



CURRENT PROGRAMMES OF METALLURGY DIVISION - 1991

1991

B.A.R.C. - 1538

GOVERNMENT OF INDIA
ATOMIC ENERGY COMMISSION

B.A.R.C. - 1538

**CURRENT PROGRAMMES OF METALLURGY DIVISION
(1991)**

BHABHA ATOMIC RESEARCH CENTRE
BOMBAY, INDIA

1991

BIBLIOGRAPHIC DESCRIPTION SHEET FOR TECHNICAL REPORT

(as per IS : 9400 - 1980)

01	Security classification :	Unclassified
02	Distribution :	External
03	Report status :	New
04	Series :	B.A.R.C. External
05	Report type :	Technical Report
06	Report No. :	B.A.R.C.-1538
07	Part No. or Volume No. :	
08	Contract No. :	
10	Title and subtitle :	Current programmes of Metallurgy Division (1991)
11	Collation :	17 p.
13	Project No. :	
20	Personal author(s) :	
21	Affiliation of author(s) :	
22	Corporate author(s) :	Bhabha Atomic Research Centre, Bombay-400 085
23	Originating unit :	Metallurgy Division, B.A.R.C., Bombay
24	Sponsor(s) Name :	Department of Atomic Energy
	Type :	Government
30	Date of submission :	January 1991
31	Publication/Issue date :	January 1991

Contd... (ii)

(ii)

40 Publisher/Distributor : Head, Library and Information
Division, Bhabha Atomic Research
Centre, Bombay-400 085

42 Form of distribution : Hard copy

50 Language of text : English

51 Language of summary : English

52 No. of references :

53 Gives data on :

60 Abstract : Current research and development programmes of the Metallurgy Division are listed under the headings: 1) Thrust Areas, 2) High Temperature Materials Section, 3) Chemical Metallurgy Section, 4) Metallurgical Thermochemistry Section, 5) Physical Metallurgy Section, 6) Mechanical Metallurgy Section, 7) Corrosion Metallurgy Section, 8) Electrochemical Science and Technology Section, 9) Ceramics Section, and 10) Fabrication and Maintenance Group. A list of equipment in the Division and a list of scientific personnel of the Division are also given.

70 Keywords/Descriptors : RESEARCH PROGRAMS; EXTRACTIVE METALLURGY;
PHYSICAL METALLURGY; RARE EARTH ALLOYS; ZIRCONIUM ALLOYS;
MICROSTRUCTURE; CORROSION; CERAMICS; SUPERCONDUCTORS; BARC

71 Class No. : B22.00; B23.00

99 Supplementary elements :

CURRENT PROGRAMMES OF METALLURGY DIVISION - 1991

Preface

The report presents a brief summary of the major ongoing R & D programmes and a list of equipment and scientific personnel of Metallurgy Division, B.A.R.C., Bombay. Only the main objectives and end use of each programme have been highlighted. The programmes are divided in two parts namely, i) thrust areas and ii) other activities in the different Sections of the Division. The R & D programmes included in thrust areas are expected to meet the immediate requirements of several projects of the Department of Atomic Energy. The main emphasis in the other R & D activities of the Division is to generate basic scientific information in different areas of metallurgy and materials science.

(S. Banerjee)

CURRENT PROGRAMMES OF METALLURGY DIVISION - 1991

THRUST AREAS

1.01 PYROCHEMICAL SEPARATION OF ZIRCONIUM AND HAFNIUM

Pilot plant studies on (i) electrothermal fluid bed chlorination of zircon sand to yield chlorides of Zr and Hf, (ii) purification of the mixed chlorides by fused salt scrubbing and (iii) extractive distillation for pyrochemical separation of Zr and Hf chlorides.

To generate design and operational data for further scaling up.

1.02 PRODUCTION OF NUCLEAR GRADE CALCIUM

Bench scale study on preparation of high purity Ca in Kg batches by aluminothermic reduction of lime in vacuum followed by distillation of the reduced metal in vacuum.

To prepare high purity Ca for its use in the reduction of nuclear and rare earth metal compounds.

1.03 RECOVERY OF METAL VALUES FROM SECONDARY RESOURCES

Laboratory scale investigations on the recovery of critical metal values from various secondary resources like spent catalyst, pickling sludge, hard metal slime, slags, grinding dust, spent acid, scrap etc. by hydro- and pyrometallurgical techniques.

To develop technology for the recovery of strategic metals like Ni, Co, V, Mo, Nb, Ta and W from industrial wastes.

1.04 EXTRACTIVE METALLURGY OF REFRACTORY METALS

Basic and applied studies on extraction and refining of refractory metals/alloys belonging to groups IV to VI.

To develop processes more efficient and more suited under indigenous conditions as an alternate to conventional route.

1.05 RARE EARTH METALS AND ALLOYS

Studies on preparation of rare earth metals/alloys by

metallothermic reduction and fused salt electrolysis.

To establish process parameters for production of RE alloys like Y-Mg, Nd-Fe-B, La-Ni and Ce-Co.

1.06 PLASMA AND ELECTRON BEAM APPLICATIONS IN EXTRACTIVE METALLURGY

Setting up of an induction coupled plasma furnace and its use in the ultra high temperature processing of minerals and compounds under neutral/oxidising/reducing conditions as well as commissioning of a 100 KW electron beam melting furnace for refining of Nb/Ta.

To establish indigenous technology for the plasma and electron beam processing of refractory materials.

1.07 DEVELOPMENT OF SHAPE MEMORY ALLOYS

Development of fabrication flowsheets and studies on martensitic transformation, bio compatibility and other characteristics of Cu-Zn-Al and Ni-Ti type shape memory alloys.

Development of fabrication flowsheets of shape memory alloys and demonstration of their nuclear and medical applications.

1.08 FABRICATION-MICROSTRUCTURE-PROPERTY CORRELATION IN Zr ALLOYS

Basic studies to determine the influence of texture, transformations, interstitial and substitutional solutes, grain size, second phase precipitation and methods of fabrication on the mechanical properties of Zr based alloys.

For better understanding of Zr alloys and development and modification of fabrication processes.

1.09 RESEARCH AND DEVELOPMENT WORK FOR 500 MWe PHWR

Studies on (i) effect of composition, homogeneity, microstructure, texture, thermal aging on mechanical properties of pressure tube materials (ii) out of pile creep and corrosion tests of fuel and pressure tube materials (iii) low cycle fatigue and fracture toughness studies and (iv) mechanical property characterization of end fitting materials.

To assess the service performance of Zr alloys and other structural materials for 500MWe PHWR.

1.10 CORROSION AND HYDRIDING BEHAVIOUR OF ZIRCONIUM ALLOYS

Studies on (i) high temperature aqueous corrosion, (ii) oxide build up and hydrogen pick up on Zr-2.5Nb alloy, (iii) effect of impurity elements in zircalloys (iii) composition - microstructure correlations brought about by alloy phase distribution in the matrix, (v) compatibility of graphite coated zircaloy tubes (vi) hydrogen charging at elevated temperatures using salt bath, (vii) mechanical/corrosion property evaluation due to hydriding of zircalloys and Zr-2.5Nb alloy (viii) hydrogen migration due to stress and thermal effects and (ix) compatibility of Zr-Nb-Cu garter spring material.

To generate basic corrosion data of nuclear materials and to develop preventive measures.

1.11 IN-PILE EXPERIMENTS - CREEP AND CORROSION

Development of experimental facilities and studies on in-pile creep and corrosion behaviour of zirconium alloys using Dhruva Reactor.

To generate in-pile creep and corrosion data for pressure tube and cladding tube materials.

1.12 HIGH TEMPERATURE OXIDE SUPERCONDUCTORS

Studies on (i) bulk synthesis of high T_c oxides (ii) different fabrication techniques to improve the critical current density and (iii) correlation between superconducting properties and microstructure using optical and electron microscopy.

To generate basic information on synthesis of high T_c superconductors and their properties and fabrication processes.

1.13 CERAMIC-METAL JOINING FOR UHV APPLICATIONS

Process developments for production of (i) ceramic feed throughs for vacuum applications and (ii) ceramic to metal joints.

Technology development for applications in various DAE units.

OTHER ACTIVITIES

2. HIGH TEMPERATURE MATERIALS SECTION

2.1 FUSED SALT ELECTROREFINING OF ZIRCONIUM ALLOY SCRAP

Laboratory and pilot plant studies on recovery of Zr from various Zr bearing scraps like Zircaloy-2 and Zr-2.5Nb (generated during fuel and pressure tube fabrication) by molten salt electrorefining in NaCl-KCl-ZrCl₄ electrolyte.

To develop molten salt electrorefining as a possible route for direct recovery of nuclear grade Zr metal from off grade scrap which cannot be recycled by conventional routes.

2.2 BORON AND BORON PRODUCTS

Laboratory and pilot plant studies on the production of various boron bearing products like B, B₄C, boron, boron nitride, BN etc.

To supply boron bearing products for nuclear and defence applications.

2.3 HAFNIUM DEVELOPMENT PROGRAMME

Bench scale studies on preparation of high purity Hf by calciothermic reduction of HfO₂ to metal powder followed by its consolidation by vacuum sintering and final purification by iodide crystal bar technique.

To establish process parameters as well as to produce sufficient Hf feed stock for its fabrication to control rod of specific designs.

2.4 MINERAL PROCESSING

Studies on hydro and pyrometallurgical processing of various minerals like wolframite, zircon and ilmenite for upgrading as well as extracting the metal values.

To develop process flowsheets for chemical upgrading of minerals.

2.5 VAPOUR DEPOSITION

Studies on both physical and chemical vapour deposition of various metallic and non metallic coatings on substrates for specific wear and corrosion resistant applications.

To develop coating technology involving chemical and

physical vapour deposition processes.

2.6 TIN DEVELOPMENT PROGRAMME

(i) Laboratory studies and pilot scale processing of Nb & Ta bearing Indian cassiterite for recovering Sn, Nb & Ta by caustic fusion and reduction roasting processes followed by aqueous leaching and (ii) Studies on processing of Sn smelting slags for recovering Sn, Nb and Ta.

Technology development for commercial processing of high Nb-Ta cassiterite.

3 CHEMICAL METALLURGY SECTION

3.1 LOW CARBON FERRO ALLOYS

Studies on the development of aluminothermic reduction technique for the production of low carbon speciality ferroalloys like FeTi, FeV, FeNb, FeCr, FeMo, FeW and FeB from indigenous resources.

To develop technology for ferroalloys productions.

3.2 CARBON BASED COATINGS

Laboratory and semi pilot plant scale development of carbon based coating techniques for various nuclear materials.

To meet the demand for carbon coated nuclear materials for specific applications in nuclear reactors, heavy water plants and radioactive material storage.

3.3 RECOVERY OF PRECIOUS METALS

Studies on recovery of precious metals like Ag and Pt from various secondary resources like analytical residue scrap and photographic effluents.

To develop efficient processes for quantitative recovery of precious metals of high purity.

4 METALLURGICAL THERMOCHEMISTRY SECTION

4.1 OXIDATION AND NITRIDATION OF NICKEL AND ZIRCONIUM ALLOYS

Studies on kinetics and mechanism of oxidation and nitridation of Ni and Zr based alloys between 900 and 1500K by thermogravimetric, ESCA, AES and SEM investigations.

To ascertain service behaviour of inconel, zircaloy-2 and

Zr-2.5 Nb alloys and to generate basic kinetic data.

4.2 COMPILATION AND EVALUATION OF PHASE DIAGRAMS OF TANTALUM BINARIES

(i) Compilation of the published work (ii) Derivation of thermodynamic and phase diagram data using suitable binary solution models and (iii) Supplement with experimental work, if necessary.

The programme is sponsored by the American Society of Metals and The Indian Institute of Metals to generate critically evaluated phase diagram and thermodynamic data.

4.3 HIGH TEMPERATURE DIFFUSION AND PHASE DIAGRAM STUDIES

Experimental determinations of phase diagram and diffusion data for M-Cr (M=Zr, Hf, Nb and Ta) and Zr-Nb systems between 1000 and 2500K using the spot technique and EPMA.

To develop a new technique for high temperature diffusion studies. Information on Zr-Nb system is required for modification of melting schedule of Zr-2.5Nb ingot at NFC.

4.4 THERMODYNAMIC PROPERTIES OF METAL-CARBON SYSTEMS BY ISOPIESTIC TECHNIQUE

(i) Determination of carbon potentials of intermediate compounds and solid solutions in the M-C systems (viz. Cr-C, V-C, Fe-Cr-C and Fe-Ni-C) using isopiestic technique and (ii) Studies on influence of oxygen on carbon potentials.

To generate basic thermodynamic data. These investigations would also help in perfecting isopiestic technique for measurements of carbon potentials of more complex systems such as mixed carbide fuels for FBR.

4.5 DEOXIDATION AND DENITRIDATION STUDIES OF GROUPS IV & V METALS AND THEIR ALLOYS

(i) Determination of oxygen and nitrogen potentials in refractory metals and their alloys (ii) Development of flow-sheets for production of Nb and Ta by carbonitrothermic process and (iii) Studies on mechanism of purification of Zr-Nb-O-N alloys by pyrovacuum treatments.

Most of these thermodynamic data are important in establishing process parameters for production of Nb, Ta and Zr-Nb alloys at NFC.

4.6 KINETICS OF PHASE TRANSFORMATIONS BY DSC

Studies on kinetics and energetics of phase transformation and precipitation in metglass and other Fe based alloys by DSC.

To generate basic thermophysical data on phase transformations and its applications in standardisation of heat treatment schedule of Maraging 350.

5 PHYSICAL METALLURGY SECTION

5.1 AMORPHOUS, QUASICRYSTALLINE AND MICROCRYSTALLINE ALLOYS PRODUCED BY RAPID SOLIDIFICATION

(i) Preparation of rapidly solidified alloys by melt spinning, (ii) Microstructures, crystallization kinetics and diffusion studies on rapidly solidified Zr, Ti, and Al based alloys and intermetallic compounds, (iii) computer simulation of quasi-crystalline and nearly crystalline structures.

To generate basic data on alloys in different states of crystalline order and structure-property correlation in these metastable systems.

5.2 SOLID STATE BONDING AND DIFFUSION STUDIES IN ZIRCONIUM AND TITANIUM ALLOYS

Studies on (i) diffusion bonding of zircaloy-2/zircaloy-2, zircaloy-2/Ti, zircaloy-2/Cu alloys, Zr alloys/SS, Ti/Fe and (ii) diffusion in Zr-Fe-Ni and Ti-Zr systems.

To establish diffusion bonding as an alternate to conventional welding and to generate basic information about the role played by intermetallic phases in the diffusion bonding process.

5.3 ALLOYS FOR HEAVY WATER PLANTS

Studies on microstructure, mechanical properties and corrosion resistance of structural alloys used in heavy water plants.

To carry out surveillance and failure analysis of various structural components of heavy water plants.

5.4 ORDERING OF ALLOYS

Studies on (i) order-disorder transformation and the formation of long period and quasiperiodic superlattices in binary and ternary alloy systems of Al, Ti, Ni and Mo and

(ii) phase transformations in Zr, Al, Ti, Al, Zr-Pe and Al-Hf-Si systems.

To generate basic information about atomistic processes occurring during order-disorder transformation in alloys.

5.5 RADIATION AND DEFORMATION INDUCED MICRO STRUCTURAL CHANGES

Studies on (i) ion irradiation on the ordering of Ni-Mo alloys and (ii) deformation induced microstructural changes of Zr-Nb and Ni alloys.

To establish radiation and deformation induced microstructure-property relationships.

5.6 UTILISATION AND MAINTENANCE OF IMAGING SPECTROSCOPY FACILITIES

Operation and maintenance of TEM, EPMA, SEM, AES/XPS and optical microscopes.

Facilities are available to provide sample analysis for various DAE units and other research institutions and to provide support to the Divisional R & D programmes.

6 MECHANICAL METALLURGY SECTION

6.1 STRUCTURAL STEELS IN NUCLEAR INDUSTRIES

Microstructure characterisation and evaluation of mechanical properties of turbine blade steels, 9Cr-1Mo steel, 3.5Ni steel and 5Ni-steel.

To generate basic data on microstructure-property correlation of structural steels for nuclear programmes.

6.2 CHARACTERISATION OF LASER TREATED MATERIALS

Studies on (i) laser surface alloying of chromium and mild steel and (ii) surface treatments by laser induced transformation hardening or melting.

To develop laser induced surface treatment techniques for specific applications.

7 CORROSION METALLURGY SECTION

7.1 CORROSION STUDIES IN SS AND NI BASED ALLOYS

Studies on (i) IGC/SCC/Pitting on austenitic and duplex SS, Inconel 600/690 and Incoloy 800, (ii) degree of

sensitization of SS and welding parameters for SS and Ni based alloys (iii) oxidation resistant intermetallic coatings and (iv) bio compatibility of SS and Zr based alloys.

To assess corrosion behaviour of nuclear materials and suggest corrosion prevention measures.

7.2 CHARACTERISATION OF MAGNETITE ON CARBON STEELS

Studies on (i) magnetite growth kinetics in high temperature (200-300 C) water and effect of environmental parameters, (ii) evaluation of hot conditioning of PHWR components and (iii) dissolution kinetics for chemical formulation.

Characterisation of magnetite on carbon steel components of PHWRs.

7.3 AQUEOUS CORROSION AND ITS INHIBITION

Studies on corrosion and its inhibition of high moly SS and alloys of Ti and Cu in salt media, SS in mineral acids and carbon steel in decontaminating chemicals.

To assess corrosion behaviour of condenser tube materials and decontamination aspects of power reactor components.

7.4 MATERIAL TESTING, FAILURE ANALYSIS AND CORROSION SERVICE

In situ metallographic examination of fabricated SS 304 L structural components, IGC/SCC and electrochemical tests, ASTM Std and non-std tests.

Materials testing, specification tests, corrosion failure analysis and consultancy for DAE units.

8 ELECTROCHEMICAL SCIENCE AND TECHNOLOGY SECTION

8.1 ELECTRO AND ELECTROLESS DEPOSITION AND ELECTROFORMING

Studies on (i) electrodeposition of Ni-Mo alloys, (ii) electroless plating of Ni, (iii) electroforming of Ni-Y₂O₃ composites and (iv) anodization of zircaloy-2.

To establish optimum process parameters for plating processes and their applications in providing corrosion, oxidation, friction and wear resistance surfaces.

8.2 METAL COATINGS FOR OPTICAL APPLICATIONS

Studies on electro and electroless coatings of Ni, brass, Cu and Al on a variety of substrates to obtain high laser threshold with highly reflective surface finish.

These coated metals find many strategic applications and are required in the Laser and Plasma Tech. Division of BARC.

8.3 DEVELOPMENT OF COATINGS FOR USE IN FBTR

Studies on (i) electroplating of Cr on SS and (ii) evaluation of wear characteristics of the coated surfaces.

To develop different coating systems for components used in FBTR and PHWR.

9 CERAMICS SECTION

9.1 ESTABLISHMENT OF HIGH TEMPERATURE FACILITIES

A graphite resistance furnace with a hearth of 80 mm dia and 80 mm height and capable of attaining 2000 C and a gas fired furnace with a hot zone of about 30 cm have been designed and are being fabricated.

Necessary facilities for R & D in advanced ceramics.

9.2 MICROSTRUCTURES, MECHANICAL PROPERTIES AND SINTERABILITY OF CERAMICS

Studies on (i) lattice defect characterisation of Mg-PSZ using thermally simulated depolarization current (ii) preparation of alumina dispersed Y-TZP powders by co-precipitation method (iii) microstructures of superconducting oxides and ZrO₂ by TEM (iv) sintering of sillimanite powder compacts and (v) preparation of micron size high purity alumina powders.

To generate basic data on microstructure-sinterability correlation of advanced ceramics.

9.3 PRODUCTION OF ALUMINA WARE, MACHINABLE CERAMICS AND TOUGHENED CERAMICS

Development of flow sheets for preparation of machinable ceramics, high alumina shapes and toughened zirconia.

To meet in-house requirements of specialized ceramic shapes and compounds.

10 FABRICATION AND MAINTENANCE GROUP

10.1 WORKSHOP SERVICES

(i) Designing and fabrication of equipment, structures and experimental facilities and (ii) general maintenance of the mechanical and electrical equipment in the Division.

To provide support for the ongoing R & D programmes of the Division.

10.2 DEVELOPMENT OF HYDROSTATIC EXTRUSION PROCESS AND EQUIPMENT

Studies on extrusion process for brittle, composites and shape memory alloys by using hydrostatic extrusion (generating 770 MPa) machine built inhouse.

To generate basic and applied data on extrusion processes.

LIST OF EQUIPMENT IN THE METALLURGY DIVISION

(* - In-house built equipment/facilities)

PROCESS METALLURGICAL EQUIPMENT

- * Electrothermal Fluidised Bed Reactor
- * 12 Stage Extractive Distillation Facility
- * 12KW Hydrogen Reduction Furnace
- * Inert Atmosphere Electrolytic cells
- Four High Rolling Mill
- 20 Ton Hydraulic Press

MICROSCOPY, SPECTROSCOPY AND DIFFRACTION

Transmission Electron Microscope (200 kV)
Transmission Electron Microscope (125 kV)
Scanning Electron Microscope with EDS Facility
Electron Probe Microanalyser with WDS Facility
Light Microscopes
Auger Electron Spectrometer
x-ray Photoelectron Spectrometer
X-ray Diffractometers

MECHANICAL TESTING EQUIPMENT

5 Ton Instron Universal Testing Machine
10 Ton Servo-Hydraulic Fatigue Machine
Hardness and Impact Testing Machines

THERMOANALYSERS

METTLER Thermoanalyser (10 micro g, 1500 C)
SETARAM Thermoanalyser (1 micro g, 2400 C)
SETARAM DSC

CORROSION AND ELECTROCHEMICAL STUDIES

DC and Pulse Power Supplies
Thickness Tester (Eddy current Type)
Couloscope
Spiral Contractometer
Adhesion Tester
Tribotester
Potentiostats/Integrated Electrochemical systems

1/2 Ton Tensile and Stress Corrosion testing machines
1 Ton Corrosion Fatigue Testing Machines
Metal Sensitization Detector
Autoclaves
High Temperature Electrochemical Assembly.

PRODUCTION AND CHARACTERIZATION OF CERAMICS

Vibratory Grinding and Ball Mills
Hydraulic, Extrusion and Isostatic Compaction Press
Injection Moulding and Slip Casting Facilities
Sedigraph 5000D
Pycnometer
Dilatronic V S (Theta Ind)
Laser Flash Thermal Diffusivity Apparatus
Porosimeter 9200
Hot-Stage Microscope (Leitz)
* 100W CO₂ Laser for Ceramic Machining.

FURNACES

15 KW Electron Beam Melting Furnace
* 4 KW Electron Bombardment Furnace (10⁻⁹ torr, 2200 C)
Silicon Carbide Vacuum Furnace
* 12 KW Pit Type Furnace
* Pt-Rh and Mo Resistance Furnaces
Vacuum Induction Melting Furnaces

MISCELLANEOUS

Workshop Facilities ■
Vacuum Hot Press (30 ton, 1600 C)
* Hydrostatic Extrusion Machine (770 MPa)
* Melt Spinning Facility

SCIENTIFIC PERSONNEL OF THE METALLURGY DIVISION

Dr.S. Banerjee, Head of the Division

MECHANICAL METALLURGY SECTION	PHYSICAL METALLURGY SECTION	CHEMICAL METALLURGY SECTION	HIGH TEMPERATURE MATERIALS SECTION
Shri P.Das Gupta Dr.G.P.Tiwari Shri I.S. Batra Shri Jugraj Singh	Head Dr.P. Mukhopadhyaya Shri Lalik Kumar Dr.M.Sundaraman Dr.G.K.Dey Shri U.D. Kulkarni Dr.S.K. Sharma Shri K. Madangopal Shri R Tiwari Shri R.T. Savalia	Head Dr.T.K. Mukherjee Shri I.G.Sharma Shri R.C.Hubli Shri S. Adhikari Shri S.P. Biswas Shri P.P. Shukla Smt. L.S. Thomas Shri P.R. Menon Shri S.P.Chakraborty Smt. P.Alex Shri V.S.Bhave	Head Shri D.K.Bose Shri R.S.Babu Shri T.S.Krishnan Dr.J.C.Sehra Shri A.K. Suri Shri Sohan Singh Shri P.L. Vijay Dr.D.Sathiyamoorthy Dr.J.M. Juneja Shri O.K.Mehra Shri V.D.Shah Shri M.G.Rajayadhyaksha Shri C. Subramanian
Dr.T.K. Sirha Shri R.N.Tank Shri R. Kishore Shri R.N. Singh Shri A.B. Tamhane	Shri S.K.Khera Shri G.B. Kale Dr.R.V.Patil Shri K.Bhanumurthy		
Shri V.V. Raman Shri J.K.Chakravarty Shri A. Haq Dr.S.L. Wadekar	Dr.G.E.Prasad Shri M.D. Vora Shri E.G. Baburaj	METALLURGICAL THERMOCHEMISTRY SECTION Dr.S.P.Garg Shri R. Venkataramani Shri N.Krishnamurthy Shri Y.J. Bhatt Dr.P.K.K.Nayar Dr. S. Mishra Shri R.V.Muraleedharan Shri Alok Awasthi	Head Shri A.C.Bidaye Dr.K.U.Nair Shri P.K.Rajagopalan Shri R.H. Rakhasia Shri S.M. Shetty Shri P.K. Tripathy Shri V.H Bafna Shri P.Mishra Shri A.K. Arya Shri Kulwant Singh Shri R.P. Tangri Shri R.D. Bedse Shri I.D. Walile Smt.Ramani Venugopalan
Dr.C.N. Rao Shri M.C. Saxena Dr.(Smt.)Uma Naik Shri M. Unnikrishnan Smt. A.J. Haq Shri S.A. Moorthy	Dr.S.J.Vijayakar Shri M.B.Vasan Shri D. Sr.vastava Shri N.T. Parekh Smt. J. Gupta		
CORROSION METALLURGY SECTION Dr.H.S. Gadiyar Dr.P.K. De Shri S.S.Chouthai Dr.S.V.Phadnis Shri G.C.Palit Dr.P.R.Shibad Shri N.S.D.Elayathyu Dr.P.R.Singh Shri S.K.Ghoshal Shri John T. John Shri A.Bose Shri R.S.Dutta Shri Vivekanand Kain Shri Chintamani Das Shri K.N. Adhe Shri K.B. Gaonkar Kum.P.T. Bagayatkar	ELECTROCHEMICAL SCIENCE AND TECHNOLOGY SECTION Head Dr.M.K.Totiani Shri A.K. Grover Shri S.N.Athavale Shri M.N. Joshi Shri A.L. Pappachan	CERAMICS SECTION Dr.A.K. Kulkarni Dr.D.D.Upadhyaya Dr.P.Y.Dalvi Shri S.N.Sharma Shri S.K.Roy Dr.B.R.Vyas Dr.B.R.Vyas Shri M.G.Joshi Shri M.B.Kakade Smt.Kanchan Ravindra	
	FABRICATION AND MAINTENANCE GROUP Shri R.N.Arya Shri R.K.Fotedar Shri P.B.Khedkar	Head Shri Ram Prasad Dr.S.Ramanathan Smt. A.K.Gulnar Shri M.R. Gonal	
		Dr.N.C.Soni Dr.N.S.Anandan Shri P.K.Agnihotri Shri P.V.George	

