INTERNATIONAL STANDARD

ISO 15165

First edition
2001-10-15

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

Céramiques techniques — Système de classification

Reference number
ISO 15165:2001(E)

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

Printed in Switzerland

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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 precursor for fine ceramics;

c) traditional ceramics based on clay, including:

1) whitewares (e.g. tableware and fine porcelain);

2) sanitary wares;

3) floor and wall tiles;

4) building ceramics (e.g. bricks and pipes);

d) unshaped and shaped refractories for tonnage applications.

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

2 Normative references

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

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

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

3 Terms and definitions

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

3.1
fine ceramic (advanced ceramic, advanced technical ceramic)
highly engineered, high-performance, predominantly non-metallic, inorganic, ceramic material having specific functional attributes

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

3.2
classification field
set of categories related to one independent aspect or feature of the classification

3.3
classification element
single category in a classification field

3.4
code
alphanumeric string with a prescribed definition in terms of material attributes

3.5
coding element
part of the alphanumeric code from one classification field

4 Objectives

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

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

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

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

5 Individual classification fields

5.1 Introduction

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

— **A** = application

— **C** = chemical character

— **P** = processing methods

— **D** = property characteristic or data

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

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

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

— **X** = any appropriate single capital letter coding character

— **n** = any appropriate single numeric coding character

5.2 Classification field for application type

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

— **electrical insulation**, i.e. insulators for a wide variety of purposes;

— **electronic/ionic conduction**, i.e. electronic or ionic conductors for heating or functional purposes;

— **mechanical functions**, including wear, at or near room temperature;

— **thermal and thermomechanical functions**, where dimensional stability at raised temperature, heat insulation, heat conduction or resistance to thermal shock are the principal functions, and where additionally mechanical loads may be applied;

— **nuclear functions**, where the component plays either an active or a passive nuclear role;

— **optical functions**, where the component plays a functional role as an optical element in reflection, refraction, transmission or absorption of electromagnetic radiation;

— **chemical functions**, including biomedical, where the component is employed for handling melts, chemicals, solutions or atmospheres because of its resistance to attack by them and, in the case of biomedical materials, a degree of bio-compatibility;

— **magnetic functions**, where the component possesses properties allowing a functional magnetic role;

— **powder functions**, where the fine ceramic is supplied in powder or granule form for use as such.

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

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

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

EXAMPLES

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

5.3 Classification field for chemical character

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

Two formats of this string are given:

— a **short format**, intended for broad description of chemical character of common types of powder or ceramic material;

— a **long format**, when more detailed chemical information is required, such as the individual chemical components present and optionally their mass fractions.

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

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

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

CXXnnnn

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

EXAMPLES

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

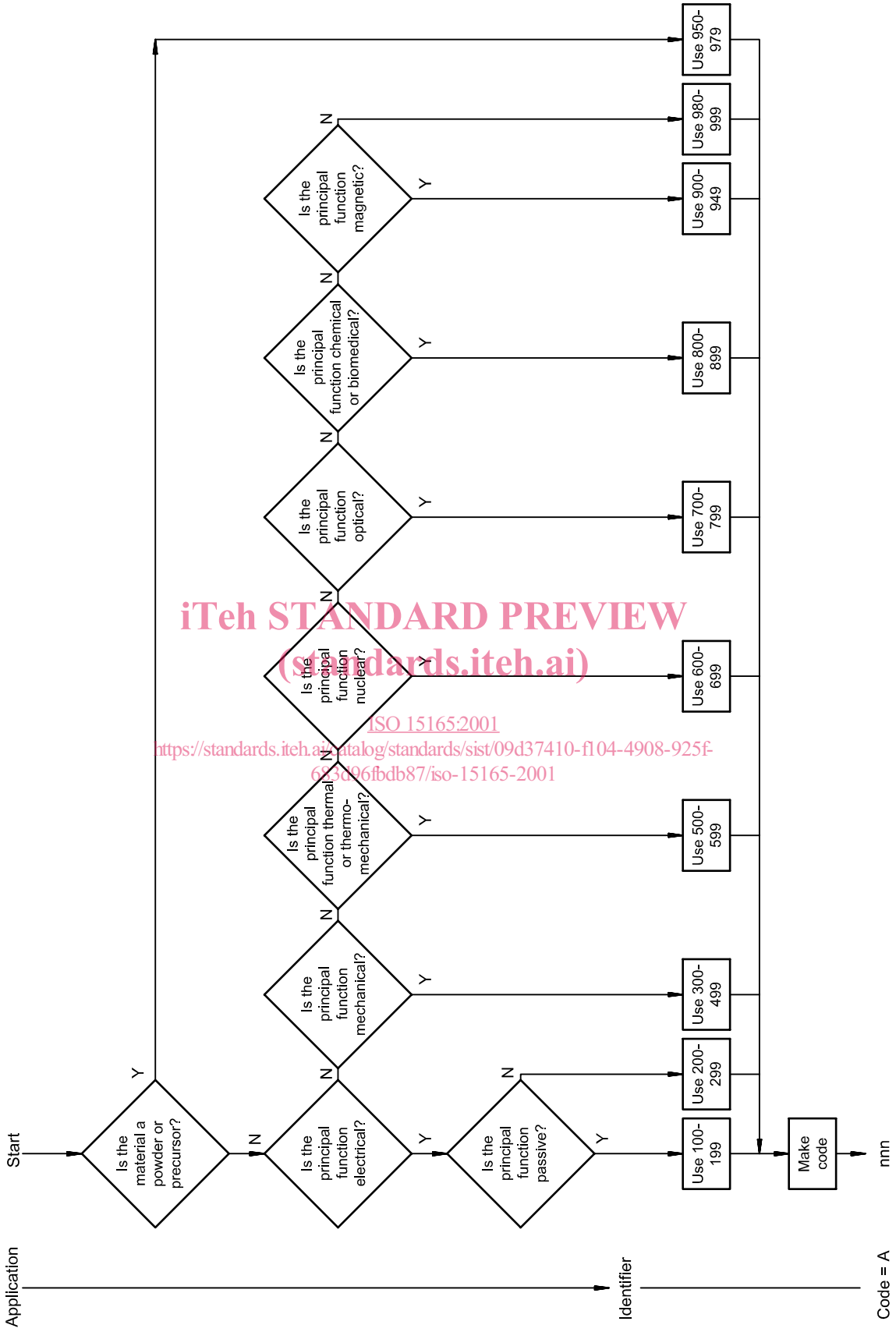


Figure 1 — Flow diagram showing the selection of codes for application

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

Important aspects to note are:

1) The code may be developed in the detail required to classify the product for the objective in mind.

2) Compositional detail may be appended if appropriate to end-use requirements. Two options are available; see Table 1 for two options, either an additional code number or a supplementary statement.

3) The minimum classification long-format code is “form” plus one identified chemical compound; all information beyond this point is non-mandatory.

4) The classification code is terminated either by no further characters, or by one of the initial characters A, P or D (or additional defined initial classification field codes) indicating the start of another classification field.

5) Effective use of the long-format code requires detailed knowledge of the formulation and microstructure of the product.

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

EXAMPLE 1

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

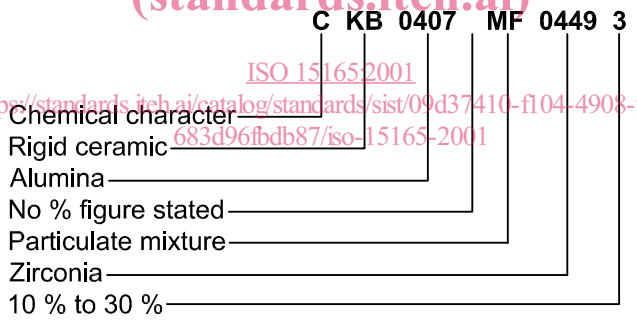


Table 1 — Construction of the long-format chemical character code

Code element	Description	
C	Chemical character code string identifier	
XX	One or two-letter code indicating the overall “form” of the product	
nnnn	Four-digit chemical character code from the numerical range 0001 to 4999 (see annex B)	
Optional **n**	**Option 1:** coding element for indicating “amount” of the species nnnn in the product expressed as mass percentage, according to the following code: 1 ⩽ 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.		

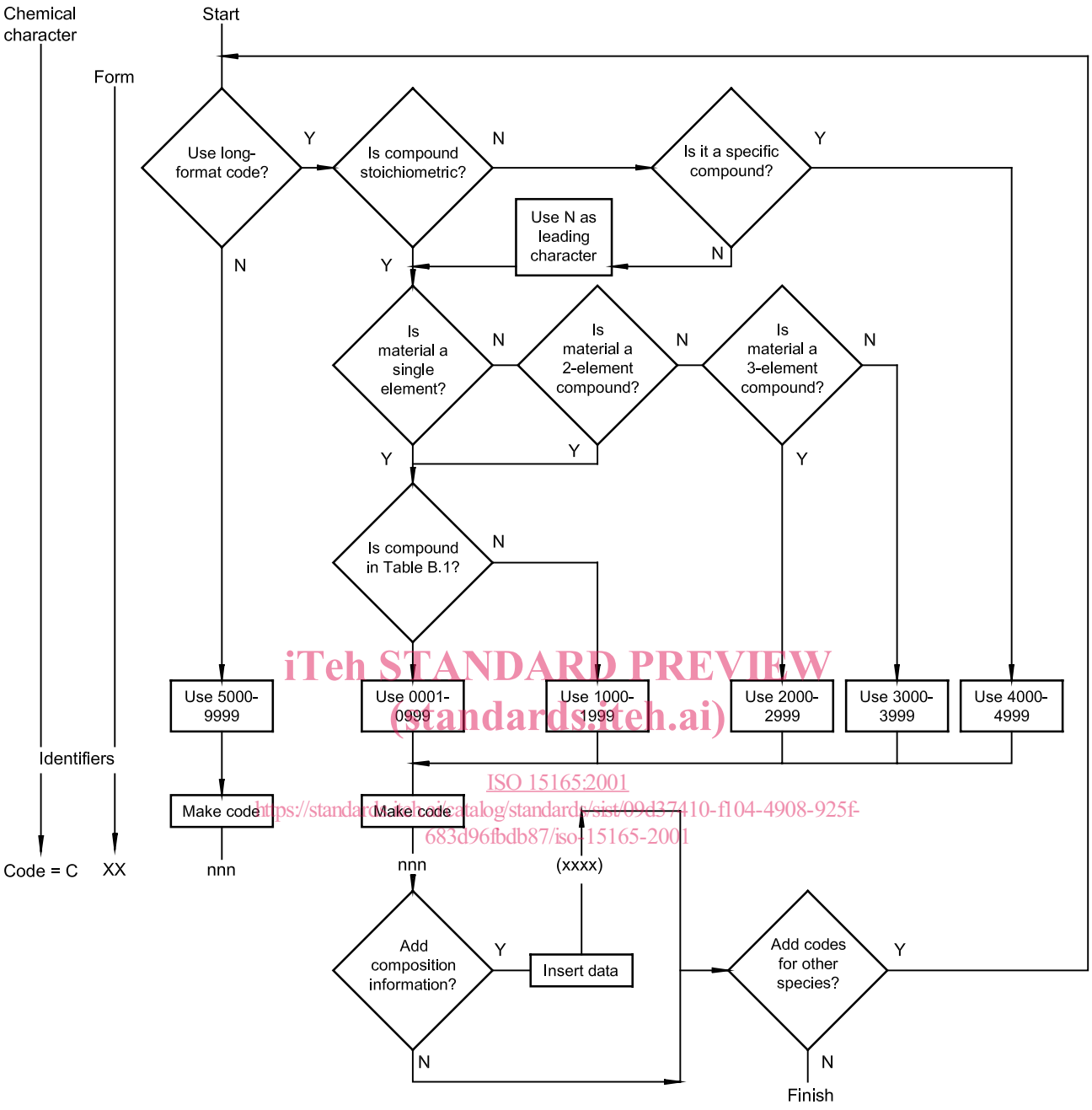
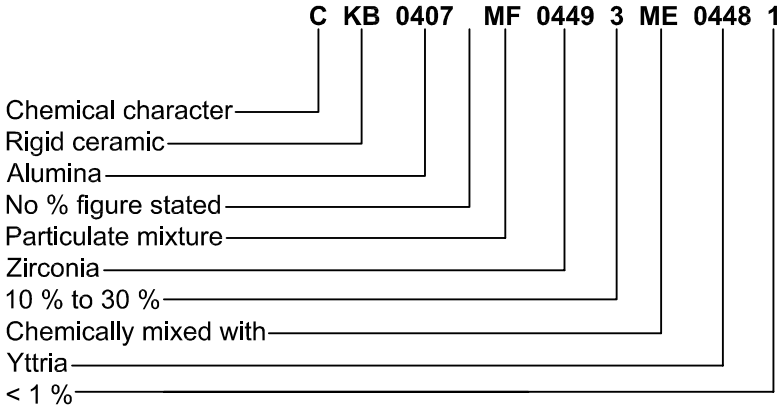


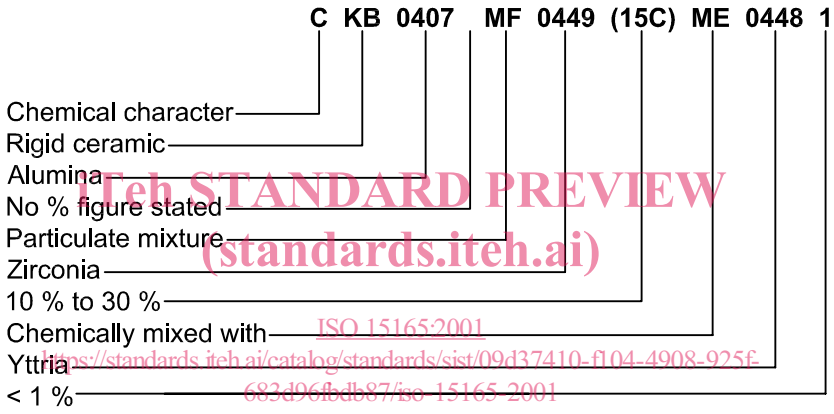
Figure 2 — Flow diagram for selection of codes representing chemical character

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):