# VAMAS

## Technical Working Area 14

# A UNIFIED CLASSIFICATION SYSTEM FOR ADVANCED TECHNICAL CERAMICS

# TESTING AND DEMONSTRATING THE VAMAS CLASSIFICATION SCHEME

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# SUMMARY OF ISSUES IN MANUAL CODING OF COMMERCIAL PRODUCTS

Final Report

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**National Physical Laboratory**

**Final Technical Report**

# TESTING AND DEMONSTRATING THE VAMAS CLASSIFICATION SCHEME - SUMMARY OF ISSUES IN MANUAL CODING OF COMMERCIAL PRODUCTS

by

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**Abstract**

This EC Standards Measurement and Test (SMT) sponsored project* has addressed the task of practically verifying that the CEN ENV for Classification of Advanced Technical Ceramics is viable when applied to real commercial products, based on a manual assessment of information and data supplied in brochures acquired from manufacturers worldwide. For the vast majority of products, coding of all aspects has been straightforward. However, a number of minor points associated with the clarity of wording, ambiguity of code description, and missing codes have been identified. Some other general issues associated with the philosophy of the scheme have also been identified, such as whether the true function of an advanced ceramic powder should be classifiable.

The annexes to this report list the issues identified in the respective coding areas of Application, Chemistry/Form, Processing (outside the scope of the current CEN standard, but included in the VAMAS report ISO TTA 1), and Data. Where feasible, recommendations on correcting these issues have been included. This report is for discussion by membership of VAMAS TWA14, CEN TC184/WG1, ASTM C28, Japan Fine Ceramics Association and ISO TC206/WG4 in order to provide a unified set of modifications to the existing or future versions of the classification standard.

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**Executive Summary**

This EC Standards Measurement and Test (SMT) sponsored project (contract no MAT1-CT940039) has addressed the task of practically verifying that the CEN ENV for Classification of Advanced Technical Ceramics is viable when applied to real commercial products, based on a manual assessment of information and data supplied in manufacturers brochures. This is a key task which provides evidence for the validity of the VAMAS approach, for coordinated correction/modification of existing standard versions, and for the justifiable conversion of the CEN ENV to an EN. It is also the initial task in the project of VAMAS Technical Working Area 14 to provide a practical demonstrator of the mode of operation of the scheme to encourage industrial uptake.

The SMT sponsored project was contracted to NPL, who then subcontracted parts to three subcontractors who were associated with the original proposal as project partners. This report is a summary of the aggregated findings of the project group. More than 300 commercial products have been examined and coded, and the findings commented upon.

The scheme has been found to be broadly usable, but with a few instances of ambiguity or difficulty that require elimination by modifying the scheme. These points can be summarised broadly as follows:

- The Coding problems found resolve into two types:
    - the specific code is not available, or not obvious
    - insufficient/incorrect explanation for unambiguous choice of code.
- A considerable number of minor revisions need to be considered.
- The major issues identified are:
    - clarification of the scope and purpose of scheme to avoid attempts to classify in excessive or unnecessary detail.
    - "Applications" for fine ceramic powders are missing.
    - the use of short-form codes for powders is unclear.
    - there may be a need to include coding for some aspects of component performance data, as distinct from material property data.
    - the language describing the meaning of a code may be unclear or too general.
- Minor issues are:
    - missing codes.
    - inconsistencies in code descriptions.

This report contains a detailed listing of the above issues, and gives some possible solutions to the problems. These issues need to be agreed by standards committees (CEN, ASTM and ISO) as proposed modifications to standard documents, and it is considered that this is best done by VAMAS TWA14 in the first instance.

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## 1. INTRODUCTION

Commencing in 1988, the VAMAS Technical Working Area 14, Classification of Advanced Ceramics, began working on a task to assess the requirements for and then to provide a detailed classification scheme. This scheme is needed to address the problem of the vast and continually expanding range of products and applications for which there was no consistent method of technical or commercial description. The only exception to this existing situation was the somewhat limited specification and classification for electrically insulating ceramics described in IEC 672, which was published in 1980 and is currently under revision.

VAMAS TWA14 conducted an international survey of industrial requirements for classification, and the results have been compiled into VAMAS Report No. 5 [1]. There was clear industrial support for a method of classifying products not only by materials characteristics, but also by their chemistry, their specific applications, and the processing routes used in their manufacture. One of the main driving forces for this was that the extant means of classifying by formal customs Commodity Coding was far too imprecise a method for the industry to obtain market information of value. It was felt that this was a considerable impediment to improving market penetration of advanced technical ceramics, and for identifying new opportunities.

An international conference was held at Ispra in 1991 which reviewed the report and methods of satisfying the requirement [2]. Following investigation of the options for classification, with especial emphasis on computer compatibility, a new approach was needed. Under sponsorship from the European Commission, CERAM Research, UK, formulated a draft scheme which took a radical approach to classification by permitting the five attributes:

- Applications
- Chemistry
- Form
- Processing method
- Property data

to be simultaneously coded as appropriate to the application of the classification. This method was published in 1994 as ISO Technology Trends Assessment No. 1 [3]. Moves were in place from 1991 to create standards versions of this classification. In Europe, an ENV (Euronorme Volotaire or pre-standard) was agreed by CEN TC184/WG1, and approved by the TC in December 1992. Publication of this ENV is imminent [4], following language translation delays resulting from its technical complexity. In ASTM, the standard went through several successive ballots and was finally published in 1994 [5].

From the outset it was recognised that the revolutionary approach to classification required some assessment of its usability and completeness. While the best efforts of the scientists and engineers involved in VAMAS TWA14 had been employed in the creation of the scheme, it had been a paper exercise, and thus had not been "tested" on real materials and components. In parallel, TWA14 also felt that simply to create a methodology on paper did not get it implemented by the industry for which it had primarily been developed. Consequently, TWA14 defined a second phase of the work, to test the viability of the scheme and to demonstrate it to industry through use of a computer program which would demonstrate a number of potential applications, with particular emphasis on product identification and trade statistical information.

In order to support this project, funding was sought from the European Commission, specifically the Framework III Standards Measurement and Test Programme, from ASTM's Institute of Standards Research (ISR), and from the Japan Fine Ceramics Association (JFCA).

The EC part of the project, the subject of this report, concerned the evaluation of the written scheme through examining how it could be applied to information in commercial brochures. In parallel, a computer expert in the US was funded through ISR and JFCA to provide a computer demonstrator, which would employ input from the EC project as its database.

This report covers the EC side of the project contracted to NPL, specifically the review of the classifications scheme and its applicability to commercial products. The working methods, the scope and findings are discussed. Possible solutions to the minor gaps and inconsistencies identified in the scheme are offered.

## 2. WORKING APPROACH

### 2.1 Contract

The EC contract was placed with NPL, the lead Partner in a four-partner proposal to the SMT Programme. NPL then made arrangements to subcontract to the other Partners in accordance with the original breakdown of costs and with the same terms and conditions as the EC contract on NPL. The other Partners were:

- Morgan Materials Technology Centre (MMT) - Dr B G Newland
- Bundesanstalt für Materialprüfung und -Forschung (BAM) - Dr R Wäsche
- Centro Ceramico Bologna (CCB) - Dr I Stamenkovic (replacing the original Proposer, Cerasiv IMEC Srl - Dr J Boog)

### 2.2 Workplan

The project was divided into two tasks:

Task 1: Definition of scope of test and agreement with VAMAS TWA14.
Task 2: Manual evaluation of the scheme and reporting.

In Task 1, discussions were held which defined the modus operandi of the Partners, and which permitted the design of a coding sheet (Figure 1) which would allow the uniform compilation of codes and identified problems. These aspects were discussed at a VAMAS meeting in April 1995, following which the agreed procedures were employed by the project partners to develop the testing. The coding sheets could also be used directly to develop the computer database from the data entered manually into the table boxes indicated as shaded.

In Task 2, the partners individually tackled data sheets acquired from industrial suppliers in their own allotted areas, which are given in Table 1. This task involved assessing individual product lines, as far as the information available permitted, in terms of the classification system. Particular emphasis was to be placed on ensuring that the coding system could be used without ambiguity, and that there were a sufficiency of codes for most eventualities. Problems of coding allocation were to be noted, and these points represent the basis of this final report. It was agreed that each Partner should tackle a minimum of 50 diverse product lines, compiling a coding sheet on each one. Powders as well as finished products were to be included. The deliverable of each Partner was a set of coded forms and a summary of findings and recommendations, which would then be compiled by NPL into a project report.

**Figure 1**

**VAMAS TWA14 - CLASSIFICATION - SHEET 1**

(Items entered in shaded boxes are used in the demonstrator database)

| | | | | | |
|---|---|---|---|---|---|
| Reference no.: | | Classified by:<br>(name) | | | |
| Material source:<br>(manufacturer) | | Country code | | Product Code | |
| Stated material type (words): | | | | | |

| A: Cited applications | VAMAS code | Comment no. |
|---|---|---|
| | | |

| F: Cited overall Form | VAMAS code | Comment no. |
|---|---|---|
| | | |

| C: Cited chemistry | VAMAS code, long form | VAMAS code, short form | Comment no. |
|---|---|---|---|
| Main component: | | | |
| Minor components: | | | |

| P: Cited/judged processing routes | VAMAS code | Comment no. |
|---|---|---|
| | | |

| D: Cited property data: | Value: | VAMAS code | Comment no. |
|---|---|---|---|
| | | | |

| No. | Comments/queries about the use of the scheme |
|---|---|
| | |

**Table 1 - Allocation of country areas**

| Partner | Countries covered |
|---|---|
| NPL | USA, Sweden (and some aspects of Japan through liaison with JFCA) |
| MMT | UK, Spain |
| BAM | Germany, Austria, Switzerland |
| CCB | France, Italy, Balkans |

### 2.3 Liaison with VAMAS TWA14

A key element of the project was to ensure that liaison with TWA14 and with the US contractor occurred on a continuous basis. This was done principally through NPL, but also by the other Partners at TWA14 meetings. This liaison was intended to ensure that communication of progress was free-flowing, and that the output from the manual assessment could be converted effectively into a database for the purposes of the computer demonstrator.

## 3. ACQUISITION AND ASSESSMENT OF DATASHEETS

### 3.1 NPL

In conjunction with the VAMAS TWA14 chairman, a large quantity of brochures was obtained from the US industry and shipped to the UK. A sample of these were evaluated by two members of NPL staff, one with experience of the scheme and the second with no experience whatsoever, the latter case as a test of its "first-time" usability. In addition, NPL liaised with Professor Takata of Nagaoka University concerning the results of Japan's own test of the scheme by various individuals in industry. The original Japanese versions of these coding sheets were supplied and arrangements were made to translate the details sufficiently for them to be assessed as part of this Project.

In total about 150 assessments were made by NPL, plus about 25 assessments from Japan. Some examples of the data sheets are given in Annex 1.

### 3.2 Morgan Materials Technology

Product literature and data were obtained from five Spanish and 19 UK suppliers of advanced technical ceramics, including 10 divisions of the largest UK/Spanish producer. This information was obtained either directly, or via the British Industrial Ceramics Manufacturers Association. From these a total of about 50 products were selected to demonstrate diversity of chemistry, form and application. All could be coded using the scheme, although there was little information concerning processing in the literature employed. Comments made on the coding forms were supplied to NPL for inclusion in this report.

### 3.3 Bundesanstalt für Materialprüfung und Forschung

Data sheets were obtained from a number of technical ceramic suppliers in Germany and

Switzerland, but none were available from Austria. The response to the request for information was not as strong as anticipated, despite the assistance of the German Industry Association (Verband der Keramische Industrie). In a proportion of cases, there was either no response, or the information provided did not allow adequate classification. A total of 54 product lines were evaluated and coded, and the issues arising were summarised in a short report to NPL.

### 3.4 Centro Ceramico Bologna

With the assistance of the Italian Trade Federation (Federceramica) brochures from most of the Italian industry were acquired and coded. Some problems arose with acquiring brochures from France, but with the assistance of the Syndicat Nationale des Industries Francaises de Produits Refractaires, a variety of documentation, notably some for long-fibre composites, was acquired. These were analysed and coded, and a report received by NPL.

## 4. CONCLUSIONS OF THE EVALUATION

### 4.1 Overall views

The general view amongst the partners is that the principle of the classification scheme does not have intrinsic problems. No issues were found that **invalidated** the principle of independent classification elements for Applications, Chemistry/Form, Processing and Data.

However, it quickly became clear that the classifier needs to have considerable background experience and scientific understanding of advanced technical ceramics in order to make a useful, meaningful and unambiguous coding for each product. Since the individuals undertaking this task had this experience, it was not always clear how much background knowledge was being brought to bear to interpret the supplied information in the manner required by the classification. There were a number of instances where this knowledge was almost unwittingly employed to select the most appropriate code, whereas an inexperienced person without this background could not make an unambiguous choice. It therefore has to be concluded that for commercial classification and statistics gathering purposes, some simplification of the scheme seems to be needed.

One possible solution is to permit the selection of "general" codes, e.g. for "alumina", where selection of one of the wide range of different types of alumina is unwarranted, or technically too complex for inexperienced staff to cope with. Some other examples where this might be done are:

Application: use a group code for all electrical insulators, rather than choose a specific product function, e.g. furnace element insulator.

Data: use a group code to indicate general corrosion resistance, rather than select a specific environment in which the product has resistance.

Another factor identified was that the coding sheets designed and employed by the project participants were not ergonomic for the process of coding. Their primary purpose was to provide both a means of logging difficulties with coding and the development of a database for the VAMAS demonstrator. It was commented that for commercial purposes it would be necessary to develop a means for fast input via computer software rather than having to use look-up tables in a document, which would also help to avoid the wrong choice of code. As a consequence, the coding was a slow process for the participants, especially when the literature on a product was extensive. However, once the coding sheet had been prepared, it proved to be possible to use the basic VAMAS code and ancillary information to create the database for the VAMAS demonstrator. It is understood that the VAMAS demonstrator will have incorporated into it the means for menu-driven code selection employing the semi-hierarchical listings of attributes which should go some way towards elimination of the current use of look-up tables. Front end software of this type would certainly improve the transfer of information to computer, and would be needed to encourage the take-up of the scheme by industry.

A large number of minor issues were uncovered in the course of the project. These are listed in detail in the Annexes 2 to 5, but the underlying problems are discussed below:

### 4.2 Application codes

A number of instances of unavailability of codes for particular product types or applications were identified from the set of product data sheets examined. One of the most significant is that there are no specific applications for powders. The application listing ignores the possibility of an advanced technical ceramic powder having a function in its own right, which may not be solely that for fabricating a solid ceramic body. The listing appears to consider only ceramic end products, which is a logical inconsistency as the scope of the scheme is said to cover powders, fibres, whiskers and other precursors. As examples other than ceramic manufacture, powders may have functions as:

- inert fillers for plastics
- thermally conducting fillers for silicone rubbers and greases
- plasma or flame spraying
- grinding/lapping/polishing grits (including toothpaste!)
- magnetic media
- phosphors
- thermal insulation
- furnace packing (e.g. powder beds)
- lubricating coatings
- cosmetics

It is considered that this issue needs addressing immediately, and it will need to be addressed in time to incorporate changes into the computer demonstrator, and in the re-coding of powder data sheets. One possibility is to provide a semi- or non-hierarchical listing of powder applications in the series A951-A998, which is presently unused. A proposal to VAMAS is being prepared.

Other missing codes are specific absences of particular applications found in commercial brochures, such as:

- sputtering targets
- gear wheels
- wire guides
- protective ferrules
- evaporation boats
- forming rolls
- printing rolls
- dental brackets
- antibacterial devices
- jewellery
- semiconducting tweezers
- moulding platens
- thermionic cathodes

While it is possible to list the majority of these as "other" by the present classification scheme, consideration needs to be given to the expansion of the scheme to include these applications specifically.

### 4.4 Form/Chemistry codes

There were only a few problems with the "Form" listing. The vast majority of products could be identified by the VAMAS scheme, although there were some uncertainties with some of the more-recently developed products. Thin ceramic tapes, for example, as used to fabricated multilayered structures, are supplied commercially, but do not have a code. Multilayer structures also present some uncertainties, an example from Germany being a multilayered glass-ceramic. Should this be coded under multilayered monolithic ceramic, or as a glass-ceramic? Perhaps in cases of uncertainty like this, the best option is to recommend the use of the "Other" category.

A number of instances of missing short-form chemistry codes were found. As for applications above, the short-form code listing has a strong emphasis, especially in the section on aluminas, for specific ceramic types, and ignores the existence of powders. It will be necessary to insert particular additional powder forms, or modify the wording for some of the categories to ensure that the implication is that it applies to powders. An example is hexagonal boron nitride where the only available codes apply to hot-pressed, pyrolytic or composite materials, and there is no code for powder alone.

In some cases, the short-form codings are too specific, e.g. $\alpha$-SiC and $\beta$-SiC ceramics, which may differ primarily as a result of different raw materials rather than distinguishable features in the finished product. If a product is just termed "SiC", which is often the case, a non-specific code is preferred. Another example is calling a tetragonal zirconia polycrystal (TZP) just by this name without specifying the stabilizer, whereas the classification offers "Y-TZP" or "$CeO_2$-TZP" with no option for just "TZP". Instances like these need rectifying.

In addition, there are specific instances of missing codes, e.g. titanium diboride, silicon oxynitride bonded SiC, and alumina/SiC composites. New codes need to be added for these products.

### 4.4 Processing codes

Although the CEN ENV does not contain processing codes, these were incorporated in the testing because they appear in the ISO TTA No. 1 report. A few missing processing codes were found, plus some ambiguities that will need elimination. Examples include:

- the addition of low-pressure injection moulding
- there is an ambiguity between codes 29 and 30, both of which refer to air sintering, but one should possibly be at raised pressure
- the addition of manufacture of ceramic tape
- the addition of glazing
- the addition of fibre weaving

A number of other instances were proposed by Japanese reviewers which will need consideration. These go more deeply into the processing routes than the existing coding, and include:

- dough kneading (e.g. clay-based materials or viscous plastic processing)
- drying
- dewaxing
- fibre spinning from salt solutions (e.g. alumina fibre)
- green part integration

coupled with temperature or time information, and these areas need further discussion in VAMAS.

Consideration will also need to be given to whether "liquid phase sintering" is, for classification purposes, significantly different from "sintering", or in the case of silicon carbide materials, from "reaction bonding" in the presence of a liquid.

### 4.5 Data codes

A considerable number of difficulties arose with data coding. One of the underlying ones is that a rule needs to be established as to how to deal with a situation where a property has a range of values which bridge two or more classification ranges. It is debatable whether the lower bound, a mean, or an upper bound should be chosen. This will need to be decided following discussion in VAMAS.

A number of important specific properties were found to be inadequately defined. Examples include:

- density is more often given as an absolute value that as a percentage of the theoretical value
- toughness needs to be numerically defined now that standards are being produced
- the type of test and the load employed in hardness testing needs a form of coding
- the type of flexural strength test
- oxidation resistance in terms of weight gain data

In addition, "properties" which have no clear measure, such as "maximum use temperature", appear frequently in literature, and decisions are needed on whether and how to cope with these. A difficult area is when the properties quoted are anisotropic, e.g. in pyrolytic boron nitride or in reinforced composites. The scheme could be considered to be inadequate in such regard, and require modifying. On the other hand, a restricted scope of coding could be employed in which, for example, "tensile strength" of a composite is always taken to be when stressed parallel to the principal direction of reinforcement.

Data items which cannot be coded at present include:

- thermal diffusivity
- shear modulus
- shear strength
- Weibull modulus
- sintering temperature (for powders)
- fluorescence/luminescence
- emissivity

A Japanese comment is that sometimes the function of the **component** or **device**, rather than a material property, is the key element desirable for effective classification, e.g. voltage withstand in a complete electrical insulators cannot be coded, only material properties of the basic material. This type of problem opens up a philosophical question as to the true function of the scheme, and just how far it is both necessary and desirable to provide a means of coding. A similar situation is developed in a number of applications, and more will undoubtedly arise in due course. While the scheme was originally established solely as a classification, some of the suggestions are beginning to move towards an ability to classify performance characteristics, permitting an assessment which is tantamount to a specification. A discussion must be initiated as to the limits of the scheme in this area. At a minimum, additional clarifying statements are required which define the purpose and limitation of classifying by property.

## 5. CONCLUSIONS AND EXPLOITATION

The overall methodology of the scheme has been found to be broadly applicable to commercial information in the form of brochure data. A number of minor changes and proposed additions have been identified based on ambiguities or inability to code specific items of data. A modified version of this report will be issued as a free-issue VAMAS report.

It is proposed that VAMAS TWA14 study the findings of this work and come to some conclusions on each of the identified items, and then to work towards provision of a list of desirable wording or coding changes that need to be made to the scheme. Some of these changes will need to be made in time to be incorporated into the computer demonstrator in order that this can cope properly with the data set derived from the work of this project. One example is "Applications" for powders. A proposal for a set of "Applications" for advanced ceramic powders for data set in the VAMAS computer demonstrator is being discussed in parallel with this report. A series of such proposals will need to be tabled and agreed, preferably in VAMAS TWA14 rather than through individual standards committees. In this way a coordinated set of international changes can be constructed. The final recommended changes to standards can then be made at times appropriate to review.

An important point in making modifications to standards is to ensure that as far as possible the existing coding method is subjected to a minimum of disruption. In other words, the existing code numbers need to be retained, and additional ones fitted in where appropriate. It is fortunate that the systems was devised in such a manner that this is possible in most cases. However, it is considered that the complexity of some of the suggested requirements for changes to the data coding will be the most difficult to solve within the existing framework.

**Acknowledgement**

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[3] ISO TTA no. 1, Advanced technical ceramics - unified classification system, April 1994.

[4] CEN ENV 12112. Advanced technical ceramics - unified method for classification, 1995.

[5] ASTM C1286-94, Standard classification for advanced ceramics.

## Annex 1 - Examples of completed coding forms

**Example 1:**

| | | | | | |
|---|---|---|---|---|---|
| Reference no.: | | Classified by: (name) | | | I Stamenkovich |
| Material source: (manufacturer) | CICE S.A | Country | 33 | Product Code | TITAL T195 |
| Stated material type (words): | Alumina for pump and seal applications | | | | |

| A: Cited applications | VAMAS code | Comment no. |
|---|---|---|
| Seal discs for mixer taps | A380 | |
| Liquid distributers (other pump applications) | A379 | |

| F: Cited overall Form | VAMAS code | Comment no. |
|---|---|---|
| Monolithic ceramic | CKB | |

| C: Cited chemistry | VAMAS code, long form | VAMAS code, short form | Comment no. |
|---|---|---|---|
| Main component: | | | |
| Alumina, 95% | 0407 | 5040 | |
| Minor components: | | | |
| Unspecified | ME | | |

| P: Cited/judged processing routes | VAMAS code | Comment no. |
|---|---|---|
| Uniaxial pressing | 16 | 1 |
| Sintering | 30 | 1 |

| D: Cited property data: | Value: | VAMAS code | Comment no. |
|---|---|---|---|
| Bulk density | 3.7 | 1017 | |
| Open porosity | 0 | 1021 | |
| Hardness, HR45N | 74 | - | 2 |
| Flexural strength, MPa | 300 | 20152 | |
| Compressive strength, MPa | 2500 | 20382 | |
| Young's modulus, GPa | 330 | 20642 | |
| Toughness, MPa $m^{0.5}$ | 4.9 | 204 | 3 |
| Coeff. expansion, 20-1000°C, $10^{-6}K^{-1}$ | 7.5 | 30436 | |
| Specific heat, J $g^{-1}$ $K^{-1}$ | 0.85 | 30240 | |
| Thermal conductivity, W $m^{-1}$ $K^{-1}$ | 25 | 30142 | |
| Dielectric breakdown voltage grad. kV/mm | 20 | 61030 | 4 |
| Permittivity, 48-62 Hz | 9 | 606302 | 4 |
| Volume resistivity, 20 °C, Ω cm | $>10^{12}$ | 601221 | |
| Loss tangent, tan δ, 20 °C/1 MHz | 0.0003 | 609423 | |
| Loss tangent, tan δ, 20 °C/1 GHz | 0.0008 | 609424 | |
| Colour | white | - | 5 |

| No. | Comments/queries about the use of the scheme |
|---|---|
| 1 | Processing methods presumed, but not specified in brochure |
| 2 | Cannot specifically code Rockwell hardness |
| 3 | Toughness value cited, but cannot be coded at this time |
| 4 | Temperature not specified, so coded 0, but presumably room temperature |
| 5 | No method of coding colour |

**Example 2:**

| | | | | | |
|---|---|---|---|---|---|
| Reference no.: | | Classified by: (name) | | | R Wäsche |
| Material source: (manufacturer) | Feodor Burgmann | Co. | 049 | Prod. Code. | BUKA 20 |
| Stated material type (words): | Silicon infiltrated silicon carbide | | | | |

| A: Cited applications | VAMAS code | Comment no. |
|---|---|---|
| Mechanical seal | A371 | |

| F: Cited overall Form | VAMAS code | Comment no. |
|---|---|---|
| Monolithic object | CKB | |

| C: Cited chemistry | VAMAS code, long form | VAMAS code, short form | Comment no. |
|---|---|---|---|
| Main component: | | | |
| Silicon carbide (86-92%) | 02087 | 6285 | Option 1 |
| Minor components: | | | |
| Silicon (8-14%) | 00082 or 00083 | | 1 |

| P: Cited/judged processing routes | VAMAS code | Comment no. |
|---|---|---|
| Sintered | 31 | |
| Melt infiltrated | - | 2 |

| D: Cited property data: | Value: | VAMAS code | Comment no. |
|---|---|---|---|
| Density, Mg $m^{-3}$ | 3.05-3.11 | - | 3 |
| Compressive strength, MPa | 1500-2750 | 2037 | 4 |
| Bend strength, MPa | 280-350 | 2015 | |
| Elastic modulus, GPa | 360-390 | 2064 | |
| Hardness, HV | 1800-3000 | 2053 | 4 |
| CTE, $10^{-6}$ $K^{-1}$ | 3.2-4.5 | 3042 | 4 |
| Thermal conductivity, W $m^{-1}$ $K^{-1}$ | 110-120 | 3016 | |
| Corrosion resistance, operation at pH < 11, at 20 °C | - | 802 | 5 |

| No. | Comments/queries about the use of the scheme |
|---|---|
| 1 | Two codes are possible because of range of Si content. |
| 2 | Melt infiltration is not in the processing code list. |
| 3 | Absolute density cannot be coded, only fractional density. |
| 4 | Other codes could be chosen owing to range of data; lower value used. |
| 5 | Code for acid corrosion resistance used, implied by being inappropriate for strong alkalis. |

**Example 3:**

| | | | | | |
|---|---|---|---|---|---|
| Reference no.: | 28 | Classified by: (name) | | | R Morrell |
| Material source: (manufacturer) | Dow Chemical Co. | Co. | 001 | Prod. Code. | XUS-35544 |
| Stated material type (words): | Developmental aluminium nitride powder | | | | |

| A: Cited applications | VAMAS code | Comment no. |
|---|---|---|
| Ceramic manufacture | - | 1 |

| F: Cited overall Form | VAMAS code | Comment no. |
|---|---|---|
| Powder without binder | CEE | |

| C: Cited chemistry | VAMAS code, long form | VAMAS code, short form | Comment no. |
|---|---|---|---|
| Main component: | | | |
| AlN (99%) | 03077 (option 1)<br>0307(99)<br>(option 2) | 5025 | 2 |
| Minor components: | Option 2: | | |
| O, 1% | ME0000(1) | | 3 |
| C, 0.06% | ME0004(0.06) | | |
| Ca, 150 ppm | ME0016(0.00015) | | 4 |
| Si, 60 ppm | ME0008(0.00006) | | 4 |
| Fe, 20 ppm | ME0031(0.00002) | | 4 |
| Cr, 10 ppm | ME0026(0.00001) | | 4 |

| P: Cited/judged processing routes | VAMAS code | Comment no. |
|---|---|---|
| Non specified | | |

| D: Cited property data: | Value: | VAMAS code | Comment no. |
|---|---|---|---|
| Surface area, $m^2 g^{-1}$ | 3.2 | D1053 | |
| Mean particle size, µm | 1.4 | D1044 | |
| Tap density, 3000 taps, g $cm^3$ | 0.74 | D1064 | |

| No. | Comments/queries about the use of the scheme |
|---|---|
| 1 | No codes for application of powders. |
| 2 | The level set for an electronic material is 200 ppm impurities, which may be the case for a solid material, but is probably unrealistic for a powder intended for this end use as a ceramic. Suggesting a single code for AlN. |
| 3 | No code for oxygen specified alone; "other" code used. |
| 4 | This appears clumsy for levels of ppm. Could shorten code by using "p" or similar before the figure in brackets. |

## Annex 2 - Issues arising in Applications coding

| Potential issues: | Potential solutions: |
|---|---|
| There is a need for a general heading code for each Application group so that general non-specific application areas, e.g. electrical insulators can be assigned to a material. | Define Group codes 100, 200 etc to perform this function. |
| There needs to be rule on how to deal with the situation when two or more codes can be used for a product description. | Since more than one application code can be cited, there is a problem only if there is genuine ambiguity in the codes for a single product. This should not arise frequently. A rule could be to use the code under the general heading which is most appropriate to its sphere of use, e.g. if it is a valve, but used biomedically, then it should be coded under biomedical. |
| No code for "hydrophones". | Add code? |
| No code for "ferrule", protective tubes for metallic components in process plant, e.g. molten metal handling. | Add code? |
| No code for sputtering targets (e.g. silicon nitride, YBCO, etc.) | Add code? |
| No code for "plasma torch nozzle". | Add code, or generalise code for welding nozzles? |
| Need codes for "thermostat bases and assemblies" and "cartridge heater element and brushes" | Is this too specific, or does the market justify these? |
| Several codes are available for cutting tools. Which one should one use if the application of the cutting tool is not adequately specified? A code is also needed for machine tools as distinct from cutting tools. | Consider reducing the number of codes for cutting tools to one, and inserting machine tools. |
| If application reads (non-specific) "electrical insulators", what code does one use, "other"? Similarly "wear-resisting applications" or "wear parts". Need a rule on dealing with such generality. | Instruction to use "other" where application is non-specific. |
| No code for forming rolls. | List under "other material shaping applications" |
| There is a code for mill linings, but not for complete mills. | Expand function of the code to include both. |

| **Potential issues:** | **Potential solutions:** |
|---|---|
| Sintered fused silica is claimed to be used in various forming operations not coded:<br>1. Tweels, seal blocks, jambs, bricks in float-glass manufacture;<br>2. Hot-press platens for Ti sheet forming;<br>3. Transfer rollers in printing. | 1. "Other material-shaping applications"?<br>2. "Dies for hot precesses"?<br>3. "Other thread/paper or tape guide applications"? |
| No code for a polycrystalline alumina "dental bracket". | Code 862 for "dental implants" is inappropriate for something which may not be implanted. |
| No code for (non-specific) metal/ceramic assemblies. | List them as "other insulators", or give a code? |
| Do powders have "applications"? If so, they are missing from the Table. Examples include magnetic media, boron nitride loaded tape and coatings, furnace beds, grinding or polishing grits, etc. It would be desirable to separate the target functions of powders from the possible end ceramic components. | Many applications for advanced ceramic powders are in the manufacture of advanced ceramics themselves, but there is a large and growing market where to powder form is used in non-ceramic products. It would be logical from the manufacturers' point of view to see a target application for a given powder product. |
| No code for ceramic gear wheels, e.g. for geared pumps | Add code under mechanical applications? |
| No code for guides for metallic wires, which is different from thread or yarn guides | Add code under mechanical applications? |
| Applications of hot injection mouldings of "micatherm" type material, perhaps with moulded in metal parts, are difficult to identify positively from the list for insulating ceramic A100-199. Additional codes will be needed. | Review specific uses and the requirements for codes. |
| **Japanese comments:** | **Project comments:** |
| No code for thermionic emitting cathodes | Code 219, other ohmic conductors? |
| Evaporation boats for metals: it is not clear where this should be coded:<br>A529: other liquid metal handling, or<br>A801: crucibles and boats for laboratory use | Agreed, additional code needed for evaporation boats? |
| Where does a filler for conductive plastic fit? Similarly for other fillers, e.g. electronic packaging. | It does not, need to consider "Applications" for powders (see above). |
| No code for luminescent/fluorescent articles, or for luminescent/fluorescent powders used as fillers in plastics. | Agreed. Another application for powders. |

| Potential issues: | Potential solutions: |
| --- | --- |
| Wafer for phosphorus diffusion processing in semiconductor industry - no specific code. | 513 - kiln furniture, but this would include it with batts and saggers. There could be a case for a more specialised breakdown of furnacing furniture |
| No code for sputtering targets | Agreed, see above |
| No codes for biomedical other than implants; examples found include: supports for antibacterial water processing, cosmetics (ceramic powders); medicines (slow release drugs); food additives. | Agreed, further consideration needed for applications of powders |
| No code for jewellery or other household goods, e.g. watch cases. | Agreed, it may be appropriate to code these specifically. |
| No code for semiconducting tweezers ($Al_2O_3$ + TiN) for handling IC tips. | Code 219 - other ohmic electrical conducting, or code in its own right? |
| Use as a "reference powder" not defined. | Applications for powders again. |

## Annex 3 - Issues arising in Form/Chemistry coding

| Potential issues: | Potential solutions: |
| --- | --- |
| Single ceramic sheets or tapes in the green or fired state are not covered. Code KM refers to a multilayer composite, i.e. a finished form, rather than an intermediate unfired form. | Add code. |
| A multilayer glass-ceramic poses a problem because KZ is a glass-ceramic and KM is a multilayer. It is not clear which to choose. | The fundamental question that needs to be asked is whether a glass-ceramic is a "Form". It is better described as a process. In this case, the form is strictly a multilayer whatever the material, while the glass-ceramic code KZ could be dropped completely as a Form code. If the multilayer code KM (or any other form code) is followed by a short-form chemistry code, a specific glass-ceramic code could be chosen. If the Form code is followed by a long-form chemistry code then one would have to rely on a processing code to identify that a glass-ceramic process had been used. This is not a perfect solution. |
| There is no code for a ceramic with moulded-in metal parts (e.g. glass-ceramic/metal units (vacuum interrupters) or "micatherm" type products). KZ for glass-ceramics in not adequate. | Consideration needs to be given to coding ceramic products with metalwork already attached. There must be discussion as to whether this falls strictly inside or outside the classification from the potential users' point of view. |
| There is no method of coding products which include dispersions of ceramics in other materials, e.g. powders, fibres or rods in polymer matrices, particulates or whiskers in metallic matrices, etc. Ceramic manufacturers are making such products, piezoelectrics being a case in point in which ceramic rods are aligned in a polymer to achieve high performance. | This issue needs to be addressed by expanding the code structure beyond those simply for CMCs. |
| In the long-form code, compositions may be quoted in ppm of minor species, while the long-form code only allows percentages (or percentage ranges in the CEN ENV). | Possible solutions are:<br>1. Ignore impurities as being an unnecessarily complicating factor in the use of the code.<br>2. Allow extension of figures in brackets to ppm by adding a further code letter. |
| There is no code for oxygen alone, which is sometimes quoted for powders, e.g. AlN | A code for oxygen could be added, although the numbering system makes this very awkward. It might be better to assume that the oxygen is combined with the major metallic species present (as is normally chemically the case). |

| Potential issues: | Potential solutions: |
|---|---|
| Increasingly, metal alloys are incorporated into ceramics, e.g. as aluminides, rather than just pure metals, while the long-form coding system permits only pure metals to be identified. | The long-form code permits the construction of a minor-phase alloy from its elemental metals by use of the ME separator between the species. If the short-form coding is to be used, such products must be listed as composites, or "other" until a definitive market product is requires a specific code. |
| Alumina powders can only be treated in the same way as dense materials in the short-form coding, whereas the descriptions give the impression that we are dealing only with solid materials. | Set aside codes 5001 to 5009 for the exclusive use of powders independent of classifications in IEC. |
| There is ambiguity in the selection of the short-form code for an aluminous porcelain, either 5070 (alumina with < 80% $Al_2O_3$) or 5330 (siliceous alkali porcelain, high strength). | This product should strictly be classified according to its IEC 672 category. There needs to be improved cross-reference to this standard. |
| There is a practical lack of ability to code aluminium titanates:<br>5350 is for stoichiometric materials;<br>5351 for stabilized materials<br>5355 is for "other".<br>Usually the type of material is not clearly specified. | It is suspected that, mostly, commercial aluminium titanates contain stabilizers, but this is not explicitly stated. On the other hand, stoichiometric materials may exist, especially as powders. A wording change is needed to make it clear that 5350 is for the basic chemical form of aluminium titanate. 5351 is for a compounded stabilized ceramic body or raw material mixture. 5355 is for any other material which is based on aluminium titanate, but contains other phases. |
| In the short-form code for AlN (5200), is 200 ppm total impurity too low for marketed electronic grades? Similarly, which code would one use if purity were not stated? | Modify to 500 ppm? Alternatively, remove the distinction? |
| For BeO, distinction between short-form codes 5450 and 5451 is unclear without specified composition or stating a thermal conductivity boundary. | Add a thermal conductivity line - e.g. from ASTM or BS4789. |
| No code for "alkalis" as a group impurity. | Ignore? |
| Short-form codes for porous aluminas and aluminosilicates are not given in same way as for dense materials. | Add more codes for porous products. Include links to IEC672 Group C 500 |

| Potential issues: | Potential solutions: |
|---|---|
| If a composition includes "other", which might be undisclosed binders or sintering aids, e.g. phosphate cements, how should this be coded. | Could use last line in long-form single species table, e.g. 400 = "other oxides", but one does not generally know whether the species is an oxide if it is only called other! Alternatively, include a code for "unknown other", as opposed to "known but not listed other"? |
| No explicit short-form code for alumina/silicon carbide materials. | Add a code if considered an "advanced" ceramic. |
| No code for explicitly silicon oxynitride bonded silicon carbide. | Add code 6301. |
| Cannot distinguish between alpha- and beta-derived SiC ceramics if not explicitly stated. | Since in the sintered state there may be no discernible or declared difference, delete beta silicon carbide ceramics (code 6270), and delete "alpha" from codes 6260-6262. |
| The coding assumes that a sintered silicon nitride is specified as containing additives, which is usually the case, but they are not usually mentioned. | Change wording associated with the code to permit its use for any SSN whether or not additives are mentioned. |
| If a product is called TZP, but is not specifically $Y_2O_3$-TZP, which code should be used? This problem also occurs for other types of zirconia. | The present coding give 6645 for $Y_2O_3$-TZP, 6650 for $CeO_2$-TZP. Is it usually safe to assume that commercially TZP is always $Y_2O_3$-TZP? For other types of zirconia, no assumptions can be made because of the wide range of possible stabilizers known and the fact that mixed stabilizers are becoming common. A review of the code wording is required to distinguish unspecified from specified stabilizer content and condition. |
| Various codes for boron carbide are too specific when the product is just called boron carbide - cannot decide between codes. | Need to clarify which are powders/grits, and which are dense ceramics. Either include a code for unspecified dense materials, or do not distinguish dense materials on basis of additives. |
| The short-form coding for BN does not allow for products other than hot-pressed or pyrolytic ceramic versions, plus various composites, but products such as BN powder or plasticized tape are commercially available. | A separate code for boron nitride (unspecified form) needs to be added. |
| No short-form code for $TiB_2$! | Code required! |

| Potential issues: | Potential solutions: |
|---|---|
| There is an inconsistency of approach to coding short-form species in which, for example, the following are allowed:<br>"5750 Lanthanum based materials"<br>"5650 Erbium based materials"<br>but not:<br>"Gallium based materials";<br>"Germanium based materials".<br>Only the oxides are explicitly given.<br>(Source T. Coyle) | Either edit:<br>"Gallium oxide" to "gallium"<br>"Germanium oxide" to "germanium"<br>or<br>add new code structure:<br>5680 "Gallium based materials"<br>5681 "Gallium oxide based materials", etc.<br>The former is probably sufficient for commercial purposes. |
| **Japanese comments:** | **Project comments:** |
| Difficult to classify honeycomb body to KE, KF or KG. | A honeycomb should be KF - 2D cellular structure, but description is misleading. It would be better to describe it as:<br>KF = 2D (e.g. honeycomb) cellular ceramic. |
| In honeycombs, the cell geometry cannot be specified. | It is considered that this is outside the intention of the scheme - is this a specification? |
| Difficult to document minor, but important impurities in the long-form code. | True - see comment above about ppm. |
| For a solid material, both KB and S (single crystal) may apply. | Use KB if polycrystalline, S for single crystal. Need to add explanation to KB that it is intended for *polycrystalline* materials. |

## Annex 4 - Issues arising in Processing coding

Note: Although processing codes do not explicitly appear in the CEN ENV version following concerns over their commercial misuse in specifications, they do appear in the ASTM and ISO TTA1 (VAMAS Report) versions. Processing issues have therefore been examined also in this present work.

| Potential issues: | Potential solutions |
|---|---|
| The processing method seldom given explicitly in brochures, e.g. the statement may just say "boron carbide", while there is a 99% chance that it is hot-pressed. Since the non-expert would have difficulty in selecting the correct code, what should be assumed and what not in coding up the data sheets for the demonstrator? | Possibilities are:<br>1. Rigid factual line: If not given, none can be stated. Reliance is then placed on appropriate short-form chemistry coding.<br>2. Intelligent line for VAMAS Demonstrator purposes: make intelligent guess that an alumina has been sintered or a boron carbide has been hot-pressed unless specifically stated otherwise. This would avoid missing materials if searched by processing method.<br>This emphasises one of the problems of limited information being available on ceramic products for commercial competitive reasons. It also suggests that the use of processing codes might be restricted to in-house specialist use or to data-base use, rather than trade statistical purposes. |
| Low pressure injection moulding is becoming more common. A code is needed. | New code. |
| Liquid phase sintering is not specifically identified, e.g. for SiC, or is this liquid phase reaction bonding. | The scheme is not specific in this regard. There are some difficulties in defining how much the SiC particles are bonded by Si, and how much by growth of SiC from reaction between Si and C. This depends on the formulation and method of processing. If specified, there is the choice of "reaction bonding" or "sintering" if either is described, and it is recommended that no attempt is made to go into further detail. There would otherwise always be uncertainties as to which products were liquid phase sintered when only minor impurities are present. |
| There is no clear difference between codes 29 and 30. | Clarify by changes of wording. |
| For components which must have been extruded, but not explicitly stated as such, there is no clear difference between codes 25 and 26. | Clarify wording. |

| Potential issues: | Potential solutions |
|---|---|
| There is no code for "adhesively bonded". | Add code. |
| There is no coded for "drilled". | Add code. |
| There is no code for "glazed". | Add code. |
| There is no code for "glass-bonded". | Add code. |
| There is no code for "thermal diffusion bonded". | Add code. |
| **Japanese comments:** | **Project Comments:** |
| Can the sintering temperature be added to the fact that it has been sintered. | Outside scope of scheme? Alternatively, add extra digit to indicate temperature of the process as in the Data coding method? |
| The kneading process (e.g. for porcelain) is not given. | True, new code needed. |
| Drying processes and dewaxing processes cannot be defined. | True, only freeze drying is given. Further codes needed? |
| Glazing processes (e.g. for porcelain) cannot be defined. | True; a new code is needed, unless it is accepted that it is an "other coating process" |
| No unique code for single crystal drawing, e.g. Czochralski growth, P55? | Use P55, melt forming or new code? |
| No code for fiber preparation by spinning from salt solutions. | Use other codes, vapour forming, sol/gel forming, melt forming as appropriate, but this makes it hard for an inexperienced person to make the coding. Perhaps we need more examples of the form (e.g. .....) |
| The process of integrating green parts together, e.g. turbo-rotor construction, cannot be displayed. | This could go under green machining by changing it to green-state processing. |
| Molten-mass spraying for the formation of granular fused silica cannot be cited. | This could be included under melt-forming (P55), but is not really appropriate, since this is intended to refer to crystal growth or glass/glass-ceramic shaping. It is not plasma/flame spraying (P43). |
| No code for fibre weaving. | Add new code? |

## Annex 5 - Issues arising in Data coding

| Potential issues | Potential solutions |
|---|---|
| In some cases, the property data are given as typical, in others as a range. In cases where the range stated covers more than one coding range, which coding range should be chosen. | A rule is needed, for example by taking the average value and choosing the code according to that value. Alternatively, the rule could be to take the least desirable value (lowest in most cases, except dielectric loss or resistivity). |
| "Maximum use temperature", either in inert conditions or air, sometimes with "short-term" or "long-term" appended, is not given in the classification, yet is often quoted in brochures. | This is difficult to define in a meaningful and consistent manner. However, pragmatically could be a useful inclusion. |
| No code for characteristics of oxidation resistance. | Coding for oxidation resistance is problematical - its a response rather than a property. While temperature could be given using the temperature code, a further two elements would be needed to indicate temperature of exposure and mass gain (the most commonly quoted value) or another parameter. |
| Density is given only as % theoretical. In principle this places all densities on the same basis, but it is seldom given in brochures or readily available. In contrast, actual density is given for most materials. | Change code to true density? The drawback is that it would not be possible to express the extent of achievement in densification. Alternatively, keep both codes? |
| The code for porosity is intended to be for open porosity. There is no code for deliberate or significant closed porosity. | Consider an additional code. |
| Open porosity is sometimes termed "water absorption". Should the same coding be used. | Add a footnote. |
| In flexural strength testing, data are variously given as three-point or four-point bending, resulting in different values. Should there be a way of coding the test method? | Possibly there should. |
| No code for Weibull modulus. | Ignore as being subjective and irrelevant to most situations? |
| There are no codes for hardness other for HV1. This is too restrictive, since a large range of other measures of hardness are used. | Need some form of subcoding for method and load in HK, HV, and HR45N, possibly even in HU. This requires a new approach to the coding, and would depart from the methodology in place. |
| Instances have been found where ceramics have been tested by HRA, Brinell and Mohs hardness, all of which are outside the scope of the classification. | These are outside presently envisaged standard test methodologies (e.g. ENV 843-3). |

| **Potential issues** | **Potential solutions** |
|---|---|
| Thermal shock resistance usually has no method ascribed in brochures. | If the product is for applications requiring thermal shock resistance, the short code could be used. More guidance on effective use of codes seems to be needed. |
| In thermal shock resistance, there is only the simple water quench test method, which correlates broadly with the Hasselman parameter R (for infinite rate of heat transfer). Other parameters are being cited for structural materials, including R′ and R″. Should these be codable. | Discussion point. This may be too complex for a general classification. |
| No code for thermal diffusivity. | Add code line. |
| No code for emissivity. | Add code line? |
| No code for shear modulus. | Add code line. |
| No code for sintering temperature (of powders). | Add code line? |
| No code methods for detailed resistance to corroding media. | Difficult to achieve in present code structure. Questionable as to whether it is necessary for classification purposes. |
| No codes for nuclear properties, e.g. capture cross-section. | Outside scope of scheme, or possibly code the material as having controlled properties for nuclear purposes (implying compositional aspects are carefully controlled to minimise capture cross-section, or to enhance moderating properties). |
| No code for temperature coefficient of resonant frequency (ppm/K). | Outside scope of classification? |
| No code for impact resistance. | No standardised tests for ceramics and difficult to quantify. |
| No code for mechanical spalling resistance of ceramic balls (ball bearings, valves, etc.) | Difficult to quantify and outside scope of classification? More an issue of specification? |

| **Potential issues** | **Potential solutions** |
| --- | --- |
| There are no codes for the following less frequently quoted parameters:<br><br>- pore diameter, μm<br>- powder distribution characteristics (sieve sizes, $d_{10}$, $d_{90}$ data)<br>- pressure drop/specific flow rate in filters<br>- thermal up-shock resistance, K<br>- Te value, °C<br>- shear modulus, GPa<br>- dissipation factor, %<br>- various parameters associated with performance of piezoelectrics<br>- Curie temperature, °C<br>- acoustic impedance<br>- maximum reverse field, V $mm^{-1}$<br>- rated voltage, $V_o$, of device<br>- capacitance range, nF<br>- ageing rate, % / yr | There may be a need to expand the scheme to encompass some of these, principally for component performance characteristics and specialist data banking purposes. |
| For materials with significant structural anisotropy there is no method of coding directional properties. This applies for example to:<br>i) hot-pressed or pyrolytic boron nitride<br>ii) most fibre composites<br>Typically a single value is codable - which should this be? Is it desirable to be able to code anisotropy. | In some cases, e.g. 1D fibre composite, tensile strength would normally be implied to be parallel to the reinforcement. In hot-pressed ceramics, it is certainly not clear. Again, there needs to be a rule to take the lower value, or a mean value, or alternatively there needs to be coding method consistent with the scheme which allows annotation of orientation. |
| Long-fibre materials are often characterized by elongation to failure. Should this be codable. | Add code. |
| Ionically conducting materials employed for fuel cell construction and other applications need to be coded specifically, not generally on this property, and on its related activation energy. | Consideration needed of this point. |
| Colour is often cited by manufacturers, and may be technically important, e.g. in electronics or thread guides, but is not given in the coding system. | Difficult to know how best to code colours. White, black, metallic, yellow and "other" could be a possible sufficiency, where other might be any colour not specifically listed. |
| Use of alternative descriptions for properties (e.g. dielectric properties) could make it difficult for the non-expert. | Include an index of property synonyms? |
| It is possible to confuse the qualifiers *m* (temperature) and *n* (frequency) in table D2 in coding suppliers information. | The coding instruction that temperature must be used when coding frequency for electrical properties is clearly stated. |

| Potential issues | Potential solutions |
|---|---|
| **Japanese comments:** | **Project comments:** |
| Features associated with performance of ceramic honeycombs cannot explicitly be given, e.g. structural anisotropy, pore size, pressure drop, etc. | Outside scope of real intention of scheme? |
| Performance of ceramic shape as an insulator cannot be displayed, only characteristics of material. | Outside scope of scheme's intention? |
| No code for shape of powder particles. | True, but a difficult problem! There could be a code line which lists powder as being:<br>spherical<br>angular equiaxed<br>acicular<br>platelets, etc.<br>but the Form code should take care of that? |
| For a substrate for printed circuit with metallized contacts, issues related to properties of the surface and strength of the joint cannot be specified, also issues like dielectric breakdown. | Comment refers to performance as a component - outside scope of the scheme? |
| For powders used as fillers for plastics, how do we specify wettability, roughness, activity, etc. | Solution unclear? |
| No code for fluorescence/luminescence as functional parameter. | Agreed - additional code? |
| For a sputtering target, which properties should be shown, those of the target or those of the product coating? | Definitely those of the target that are relevant. |
| For a Fe-Mn-Zn ferrite the Curie temperature and magnetic saturation cannot be given. | New codes needed? |
| Weibull modulus cannot be displayed. | See comment above on subjectivity. |
| Anti-oxidation characteristics cannot be displayed. | Agreed, but see comment above |
| Varistor characteristics cannot be displayed. Similarly, anti-lightning performance cannot be displayed. | Code 602 indicates product has non-linear characteristics. More detailed description outside scope of coding? Lightning conduction is component performance aspect and outside scope? |
| No code for vapour pressure or diffusion coefficients in components for semiconductor processing. | Too detailed for "classification"? |

Distribution:

Unlimited