

INTERNATIONAL UNION OF PURE  
AND APPLIED CHEMISTRY

INORGANIC CHEMISTRY DIVISION

COMMISSION ON HIGH TEMPERATURES AND REFRACTORY MATERIALS

**INTERNATIONAL COOPERATION ON  
CHARACTERIZATION AND TERMINOLOGY  
OF CARBON AND GRAPHITE**

Prepared for publication by  
W. S. HORTON

National Bureau of Standards, USA

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INTERNATIONAL COOPERATION ON CHARACTERIZATION AND

TERMINOLOGY OF CARBON AND GRAPHITE

At its 1970 meeting the IUPAC Commission on High Temperatures and Refractory Materials (II.3) authorized Professor Erich Fitzer, Karlsruhe, to organize an international group for codifying and standardizing methods of characterization of and terms related to carbon and graphite. After several years of effort Professor Fitzer succeeded in forming the International Committee for Characterization and Terminology of Carbon. The current members include the following:

|                  |              |                 |
|------------------|--------------|-----------------|
|                  | E. Fitzer    | Chairman        |
|                  | W. S. Horton | Vice-Chairman   |
| H. P. Boehm      |              | H. Marsh        |
| R. J. Diefendorf |              | S. Mrozowski    |
| J. P. Donnet     |              | A. Oberlin      |
| M. Inagaki       |              | F. Rozploch     |
| I. Letizia       |              | T. Tsuzuku      |
| A. Marchand      |              | R. A. Ubbelohde |
| E. Wege          |              |                 |

This communication constitutes a progress report.

Considering terminology to be a more difficult subject on which to reach agreement, the Committee began to codify methods of characterization first, although a beginning has been made to select and define some carbon-related terms. The following tables, compiled by E. Fitzer, K. -H. Kochling, and G. Schwartz, and edited by W. S. Horton present a provisional concordance of identifying test numbers of methods for measuring the same property in different countries. At this stage there are many blanks and, no doubt, some misplaced entries. The International Committee is anxious to receive comments of any nature about this work. These may be sent to:

Professor Dr. E. Fitzer  
Institut für Chemische Technik  
Kaiserstrasse 12  
D-7500 Karlsruhe 1  
Federal Republic of Germany

For information about particular methods readers should write directly to the organizations involved. Below are given explanations of organizational abbreviations, where used, and the appropriate mailing addresses.

ASTM

American Society for Testing and Materials  
1916 Race Street  
Philadelphia, PA 19103 U.S.A

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\*Membership March 1978: Titular Members: C. B. Alcock, Chairman (Canada); G. D. Rieck, Secretary (The Netherlands); A. M. Anthony (France); P. W. Gilles (USA); J. Hlavác (Czechoslovakia); G. DeMaria (Italy); E. E. Shphil'rain (USSR); K. Komarek (Austria); Associate Members: E. Fitzer (Federal Republic of Germany); W. S. Horton (USA); S. Mrowec (Poland); R. W. Ohse (Commission of the European Community); T. Sata (Japan); R. Sersale (Italy); W. Worrell (USA); National Representatives: M. S. E. El-Sweify (Egypt); E. R. McCartney (Australia); J. Drowart (Belgium); R. Collongues (France); A. P. B. Sinha (India); R. Hammer (Israel); A. Magnéli (Sweden); G. D. Bayer (Switzerland); L. V. Gurvich (USSR); M. M. Ristić (Yugoslavia)

## AKK

Arbeitskreis Kohlenstoff (Carbon Working Group of the German Ceramic Society); Information available from Prof. Fitzer.

## DIN

Deutsches Institut für Normung  
Burggrafenstrasse 4-7  
Postfach 1107  
D-1000 Berlin 30  
Federal Republic of Germany

## ISO

International Organization for Standardization  
1, Rue de Varembe  
Case postale 56  
1211 Genève 20  
Switzerland

## British Standards:

British Standards Institute  
2 Park Street  
London W1A 2BS  
United Kingdom

## Italian Standards:

Ente Nazionale Italiano di Unificazione  
Piazza Armando Diaz 2  
120123 Milano  
Italy

Meetings of the Committee, which are open to all persons interested in the subject, are held annually. Alternately the locations are in the United States and in Europe at carbon conferences. The next two are scheduled to be held during the 14th Biennial Conference on Carbon at Pennsylvania State University, U. S. A., 24-29, June 1979 and during CARBON 80 at Baden-Baden, F. R. G.

## INDEX OF STANDARDIZED METHODS

ASTM (USA)

| NUMBER   | YEAR | TITLE   |
|----------|------|---|
| C 20-74  | 1974 | Apparent porosity, water absorption, apparent specific gravity, and bulk density by boiling water |
| C 493-70 | 1976 | Bulk density and porosity of granular refractory materials by mercury displacement                |
| C 558-69 | 1975 | Measurement of lattice spacing of nuclear graphite  |
| C 559-77 | 1977 | Bulk density in air of manufactured carbon and graphite articles by physical measurement          |
| C 560-77 | 1977 | Chemical analyses of carbon and graphite  |
| C 561-69 | 1969 | Ash in graphite   |
| C 562-69 | 1969 | Moisture in graphite  |
| C 565-71 | 1971 | Tension testing of carbon-graphite mechanical materials   |
| C 571-70 | 1976 | Chemical analyses of carbon and carbon-ceramic refractories                                       |

| NUMBER    | YEAR | TITLE   |
|-----------|------|---|
| C 604-67  | 1977 | True specific gravity of refractory materials by gas comparison pycnometer                                  |
| C 611-69  | 1976 | Electrical resistivity of manufactured carbon and graphite articles at room temperature                     |
| C 613-67  | 1973 | Resin content of carbon and graphite prepregs by solvent extraction   |
| C 626-71  | 1978 | Estimating the thermal neutron absorption cross section of nuclear graphite                                 |
| C 651-70  | 1977 | Flexural strength of manufactured carbon and graphite articles using four-point loading at room temperature |
| C 695-75  | 1975 | Compressive (crushing) strength of graphite   |
| C 714-72  | 1972 | Thermal diffusivity of carbon and graphite by a thermal pulse method  |
| C 747-74  | 1974 | Moduli of elasticity and fundamental frequencies of carbon and graphite materials by sonic resonance        |
| C 749-73  | 1973 | Tensile stress-strain of carbons and graphite   |
| C 819-77  | 1977 | Specific surface area of carbon or graphite   |
| D 36-76   | 1976 | Softening point of bitumen (Ring and Ball Method)   |
| D 1367-64 | 1978 | Lubricating qualities of graphites  |
| D 1480-62 | 1976 | Density and relative density (specific gravity) of viscous materials by Bingham pycnometer                  |
| D 1481-62 | 1976 | Density and relative density (specific gravity) of viscous materials by Lipkin bicapillary pycnometer       |
| D 1506-75 | 1975 | Carbon black-Ash content  |
| D 1509-75 | 1975 | Carbon black-Heating loss   |
| D 1510-76 | 1976 | Carbon-black-Iodine absorption number   |
| D 1511-74 | 1974 | Carbon black-Pellet size distribution   |
| D 1512-75 | 1975 | Carbon black-pH-value   |
| D 1513-74 | 1974 | Carbon black-Pelleted, Pour density   |
| D 1514-74 | 1974 | Carbon black-Sieve residue  |
| D 1553-64 | 1978 | Analysis of graphites used as lubricants  |
| D 1619-77 | 1977 | Carbon black-Sulfur content   |
| D 2318-76 | 1976 | Quinoline-insoluble content of tar and pitch  |
| D 2355-70 | 1976 | Liquid phase evaluation of activated carbon   |
| D 2414-76 | 1976 | Carbon black-Dibutyl phthalate absorption number  |
| D 2416-73 | 1973 | Coking value of tar and pitch (modified Conradson method)   |
| D 2854-70 | 1976 | Apparent density of activated carbon  |
| D 2862-70 | 1970 | Particle size distribution of granular activated carbon   |
| D 2866-70 | 1976 | Total ash content of activated carbon   |

| NUMBER     | YEAR         | TITLE   |
|------------|--------------|---|
| D 2867-70  | 1976         | Moisture in activated carbon  |
| D 3037-76  | 1976         | Carbon black-Surface area   |
| D 3313-74  | 1974         | Carbon black-Individual pellet crush strength   |
| D 3392-75  | 1975         | Carbon black extractables - Light absorption characteristics  |
| D 3493-76  | 1976         | Carbon black-Dibutyl phthalate absorption number of compressed sample   |
| E 228-71   | 1971         | Linear thermal expansion of rigid solids with a vitreous silica dilatometer   |
| <u>AKK</u> | <u>(BRD)</u> |   |
| 001        | 1975         | Bestimmung der Dichte nach der Xylol-Methode  |
| 002        | 1975         | Bestimmung der Wärmeleitfähigkeit nach dem Vergleichsverfahren  |
| 003        | 1975         | Bestimmung des linearen thermischen Ausdehnungskoeffizienten  |
| 004        | 1975         | Bestimmung der Biegefestigkeit nach der 3-Punkt-Methode   |
| 005        | 1975         | Bestimmung der Druckfestigkeit  |
| 006        | 1975         | Bestimmung des Aschewertes  |
| 007        | 1975         | Bestimmung des Wassergehaltes   |
| 101        | 1976         | Bestimmung der Dichte von Pech  |
| 102        | 1976         | Bestimmung des anthrazenunlöslichen Anteiles  |
| 103        | 1976         | Bestimmung des toluolunlöslichen Anteiles   |
| 104        | 1976         | Bestimmung des chinolinunlöslichen Anteiles   |
| 105        | 1976         | Bestimmung des Verkokungsrückstandes  |
| 201        | 1978         | Qualitative röntgenografische Charakterisierung des mikrostrukturellen Ordnungszustandes von Kohlenstoffprobe                             |
| 202        | 1978         | Röntgenografische Bestimmung des mittleren Schichtebenenabstandes in c-Richtung von Kohlenstoffen   |
| 203        | 1975         | Röntgenografische Bestimmung der Kristallitgröße und der Gitterverzerrung in c-Richtung von Kohlenstoffen                                 |
| 204        | 1975         | Röntgenografische Bestimmung der Kristallitgröße in a-b-Richtung von Kohlenstoffen  |
| 205        | 1975         | Röntgenografische Bestimmung der Halbwertsbreite der (112)-Interferenz von Kohlenstoffen  |
| 206        | 1975         | Quantitative röntgenografische Bestimmung der hochgeordneten Bereiche in heterogenen Kohlenstoffproben                                    |
| 220        | 1978         | Anwendung der Hellfeldabbildung und der Feinbereichsbeugung zur Charakterisierung von Kohlenstoff durch elektronenmikroskopische Methoden |

| NUMBER                                | YEAR | TITLE  |
|---------------------------------------|------|--|
| 221                                   | 1978 | Anwendung der Dunkelfeldabbildung zur Charakterisierung von Kohlenstoff durch elektronenmikroskopische Methoden                  |
| 222                                   | 1978 | Anwendung der Netzebenenabbildung zur Charakterisierung von Kohlenstoff durch elektronenmikroskopische Methoden                  |
| 260                                   | 1976 | Bestimmung der spezifischen Oberfläche von Kohlenstoffproben aus der Stickstoff-Adsorption und Auswertung nach dem BET-Verfahren |
| 280                                   | 1977 | Bestimmung des elektrischen Widerstandes von Kohlenstoffen und Graphiten bei Raumtemperatur                                      |
| <u>DIN (BRD)</u>                      |      |  |
| 51 045                                | 1976 | Bestimmung der Längenänderung fester Körper unter Wärmeeinwirkung  |
| 51 046                                | 1976 | Bestimmung der Wärmeleitfähigkeit bei Temperaturen bis 1600 °C nach dem Heißdrahtverfahren                                       |
| 51 056                                |      | Bestimmung des offenen Porenraumes   |
| 51 057                                | 1969 | Bestimmung der Dichte körniger und pulverförmiger Stoffe mit dem Pycnometer  |
| 51 065                                | 1976 | Bestimmung der Rohdichte   |
| 51 718                                | 1950 | Bestimmung des Wassergehaltes  |
| 51 719                                | 1967 | Bestimmung des Aschegehaltes   |
| 51 720                                | 1967 | Bestimmung des Gehaltes an fluchtigen Bestandteilen und der Ausbeute an Tiegelkoks   |
| 51 721                                | 1950 | Bestimmung des Gehaltes an Kohlenstoff und Wasserstoff   |
| 51 722                                | 1954 | Bestimmung des Stickstoffgehaltes  |
| 51 724                                | 1975 | Bestimmung des Schwefelgehaltes  |
| 51 725                                | 1955 | Bestimmung des Phosphorgehaltes  |
| 52 612                                | 1973 | Bestimmung der Wärmeleitfähigkeit mit dem Plattengerdt   |
| 52 616                                | 1975 | Bestimmung der Wärmeleitfähigkeit mit dem Wärmestrommessung  |
| 66 131                                |      | Bestimmung der Oberfläche durch Stickstoffadsorption und BET-Auswertung  |
| <u>ISO/R (international)</u>          |      |  |
| 334                                   | 1963 | Bestimmung des Gesamt-Schwefel-Gehaltes  |
| 351                                   | 1963 | Bestimmung des Gesamt-Schwefel-Gehaltes der Steinkohle nach dem Eschka-Verfahren   |
| 926                                   | 1969 | Bestimmung des Gesamt-Schwefel-Gehaltes der Steinkohle nach dem Hochtemperatur-Verbrennungs-Verfahren                            |
| <u>ISO/TC 47/SC 7 (international)</u> |      |  |
| 115(Suisse 13)                        |      | Coke and carbon products used for production of aluminum. Determination of the density in xylene by a pycnometric method         |
| 163(Canada 8)                         | 1975 | Green and calcined coke, determination of ash content  |
| 176(Suisse 22)                        | 1974 | Determination of coking residue  |

| NUMBER         | YEAR | TITLE  |
|----------------|------|--|
| 177(Suisse 23) | 1975 | Density of pitch   |
| 188(France 21) |      | Determination of compounds insoluble in toluene  |
| 190(Sweden 7)  |      | Determination of quinoline insoluble matter content in pitch binder                                |
| 192(Italy 30)  | 1976 | Analysis of the calcined petroleum coke. Determination of the density by air comparison pycnometer |

ITALY

|       |      |   |
|-------|------|---|
| A 4/1 |      | Ash content of carbon and graphite materials  |
| A 8   |      | Cold compressive (crushing) strength of manufactured carbon and graphite articles                               |
| A 9/1 |      | Determination of thermal conductivity   |
| B 1   |      | Real density of carbon and graphite materials   |
| B 5   |      | Cold flexural strength of manufactured carbon and graphite articles   |
| B 8   |      | Mean coefficient of linear thermal expansion of manufactured carbon and graphite articles by dilatometer method |
| ELCA  | 1976 | Determination of the true specific gravity by air comparison pycnometer   |

UNITED KINGDOM

|           |       |  |
|-----------|-------|--|
| RT 8-62   | 1962  | Matter insoluble in toluene                        |
| PT 7-67   | 1967  | Determination of toluene insoluble fraction        |
| PT10-67   | 1967  | Determination of coking residue                    |
| QC 2/8    | 1974? | Determination of real density and specific gravity |
| D 4       | 1957  | Determination of pycnometer density                |
| 200.7/14  | ?     | Thermal conductivity at low temperatures           |
| BMS/EM 69 | 1969  | Transverse breaking strength at room temperature   |

| NUMBER | CLASSIFICATION  | ASTM     | AKK | DIN   | ISO | ITALY | U.K.             |
|--------|---|----------|-----|-------|-----|-------|------------------|
| A.     | <u>PREPARATIVE PROCEDURES</u>   |          |     |       |     |       |                  |
|        | The maximum possible information should be provided such commercial and other constraints that operate at the time of writing |          |     |       |     |       |                  |
| A.1.   | <u>SINGLE COMPONENT MATERIALS</u>   |          |     |       |     |       |                  |
| 1.1.   | Description of source materials   |          |     |       |     |       |                  |
| 2.     | Method used to prepare solid carbon   |          |     |       |     |       |                  |
| 3.     | Thermal treatments including densification processes  |          |     |       |     |       |                  |
| 4.     | Product handling including sample preparation techniques  |          |     |       |     |       |                  |
| A.2    | <u>MULTIPLE COMPONENT MATERIALS</u>   |          |     |       |     |       |                  |
| 2.1.   | Identification of source materials  |          |     |       |     |       |                  |
| 2.     | Solid carbon  |          |     |       |     |       |                  |
| 2.1.   | Resin content of carbon and graphite prepreps by solvent extraction   | C613-67  |     |       |     |       |                  |
| 3.     | Binders and binder precursors   |          |     |       |     |       |                  |
| 3.1.   | Density of pitch  | D1480-62 | 101 |       | 177 |       |                  |
|        |   | D1481-62 |     |       |     |       |                  |
| 2.     | Determination of anthracene insoluble fraction  |          | 102 |       |     |       | RT8-62<br>RT7-67 |
| 3.     | Determination of toluene insoluble fraction   |          | 103 |       | 188 |       |                  |
| 4.     | Determination of quinoline insoluble fraction   | D2318-76 | 104 |       | 190 |       |                  |
| 5.     | Determination of coking residue   | D2416-73 | 105 | 51720 | 176 |       | Pt10-67          |
| 6.     | Determination of softening point (ring and ball method)   |          |     |       |     |       |                  |
| 4.     | Other additives   | D36-76   |     |       | 152 |       |                  |
| 5.     | Impregnants   |          |     |       |     |       |                  |
| 6.     | Method of solid carbon formation  |          |     |       |     |       |                  |
| 7.     | Thermal treatment including densification procedures  |          |     |       |     |       |                  |



| NUMBER  | CLASSIFICATION  | ASTM  | AKK | DIN   | ISO                  | ITALY | U.K. |
|---|---|---|-----|-------|----------------------|-------|------|
| <b>B. SCIENTIFIC CLASSIFICATION OF PROPERTIES</b> |   |   |     |       |                      |       |      |
| <b><u>INDEPENDENT OF THE BULK STRUCTURE</u></b>   |   |   |     |       |                      |       |      |
| <b>B.1. CHEMICAL COMPOSITION</b>                  |   |   |     |       |                      |       |      |
| 1.1.  | Elemental analysis  |   |     |       |                      |       |      |
| 1.1.1.  | Carbon  |   |     | 51721 |                      |       |      |
| 2.  | Hydrogen  |   |     | 51721 |                      |       |      |
| 3.  | Nitrogen  |   |     | 51722 |                      |       |      |
| 4.  | Sulfur  |   |     |       |                      |       |      |
| 5.  | Carbon black - pH value                                     | D1512-75  |     |       |                      |       |      |
| 1.2.  | Compound analysis   |   |     |       |                      |       |      |
| 2.1.  | Chemical analysis of carbon and carbon ceramic refractories | C571-70   |     |       |                      |       |      |
| 2.  | Chemical analysis of carbon and graphite                    | C560-77   |     | 51725 |                      |       |      |
| 3.  | Combustion analysis   |   |     |       |                      |       |      |
| 3.1.  | Ash content   | C561-69<br>D1506-75<br>D1553-64<br>D2866-70<br>D1619-77 | 006 | 51719 | 163                  | A4/1  |      |
| 2.  | Sulfur content  |   |     | 51724 | R334<br>R351<br>R926 |       |      |
| 4.  | X-ray fluorescence analysis                                 |   |     |       |                      |       |      |
| 5.  | Optical spectroscopic analysis                              |   |     |       |                      |       |      |
| 5.1.  | Carbon black - light absorption characteristics             | D3392-75  |     |       |                      |       |      |
| 6.  | Moisture  | C562-69<br>D1509-75<br>D1553-64<br>D2867-70             | 007 | 51718 |                      |       |      |
| 7.  | Volatile carbonaceous matter                                |   |     |       |                      |       |      |
| 8.  | Thermal neutron absorption cross section                    | C626-71<br>C561-69<br>C560-77                           |     |       |                      |       |      |
| 8.1.  | Ash content   |   |     |       |                      |       |      |
| 2.  | Boron content   |   |     |       |                      |       |      |

| NUMBER | CLASSIFICATION   | ASTM    | AKK | DIN   | ISO | ITALY | U.K.  |
|--------|--|---------|-----|-------|-----|-------|-------|
| B.2.   | ATOMIC CONFIGURATION (deviation from the ideal graphite, lattice, defect concentration, description as elemental layer stacks) |         |     |       |     |       |       |
|        | Microstructure at temperatures below the previous HTT as far as can be measured by   |         |     |       |     |       |       |
| 2.1.   | X-ray diffraction methods  |         |     |       |     |       |       |
| 1.1.   | Qualitative characterization of microstructure   | 201     |     |       |     |       |       |
| 2.     | Determination of interlayer spacing $c/2$  | C558-69 | 202 |       |     |       |       |
| 3.     | Determination of coherent scattering areas in c-direction and lattice distortion   |         | 203 |       |     |       |       |
| 4.     | Determination of coherent scattering areas in a-b-direction  |         | 204 |       |     |       |       |
| 5.     | Determination of the half-width of (112)-interference  |         | 205 |       |     |       |       |
| 6.     | Quantitative determination of content of high ordered areas in heterogeneous samples   |         | 206 |       |     |       |       |
| 2.     | Electron diffraction methods   |         |     |       |     |       |       |
| 3.     | Neutron diffraction methods  |         |     |       |     |       |       |
| 4.     | Transmission electron microscopy   |         |     |       |     |       |       |
| 4.1.   | High resolution TEM  |         |     |       |     |       |       |
| 1.1.   | Bright-field imaging   |         | 220 |       |     |       |       |
| 2.     | Dark-field imaging   |         | 221 |       |     |       |       |
| 3.     | Lattice imaging  |         | 222 |       |     |       |       |
| 2.     | Conventional TEM   |         |     |       |     |       |       |
| 5.     | Optical reflexion microscopy   |         |     |       |     |       |       |
| 6.     | Powder density   |         |     |       |     |       | QC2-8 |
| 6.1.   | Helium density   |         |     |       |     |       | D4    |
| 2.     | Xylene density   | C604-67 | 001 | 51056 | 115 | B1    |       |
|        |  |         |     | 51057 |     |       |       |
| 3.     | Air density  |         |     |       | 192 | ELCA  |       |

| NUMBER | CLASSIFICATION  | ASTM     | AKK | DIN | ISO | ITALY | U.K.    |
|--------|---|----------|-----|-----|-----|-------|---------|
| B.3.   | <u>MICROSTRUCTURAL CHANGES DURING HTI</u>                                 |          |     |     |     |       |         |
| 3.1.   | In situ measurement of X-ray diffraction behaviour up to 2900 K           |          |     |     |     |       |         |
| 2.     | Measurement of reversible and irreversible thermal expansion up to 2900 K |          |     |     |     |       |         |
| B.4.   | <u>MICROSTRUCTURAL CHANGES DURING IRRADIATION</u>                         |          |     |     |     |       |         |
| 4.1.   | Magnetic susceptibility   |          |     |     |     |       |         |
| 2.     | ESR   |          |     |     |     |       |         |
| 3.     | Specific Heat   |          |     |     |     |       |         |
| B.5.   | <u>CHEMICAL REACTIVITY</u>  |          |     |     |     |       |         |
| 5.1.   | Enthalpy of reaction  |          |     |     |     |       |         |
| 2.     | Enthalpy of solution  |          |     |     |     |       |         |
| 3.     | Enthalpy of adsorption  |          |     |     |     |       |         |
| 4.     | Reactivity and reaction kinetics  |          |     |     |     |       |         |
| 4.1.   | Chemical reactivity in liquid oxidizing media                             |          |     |     |     |       |         |
|        | <u>PROPERTIES DEPENDENT ON DIMENSION</u>                                  |          |     |     |     |       |         |
| C.1.   | <u>GRANULARITY AND HETEROGENEITY</u>                                      |          |     |     |     |       |         |
| 1.1.   | Size distribution   |          |     |     |     |       |         |
| 1.1.   | Particle size distribution of granular activated carbon                   | D2862-70 |     |     |     |       |         |
| 2.     | Carbon black-Pellet size distribution                                     | D1511-74 |     |     |     |       |         |
| 3.     | Carbon black-Sieve residue  | D1514-74 |     |     |     |       |         |
| 2.     | Optical microscopy  |          |     |     |     |       |         |
| 3.     | Electron microscopy   |          |     |     |     |       |         |
| C.2.   | <u>ANISOTROPY REGARDING ATOMIC CONFIGURATION</u>                          |          |     |     |     |       |         |
| 2.1.   | X-ray diffraction methods   |          |     |     |     |       |         |
| 2.     | Optical properties  |          |     |     |     |       |         |
| 3.     | Electrical resistivity (4-point method)                                   | C611-77  | 280 |     |     |       |         |
| 4.     | Dynamic elastic modulus   |          |     |     |     |       |         |
| 4.1    | Elastic modulus and resonance frequencies by a sonar method               |          |     |     |     |       | C747-74 |

| NUMBER | CLASSIFICATION   | ASTM     | AKK | DIN   | ISO | ITALY | U.K.     |
|--------|--|----------|-----|-------|-----|-------|----------|
| C.2.5. | Thermal expansion  |          |     |       |     |       |          |
| 5.1.   | Linear thermal expansion coefficient                                   | E228-71  | 003 | 51045 |     | B8    |          |
| 6.     | Lubricating qualities  | D1367-64 |     |       |     |       |          |
| C.3.   | POROSITY AND DENSITY (separation of atomic configuration is essential) |          |     |       |     |       |          |
| 3.1.   | Density  |          |     |       |     |       |          |
| 1.1.   | Bulk density   | C559-77  |     | 51065 |     |       |          |
| 2.     | Geometric density  | C559-77  |     |       | 192 | ELCA  |          |
| 3.     | Density in air   | C493-70  |     |       |     |       |          |
| 4.     | Mercury density  | C604-67  |     |       |     |       |          |
| 5.     | Helium density   | D2854-70 |     |       |     |       |          |
| 6.     | Apparent density   | D1513-74 |     |       |     |       |          |
| 7.     | Carbon black-Pour density  |          |     |       |     |       |          |
| 3.2    | Porosity   |          |     |       |     |       |          |
| 2.1.   | Total open pore volume   | C20-74   |     |       |     |       |          |
| 1.1.   | Helium density   | C604-76  |     |       |     |       |          |
| 2.     | Water absorption   | C20-74   |     | 51056 |     |       |          |
| 3.     | Mercury porosity   | C493-70  |     |       |     |       |          |
| 3.3.   | Pore size distribution   |          |     |       |     |       |          |
| 4.     | Shape of pores   |          |     |       |     |       |          |
| 5.     | Surface area   | D3037-76 |     |       |     |       |          |
| 5.1.   | Nitrogen adsorption and BET-evaluation                                 | C819-77  | 260 | 66131 |     |       |          |
| 2.     | Liquid phase evaluation of activated carbon                            | D2355-70 |     |       |     |       |          |
| C.4.   | PHYSICAL BULK PROPERTIES   |          |     |       |     |       |          |
| 4.1.   | Thermal properties   |          |     |       |     |       |          |
| 1.1.   | Thermal expansion  | E228-71  | 003 | 51045 |     | B8    |          |
| 2.     | Thermal conductivity   |          |     |       |     |       |          |
| 2.1.   | Comparison method  |          | 002 | 51612 |     | A9/1  | 200.7-14 |
|        |  |          |     | 51616 |     |       |          |
| 2.     | Thermal pulse method   | C714-72  |     |       |     |       |          |
| 3.     | Hot wire method  |          |     |       |     |       |          |
| 4.2.   | Electrical properties  |          |     |       |     |       |          |
|        |  |          |     | 51046 |     |       |          |

| NUMBER     | CLASSIFICATION  | ASTM     | AKK | DIN | ISO | ITALY | U.K.   |
|------------|---|----------|-----|-----|-----|-------|--------|
| C.4.2.1.1. | Electrical resistivity at room temperature                            | D611-77  | 280 |     |     |       |        |
| 4.3.       | Magnetic properties   |          |     |     |     |       |        |
| 3.1.       | Magneto-resistance  |          |     |     |     |       |        |
| 2.         | Hall coefficient  |          |     |     |     |       |        |
| 3.         | Magnetic susceptibility   |          |     |     |     |       |        |
| 4.4.       | Mechanical properties   |          |     |     |     |       |        |
| 4.1.       | Breakage strength   | C651-70  | 004 |     |     | B5    | BMS/EM |
| 2.         | Tensile strength  | C565-71  |     |     |     |       |        |
|            |   | C749-73  |     |     |     |       |        |
| 3.         | Compressive strength  | C695-75  | 005 |     |     | A8    |        |
| 3.1.       | Carbon black-Individual pellet crush strength                         | D3313-74 |     |     |     |       |        |
| 4.         | Shear modulus   |          |     |     |     |       |        |
| C.5.       | <u>BEHAVIOUR DURING HEAT TREATMENT</u>                                |          |     |     |     |       |        |
| C.6.       | <u>SURFACE PROPERTIES</u>   |          |     |     |     |       |        |
| 6.1.       | Optical (total spectrum of wave length)                               |          |     |     |     |       |        |
| 2.         | Thermal radiation   |          |     |     |     |       |        |
| 3.         | Adsorption  |          |     |     |     |       |        |
| 3.1        | Carbon black-Iodine absorption number                                 | D1510-76 |     |     |     |       |        |
| 2.         | Carbon black-Dibutyl phthalate absorption number                      | D2414-76 |     |     |     |       |        |
| 3.         | Carbon black-Dibutyl phthalate absorption number of compressed sample | D3493-76 |     |     |     |       |        |
| 4.         | Chemical reactivity   |          |     |     |     |       |        |