2C_3	0332	0432	0532	x	0732 Fe_3P	0832 Fe_2S_3	x
Co(2)	0033	0133 Co_xB	x	x	0433	0533 (h)	0633 CoSi	0733 Co_2P	0833 CoS	0933
Co(3)	x	x	x	0334	0434	0534	0634 $CoSi_2$	x	0834 Co_2S_3	x
Ni	0035	0135 Ni_xB_y	0235 Ni_3C	0335	0435 NiO_x	0535	0635 Ni_xSi_y	0735 Ni_3P	0835 NiS_x	0935
Cu(1)	x	x	x	x	0436	0536	x	0736 Cu_3P	0836 Cu_2S	0936
Cu(2)	0037	0137Cu_xB_y	x	x	0437	0537 (h)	0637	0737 Cu_3P_2	0837 CuS	x
Zn	0038	0138 ZnB_2	x	x	0438	0538	x	0738 Zn_3P_2	0838	0938
Ga	0039	x	x	x	0439	0539	x	0739	0839 Ga_xS_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_xGe_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_2I_2
Rb	0046	x	0246	x	0446 Rb_xO_y	0546	x	0746	0846 Rb_xS_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_3B_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_2C	0352	0452	x	x	0752MoP	x	x
Mo(6)	x	0153 MoB_2	x	x	0453	0553 MoF_6	0653$MoSi_2$	0753MoP_2	0853 Mo_xS_y	0953MoI_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_xB_y	x	x	0456 RuO_4	0556 RuF_5	0656 RuSi	x	0856 RuS_2	0956 RuI
Rh	0057	0157 Rh_xB_y	x	x	0457 Rh_xO_y	0557	x	0757	0857 Rh_xS_y	x
Pd	0058	0158 Pd_xB_y	x	x	0458 Pd_xO_y	0558 Pd_xF_y	0658 Pd_2Si	x	0858 Pd_xS_y	0958
Ag	0059	x	x	x	0459 AgO	0559 Ag_xF	0659	x	0859 Ag_xS	0959
Cd	0060	x	x	x	0460	0560	x	x	0860	0960
In	0061	x	x	x	0461 In_xO_y	0561	0661	0761 InP	0861 In_xS_y	0961 InI_x
Sn(2)	x	x	x	x	0462	0562	x	0762 Sn_xP_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_xO_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_2C_3	x	0471	0571	x	0771	871 Ce_2S_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_xC_y	0373	0473 Pr_xO_y	0573	0673	x	873 Pr_2S_3	x
Nd(3)	0074	0174 NdB_6	0274 Nd_2C_3	0374	0474	0574	0674 Nd_2Si_3	0774	874 Nd_2S_3	0974
Nd(4)	x	0175 NdB_4	0275 NdC_2	x	x	x	0675 Nd_3Si_4	x	x	x
Sm	0076	0176 $SmB_{4;6}$	0276 Sm_xC_y	0376	0476	0576	0676	0776	876	0976
Eu	0077	0177 $EuB_{4;6}$	0277 Eu_xC_y	0377	0477	x	x	x	877 EuS	x
Gd	0078	0178 $GdB_{4;6}$	0278 Gd_xC_y	x	0478	0578	0678 $GdSi_2$	0778	878 Gd_2S_3	x
Dy	0079	0179 $DyB_{4;6}$	0279 Dy_xC_y	0379	0479	x	0679	0779	879	x
Ho	0080	0180 $HoB_{4;6}$	0280 Ho_xC_y	0380	0480	x	x	x	x	x
Er	0081	0181 $ErB_{4;6}$	0281 Er_xC_y	0381	0481	x	0681	0781	x	x
Yb	0082	0182 $YbB_{4;6}$	0282 Yb_xC_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_2Si	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_2C	0386 W_2N	0486 WO_2	x	0686 WSi_x	0786 WP	886 WS	0986 WI_2
W(6)	0087	0187 W_xB_y	0287 WC	0387 WN	0487 WO_3	0587 (g)	x	0787 WP_2	887 WS_2	0987 WI_4
Re	0088	0188 Re_xB_y	x	x	0488 Re_xO_y	0588 $ReF_{4,6}$	x	x	x	x
Ir	0089	0189 Ir_xB_y	x	x	0489 Ir_xO_y	0589 IrF_6	0689	x	889 IrS_x	0989 IrI_x
Pt	0090	0190 PtB	x	x	0490 Pt_xO_y	x	0690	x	890 PtS_x	0990 $PtI_{2,4}$
Au	0091	0191 Au_xB_y	x	x	0491 Au_xO_y	x	x	0791	891	0991
Tl	0092	x	x	0392 TlN_3	0492 Tl_xO_y	0592 $TlF_{1,3}$	x	x	892 Tl_xS_y	0992 Tl_xI_y
Pb(2)	x	x	x	x	0493 PbO	0593	x	x	893 PbS	0993 PbI
Pb(4)	0094	x	x	x	0494 PbO_2	x	x	x	x	0994 PbI_2
Bi	0095	x	x	x	0495	0595	x	x	895 Bi_2S_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_3O_8	x	0697 U_3Si	x	897 U_2S_3	0997
U(4)	0098	x	0298 d-UC	x	0498 UO_2	0598	0698 U_3Si_2	0798 U_3P_4	898 US_2	0998
U(6)	x	0199 U_xB_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

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

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 ($2MgO{\cdot}SiO_2$, 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

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

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. Al_2O_3/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 $MgO/CaO/SiO_2$ 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 $MgO/CaO/SiO_2$ 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 $MgO/CaO/SiO_2$ additive
5063 with MnO/TiO_2 additive
5069 with other specified additives
5070 Al_2O_3 materials - $\leqslant$ 80% alumina

5080 Al_2O_3/ZrO_2 materials
5090 Al_2O_3/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 ZrO_2 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 % $\geqslant$ AlN $\geqslant$ 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 Molochite based
5225 Sillimanite based
5226 Kyanite based
5227 Andalusite based
5228 Pyrophillite 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 % Al_2O_3), high strength (including IEC 60672 Group C 120)
5330 Siliceous alkali porcelain materials (aluminous porcelain, typically 50 % to 80 % Al_2O_3), 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 (Cr_2O_3) 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 $\leqslant$ 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 Hydoxyapatite
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 (TiO_2) 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 (willemite) 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 Y_2O_3-stabilized (Y-tetragonal zirconia polycrystal (TZP) type)

6650 CeO_2-stabilized (Ce-TZP)

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

6656 TZP containing Al_2O_3 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

820 Chemical ion exchange
821 Surface ion implantation
899 Other post-consolidated processes

Other processes
999 Other specified processes

C.4 Alphabetical index to Processing codes

Annex D
(normative)

Property data classification field

D.1 Introduction

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

The information contained in this field of classification relates to the identification of the important properties together with an indication, either:

a) that property is a target in the formulation of the material, in which case the presence of the code is sufficient to indicate this or

b) of a numerical range into which the property falls for classification purposes.

NOTE Numerical data ranges should be used only when the data are determined according to an appropriate standardized test method.

Since a number of properties may need to be identified, the field identifier, **D** also acts as a separator in a multi-element data coding string.

D.2 Coding structure

The coding for this descriptor should contain the following essential items of information:

a) descriptor identification (letter D);

b) property type (digit);

c) property (two digits);

d) numerical range of property (digit) when known and appropriate.

Optional information which may be included if desired or necessary to aid classification are qualifications such as:

e) temperature at which or up to which the property range refers;

f) frequency at which or up to which the property range refers (primarily electrical properties).

The format for the property data classification code is:

$$\mathbf{D}jk_1k_2lmn$$

where

j is a single digit indicating the property group (physical, thermal, electrical, etc.);

k_1k_2 is a two-digit number identifying the specific property within that group;

l is a single digit indicating the range of that property;

m is a single digit indicating qualification of the property range by temperature (when necessary);

n is a single digit indicating qualification of the property range by frequency (when necessary, but must follow the temperature code element).

In many cases either or both of the latter two digits may be redundant and could be omitted to yield a simplified code such as:

Djk_1k_2l or **D**jk_1k_2lm

If the property or characteristic needs to be identified as relevant to a material or product, but no specific range can be cited, the digit corresponding to l is also omitted.

If the property to be coded is given as a range, then two codes or more codes covering that range are to be used.

D.3 Property data classification

Table D.1 gives the property data coding. The numerical coding associated with the property data descriptor field are obtained from the individual parts of the code as follows:

— j (column 2 in Table D.1) - property type;

— k_1k_2 (column 3 in Table D.1) - property;

— l (columns 4-12 in Table D.1) - range;

— m (see Table D.2) - temperature qualifier;

— n (see Table D.2) - frequency qualifier.

The property data code is constructed from elements j and k_1k_2 **at least**. If a numerical value is ascribed to the property measured according to an appropriate test method (column 13 of Table D.1), element l may be added. Unless the temperature code m is added (see Table D.2) the property shall be that at room temperature. The temperature code shall always be used for thermal expansion data. If frequency is to be added for electrical properties (see Table D.2), it is essential that it is preceded by the temperature code to avoid ambiguity.

Examples of test methods associated with specific properties are given in the last column of Table D.1 which, as a note, has advisory status and references to which are given in annex E.

NOTE Many properties have not yet been classified by numerical bands. This is because as yet no standard method can be cited by which the property can be determined. When such standards exist, and classification property ranges can be defined with reference to them, the table will be amended accordingly. Until this position is reached, the citation of such a property data code should be taken to imply that the property is important to the product's function.

When required to provide traceability, the test method employed to obtain the data, or further details associated with the classification (e.g. colour) may be cited in a **supplementary statement** comprising alphanumeric characters in parentheses (...), e.g.:

— Flexural strength D2015(ISO 14704, 3 point bend, 30 mm span)

— Thermal expansion D3044(EN 821-1)

— Colour D403(red)

— Rockwell hardness D2057(HR45N)

The supplementary statement may also contain information concerning the orientation of the test-piece relative to any microstructural anisotropy. To do this, a single code letter, X, Y or Z shall be used, preceding information on the test method. For the purposes of this International Standard Table D.3 gives the interpretation of the orientation code.

EXAMPLES

Tensile stength **D2075(X)D2072(Z)** for a 2-D fibre composite

Thermal conductivity **D3016(Z)D3011(X)** for a CVD boron nitride coating

Table D.1 — Property data classification

Property and type	j	k_1k_2	l									Relevant test methods [a]
			1	2	3	4	5	6	7	8	9	
Physical properties	1	Product displays physical properties critical to its function										
Bulk density, % of theoretical	1	01	⩽ 20	> 20 to 40	> 40 to 60	> 60 to 80	> 80 to 95	> 95 to 99	> 99			
Bulk density, Mg m^{-3}	1	15	⩽ 1	> 1 to 1,5	> 1,5 to 2	> 2 to 3	> 3 to 4	> 4 to 5	> 5 to 7	> 7 to 10	> 10	A: ISO 18754 A: EN 623-2 B: ENV 1389 A: JIS R1634
Open porosity, % (sometimes known as water absorption)	1	02	⩽ 1	> 1 to 5	> 5 to 10	> 10 to 30	> 30 to 50	> 50 to 80	> 80			A: ISO 18754 A: IEC 60672-2 A: EN 623-2 A: JIS R1634 D: JIS R1628
Closed porosity, %	1	14	0	> 0 to 1	> 1 to 3	> 3 to 10	> 10 to 20	> 20 to 40	> 40 to 70	> 70		C: ENV 1071-5
Mean open pore diameter, µm	1	16	⩽ 0,01	> 0,01 to 0,1	> 0,1 to 1	> 1 to 10	> 10 to 100	> 100 to 1 000	> 1 000			
Grain size (µm), mean linear intercept method	1	03	⩽ 1	> 1 to 3	> 3 to 8	> 8 to 25	> 25 to 100	> 100				A: ENV 623-3
Powder particle size, µm (d_{50} unless otherwise specified)	1	04	⩽ 0,01	> 0,01 to 0,05	> 0,05 to 1	> 1 to 3	> 3,0 to 10	> 10 to 30	> 30 to 100	> 100		D: ASTM C1282 D: EN 725-6 D: JIS R1619 D: JIS R1629
Powder surface area, m^2g^{-1}	1	05	⩽ 1	> 1 to 2	> 2 to 5	> 5 to 10	> 10 to 20	> 20 to 50	> 50 to 100	> 100		D: ISO 18757 D: ASTM C1251 D: ASTM C1274 D: EN 725-5 D: JIS R1626
Powder tap density, mg m^{-3}	1	06	⩽ 0,1	> 0,1 to 0,2	> 0,2 to 0,5	> 0,5 to 1,0	> 1 to 1,5	> 1,5 to 2	> 2 to 3	> 3 to 5	> 5	D:EN 725-8
Powder flow cone angle	1	07	Important characteristic of product									
Fibre/whisker diameter, mean, µm	1	08	⩽ 0,1	> 0,1 to 0,5	> 0,5 to 1	> 1 to 3	> 3 to 8	> 8 to 15	> 15 to 50	> 50		B: ENV 1007-3
Chopped fibre or whisker length, mean	1	09	Important characteristic of product									

Table D.1 *(continued)*

Property and type	j	k_1k_2	l									Relevant test methods [a]
			1	2	3	4	5	6	7	8	9	
Fibre/whisker aspect ratio	1	10	Important characteristic of product									
Fibre/whisker/platelet volume fraction	1	11	Important characteristic of product									
Coating thickness, µm	1	12	⩽ 0,1	> 0,1 to 1	> 1 to 10	> 10 to 100	> 100 to 1 000	> 1 000 to 10 000	> 10 000			C: ENV 1071-1 C: ENV 1071-2
Surface roughness, *Ra*, µm	1	13	⩽ 0,01	> 0,01 to 0,02	> 0,02 to 0,05	> 0,05 to 0,1	> 0,1 to 0,2	> 0,2 to 0,5	> 0,5 to 1	> 1 to 2	> 2	A: ENV 623-4
Mechanical properties	2	Product displays mechanical properties critical to its function										
Flexural strength [b], MPa	2	01	⩽ 20	> 20 to 50	> 50 to 100	> 100 to 200	> 200 to 400	> 400 to 1 000	> 1 000			A: ISO 14704 A: IEC 60672-2 A: ASTM C1161 A: EN 843-1 JIS R1601 A: ISO 17565 A: EN 821-1 B: ASTM C1341 B: ENV 658-3
Shear strength, MPa	2	02	⩽ 20	> 20 to 50	> 50 to 100	> 100 to 200	> 200 to 400	> 400 to 1 000	> 1 000			B: ASTM C1292 B: ENV 658-4, -5, -6
Compressive strength, MPa	2	13	⩽ 10	> 10 to 50	> 50 to 200	> 200 to 500	> 500 to 2 000	> 2 000				A: ASTM C1424 A: JIS R1608 B: ASTM C1358 B: ENV 658-2 B: ENV 12290 B: ENV 12291
Toughness	2	04	Important characteristic of product									A: ISO 15732 A: ISO 18756 A: ASTM C1421 A: JIS R1607
Hardness (units: either none or as appropriate)	2	05	HV, HK ⩽ 1 000	HV, HK > 1 000 to 1 500	HV, HK > 1 500 to 2 000	HV, HK > 2 000	HR ⩽ 60	HR 60 to 80	HR > 80 to 90	HR > 90 to 95	HR > 95	A: ISO 14705 A: ASTM C1326/7 A: ENV 843-4 A: JIS R1610
Young's modulus, GPa	2	06	⩽ 50	> 50 to 100	> 100 to 200	> 200 to 400	> 400					A: ISO 17561 A: ASTM C1198 A: ASTM C1259 A: ENV 843-2 A: JIS R1602

Table D.1 *(continued)*

Property and type	j	k_1k_2	l									Relevant test methods [a]
			1	2	3	4	5	6	7	8	9	
Shear modulus, GPa	2	09	⩽ 20	> 20 to 50	> 50 to 100	> 100 to 200	> 200					A: ASTM C1198 A: ASTM C1259 A: ENV 843-2 A: JIS R1602
Poisson's ratio	2	08	⩽ 0,1	> 0,1 to 0,15	> 0,15 to 0,2	> 0,2 to 0,25	> 0,25 to 0,3	> 0,3				A: ASTM C 1198 A: ENV 843-2 A: JIS R1602
Temperature dependence of Young's modulus, ppm/°C	2	10	⩽ – 2 000	> – 2 000 to – 1 000	> – 1 000 to – 500	> – 500 to 0	> 0 to 500	> 500 to 1 000	> 1 000 to 2 000	> 2 000		
Temperature dependence of shear modulus, ppm/°C	2	11	⩽ – 2 000	> – 2 000 to – 1 000	> – 1 000 to – 500	> – 500 to 0	> 0 to 500	> 500 to 1 000	> 1 000 to 2 000	> 2 000		
Tensile strength, MPa	2	07	⩽ 20	> 20 to 50	> 50 to 100	> 100 to 200	> 200 to 400	> 400 to 1 000	> 1 000			A:ISO 15490 A: ASTM C1273 A: JIS R1606 B: ASTM C1272 B:ISO 15733 B:EN 658-1
Elongation at failure, %	2	12	⩽ 0,05	> 0,05 to 0,1	> 0,1 to 0,2	> 0,2 to 0,5	> 0,5 to 1	> 1 to 2	> 2 to 5	> 5		B:ISO 15733
Thermal properties	3	Product displays thermal properties critical to its function										
Thermal conductivity, W m^{-1} K^{-1}	3	01	⩽ 2	> 2 to 4	> 4 to 10	> 10 to 30	> 30 to 50	> 50 to 100	> 100 to 150	> 150 to 200	> 200	
Specific heat, J g^{-1} K^{-1}	3	02	⩽ 0,3	> 0,3 to 0,5	> 0,5 to 0,7	> 0,7 to 1	> 1					A:ENV 821-3 B: ENV 1159-3
Water quench thermal shock resistance, ΔT, K	3	03	⩽ 100	> 100 to 200	> 200 to 400	> 400						A: IEC 60672-2 A: ENV 820-3
Coefficient of thermal expansion, 10^{-6} K^{-1} [c]	3	04	⩽ 2	> 2 to 4	> 4 to 8	> 8 to 10	> 10 to 20	> 20				A: ISO 17562 A:EN 821-1 A: JIS R1618 A: ASTM E228 B: ENV 1159-1
Self-loaded deformation temp. in air, °C	3	05	⩽ 200	> 200 to 500	> 500 to 800	> 800 to 1 000	> 1 000 to 1 200	> 1 200 to 1 600	> 1 600			A: ENV 820-2
Glass transition temperature, °C	3	06	⩽ 200	> 200 to 300	> 300 to 400	> 400 to 500	> 500 to 600	> 600 to 700	> 700 to 800	> 800		A: IEC 60672-2

Table D.1 *(continued)*

Property and type	j	k_1k_2	l									Relevant test methods [a]
			1	2	3	4	5	6	7	8	9	
Thermal diffusivity, 10^{-6} m^2s^{-1}	3	07	$\leqslant$ 1	> 1 to 3	> 3 to 6	> 6 to 10	> 10 to 15	> 15 to 25	> 25 to 40	> 40 to 70	> 70	A: ISO 18755 A: EN 821-2 A: JIS R1611 B: ENV 1159-2
Emissivity	3	08	Important characteristic of product									
Maximum short-term use temperature in air, °C	3	09	$\leqslant$ 300	> 300 to 500	> 500 to 700	> 700 to 900	> 900 to 1 100	> 1 100 to 1 300	> 1 300 to 1 500	> 1 500 to 1 700	> 1 700	
Maximum short-term use temperature in inert atmosphere, °C	3	10	$\leqslant$ 300	> 300 to 500	> 500 to 700	> 700 to 900	> 900 to 1 100	> 1 100 to 1300	> 1 300 to 1 500	>1 500 to 1 700	> 1 700	
Optical properties	4	Product displays optical properties critical to its function										
Refractive index	4	01	Important characteristic of product									
Transmittance	4	02	Important characteristic of product									
Colour	4	03	Important characteristic of product (use supplementary statement to define colour)									
Birefringence	4	04	Important characteristic of product									
Fluorescence/ luminescence	4	05	Important characteristic of product									
Magnetic properties	5	Product displays magnetic properties critical to its function										
Relative permeability	5	01	Important characteristic of product									
Remanence	5	02	Important characteristic of product									
Coercivity	5	03	Important characteristic of product									
Ferromagnetic	5	04	Important characteristic of product									
Diamagnetic	5	05	Important characteristic of product									
Magnetostrictive properties	5	06	Important characteristic of product									
Electrical properties	6	Product displays electrical properties critical to its function										
Resistivity (electronic), Ω cm	6	01	$\geqslant 10^{14}$	$< 10^{14}$ to 10^{10}	$< 10^{10}$ to 10^{6}	$< 10^{6}$ to 10^{3}	$< 10^{3}$ to 10^{1}	$< 10^{1}$ to 10^{-1}	$< 10^{-1}$			A: IEC 60672-2
Non-linear resistivity	6	02	Important characteristic of product									
Superconductivity, critical temperature	6	03	Important characteristic of product									

Table D.1 *(continued)*

Property and type	j	k_1k_2	l									Relevant test methods [a]
			1	2	3	4	5	6	7	8	9	
Superconducting critical current	6	04	Important characteristic of product									
Resistivity (ionic), Ω cm	6	05	$\leqslant 10^{-6}$	> 10^{-6} to 10^{-4}	> 10^{-4} to 10^{-2}	> 10^{-2} to 1	> 1 to 10^{2}	> 10^{2} to 10^{4}	> 10^{4} to 10^{6}	> 10^{6}		
Relative permittivity	6	06	$\leqslant 5$	> 5 to 8	> 8 to 12	> 12 to 20	> 20 to 100	> 100 to 500	> 500 to 2 000	> 2 000		A: IEC 60672-2 A: JIS R1627
Temperature coefficient of permittivity	6	07	Important characteristic of product									
Ferroelectric transition temperature	6	08	Important characteristic of product									
Loss tangent, tan δ	6	09	$\geqslant 0{,}1$	< 0,1 to 0,01	< 0,01 to 0,001	< 0,001 to 10^{-4}	< 10^{-4}					A: IEC 60672-2 A: JIS R1627
Dielectric breakdown voltage gradient kV mm^{-1}	6	10	$\leqslant 5$	> 5 to 10	> 10 to 20	> 20 to 40	> 40					A: IEC 60672-2
Pyroelectric properties	6	11	Important characteristic of product									
Thermoelectric characteristics	6	12	Important characteristic of product									
Negative temperature coefficient	6	13	Important characteristic of product									
Positive temperature coefficient	6	14	Important characteristic of product									
Piezoelectric characteristics	6	15	Important characteristic of product									
Electrostrictive characteristics	6	16	Important characteristic of product									
Electro-optic characteristics	6	17	Important characteristic of product									
Curie temperature, dielectric, °C	6	18	$\leqslant 0$	> 0 to 50	> 50 to 100	> 100 to 150	> 150 to 200	> 200 to 300	> 300			
Te value, °C	6	19	$\leqslant 300$	> 300 to 400	> 400 to 500	> 500 to 700	> 700 to 1 000	> 1 000 to 1 200	> 1 200			A: IEC 60672-2

Table D.1 *(continued)*

Property and type	*j*	k_1k_2	*l*									Relevant test methods [a]
			1	2	3	4	5	6	7	8	9	
Wear resistance	7	Product displays wear resistant properties critical to its function										
Abrasive wear resistance	7	01	Important characteristic of product									
Sliding wear resistance	7	02	Important characteristic of product									A: JIS R1613
Erosive wear resistance	7	03	Important characteristic of product									
Corrosion resistance	8	Product is specifically designed for resistance to corroding media										A: ENV 12923-1
Water	8	01	Important characteristic of product									
Acid solutions	8	02	Important characteristic of product									A: JIS R1614
Alkali solutions	8	03	Important characteristic of product									A: JIS R1614
Oxidizing gases	8	04	Important characteristic of product									A: JIS R1609
Reducing gases	8	05	Important characteristic of product									
Other vapours	8	06	Important characteristic of product									
Molten metals	8	07	Important characteristic of product									
Molten salts	8	08	Important characteristic of product									
Molten siliceous slags	8	09	Important characteristic of product									
Biological resorbability	8	20	Important characteristic of product									
Biological inertness	8	21	Important characteristic of product									
Biological reactivity (not resolvable)	8	22	Important characteristic of product									
Nuclear characteristics	9	Product is specifically designed for nuclear applications										
Neutron capture cross-section	9	01	Important characteristic of product									

a A = monolithic; B = composites; C = coatings; D = powders.

b The data figures refer to a 40 mm span four-point bending test using test-pieces with a fine lapped surface finish.

c For thermal expansion, the temperature qualifier shall always be used to indicate the range from room temperature over which the data apply.

Table D.2 — Temperature and frequency qualifiers, code elements m and n

Property data code m or n	Temperature qualifier, m, range in °C	Frequency qualifier, n, range in Hz
1	$\leqslant 0$	d.c.
2	> 0 to 100	$\leqslant 10^3$
3	> 100 to 300	$> 10^3$ to 10^6
4	> 300 to 600	$> 10^6$ to 10^9
5	> 600 to 900	$> 10^9$
6	> 900 to 1 200	—
7	> 1 200 to 1 400	—
8	> 1 400 to 1 600	—
9	> 1 600	—
0	not defined	not defined

Table D.3 — Definitions of orientations for anisotropic properties

Direction code	Applicable form code	Direction defined as
X	KB, KG	Perpendicular to hot-pressing or extrusion direction
	KS	Parallel to uniform 1D fibre reinforcement
	KT	Parallel to a principal direction of 2D reinforcement
	KU	Perpendicular to a principal direction in 3D reinforcement
	LB, LE, LF	Perpendicular to deposition direction of thin film or coating
	EL	Parallel to plane of thin sheet or laminate
	S	Parallel to the a-axis in orthorhombic or hexagonal crystals
Z	KB, KG	Parallel to hot-pressing or extrusion direction
	KS	Perpendicular to uniform 1D fibre reinforcement (out of plane of sheet)
	KT	Perpendicular to 2D reinforcement (out of plane of sheet)
	KU	Parallel to principal direction in 3D reinforcement
	LB, LE, LF	Parallel to deposition direction of thin film or coating
	EL	Perpendicular to plane of thin sheet or laminate
	S	Parallel to c-axis in orthorhombic or hexagonal single crystal
Y	All	Orthogonal to X and Z directions

Annex E
(informative)

Bibliography to annex D

E.1 Introduction

This annex lists standards for test methods which might be used for determining property data used for classifying products using the property data coding elements listed in annex D. This listing is unlikely to be complete, but is intended purely for guidance.

E.2 Test method standards

E.2.1 ISO and IEC Standards

— ISO 14703, *Fine ceramics (advanced ceramics, advanced technical ceramics) — Sample preparation for the detemination of particle size distribution of ceramic powders*

— ISO 14704, *Fine ceramics (advanced ceramics, advanced technical ceramics) — Test method for flexural strength of monolithic ceramics at room temperature*

— ISO 14705, *Fine ceramics (advanced ceramics, advanced technical ceramics) — Test method for hardness of monolithic ceramics at room temperature*

— ISO 15490, *Fine ceramics (advanced ceramics, advanced technical ceramics) — Test method for tensile strength of monolithic ceramics at room temperature*

— ISO 15732, *Fine ceramics (advanced ceramics, advanced technical ceramics) — Test method for fracture toughness of monolithic ceramics at room temperature by single edge precracked beam (SEPB) method*

— ISO 15733, *Fine ceramics (advanced ceramics, advanced technical ceramics) — Test method for tensile stress-strain behaviour of continuous fibre-reinforced composites at room temperature*

— ISO 17561, *Fine ceramics (advanced ceramics, advanced technical ceramics) — Test method for elastic moduli of monolithic ceramics at room temperature by sonic resonance*

— ISO 17562, *Fine ceramics (advanced ceramics, advanced technical ceramics) — Test method for linear thermal expansion of monolithic ceramics by push rod technique*

— ISO 17565, *Fine ceramics (advanced ceramics, advanced technical ceramics) — Test method for flexural strength of monolithic ceramics at elevated temperature*

— ISO 18754, *Fine ceramics (advanced ceramics, advanced technical ceramics) — Determination of density and apparent porosity*

— ISO 18755, *Fine ceramics (advanced ceramics, advanced technical ceramics) — Determination of thermal diffusivity of monolithic ceramics by laser flash method*

— ISO 18756, *Fine ceramics (advanced ceramics, advanced technical ceramics) — Determination of fracture toughness of monolithic ceramics at room temperature by the surface crack in flexure (SCF) method*

— ISO 18757, *Fine ceramics (advanced ceramics, advanced technical ceramics) — Determination of specific surface area of ceramic powders by gas absorption using the BET method*

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

E.2.2 American Society for Testing and Materials (ASTM) standards

— ASTM C1161, *Standard Test Method for Flexural Strength of Advanced Ceramics at Ambient Temperature*

— ASTM C1198, *Standard Test Method for Dynamic Young's Modulus, Shear Modulus, and Poisson's Ratio for Advanced Ceramics by Sonic Resonance*

— ASTM C1251, *Standard Guide for Determination of Specific Surface Area of Advanced Ceramic Materials by Gas Adsorption*

— ASTM C1259, *Standard Test Method for Dynamic Young's Modulus, Shear Modulus, and Poisson's Ratio for Advanced Ceramics by Impulse Excitation of Vibration*

— ASTM C1273, *Standard Test Method for Tensile Strength of Monolithic Advanced Ceramics at Ambient Temperatures*

— ASTM C1274, *Standard Test Method for Advanced Ceramic Specific Surface Area by Physical Adsorption*

— ASTM C1275, *Standard Test Method for Monotonic Tensile Behavior of Continuous Fiber-Reinforced Advanced Ceramics with Solid Rectangular Cross-Section Specimens at Ambient Temperatures*

— ASTM C1282, *Standard Test Method for Determining the Particle Size Distribution of Advanced Ceramics by Centrifugal Photosedimentation*

— ASTM C1292, *Standard Test Method for Shear Strength of Continuous Fiber-Reinforced Advanced Ceramics at Ambient Temperatures*

— ASTM C1326, *Standard Test Method for Knoop Indentation Hardness of Advanced Ceramics*

— ASTM C1327, *Standard Test Method for Vickers Indentation Hardness of Advanced Ceramics*

— ASTM C1341, *Standard Test Method for Flexural Properties of Continuous Fiber-Reinforced Advanced Ceramic Composites*

— ASTM C1358, *Standard Test Method for Monotonic Compressive Strength Testing of Continuous Fiber-Reinforced Advanced Ceramics with Solid Rectangular Cross-Section Specimens at Ambient Temperatures*

— ASTM C1421, *Standard Test Methods for Determination of Fracture Toughness of Advanced Ceramics at Ambient Temperatures*

— ASTM C1424, *Standard Test Method for Monotonic Compressive Strength of Advanced Ceramics at Ambient Temperatures*

— ASTM E228, *Standard Test Method for Linear Thermal Expansion of Solid Materials With a Vitreous Silica Dilatometer*

E.2.3 European Standards

— EN 623-2, *Advanced technical ceramics — Monolithic ceramics — General and textural properties — Part 2: Determination of density and porosity*

— ENV 623-3, *Advanced technical ceramics — Monolithic ceramics — General and textural properties — Part 3: Determination of grain size*

— ENV 623-4, *Advanced technical ceramics — Monolithic ceramics — General and textural properties — Part 4: Determination of surface roughness*

— EN 658-1, *Advanced technical ceramics — Mechanical properties of composite materials at room temperature — Part 1: Determination of tensile properties*

— ENV 658-2, *Advanced technical ceramics — Mechanical properties of composite materials at room temperature — Part 2: Determination of compressive strength*

— ENV 658-3, *Advanced technical ceramics — Mechanical properties of composite materials at room temperature — Part 3: Determination of flexural strength*

— ENV 658-4, *Advanced technical ceramics Mechanical properties of composite materials at room temperature — Part 4: Determination of shear strength by compression loading of notched specimens*

— ENV 658-5, *Advanced technical ceramics — Mechanical properties of composite materials at room temperature — Part 5: Determination of shear strength by short span bend test (three-point)*

— ENV 658-6, *Advanced technical ceramics — Mechanical properties of composite materials at room temperature — Part 6: Determination of shear strength by double punch shearing*

— EN 725-5, *Advanced technical ceramics — Methods of test for ceramic powders — Part 5: Determination of the particle size distribution*

— EN 725-6, *Advanced technical ceramics — Methods of test for ceramic powders — Part 6: Determination of the specific surface area*

— EN 725-8, *Advanced technical ceramics — Methods of test for ceramic powders — Part 8: Determination of tapped bulk density*

— ENV 820-1, *Advanced technical ceramics — Monolithic ceramics — Thermomechanical properties — Part 1: Determination of flexural strength at elevated temperature*

— ENV 820-2, *Advanced technical ceramics — Monolithic ceramics — Thermomechanical properties — Part 2: Determination of selfloaded deformation*

— ENV 820-3, *Advanced technical ceramics — Monolithic ceramics — Thermomechanical properties — Part 3: Determination of resistance to thermal shock by water quenching*

— EN 821-1, *Advanced technical ceramics — Monolithic ceramics — Thermo-physical properties — Part 1: Determination of thermal expansion*

— EN 821-2, *Advanced technical ceramics — Monolithic ceramics — Thermo-physical properties — Part 2: Determination of thermal diffusivity by the laser flash (or heat pulse) method*

— ENV 821-3, *Advanced technical ceramics — Monolithic ceramics — Thermo-physical properties — Part 3: Determination of specific heat capacity*

— EN 843-1, *Advanced technical ceramics — Monolithic ceramics — Mechanical properties at room temperature — Part 1: Determination of flexural strength*

— ENV 843-2, *Advanced technical ceramics — Monolithic ceramics — Mechanical properties at room temperature — Part 2: Determination of elastic moduli*

— ENV 843-4, *Advanced technical ceramics — Monolithic ceramics — Mechanical properties at room temperature — Part 4: Vickers, Knoop and Rockwell Superficial hardness tests*

— ENV 1007-3, *Advanced technical ceramics — Ceramic composites — Methods of test for reinforcements — Part 3: Determination of filament diameter*

— ENV 1071-1, *Advanced technical ceramics — Methods of test for ceramic coatings — Part 1: Determination of coating thickness by contact probe profilometer*

— ENV 1071-2, *Advanced technical ceramics — Methods of test for ceramic coatings — Part 2: Determination of coating thickness by the cap grinding method*

— ENV 1071-5, *Advanced technical ceramics — Methods of test for ceramic coatings — Part 5: Determination of porosity*

— ENV 1159-1, *Advanced technical ceramics — Ceramic composites — Thermophysical properties — Part 1: Determination of thermal expansion*

— ENV 1159-2, *Advanced technical ceramics — Ceramic composites — Thermophysical properties — Part 2: Determination of thermal diffusivity*

— ENV 1159-3, *Advanced technical ceramics — Ceramic composites — Thermophysical properties — Part 3: Determination of specific heat capacity*

— ENV 1389, *Advanced technical ceramics — Ceramic composites — Physical properties — Determination of density and apparent porosity*

— ENV 12290, *Advanced technical ceramics — Mechanical properties of ceramic composites at high temperature under inert atmosphere — Determination of compression properties*

— ENV 12291, *Advanced technical ceramics — Mechanical properties of ceramic composites at high temperature in air at atmospheric pressure*

— ENV 12923-1, *Advanced technical ceramics — Monolithic ceramics — Part 1: General practice for undertaking corrosion tests*

E.2.4 Japanese Industrial Standards

— JIS R 1601, *Testing method for flexural strength (modulus of rupture) of fine ceramics*

— JIS R 1602, *Testing methods for elastic modulus of fine ceramics*

— JIS R 1606, *Testing methods for tensile strength of fine ceramics at room and elevated temperature*

— JIS R 1607, *Testing methods for fracture toughness of fine ceramics*

— JIS R 1608, *Testing methods for compressive strength of high performance ceramics*

— JIS R 1609, *Testing methods for oxidation resistance of non-oxide high performance ceramics*

— JIS R 1610, *Testing method for Vickers hardness of high performance ceramics*

— JIS R 1611, *Test methods of thermal diffusivity, specific heat capacity, and thermal conductivity for fine ceramics by laser flash method*

— JIS R 1613, *Testing method for wear resistance of high performance ceramics by ball-on disk method*

— JIS R 1614, *Testing method for corrosion of high performance ceramics in acid and alkaline solutions*

— JIS R 1618, *Measuring method of thermal expansion of fine ceramics by thermomechanical analysis*

— JIS R 1619, *Testing method for size distribution of fine ceramic particles by liquid photosedimentation method*

— JIS R 1626, *Measuring methods for the specific surface area of fine ceramic powders by gas adsorption using the BET method*

— JIS R 1627, *Testing method for dielectric properties of fine ceramics at microwave frequency*

— JIS R 1628 *Test method for bulk density of fine ceramic powder*

— JIS R 1629, *Determination of particle size distributions for fine ceramic raw powders by laser diffraction method*

— JIS R 1634, *Test methods for density and apparent porosity of fine ceramics*

Bibliography

[1] SCHNEIDER, S.J., *International survey on the classification of advanced ceramics*, VAMAS Report No. 5, 1990, published by National Physical Laboratory, Teddington, TW11 0LW, UK

[2] REYNARD, K.R., *Proceedings of Workshop on Classification of Advanced Ceramics*, Ispra, June 1990, Elsevier, Barking, published in *Ceramics International*, 1993, **19**(1), 1 et seq.

[3] COTTON, J.W. and EVERILL, J.B., Report to VAMAS TWA14 — *A unified classification system for advanced technical ceramics*, British Ceramic Research Ltd Report to VAMAS TWA14, November 1992

[4] SCHNEIDER, S.J., Final report of VAMAS Technical Working Area 14, *Classification of Advanced Technical Ceramics*, 1993, VAMAS Report 15, National Institute for Standards and Technology, Gaithersburg, MD, USA

[5] MORRELL, R., NEWLAND, B.G., STAMENKOVICH, I. and WÄSCHE, R., *Testing and demonstrating the VAMAS classification scheme — Summary of issues in manual coding of commercial products*, 1996, VAMAS Report 23, National Physical Laboratory, Teddington, UK

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