Role of Ceramics in a
Self-sustaining Environment
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STANDARDIZATION IN CERAMICS

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In response to a proposal of "Early-Stage Standardization" by the ISO/IEC Presidents' Advisory Board on Technological Trends; the Technical Committee ISO/TC 206 on Fine Ceramics was established in 1992. The scope of ISO/TC 206 is a standardization in the field of fine ceramic materials and products in all forms: powders, monoliths, coatings and composites, intended for specific functional applications including mechanical, thermal, chemical, electrical, magnetic, optical and combinations thereof. The term "fine ceramics" is defined as „a highly engineered, high performance, predominantly nonmetallic, inorganic material having specific functional attributes". A summary overview is given of membership, organization structure, work program and future work of ISO/TC 206.

1. Introduction

The term *"Fine Ceramics"* is the same as ***"Advanced Ceramics"*** or ***"Advanced Technical Ceramics"***, and is defined as "***a highly engineered, high performance, predominantly nonmetallic, inorganic material having specific functional attributes***" (1). This definition describes a diverse range of materials and product classes usually distinguished by their primary physical application, e.g. mechanical, thermal, electrical, etc. In Table 1, the classification list for applications of fine ceramics is given together with typical products (1), (2). The unified classification system has been originally developed in the Versailles Project on Advanced Materials and Standards (VAMAS), Technical Working Area (TWA) 14 (1) and the achievements were published as the ISO/TTA 1 in 1994 (2).

2. Current trends and future expectation of market size of fine ceramics industry

Fine ceramic materials have been put to practical use in various industrial and consumer products such as electronic, structural, thermal, optical and medical devices and systems. According to reports of "Annual Giants in Ceramics" by the Ceramic Industry (3), fine ceramics sales are on a growth trend, reaching $ 20.2 billion in 1994, or about 25% of the total ceramic industry sales. As shown in Table 2, the highest percentage of overall fine ceramics sales in 1994 was in the category of ***engineering ceramics*** (32%), which includes structural components such as wear parts, cutting tools and heat engine components. Percent of sales for the category of ***electrical and electronic ceramics*** including capacitors, substrates and packages was more than 40%. Recently, ***bioceramics*** including artificial bones, dental roots and crowns have appeared as a new category of fine ceramics products.

Table 1 Applications of Fine Ceramic Materials and Components (1), (2)

Classification of application types	Typical products
Passive electrical application	
Power insulators	Spark-plug, Igniter, Glow-plug
Insulators for electronics	Substrates, Heat sinks
Microwave insulators	Windows, Phase shifters
Active electrical applications	
Ohmic electrical conductors	Heating element, Electrodes
Ionic conductors	Gas detectors, Oxygen sensors
Capacitor applications	Multilayer chip capacitors
Non-ohmic electrical conductors	Varistors, Thermistors
Piezoelectric applications	Force and pressure transducers
Mechanical applications	
Milling and crushing machinery	Mill linings, Milling media
Agricultural applications	Pulverizing nozzles
Wear-resistant facings for plant and machinery	Mould and die liners, Nozzles
Ballistic applications	Ballistic armour, projectiles
Material-cutting applications	Paper-cutting, Domestic knives
Material-shaping applications	Extrusion and drawing dies
Pump applications	Vanes and impellers, Shafts
Valve and tap (faucet) applications	Tap valves for water
Guides for thread, paper, tape, etc.	Thread-spinning nozzles
Bearing applications	Precision balls for bearings
Precision jigs and metrological devices	Sizing rings, Gauge blocks
Sports goods	Fishing-rod ring liners
Thermal and thermomechanical applications	
Temperature-resistant electrical applications	Thermocouple insulators
High-temperature materials processing applications	Muffle tubes for furnaces
Aerospace applications	Rocket nozzles
Domestic applications	Cooker tops, Cookware
Reciprocating engine applications	Turbocharger rotors
Applications in turbine engines	Rotors, blades and stators
Nuclear applications	Nuclear fuel elements
Optical applications	
Reflective applications	Telescope mirrors
Non-optical structural components for optical systems	Ferrules for fibre optics
Laser components	Laser waveguides, rods
Optical window applications	Optical & infrared wavelengths
Lamp envelopes	High-power lamp envelopes
Active optical components	Optical modulators
Chemical and biomedical applications	
Laboratory chemical equipment	Crucibles and boats, Funnels
Chemical plant applications	Vessels and pipes, Ball valves
Chemical moulding parts	Rubber dipping formers
Filter bodies and materials	Ceramic filter membranes
Catalysts and catalyst supports	Catalysts, Catalyst supports
Biomedical applications	Dental implants
Magnetic applications	Components for transducers
Other applications	

Table 2 Current Trends of Industry Sales in Ceramics and Advanced (Fine) Ceramics (3)

Years	1990	1991	1992	1993	1994
Total sales of ceramics (billion $)	**73.3**	**82.3**	**88.1**	**90.4**	**82.4**
Distribution of Industry Sales			(%)		
Glass	56	54	55	53	60
Advanced ceramics	**19**	**19**	**17**	**20**	**25**
Whiteware	8	10	10	9	7
Porcelain enamel	10	9	9	9	–
Refractories	7	7	7	6	6
Structural clay	–	1	2	2	2
Number of companies responded to the survey	438	400	400	396	240
Total advanced ceramics sales (billion $)	**13.6**	**15.3**	**14.8**	**18.3**	**20.2**
Distribution of Advanced Ceramics Sales			(%)		
Capacitors/substrates/packages	48	38	36	33	20
Other electrical/electronic ceramics	17	25	23	8	21
Electrical porcelain	12	10	12	3	5
Engineering ceramics	10	11	8	26	32
Optical fibers	9	13	8	4	–
Bioceramics	–	–	–	–	1
Others	4	4	13	26	21
Number of companies responded to the survey	145	132	117	112	80
References (3)	(a)	(b)	(c)	(d)	(e)

It is noted that the sales figures in Table 2 are based on the responses of those participating in the survey of Ceramic Industry. Consequently, this survey does not reveal the total sales of the world-wide ceramic industries.
The Freedonia Group, Inc. analyzed global demand for advanced ceramic materials, application and regional market, and provided historical data and forecasts. World demand for advanced ceramics is projected to expand 7.2% annually to $25 billion in the year 2000 (4).
As shown in Table 3, world demand for advanced ceramics will be supported mainly by the US, Germany, and France and Japan. These countries have the required industries and infrastructure to provide a strong market for products made of advanced ceramics. In the year 2000, North America ceramics demand will account for close 40% of the total world advanced ceramics demand. West Europe advanced ceramics demand will be expected account for 10% of total world advanced ceramics demand in 2000. Demand in Asia and Oceania, dominated by Japan, will account for 50% of the world total market in the year 2000.

Table 3 World Demand for Advanced Ceramics by Region (4)

Item	billion US $/year			% Annual Growth	
	1985	1994	2000	94/85	00/94
Advanced Ceramics Demand	**5.831**	**16.754**	**25.370**	12.4	7.2
North America	2.145	6.225	9.930	12.6	8.1
Western Europe	0.797	1.687	2.580	8.7	7.3
Japan	2.675	8.070	11.580	13.1	6.2
Asia/Oceania Excluding Japan	0.144	0.608	1.000	17.4	8.6
Other Regions *	0.070	0.164	0.280	9.9	9.3

* Eastern Europe, Central & South America, Africa and the Mideast.
Source: The Freedonia Group, Inc.

Table 4 Advanced Ceramic Components Market in the U.S.A. (5)

U.S. market by segment	billion $/year (%) 1994	2000	AAGR* (%)
Structural ceramics	0.475 (9.7)	1.0 (11.7)	13.5
Electronic ceramics	3.9 (79.6)	6.6 (77.3)	9.3
Ceramic coatings	0.525 (10.7)	0.94 (11.0)	10.2
Total	4.9 (100)	8.5 (100)	–

* AAGR: Average annual growth rate. Source: Business Communications Inc.

According to the report of Business Communications Inc. (5), the U.S. advanced ceramic components market for 1994 is estimated to be $4.9 billion. This is expected to increase to $8.5 billion by 2000, reflecting a 9.8% average annual growth as given in Table 4. In terms of market share, electronic ceramics constitute 79% of the market in 1994. With the increased use of structural ceramics, the market share of the electronics ceramics will decrease to 77% by the year 2000. The report states that, in the last few years, the total number of U.S. advanced ceramic supplier companies, including foreign-owned U.S. companies, has increased. At the same time, more consolidation of efforts between companies is occurring due to the following factors:

1) the extraordinarily complex technical requirements
2) the level of sophistication necessary to manufacture advanced ceramics
3) the advantages of pooling technology, personnel and/or company facilities
4) the finite amount of business that can support these suppliers

Japan Fine Ceramics Association estimated the fine ceramic components market in Japan for 1994 to be $13.36 billion (1.3 trillion yen) (6). As given in Table 5, this is expected to increase to $28.2 billion by 2000 and to $40.6 billion by 2005 under the condition of 7.3% average annual growth rate. In this prediction, electromagnetic materials will possibly reduce the share from the majority to less than 50%. Each item of the materials will change its share considerably. Still they will remain as the core of the fine ceramic market. Optical and other materials will show the most high growth rates. Especially the super conducting materials are expected to grow, though the absolute amount is still small. Structural materials such as mechanical and thermal materials are late to show growth. Though they have grown in monetary terms, it will take some time for them to have a large share in the market. As to chemical/biomedical materials, they will not enlarge their share so much as a whole, though some items in this category will show rapid growth.

Unfortunately, comparison of industrial sales between the U.S. and Japan cannot be made since the segments of fine ceramic market are not coincide with each other. It is strongly expected to unify the terminology and classification of fine ceramics together with testing method of material properties of fine ceramics.

Table 5 Prediction of the Fine Ceramics Industrial Market in Japan (6)

Classification of Applications	billion $/year (%) 1994	2000	2005
Electromagnetic	9.32 (69.8)	14.06 (49.9)	19.35 (47.7)
Optical	0.72 (5.4)	2.89 (10.2)	5.40 (13.3)
Mechanical	2.45 (18.3)	5.24 (18.6)	7.41 (18.3)
Thermal/Nuclear	0.31 (2.3)	1.42 (5.0)	1.90 (4.7)
Chemical/Biomedical	0.54 (4.0)	1.76 (6.3)	2.36 (5.8)
Domestic/Miscellaneous	0.01 (0.1)	0.72 (2.6)	0.91 (2.2)
Others	0.01 (0.1)	2.12 (7.5)	3.29 (8.0)
Total	13.36 (100)	28.20 (100)	40.60 (100)

In order for the fine ceramics industry to further grow to contribute to the 21st century as a new materials industry, the following issues have to be overcome:

1) further promotion of research and development in terms of the material itself, development of new uses and application technologies;
2) research on manufacturing processes, and cost-reduction through corporate efforts;
3) establishment of testing and evaluation methods and standardization of the methods to prepare a basis for research and development, application and popularization; and
4) promoting international cooperation in the fields of research and development, and standardization.

3. Current standardization activities on fine ceramics

3.1 Standardization activities in Japan

As early as 1981, Japanese Industrial Standards Committee (JISC) published JIS R1601 "Testing method for flexural strength of high performance ceramics". In 1988, the Agency of Industrial Science and Technology (AIST) in Ministry of International Trade and Industry (MITI) set up the Special Committee for Standardizing New Materials within JISC. The Committee compiled "Recommendations for Promotion of Standardizing New Materials". A basic guideline for standardization has been set up for 219 separate items of fine ceramics which is supervised by the Japan Fine Ceramics Association (JFCA). Table 6 shows the Progress of Survey and Research on the Standardization of Fine Ceramics. The standards developed by JISC as of July 1996 are listed in Appendix 1.

3.2 Standardization activities in USA

ASTM Committee C-28 on Advanced Ceramics was organized in 1986. An advanced ceramic is defined as " a highly engineered, high performance, predominantly non-metallic, inorganic ceramic material having specific functional attributes". The ASTM Committee C-28 is originally organized into five subcommittees as shown in Table 7. Following the establishment of ISO/TC 206 on fine ceramics in 1992, the subcommittee C28.94 was recently organized to coordinate the tasks for ISO/TC 206 (7). A list of completed and draft standards as of July 1996 is given in Appendix 2 (8).

3.3 Standardization activities in Europe

British Standards Institution (BSI, UK) formed its "Engineering Ceramics Committee" in 1985. The Association Francaise de Normalisation (AFNOR, France) and the Deutsches Institut fur Normung (DIN, Germany) which are active with regard to fine (advanced) ceramics began independent action in the late 1980s. Taking into consideration of the 1992 Single European Market, the Commission of the European Communities mandated the establishment of Committee for European Normalization (CEN) standards for advanced technical ceramics in 1988, and CEN/TC 184 was established in 1989. The member bodies are composed of 18 countries as listed in Table 8. The working groups and their conveners are also listed in Table 8. The work programme of the first and second mandate is shown in Appendix 3 (9, 10, 11). In order to prevent publication of conflicting National Standards, "standstill" arrangements were introduced which require that once a project is acceptable into the CEN programme, work on a national project on the same subject must cease.

Table 6 Progress of Survey and Research on the Standardization of Fine Ceramics

Item	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92	'93	'94	'95	'96	'97	JIS
1. Terminology											●					R 1600-93
2. Classification System							- - -	- - -	- - -	- - -						VAMAS
3. Elastic Modulus (RT)				●									◆			R 1602-95
4. Elastic Modulus (HT)			=	=	○		●						◆			R 1605-95
5. Elastic Modulus of Composites														=	=	S/R
6. Internal Friction (tan δ)														=	=	S/R
7. Thermal Expansion Coefficient								=	=		○	●				R 1618-94
8. Thermal Conductivity					=	=	=	○	●							R 1611-91
9. Specific Heat Capacity					=	=	=	○	●							R 1611-91
10. Flexural Strength (RT)													◆			R 1601-95
11. Flexural Strength (HT)	=	=	=	○	●							◆				R 1604-94
12. Tensile Strength (RT & HT)		=	=	=	=	○		●					◆			R 1606-95
13. Compressive Strength					=	=	○	●								R 1608-90
14. Shear Strength of Composites													=	=	=	S/R
15. Fracture Toughness (RT)		=	=	=	=	○	●						◆			R 1607-95
16. Fracture Toughness (HT)							=	=	○			●				R 1617-94
17. Creep (Flexural)					=	=	=	=	○		●					R 1612-93
18. Creep (Tensile)											=	=	=			S/R
19. Cyclic Fatigue							=	=	=	=	○		●			R 1621-95
20. Static Fatigue											=	=	=			S/R
21. Thermal Shock Resistance								=	=	○	●					R 1615-93
22. Joining Strength (Flexural)								=	=	=		○	●			R 1624-95
23. Joining Strength (Tensile)											=	=	○			Draft
24. Statistical Analysis of Strength										=	=	○		●		R 1625-96
25. Hardness (RT)						=	=	○	●							R 1610-91
26. Hardness (HT)										=	=	○	●			R 1623-95
27. Wear Resistance					=	=	=	=	○		●					R 1613-93
28. Oxidation Resistance				=	=	=	○	●								R 1609-90
29. Corrosion (Solution)					=	=	=	=	○		●					R 1614-93
30. Chem. Analysis, Si_3N_4					●							◆				R 1603-94
31. Chem. Analysis, SiC											○	●				R 1616-94
32. Sample Preparation for Particle Size Analysis										=	=	○	●			R 1622-95
33. Particle Size Distribution (Photosedimentation Method)							=	=	=	=	=	○	●			R 1619-95
34. Particle Size Distribution (Laser Diffraction Method)										=	=	=	○			Draft
35. Density of Particle								=	=	=	○		●			R 1620-95
36. Bulk Density of Powders											=	=	○			Draft
37. Specific Surface Area									=	=	=	○		●		R 1626-96
38. Granule Properties												=	=	=		S/R
39. Slurry Properties (ζ-Potential)												=	=	=		S/R
40. Slurry Properties (Viscosity)														=	=	S/R
41. Sample Preparation for SEM												=	=			S/R
42. Phase Composition													=	=		S/R
43. Density and Porosity												=	=			S/R
44. Dielectric Properties at Microwave									=	=		○		●		R 1627-96
45. Dielectric Properties of Substrates at Microwave													=	=	=	S/R
46. Thermoelectric Properties														=	=	S/R
47. Pyroelectric Properties														=	=	S/R
48. Optical Properties (Transmittance)											=	=	=			S/R

=====: Survey & Research ○: Draft ●: Establishment ◆: Revision

Table 7 ASTM Committee C-28 Advanced Ceramics (Organized in 1986) (7), (8)

Chairman:	George Quinn (NIST)	
Vice Chairman:	Michael Foley (St.Gobain/Norton)	
Recording Secretary:	Terry Richardson (Allied-Signal)	
Membership Secretary:	Curtis Johnson (General Electric)	
Staff Manager:	Gloria Collins (ASTM)	
Title:	Advanced Ceramics	
Scope:	The promotion of knowledge, stimulation of research and the development of standards (classifications, specifications, nomenclature, test methods, guides, and practices) relating to processing, properties, characterization, and performance of advanced ceramic materials. This committee will work in concert with other ASTM technical committees and other national and international organizations having mutual or related interests.	
Organization		
C28.01	Properties and performance (Mechanical testing, monolithic ceramics)	- C.Brinkman (ORNL)
C28.02	Design and evaluation (NDE, statistical analysis, design)	- R.McClung (ORNL)
C28.05	Characterization and processing (Characterization, particle size)	- R.MaCauley (Rutgers)
C28.07	Ceramic composites (Mechanical testing)	- D.Cranmer (NIST) M.Jenkins (Univ. Washington)
C28.91	Nomenclature (Glossary of terms)	- D.Leigh (Clemson Univ.)
C28.94	U.S. TAG ISO/TC206 (ISO/TC 206 Coordination)	- R.Spriggs (Alfred Univ.) E.Anderson (Alcoa)

Table 8 CEN/TC 184 Advanced Technical Ceramics (Creation: 1989) (9, 10)

Secretariat:	BSI (UK)
Chairman:	Dr.Barry Newland (Morgan Materials Technology Ltd., UK)
Secretary:	Mr.Ashok A.Ganesh (BSI Standards, Chiswick, London, UK)
Member Body:	Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxenburg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom (18 Countries)
Title:	Advanced Technical Ceramics
Scope:	Standardization in the field of advanced technical ceramics with specific tasks being classification, terminology, sampling and methods of tests. The methods of tests are to include physical, chemical, mechanical, thermal and textural properties for ceramic powders, monolithic ceramics, ceramic composites (including ceramic fibres and whiskers) and ceramic coatings.
Organizational Structure:	
WG 1	Classification and terminology Convenor: Dr.H.M.Verhog (The Netherlands)
WG 2	Ceramic powders Convenor: Mr.Claude Prieur (Societe francaise de Ceramique, France)
WG 3	Monolithic ceramics Convenor: Dr.R.Morrell (National Physical Laboratory, UK)
WG 4	Ceramic composites (elevated to SC 1)
WG 5	Ceramic coating Convenor: Dr.H.R.Vetters (Stiftung Institut fur Werkstofftechnik, Germany)
SC 1	Secretariat: AFNOR (France) Chairman: Mr.M.Bourgeon (Inst. Materiaux Composites, France) Secretary: Ms.N.Thilakarana (AFNOR, France) Title: Ceramic composites Scope: Standardization of test methods for ceramic matrix composite materials with continuous reinforcement and their reinforcements.

3.4 VAMAS Project

VAMAS, the Versailles Project on Advanced Materials and Standards, arose out of the Economic Summit meeting at Versailles in 1982 and operates under a Memorandum of Understanding signed in 1987 by the Group of seven Economic Summit nations and the Commission of the European Community. The overall objective of VAMAS is to help promote trade in high technology products through international collaboration in pre-standards research in order to generate the technical basis from which commonly acceptable standards and specifications for advanced materials can be developed (12). Pre-standards research under VAMAS is organized into Technical Working Areas (TWAs) which are led by international chairmen. So far twenty-one TWAs have been established although two TWAs have already completed their works as given in Table 9 (13). The VAMAS Secretariat of the first phase (1987-1992) was allocated to National Physical Laboratory, UK and was transferred to National Institute of Standards and Technology, USA during the second phase (1992-1997). The VAMAS Secretariat will be transferred again to NPL in the third phase (1997-).

Table 9 VAMAS Project (Versailles Project on Advanced Materials and Standards) (13)

Secretariat:	National Physical Laboratory (UK)	
Chairman:	Dr.Kamal Hossain (NPL, UK)	
Secretary:	Mr.John Sillwood (NPL, UK)	
Member Body:	Canada, France, Germany, Italy, Japan, UK, USA, CEC	
Organizational Structure:		- Chairman (Country)
TWA 1	Wear Test Methods	- Eric Santner (Germany)
TWA 2	Surface Chemical Analysis	- Martin P.Seah (UK)
TWA 3	Ceramics	- George D.Quinn (USA)
TWA 4	Polymer Blends	- Ivana K.Partridge (UK)
TWA 5	Polymer Composites	- Graham D.Sims (UK)
TWA 6	Superconducting & Cryogenic	(Divided into TWA 16 & TWA 17)
TWA 7	Bioengineering Materials	- Tetsuya Tateishi (Japan)
TWA 8	Hot Salt Corrosion Resistance	- Stuart R.J.Saunders (UK)
TWA 9	Weld Characteristics (completed)	
TWA 10	Material Databanks	- Yoshio Monma (Japan)
TWA 11	Creep Crack Growth (completed)	
TWA 12	Efficient Test Procedures for Polymer Properties	- Roger P.Brown (UK)
TWA 13	Low Cycle Fatigue	- Fathy A.Kandil (UK)
TWA 14	The Technical Basis for a Unified Classification Systems for Advanced Ceramics	- Samuel Schneider (USA)
TWA 15	Metal Matrix Composites	- W.Steven Johnson (USA)
TWA 16	Superconducting Materials	- Hiroshi Wada (Japan)
TWA 17	Cryogenic Structural Materials	- Toshio Ogata (Japan)
TWA 18	Statistical Techniques for International Studies and Related Projects	- Klaus Doerffel (Germany)
TWA 19	High Temperature Fracture of Brittle Materials	- Karl-Heinz Schwalbe (Germany)
TWA 20	Measurement of Residual Stress	- George A.Webster (UK)
TWA 21	Mechanical Measurements for Hardmetals	- Bryan Roebuck (UK)

3.5 IEA/Annex II Cooperative Program

In 1984, under leadership of the U.S. Department of Energy (DOE), an international cooperative study on advanced ceramics was started under the auspices of the International Energy Agency (IEA), and included industrial and selected laboratories in the United States, Germany, and Sweden. An IEA Annex II entitled, "Implementating Agreement for a Programme of Research and Development of High Temperature Materials for Automotive Engines", was signed by Germany, Sweden, and the United States, and extensive work was done on characterizing ceramic powders, chemical characterization of sintered structural ceramics, and methods studied for measuring the fracture strengths of these materials as given in Table 10. Japan (1990) and Belgium (1994) joined the Cooperative Programme of IEA/Annex II (14).

Table 10 IEA/Annex II Cooperative Program (14)

Chairman:		Robert B.Schulz (DOE, USA)	
Technical Representative:		Victor J.Tennery (ORNL, USA)	
Recording Secretary:		Felicia M.Foust (ORNL, USA)	
Participants:		USA, Germany, Sweden, Japan and Belgium	
		Implementing Agreement for a Programme of Research and Development on High Temperature Materials for Automotive Engines	
Annex I		Ceramics for Automotive Gas Turbine Engines – USA & Germany –	(1979–1997)
Annex II		Co-operative Programme on Ceramics for Advanced Engines and Other Conservation Applications	(1986–1997)
	Subtask 1	Technology Information Exchange – USA, Germany, Sweden, Japan, Belgium –	(1986–1997)
	Subtask 2	Powder Characterization Studies	(1986–1989)
	Subtask 3	Ceramic Characterization	(1986–1989)
	Subtask 4	Mechanical Properties Testing – USA, Germany, Sweden –	(1986–1989)
	Subtask 5	Mechanical Characterization of Structural Ceramics	(1990–1993)
	Subtask 6	Ceramic Powders Characterization I – USA, Germany, Sweden, Japan –	(1990–1993)
	Subtask 7	Mechanical Properties of Structural Ceramics and Other Areas	(1994–1996)
	Subtask 8	Ceramic Powders Characterization II – USA, Germany, Sweden, Japan, Belgium –	(1994–1996)
	Subtask 9	Thermal Shock of Structural Ceramics	(1996–1998)
	Subtask 10	Ceramic Powders Characterization III – USA, Germany, Sweden, Japan, Belgium –	(1996–1996)

4. Activities of ISO/TC 206 on Fine Ceramics

4.1 Establishment of ISO/TC 206

In 1990, ISO/IEC Presidents' Advisory Board on Technological Trends (ABTT) proposed a concept of '***Multipurpose aspects of standardization in innovation/market development cycles***' in which a three-phase approach in developing standards was suggested (15).

First phase standardization is mainly concerned with standardizing the language and terminology in early stages of new technology development. The second phase involves the standardization of materials characterization and test methods prior to market entry. Product standardization is a third phase objective to achieve production rationalization, interface compatibility, reliability, etc.

Table 11 Membership of ISO/TC 206 on Fine Ceramics (as of July 1996)

	P (Participating)-member (10)	
1	Australia	Standards Australia (SAA)
2	Canada	Standards Council of Canada (SCC)
3	China	China State Bureau of Technical Supervision (CSBTS)
4	Indonesia	Dewan Standardisasi National - DSN (DSN)
5	Japan	Japanese Industrial Standards Committee (JISC)
6	Korea, Republic of	National Institute of Technology and Quality (KNITQ)
7	Malaysia	Standards and Industrial Research Institute of Malaysia (SIRIM)
8	Russian Federation	Committee of the Russian Federation for Standardization, Metrology and Certification (GOST R)
9	Ukraine	State Committee of Ukraine for Standardization, Metrology and Certification (DSTU)
10	USA	American National Standards Institute (ANSI)
	O (Observer)-member (24)	
1	Austria	Osterreichisches Normungsinstitut (ON)
2	Belgium	Institut Belge de Normalisation (IBN)
3	Cuba	Oficina Nacional de Normalizacion (NC)
4	Denmark	Dansk Standard (DS)
5	Ecuador	Instituto Ecuatoriano de Normalizacion (INEN)
6	Egypt	Egyptian Organization for Standardization and Quality Control (EOS)
7	France	Association Francaise de Normalisation (AFNOR)
8	Germany	DIN Deutsches Institut fur Normung (DIN)
9	Italy	Ente Nazionale Italiano di Unificazione (UNI)
10	Jamaica	Jamaica Bureau of Standards (JBS)
11	Netherlands	Nederlands Normalisatie-Instituut (NNI)
12	Norway	Norges Standardiseringsforbund (NSF)
13	Philippines	Bureau of Product Standards (BPS)
14	Poland	Polish Committee for Standardization (PKN)
15	Slovakia	Slovak Office of Standards, Metrology and Testing (UNMS)
16	South Africa	South Africa Bureau of Standards (SABS)
17	Spain	Asociacion Espanola de Normalizacion y Certificacion (AENOR)
18	Sweden	SIS-Standardiseringen i Sverige (SIS)
19	Switzerland	Swiss Association for Standardization (SNV)
20	Thailand	Thai Industrial Standards Institute (TISI)
21	Turkey	Turk Standardlari Enstitusu (TSE)
22	United Kingdom	British Standards Institution (BSI)
23	Yugoslavia	Savezni za standardizaciju (SZS)
24	Uganda	Uganda National Bureau of Standards (UNBS)

P-members (Participating members):
Member bodies which decided to take an active part in the work of a technical committee or subcommittee.
They have an obligation to vote and, whenever possible, to attend meetings.

O-members (Observers):
Member bodies which wish only to be kept informed of the work of a technical committee or subcommittee.

Table 12 Title and Scope of ISO/TC 206

Title:	Fine Ceramics *
Scope:	Standardization in the field of fine ceramic materials and products in all forms: powders, monoliths, coatings and composites, intended for specific functional applications including mechanical, thermal, chemical, electrical, magnetic, optical and combinations thereof. The term 'fine ceramics' is defined as "a highly engineered, high performance, predominantly nonmetallic, inorganic material having specific functional attributes'.
	* Alternative terms for fine ceramics are advanced ceramics, engineered ceramics, technical ceramics, or high performance ceramics.

New fine ceramics materials require a long period of time to establish their reliability for practical applications. Therefore, global collaboration on standardization at the early stage of technology innovation (early stage standardization) proposed by ABTT is very attractive to provide useful standards for fine ceramics.

In response to a proposal of *"**early stage standardization**"* by ABTT, the Japanese member body, Japanese Industrial Standards Committee (JISC) made a formal proposal to ISO to establish a new ISO Technical Committee on Fine Ceramics. Following a ballot among the ISO member bodies, the ISO Council approved the establishment of this new technical committee in November 1992. In December 1992, the ISO Technical Board registered this new technical committee as ***ISO/TC 206*** (15).

The ISO/TB allocated the secretariat for ISO/TC 206 to JISC (Japan). The JISC appointed Dr.Takashi Kanno (Research Center, Asahi Glass Co., Ltd., Japan) as Secretary and the ISO/TB appointed Mr.Samuel Schneider (Materials Science and Engineering Laboratory, National Institute of Standards and Technology, USA) as the ISO/TC 206 Chairman.

4.2 Membership of ISO/TC 206

At present, the membership of ISO/TC 206 consists of ten *"**P-members**"* in Pacific Rim countries and twenty-four *"**O-members**"* including most of the European countries (Table 11).

4.3 The title and scope of ISO/TC 206

At the first plenary meeting of ISO/TC 206 held in Tokyo in May 1994, the ISO/TC 206 approved the ***Title*** and ***Scope*** of ISO/TC 206 as given in Table 12 (16).

It was also agreed to establish a ***Cooperation*** with CEN/TC 184 on Advanced Technical Ceramics and ***Liaisons*** with relevant ISO or IEC Technical Committees, and other organizations (Table 13).

Table 13 Cooperation and Liaisons with Other Organizations

CEN/TC 184	Advanced Technical Ceramics
ISO/TC 3	Limits and fits
ISO/TC 24	Sieves, sieving and other sizing methods
ISO/TC 33	Refractories
ISO/TC 164	Mechanical testing of metals
IEC/SC 15C	Specifications of Insulating materials
VAMAS	Versailles Project on Advanced Materials and Standards
	TWA 1 Wear Test Method
	TWA 3 Ceramics
	TWA 10 Material Databanks
	TWA 14 Unified Classification Systems for Advanced Ceramics
ICF	International Ceramic Federation

4.4 Organization Structure of ISO/TC 206

At the Tokyo meeting, four Working Groups (WG 1, WG 2, WG 3 and WG 4) were organized to address each New Work Item in Table 15. An Advisory Group on Planning (AG) was also established to plan and recommend the future work items for ISO/TC 206. At the Second Plenary Meeting of ISO/TC 206 held in Kuala Lumpur, Malaysia on 1st and 2nd June 1995, additional two Working Groups (WG 5 and WG 6) were organized to address additional New Work Items, i.e. ISO/NP 15490 and NP 5, respectively (17, 18).

At the Third Plenary Meeting held in Cairns, Australia on 20th July 1996, further four Working Groups (WG 7, WG 8, WG 9 and PWI) were established corresponding to the approval of three New Work Item Proposals and a Preliminary Work Item given in the Table 15. In Table 14, the titles and conveners for each Working Group were listed.

4.5 Progress of Work in ISO/TC 206

The five of the New Projects, approved to include in the Work Program of the ISO/TC 206 at the First Plenary Meeting in Tokyo and the Second Plenary Meeting in Kuala Lumpur, were registered by the ISO Central Secretariat with the numbers and titles as given in Table 15. The first two Work Items, i.e., *ISO/NP 14703-1 and ISO/NP 14705* have advanced to a Committee Stage (Stage 3), and the first Committee Drafts and the comments concerned were discussed at the Cairns Meeting to prepare revised Committee Drafts for voting on registration as Draft International Standards (DISs). The target dates for submission as a DIS are December 1997.

The second three New Projects, i.e., *ISO/NP 14704, ISO/NP 15165* and ISO/NP 15490 are in a Preparatory Stage (Stage 2) at present, and the first Working Drafts were circulated to Working Group Members for a submission of comments (18, 19).

Table 14 Organization Structure of ISO/TC 206

AG *	Advisory Group on Planning - Convener: Dr.Philip A.Walls (ANSTO, Australia)
WG 1	Particle Size Distribution of Ceramic Powders - Convener: Dr.Tsubaki Junichiro (Nagoya University, Japan)
WG 2	Flexural Strength of Monolithic Ceramics at Room Temperature - Convener: Mr.George Quinn (NIST, USA)
WG 3	Hardness of Monolithic Ceramics at Room Temperature - Convener: Mr.Shuji Sakaguchi (NIRI Nagoya, Japan)
WG 4	Classification of Fine Ceramics - Convener: Dr.Roger Morrell (NPL, United Kingdom)
WG 5	Specific Surface Area of Ceramic Powders - Convener: Mr.Edward M.Anderson (Alcoa Industrial Chemicals, USA)
WG 6	Tensile Strength of Monolithic Ceramics at Room Temperature - Convener: Dr.Tatsuki Ohji (NIRI Nagoya, Japan)
WG 7	Fracture Toughness by SEPB - Convener: Mr.Tetsuro Nose (Nippon Steel Co.,Japan)
WG 8	Flexural Strength at Elevated Temperature - Convener: Mr.George Quinn (NIST, USA)
WG 9	Tensile Behaviour of Composites - Convener: Dr.Michael Jenkins (University of Washington, USA)
PWI **	Particle Size Distribution by Laser Diffraction - Convener: Mr.Ross Campbell (ANSTO, Australia)
* **	The task of the Advisory Group on Planning is to plan and recommend the future work items for ISO/TC 206 PWI: Preliminary Work Item

Table 15 Work Programme of ISO/TC 206 (as of July 1996)

Committee stage (Stage 3)	
ISO/NP 14703-1	Ceramic powders - Determination of particle size distribution - Part 1 : Sample preparation
ISO/NP 14705	Monolithic ceramics - Hardness test at room temperature
Preparatory stage (Stage 2)	
ISO/NP 14704	Advanced (fine) ceramics - Determination of flexural strength at room temperature
ISO/NP 15165	Fine ceramics - Classification
ISO/NP 15490	Fine ceramics - Monolithic ceramics - Determination of tensile strength at room temperature
Proposal stage (Stage 1)	
NP 5	Determination of specific surface area of fine ceramic powders by gas adsorption using the BET method
NP 7	Fine ceramics (Advanced ceramics, Advanced technical ceramics) - Determination of fracture toughness at ambient temperature by the single edge precracked beam (SEPB) method
NP 8	Fine ceramics (Advanced ceramics, Advanced technical ceramics) - Test method of flexural strength at elevated temperatures
NP 9	Fine ceramics (Advanced ceramics, Advanced technical ceramics) - Test method for tensile stress-strain behaviour of continuous fiber-reinforced composites at ambient temperature
Preliminary stage (Stage 0)	
PWI 1	Fine ceramics (Advanced ceramics, Advanced technical ceramics) - Determination of particle size distribution of ceramic powders by laser diffraction

Additional four Work Items in Table 15, which have been approved to include in the Work Program at the Second Plenary Meeting in Kuala Lumpur and at the Third Plenary Meeting in Cairns, are in a Proposal Stage (Stage 1). The "Votes on New Work Item Proposal" for NP 5, NP 7, NP 8 and NP 9 will be circulated immediately when the Conveners complete each first working document or an outline for discussion.

At the Cairns meeting, it was also agreed that the New Work Item Proposal on the *"Determination of particle size distribution of ceramic powders by laser diffraction"* should be submitted in a Preliminary Stage (Stage 0).

In Appendix 4, the Work Items which have been approved to include in the Work Program of ISO/TC 206 were summarized together with those of CEN/TC 184, ASTM Committee C28 and JIS. Most of the Work Items in the Projects of ISO/TC 206 have already been established as National or Regional Standards. Consequently, the major works in preparing Working Drafts in ISO/TC 206 are focussed on harmonizing respective National and Regional Standards.

4.6 Future Plan of ISO/TC 206

The Fourth Plenary Meeting of ISO/TC 206 will be held in June or July in China (Tsing Tao). Further information will be circulated as soon as the details of the schedule are decided.

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Appendix 1 Standards Developed by JISC on Fine Ceramics (as of April 1996)

COMPLETED STANDARDS (28)	
R1600-1993	Glossary of terms relating to fine ceramics
R1601-1995	Testing method for flexural strength (modulus of rupture) of fine ceramics
R1602-1995	Testing method for elastic modulus of fine ceramics
R1603-1994	Method for chemical analysis of fine silicon nitride powders for fine ceramics
R1604-1995	Testing method for flexural strength of fine ceramics at elevated temperature
R1605-1995	Testing methods for elastic modulus of fine ceramics at elevated temperature
R1606-1995	Testing methods for tensile strength of fine ceramics at room and elevated temperature
R1607-1995	Testing methods for fracture toughness of fine ceramics at room temperature
R1608-1990	Testing method for compressive strength of high performance ceramics
R1609-1990	Testing method for oxidation resistance of non-oxide high performance ceramics
R1610-1991	Testing method for Vickers hardness of high performance ceramics
R1611-1991	Testing method for thermal diffusivity, specific heat capacity, and thermal conductivity for high performance ceramics by laser flash method
R1612-1993	Testing method for bending creep of high performance ceramics
R1613-1993	Testing method for wear resistance of high performance ceramics by ball-on disk method
R1614-1993	Testing method for corrosion of high performance ceramics in acid and alkaline solutions
R1615-1993	Testing method for adaption assessment of high performance ceramics under high temperature and high pressure
R1616-1994	Method for chemical analysis of fine silicon carbide powders for fine ceramics
R1617-1994	Testing method for fracture toughness of fine ceramics at elevated temperature
R1618-1994	Measuring method of thermal expansion of fine ceramics by thermo-mechanical analysis
R1619-1995	Determination of size distribution of fine ceramic particles by liquid photosedimentation method
R1620-1995	Testing methods for particle density of fine ceramic powder
R1621-1995	Methods of bending fatigue testing of fine ceramics at room temperature
R1622-1995	General rules for the sample preparation of particle size analysis of fine ceramic raw powder
R1623-1995	Testing method for Vickers hardness of fine ceramics at elevated temperature
R1624-1995	Testing method of bending strength of fine ceramic joint
R1625-1996	Weibull statistics of strength data by unimodal 2-parameter function
R1626-1996	Determination of the specific surface area of fine ceramic powders by gas adsorption using the BET method
R1627-1996	Testing method for dielectric properties of fine ceramics at microwave frequency
DRAFT STANDARDS (3)	
R16xx-1996	Testing methods for bulk density of fine ceramic powder
R16xx-1996	Determination of particle size distributions for fine ceramic raw powders by laser diffraction method
R16xx-1996	Testing method for tensile strength of fine ceramic joint

Appendix 2-1 ASTM Committee C-28, Advanced Ceramics (as of June 1996)

COMPLETED STANDARDS (27) ASTM Annual Book of Standards, Vol. 15.01	
C 1145-96	Standard Definition of Terms Relating to Advanced Ceramics
C 1161-94	Standard Test Method for Flexural Strength of Advanced Ceramics at Ambient Temperature
C 1175-91	Standard Guide to Test Methods for Nondestructive Testing of Advanced Ceramics
C 1198-94	Standard Test Method for Dynamic Young's Modulus, Shear Modulus, and Poisson's Ratio for Advanced Ceramics by Sonic Resonance
C 1211-92	Standard Test Method for Flexural Strength of Advanced Ceramics at Elevated Temperature
C 1212-92	Standard Practice for Fabricating Ceramic Reference Specimens Containing Seeded Voids
C 1239-93	Standard Practice for Reporting Uniaxial Strength Data and Estimating Weibull Distribution Parameters for Advanced Ceramics
C 1251-93	Standard Guide for Determination of Specific Surface Area of Advanced Ceramics by Gas Adsorption
C 1259-94	Standard Test Method for Dynamic Young's Modulus, Shear Modulus, and Poisson's Ratio for Advanced Ceramics by Impulse Excitation of Vibration
C 1273-94	Standard Test Method for Tensile Strength of Monolithic Advanced Ceramics at Ambient Temperatures
C 1274-94	Standard Test Method for Advanced Ceramic Specific Surface Area by Physical Adsorption
C 1275-94	Standard Test Method for Monotonic Tensile Strength Testing of Continuous Fiber-Reinforced Advanced Ceramics with Solid Rectangular Cross-Section Specimens at Ambient Temperatures
C 1282-94	Standard Test Method for Determination the Particle Size Distribution of Advanced Ceramics by Centrifugal Photosedimentation
C 1286-95	Standard System for Classification of Advanced Ceramics
C 1291-95	Standard Test Method for Elevated Temperature Tensile Creep Strain, Creep Strain Rate, and Creep Time-to-Failure for Advanced Monolithic Ceramics
C 1292-95	Standard Test Method for Shear Strength of Continuous Fiber-Reinforced Advanced Ceramics at Ambient Temperatures
C 1322-96	Standard Practice for Fractography and Characterization of Fracture Origins in Advanced Ceramics
C 1323-96	Standard Test Method for Ultimate Strength of Advanced Ceramics With Diametrally Compressed C-Ring Specimens at Ambient Temperatures
C 1326-96	Standard Test Method for Knoop Indentation Hardness of Advanced Ceramics
C 1327-96	Standard Test Method for Vickers Indentation Hardness of Advanced Ceramics
C 1331-96	Standard Practice for Measuring Ultrasonic Velocity in Advanced Ceramics With the Broadband Pulse-Echo Cross-Correlation Method
C 1332-96	Standard Test Method for Measurement of Ultrasonic Attenuation Coefficients of Advanced Ceramics by the Pulse-Echo, Contact Technique
C 1336-96	Standard Practice for Fabricating Non-Oxide Ceramic Reference Specimens Containing Seeded Inclusions
C 1337-96	Standard Test Method for Creep and Creep Rupture of Continuous Fiber-Reinforced Ceramic Composites Under Tensile Loading at Elevated Temperature

Appendix 2-2 ASTM Committee C-28, Advanced Ceramics (as of June 1996)

STANDARDS IN THE BALLOTING PROCESS	
C xxxx-96	Standard Test Method for Flexural Properties of Continuous Fiber Reinforced Advanced Ceramic Composites
C xxxx-96	Standard Test Method for Monotonic Tensile Strength Testing of Continuous Fiber-Reinforced Advanced Ceramics with Solid Rectangular Cross-Section Specimens at Elevated Temperatures
C xxxx-96	Standard Practice for Constant-Amplitude, Axial, Tension-Tension Cyclic Fatigue of Continuous Fiber-Reinforced Advanced Ceramics at Ambient Temperatures
C xxxx	Standard Test Method for Ultimate Strength of Advanced Ceramics With Diameterally Compressed O-Ring Specimens at Ambient Temperatures
C xxxx	Standard Test Method for Tensile Strength of Monolithic Ceramics at Elevated Temperatures
C xxxx	Standard Test Methods for the Determination of Fracture Toughness of Advanced Ceramics
C xxxx	Standard Practice for Contact-Amplitude, Axial, Tension-Tension Cyclic Fatigue of Advanced Ceramics at Ambient Temperatures
C xxxx	Standard Test Method for Slow Crack Growth Parameters of Advanced Ceramics by Constant Stress Rate Flexural Testing at Ambient Temperature
C xxxx	Standard Test Method for Particle Size Distribution of Silicon Nitride or Silicon Carbide Powders by X-Ray Monitoring of Gravity Sedimentation
C xxxx	Standard Test Method for Monotonic Compressive Strength Testing of Continuous Fiber-Reinforced Advanced Ceramics with Solid Rectangular Cross-section Specimens at Ambient Temperatures
C xxxx	Standard Test Method for Tensile Strength and Young's Modulus for High-Modulus Single Filament Advanced Ceramics
DRAFT STANDARDS	
C xxxx	Standard Test Method for Monotonic Compressive Strength Testing of Advanced Ceramics at Ambient Temperatures
C	Standard Test Method for Determination of Total Carbon in Oxide and Nitride Advanced Ceramic Powders by Direct Combustion-Infrared Detection Method
C	Standard Test Method for Determination of Total Carbon in Carbide and Nitride Advanced Ceramic Powders by Direct Combustion-Infrared Detection Method
C	Standard Test Method for Determination of Total Nitrogen in Carbide and Oxide Advanced Ceramic Powders by .... Method
C	Standard Test Method for X-ray Emission Spectrometric Analysis of Ceramic Powders
TASK GROUP PROJECTS - Draft Outlines	
C	Standard Practice for Scaling Strength Data for Specimen Size (?)
C	Standard Practice for Pooling Strength Data (?)
SPECIAL TECHNICAL PUBLICATIONS	
STP 1201	Life Prediction Methodologies and Data for Ceramic Materials

Appendix 3-1 Programme of CEN/TC 184 (First Mandate)

Work Item No	Title (abbreviated)	EN(V) Number	
GENERAL			
1	Classification	ENV	12212
POWDERS			
2	Impurities in Al_2O_3	EN	725-1
3	Impurities in $BaTiO_3$	ENV	725-2*
4	O_2 in non-oxides (thermal ext.)	EN	725-3*
83	O_2 in non-oxides (XRF)	ENV	725-4
5	Particle size distribution	EN	725-5
6	Specific area	EN	725-6
7	Absolute density	EN	725-7
84	Tap density	EN	725-8
85	Untapped density	EN	725-9
8	Compaction	EN	725-10
9	Sintering curve	ENV	725-11*
MONOLITHIC CERAMICS			
10	Sampling and testing	ENV	1006*
11	Cracks by dye penetration	EN	623-1*
12	Density and porosity	EN	623-2*
13	Grain size	ENV	623-3*
14	Surface roughness	ENV	624-4*
15	Flexural strength	EN	843-1*
16	Elastic moduli	ENV	843-2
17	Sub-critical crack growth	ENV	843-3
18	Hardness	ENV	843-4*
19	Flexural strength, high temp.	ENV	820-1*
20	Deformation	ENV	820-2*
21	Thermal shock	ENV	820-3*
22	Thermal expansion	EN	821-1*
23	Thermal diffusivity	EN	821-2
24	Specific heat	ENV	821-3*
LONG-FIBER COMPOSITES			
25	Tensile strength	ENV	658-1*
26	Compressive strength	ENV	658-2*
27	Flexural strength	ENV	658-3*
28	Shear strength (Compression)	ENV	658-4*
86	Shear strength (3-point)	ENV	658-5*
87	Shear strength (double punch)	ENV	658-6*
29	Thermal expansion	ENV	1159-1*
30	Thermal diffusivity	ENV	1159-2*
31	(Deleted)		
32	Specific heat	ENV	1159-3*
33	Density	ENV	1389*
FIBER PROPERTIES			
34	Size level	ENV	1007-1*
35	Linear mass	ENV	1007-2*
36	Filament diameter	ENV	1007-3*
37	Filament strength	ENV	1007-4*
COATINGS			
69	Chemical comp. (EPMA)	ENV	1071-4
70	Thickness (probe profilometer)	ENV	1071-1*
88	Thickness (cap grinding)	ENV	1071-2*
71	(Deleted)		
72	Porosity (metallography)	ENV	1071-5*
73	Adhesion (scratch)	ENV	1071-3*

* Published

Appendix 3-2 Programme of CEN/TC 184 (Second Mandate)

Work Item No	Title (abbreviated)
GENERAL	
89	Terminology
POWDERS	
90	Impurities in zirconia
91	Crystalline phase in zirconia
92	Impurities in silicon nitride
93	Flowability of powders
MONOLITHIC CERAMICS	
94	Statistical evaluation of fracture testing
95	Oxidation testing, method for
96	Flexural creep
97	Microstructural analysis
98	Fractography, standard practice
99	Elastic moduli, high temp.
100	Fracture toughness (preliminary)
101	Chem. corrosion testing, laboratory procedures for
CERAMIC COMPOSITES	
102	Notations and symbols
103	Tensile properties (inert atmosphere, 2000℃)
104	Tensile properties (air 1700℃)
105	Shear strength, in-plane
106	Interlaminar shear strength, high temp. (inert atmosphere, 3-point)
107	Tensile properties of a dry fiber tow (r.t.)
108	Flexural strength (inert atmosphere, 2000℃)
109	Flexural strength (air, 1700℃)
110	Thermal conductivity
111	Compression properties (neutral atmosphere, 2000℃)
112	Compression properties, high temp. (air)
113	Resistance to crack propagation
114	Elastic properties by NDT
115	Resistance to creep
116	Tensile strength of single filament, high temp.
COATINGS	
117	Chemical comp. (optical emission spectroscopy)
118	Chemical comp. (X-ray spectroscopy)
119	Chemical comp. (Atomic adsorption spectroscopy)
120	Chemical comp. (Electron spectroscopy)
121	Coating hardness
122	Testing of cavitation erosion by ultrasonic testing
123	Rockwell indentation test for the determination of adhesion
124	Determination of elastic modulus

Appendix 4-1 Summary of the Activities in CEN/TC 184, ASTM C28, JIS and ISO/TC 206

Work item No	Title (abbreviated)	CEN/TC 184 EN(V) Number	ASTM Committee C28 Number	JIS Number	ISO/TC 206 Project Number
GENERAL					
1	Classification	ENV 12212	C 1286-95	-	ISO/NP 15165
2	Terminology	WI 89	C 1145-89	R 1600-93	
POWDERS					
1	Impurities in Al_2O_3	EN 725-1	(C 573)	CSJ	
2	Impurities in $BaTiO_3$	ENV 725-2*	-	-	
3	O_2 in non-oxides (thermal ext.)	EN 725-3*	C	R 1603-94	
4	O_2 in non-oxides (XRF)	ENV 725-4	C	R 1603-94	
5	Particle size distribution	EN 725-5	C 1282-95/xxxx	R 1619-95	ISO/NP 14703-1
6	Specific area	EN 725-6	C 1251-93/1274-94	R 1626-96	NP 5
7	Absolute density	EN 725-7	C	R 1620-95	
8	Tap density	EN 725-8	C	R	
9	Untapped density	EN 725-9	C	R	
10	Compaction	EN 725-10	-	-	
11	Sintering curve	ENV 725-11*	-	-	
12	Impurities in zirconia	WI 90	(C 705)	-	
13	Crystalline phase in zirconia	WI 91	-	-	
14	Impurities in silicon nitride	WI 92	-	R 1603-94	
15	Flowability of powders	WI 93	-	-	
16	Chem. analysis of silicon carbide	-	-	R 1616-94	
MONOLITHIC CERAMICS					
1	Sampling and testing	ENV 1006*	-	-	
2	Cracks by dye penetration	EN 623-1*	-	-	
3	Density and porosity	EN 623-2*	(C 2141)	(F 77, C 373)	
4	Grain size	ENV 623-3*	-	-	
5	Surface roughness	ENV 624-4*	-	-	
6	Flexural strength	EN 843-1*	C 1161-90	R 1601-95	ISO/NP 14704
7	Elastic moduli	ENV 843-2	C 1198-91/1259-94	R 1602-95	
8	Sub-critical crack growth	ENV 843-3	-	-	
9	Hardness	ENV 843-4*	C 1326/1327-96	R 1610-91	ISO/NP 14705
10	Flexural strength, high temp.	ENV 820-1*	C 1211-92	R 1604-95	NP 8
11	Deformation	ENV 820-2*	C xxxx	R 1612-93	
12	Thermal shock	ENV 820-3*	(C 554)	R 1615-93	
13	Thermal expansion	EN 821-1*	(D 116)	R 1618-94	
14	Thermal diffusivity	EN 821-2	-	R 1611-91	
15	Specific heat	ENV 821-3*	(D 3650)	R 1611-91	
16	Statistical evaluation of fracture testing	WI 94	C 1239-93	R 1625-96	
17	Oxidation testing, method for	WI 95	-	R 1609-90	
18	Flexural creep	WI 96	-	R 1612-93	
19	Microstructural analysis	WI 97	-	-	
20	Fractography, standard practice	WI 98	C 1322-96	-	
21	Elastic moduli, high temp.	WI 99	C 1198-91	R 1605-95	
22	Fracture toughness (preliminary)	WI 100	C xxxx	R 1607-95	NP 7
23	Chem. corrosion testing, laboratory procedures for	WI 101	-	R 1614-93	
24	Tensile strength at room temperature	-	C 1273-94	R 1606-95	ISO/NP 15490
25	Tensile strength, high temp.	-	C xxxx	R 1606-95	
26	Compressive strength	-	(C 773)	R 1608-90	
27	Wear resistance	-	G-99-90	R 1613-93	
28	Erosion resistance	-	-	R 1615-93	
29	Nondestructive testing	-	C 1175-91	-	
30	Fracture toughness, high temp.	-	-	R 1617-94	
31	Ultimate strength, diametrally compressed C-ring specimens	-	C 1323-96	-	
32	Ultimate strength, diametrally compressed O-ring specimens	-	C xxxx	-	
33	Tensile creep, high temp.	-	C 1291-95	R	
34	Reference specimens with seeded voids	-	C 1212-92	-	
35	Reference specimens with seeded inclusions	-	C xxxx	-	
36	Hardness, high temp.	-	-	R 1623-95	
37	Bending fatigue testing, r.t.	-	-	R 1621-96	
38	Bending strength for fine ceramic joint	-	-	R 1624-96	
39	Tensile strength of fine ceramic joint	-	-	R xxxx	
40	Tension-tension cyclic fatigue, r.t.	-	C xxxx	-	
41	Ultrasonic velocity	-	C xxxx	-	

* Published

Appendix 4-2 Summary of the Activities in CEN/TC 184, ASTM C28, JIS and ISO/TC 206

Work item No	Title (abbreviated)	CEN/TC 184 EN(V) Number	ASTM Committee C28 Number	JIS Number	ISO/TC 206 Project Number
CERAMIC COMPOSITES					
1	Tensile strength	ENV 658-1*	C 1275-95	–	NP 9
2	Compressive strength	ENV 658-2*	C xxxx	R	
3	Flexural strength	ENV 658-3*	C xxxx	–	
4	Shear strength (Compression)	ENV 658-4*	C 1292-95	–	
5	Shear strength (3-point)	ENV 658-5*	C xxxx	–	
6	Shear strength (double punch)	ENV 658-6*	–	–	
7	Thermal expansion	ENV 1159-1*	–	–	
8	Thermal diffusivity	ENV 1159-2*	–	–	
9	Specific heat	ENV 1159-3*	–	–	
10	Density	ENV 1389*	–	–	
11	Size level	ENV 1007-1*	–	–	
12	Linear mass	ENV 1007-2*	–	–	
13	Filament diameter	ENV 1007-3*	–	–	
14	Filament strength	ENV 1007-4*	C xxxx	–	
15	Notations and symbols	WI 102	–	–	
16	Tensile properties (inert atmosphere, 2000℃)	WI 103	–	–	
17	Tensile properties (air 1700℃)	WI 104	C xxxx	–	
18	Shear strength, in-plane	WI 105	–	–	
19	Interlaminar shear strength, high temp. (inert atmosphere, 3-point)	WI 106	–	–	
20	Tensile properties of a dry fiber tow (r.t.)	WI 107	–	–	
21	Flexural strength (inert atmosphere, 2000℃)	WI 108	–	–	
22	Flexural strength (air, 1700℃)	WI 109	–	–	
23	Thermal conductivity	WI 110	–	–	
24	Compression properties (neutral atmosphere, 2000℃)	WI 111	–	–	
25	Compression properties, high temp. (air)	WI 112	–	–	
26	Resistance to crack propagation	WI 113	–	–	
27	Elastic properties by NDT	WI 114	–	–	
28	Resistance to creep	WI 115	–	–	
29	Tensile strength of single filament, high temp.	WI 116	C xxxx	–	
30	Tension-tension cyclic fatigue	–	C xxxx	–	
31	Creep, creep rupture under tensile loading at h.t.	–	C xxxx	–	
32	Tension-tension cyclic fatigue, r.t.	–	C xxxx	–	
COATINGS					
1	Chemical comp. (EPMA)	ENV 1071-4	–	–	
2	Thickness (probe profilometer)	ENV 1071-1*	–	–	
3	Thickness (cap grinding)	ENV 1071-2*	–	–	
4	(Deleted)	–	–	–	
5	Porosity (metallography)	ENV 1071-5*	–	–	
6	Adhesion (scratch)	ENV 1071-3*	–	–	
7	Chemical comp. (optical emission spectroscopy)	WI 117	–	–	
8	Chemical comp. (X-ray spectroscopy)	WI 118	–	–	
9	Chemical comp. (Atomic adsorption spectroscopy)	WI 119	–	–	
10	Chemical comp. (Electron spectroscopy)	WI 120	–	–	
11	Coating hardness	WI 121	–	–	
12	Testing of cavitation erosion by ultrasonic testing	WI 122	–	–	
13	Rockwell indentation test for the determination of adhesion	WI 123	–	–	
14	Determination of elastic modulus	WI 124	–	–	

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