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AGARD

ADVISORY GROUP FOR AEROSPACE RESEARCH & DEVELOPMENT

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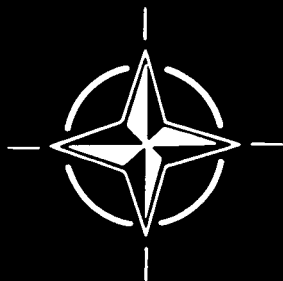
AGARD REPORT No. 585

on

**Directory of Organizations,
Investigators, and Programs
in
High Temperature Corrosion Research**

A

NORTH ATLANTIC TREATY ORGANIZATION



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- Providing scientific and technical advice and assistance to the North Atlantic Military Committee in the field of aerospace research and development;
- Continuously stimulating advances in the aerospace sciences relevant to strengthening the common defence posture;
- Improving the co-operation among member nations in aerospace research and development;
- Exchanging of scientific and technical information;
- Providing assistance to member nations for the purpose of increasing their scientific and technical potential;
- Rendering scientific and technical assistance, as requested, to other NATO bodies and to member nations in connection with research and development problems in the aerospace field.

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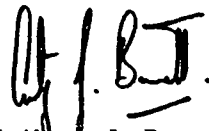
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SUMMARY

This directory of research organizations, investigators, and research programs or areas of research was prepared from information gathered by the NATO/AGARD Working Group on Basic and Applied Research on High-Temperature Corrosion, and the European Federation of Corrosion's Working Group on Corrosion by Hot Gases and Products of Combustion.

The directory lists the organizations, together with the investigators and the research areas (or specific programs) in which they are working, alphabetically by countries. There are 178 organizations from eleven NATO countries included. A category index indicates the high-temperature corrosion research areas in which the various organizations are conducting research. The two research areas currently receiving the most attention are (1) material behavior under corrosion and (2) reaction kinetics and diffusion processes, in which 119 and 97 organizations, respectively, are working. An alphabetical index of investigators includes approximately 240 names.

The AGARD Structures and Materials Panel has an ongoing program of work in this field, organized and coordinated by the Working Group listed on page "v" under the Chairmanship of Mr. T. F. Kearns.



Anthony J. Barrett
Chairman,
Structures and Materials Panel
AGARD

DIRECTORY OF HIGH TEMPERATURE CORROSION RESEARCH
Organizations, Investigations, and Programs

In recent years increased attention has been devoted to the topic of high temperature oxidation and corrosion of structural alloys as a result of increasing operating temperatures being used in the design of aerospace propulsion systems and airframes. The Advisory Group for Aeronautical Research and Development (AGARD) organized under the North Atlantic Treaty (NATO) set up a Working Group on Basic and Applied Research on High Temperature Corrosion Organization of Aerospace Alloys to Study this important topic. At the request of this Working Group, DMIC prepared this directory of the research organizations and principal investigators active in high temperature corrosion and the topics on which they are working. We believe that the directory affords an overview of work in progress and will aid in the assessment of the distribution of the effort and recognition of gaps and objectives not being effectively pursued.

Information on U. S. and Canadian programs in the directory was obtained by DMIC through a direct mail questionnaire sent in 1970 to researchers who were believed to be active in high-temperature corrosion research. Information on European programs was taken from a 1967 survey of European high-temperature corrosion research conducted by the Working Group on "Corrosion by Hot Gases and Products of Combustion" of the European Federation of Corrosion (EFC). The information selected from the EFC survey was limited to NATO countries* and to high-temperature corrosion in the categories listed below.

Category Index

- 1.1 Thermodynamics, phase diagrams, reaction equilibria
- 1.2 Electrochemical problems
- 1.3 Reaction kinetics and diffusion processes
- 1.4 Aerodynamic factors (mechanism of deposition)
- 1.5 Rheological investigations (viscosity of the melts)
- 2.1 Development of corrosion-resistant materials
- 2.2 Surface protection of materials
- 2.3 Material behavior under corrosion
- 3.1 Additives
- 3.4 Surface treatment of pipes, supports, and other parts of furnaces, boilers, turbines, etc., exposed to high temperature

In the interest of uniformity, these category codes were used in Table 2 of this directory. In addition, when more complete information was not available, these categories were used to indicate the areas, in Table 1, in which research was being conducted by the European laboratories.

(*) Spain is not within NATO but some laboratories in this Country known to have interests in High Temperature Corrosion work have been included in this directory by courtesy of the Spanish laboratories concerned.

Members of the NATO/AGARD Working Group on Basic and Applied Research on High-Temperature Corrosion

T. F. Kearns	United States, Chairman
A. Deruyttere	Belgium
H. V. Kinsey	Canada
J. P. Poulignier	France
F. Bollenrath	Germany
A. Griselli	Italy
P. Kofstad	Norway
A. d'Oliveira Sampaio	Portugal
H. P. van Leeuwen	Netherlands
K. A. Rowland	United Kingdom
N. Tallan	United States
R. I. Jaffee	U. S., Specialist
J. Dunham	U. K., Liaison, Propulsion and Energetics Panel, AGARD

Members of the European Federation of Corrosion Working Group on Corrosion by Hot Gases and Combustion Products

H. Souresny	Austria
H. Zitter	"
M. Caubo	Belgium
Prof. Leclerc	"
Prof. Pourbaix	"
E. Aggernaes	Denmark
Z. Bret	Czechoslovakia
Prof. Tikkanen	Finland
Prof. Bardolle	France
Dr. Manenc	"
K. Lorenz	Germany
W. Möller	"
A. Rahmel	"
W. Schlüter	"
Dr. Tuillo	Italy
D. Borgese	"
J. M. N. Jelgersma	Netherlands
Dr. de Jonge	"
P. Kofstad	Norway
S. Feliu	Spain
J. H. González	"
L. O. Härdelius	Sweden
O. Stelling	"
A. Bukowiecki	Switzerland
Th. Geiger	"
M. Heise	"
A. B. Hart	United Kingdom
G. Wood	"

TABLE 1. DIRECTORY OF ORGANIZATIONS, INVESTIGATORS, AND PROGRAMS

-
- BELGIUM
1. Belgian Center for Corrosion Study, CEBELCOR
 Avenue Paul Héger, Grille 2
 B-1050 Bruxelles
 M. Pourbaix (02)49.63.96
 A. Pourbaix
 G. vanMuyldaer
 Programs:
 1. Preparation of an atlas of chemical and electrochemical equilibria for oxides, hydrides, sulfides, chlorides, hydrates, and other compounds, with special reference to the conditions of stability of protective films
 2. Preparation of diagrams of electrochemical equilibria of materials in the presence of molten salts (carbonates, chlorides, fluorides, sulfates) and in the presence of semi-conductive oxides
 2. Centre de Recherches Metallurgiques (C.R.M)
 rue du Val Benoit, 69
 B-4000, Liege (04) 52.70.50
 A. Davin
 D. Coutsouradis
 L. Habraken
 Programs:
 1. Dry corrosion of superalloys in sulphidizing and carburizing atmospheres
 2. Development of hot corrosion resistant cobalt base alloys
 3. Evaluation of coating stability under hot corrosion conditions
 3. Faculté Polytechnique
 Département de Chimie
 Laboratoire d'Electrochimie
 Rue de l'Epargne
 Mons
 Prof. H. Van der Poorten
 Programs:
 1. Corrosion of refractory metals by molten silicates
 2. Reaction kinetics and diffusion processes
 3. Material behavior under corrosion
 4. Institut Belge des Hautes Pressions
 Sterrebeek
 L. Deffet
 P. Hestermans
 Research Areas:
 2.3
 5. Institut de Metallurgie de la Faculte des Sciences Appliquees de l'Universite Catholique de Louvain de Croylaan, 2
 3030 Heverlee
 Leuven
 Claude Vanleugenhaghe 016/327.47
 Program:
 1. Corrosion of inconel 600 alloy in water vapor at high temperature
 2. Reactions in the system $Ac_2O_3-ThO_2-W$ and $La_2O_3-ThO_2-W$ including daughter products Re, Pb, and O. Study of phase diagrams, volatilization, permeability
 3. Reactions in the system $ThO_2-W-O-Re-Pb$
 4. Reactions in the system $LaN-AlN-N-W-Pb$
 5. Steam oxidation of chromium coatings on steel
 6. Hot salt cracking of titanium alloys
 6. Katholieke Universiteit Leuven
 Department Metaalkunde
 3030 Heverlee
 Leuven
 Dr. M. J. Brabers
 Research Areas:
 1.1, 1.3, 2.2, 2.3
 1. Reactions in the system $Ac_2O_3-ThO_2-W$ and $La_2O_3-ThO_2-W$ including daughter products He, Pb and O. Study of phase diagrams, volatilization, permeability.
 2. Reactions in the system $ThO_2-W-O-He-Pb$
 3. Reactions in the system $LaN-AlN-N-W-Pb$
 4. Steam oxidation of chromium coatings on steel
 5. Hot salt cracking of titanium alloys
 7. Laboratoire Belge de l'Industrie Electrique, LABORELEC
 Rhode-Saint-Gènese
 G. Taelmens
 Research Areas:
 2.2, 3.4
 8. Laboratoire Central
 Rue de la Discipline
 6060 Gilly
 S. A. Glaverbel (07)31.01.65
 Programs:
 1. Reaction of alloys with molten salts (silicates)
 2. High temperature coatings development (plasma-spraying and diffusion coatings)
 3. Temperature effects on coatings and intermediate layers
 9. SCK/CEN (Centre D'Etude de L'energie Nucléaire) Metallurgy Department
 2400 Mol
 F. Casteels
 Programs:
 1. Compatibility of W(W-Re) with oxides (PbO, WO_3 , Bi_2O_3 , ThO_2 , La_2O_3 , Ac_2O_3 , BaO, Ba, Pb, Bi) in the temperature range 1500 - 2200 C
- CANADA
10. Atomic Energy of Canada Limited
 Chalk River Nuclear Laboratories
 Materials Science Branch
 Chalk River, Ontario
 B. Cox (613) 687-5581 Ext. 563
 Programs:
 1. Oxidation of zirconium
 11. Ecole Polytechnique
 Département de Génie Métallurgique Chimique
 Division de Métallurgie
 2500 Avenue Marie Guyard
 Montreal, 250, Quebec
 M. Rigaud (514) 739-2451 Ext. 282 or 241
 Programs:
 1. Oxidation of nickel, cobalt, niobium, nickel-cobalt, nickel-niobium alloys
 2. Initial stages of film formation
 3. Spectrophotometric study of products formed during the oxidation of nickel binary alloys Ni-Nb, Ni-Ti, Ni-Al

12. Falconbridge Nickel Mines, Ltd.
Metallurgical Laboratories
Process and Products Development Group
8810 Yonge Street
P.O. Box 900
Thornhill, Ontario
Dr. L. A. Morris
Programs:
1. Oxidation of austenite stainless steels
2. Oxidation and hot corrosion of high chromium, nickel-chromium alloys
3. Sulfidation of high chromium, nickel chromium, alloys
13. McMaster University
Department of Metallurgy and Materials Science
Hamilton, Ontario
Prof. W. W. Smeltzer (416) 522-4971
Programs:
1. Oxidation properties of zirconium and a zirconium-2.5 w/o niobium alloy
2. Oxidation-decarburization properties of steels
3. Thermodynamics of binary alloys and oxygen
4. Oxidation properties of iron-silicon and nickel-iron alloys
5. Oxidation properties of nickel
6. Reactant transport properties in oxide films and scales
7. Sulfidation properties of nickel-chromium alloys
14. National Research Council of Canada
Metallic Corrosion and Oxidation Section
Chemistry Division
Ottawa 7, Ontario
Donald Caplan (613) 993-2518
Programs:
1. Oxidation of Fe, Ni, Cr: kinetics, effect of pressure, purity, surface preparation, cold work, surface contamination with Si, C, S
2. Electron-optical characterization of metal surfaces: high energy electron diffraction and X-ray emission analysis of surfaces and their reaction products: Fe, Ni, W, Ta, Si
3. Initial stages of film formation on Fe, Ni, Si, and W single crystals: nucleation, epitaxy, kinetics, ultrahigh vacuum techniques
4. Grain structure and cavities in oxide layers
5. Oxidation of Fe-C alloys
6. Anodically formed oxides on Fe: kinetics, electrochemistry, electron-optical examination, and autoradiography
7. Contamination of metal surfaces from hot ceramics; gas phase transport mechanism
15. National Research Council of Canada
National Aeronautical Establishment
Structures and Materials Laboratory
Ottawa, Ontario
J. M. Trenouth (613) 993-2812
Dr. W. Wallace (613) 993-9280
Dr. E. P. Whelan (613) 993-2812
Programs:
1. Preparation and evaluation of vacuum pack Cr-Ti-Si coatings on B66 alloy (nearing completion)
2. Oxidation of silicide compounds, diffusion coatings, and binary Nb alloys (being initiated)
3. Corrosion of silicide coatings by Na₂SO₄ and NaCl
4. Oxidation kinetics and breakdown mechanisms in diffusion coated niobium and niobium-base alloys
5. Oxidation kinetics and structural stability of intermetallic compounds
6. Impurity diffusion of Cr, Ti, Si in niobium
7. Oxidation resistance of commercial aluminide coatings on superalloys 713C and IN-100 (recently completed)
16. Orenda Limited
Box 6001
Toronto International Airport
Toronto, Ontario
W. Paul (416) 677-3250
Programs:
1. Evaluation of high-temperature corrosion properties of nickel- and cobalt-base superalloys after long term exposure to straight oxidizing atmospheres
2. Evaluation of turbine components after long periods of service in Orenda's industrial base turbine engines
3. Study of the effects of various surface treatments such as shot peening and aluminide coatings
17. Queen's University
Centre for Metal and Mineral Technology
Chemical Metallurgy Research Group
Kingston, Ontario
John R. Wilson (613) 547-2816
Programs:
1. High-temperature corrosion of metallic and refractory materials in oil combustion products (including sulfidation and vanadate corrosion)
2. High-temperature corrosion of molybdenum in aggressive gaseous environments (mainly halogen gases and hydrogen sulfide)
3. Corrosion of metallic and refractory materials by molten salts and slags (predominantly the refractory metals by molten fluorides, and commercial refractories by molten oxides)
18. Sherritt Gordon Mines, Ltd.
Research and Development Division
Fort Saskatchewan, Alberta
L. F. Norris (403) 543-2211
Programs:
1. Improvement of the oxidation resistance of dispersion strengthened nickel-chromium alloys (includes static and dynamic oxidation testing, hot corrosion testing from 1800 - 2200 F)
19. University of Western Ontario
Faculty of Engineering Science
Materials Science Group
London, Ontario
C. Roy
J. S. Sheasby (519) 679-3302
Programs:
1. Stress generation during oxidation of zirconium alloys
2. Effects of growth stresses on oxide morphology for zirconium alloys
3. High-temperature corrosion resistant coatings for zirconium alloys
4. Effect of surface orientation of the metal substrate on the oxide film growth
5. High-temperature oxidation behavior of niobium
6. Lower oxide formation during oxidation reactions
7. Electrical properties of oxides during formation on a metal

DENMARK

20. Universität von Kopenhagen, Kemisk Lab. IV
 Copenhagen
 N. F. Grönlund
 Research Areas:
 1.1, 1.2

FRANCE

21. Centre d'Etudes Nucléaires de Saclay
 Service de Chimie des Solides
 Boîte Postale N° 6
 92 Fontenay-aux-Roses
 R. Darras
 J. Paidassi
 Research Areas:
 1.3
22. Centre National de la Recherche Scientifique
 15 Rue Georges Urbain
 94 Vitry-sur-Seine
 P. Lehr
 Research Areas:
 1.1, 2.1, 2.2, 2.3
23. Centre de Recherches Métallurgiques de l'Ecole
 des Mines
 60, Boulevard Saint-Michel
 75 Paris V°
 P. Lacombe
 G. Beranger
 Research Areas:
 1.2
24. Centre de Recherches de la Société Métallurgique
 d'Imphy
 Imphy-58
 P. Legendre
 Research Areas:
 2.1, 2.2, 2.3
25. Ecole Centrale des Arts et Manufactures
 Centre Recherche Physique
 1 Rue Mongolfier
 Paris 3e
 Gregoire
 Research Areas:
 2.3
26. Ecole des Mines
 Laboratoire de Chimie-Metallurgie
 Parc de Saurupt
 54 Nancy
 Roux
 Slama
 Research Areas:
 1.1, 1.3
27. Ecole Nationale Supérieure de Chimie de Paris
 47 Rue des Ecoles
 75 Paris 5°
 J. Benard (See also #42)
 J. Oudar
 Research Areas:
 1.2, 2.2
28. Ecole Nationale Supérieure Electrochimie et
 Electrometallurgie
 39-41 Boulevard Gambetta et Rue Hoche
 38 Grenoble
 Besson
 Research Areas:
 1.2, 1.3
29. Forges et Acieries du Saut du Tarn
 6 avenue de Messine
 75-Paris 8eme
 M. Mailhos
 Research Areas:
 2.2
30. Institut de Recherches de la Siderurgie
 185 Rue du Président-Roosevelt
 78 St.-Germain-en-Laye
 J. Manenc
 Research Areas:
 1.3, 2.2
31. Laboratoire de Recherche sur la Réactivité des
 Solides associés au CNRS
 21 Rue Monge
 21 Dijon
 P. Barret
 Research Areas:
 1.1, 1.3
32. Office National d'Etudes et de Recherches
 Aérospatiales-ONERA
 29, Avenue de la Division Leclerc
 92 Chatillon-sous-Bagneux
 P. Galmiche
 A. Hivert
 R. Pichoir
 G. Slodzian
 H. Bückle
 Research Areas:
 1.1, 1.3, 2.1, 2.2
33. Société Nationale d'Etudes et de Construction
 de Moteurs Aéronautiques-SNECMA, Laboratoire
 Central-Usine d'Evry-Corbeil
 Boite Postale N° 56
 91 Corbeil
 Brunetaud
 Ferre
 Research Areas:
 2.2, 2.3
34. Société Nationale Industrielle Aérospatiale-
 SNIAS
 Laboratoire Central
 Rue de l'Industrie
 92 Courbevoie
 Sertour
 Research Areas:
 2.2
35. Société Ugine-Kuhlmann
 Laboratoire de Venthon
 73 Albertville
 J. P. Givord
 Research Areas:
 2.2
36. Trefimetaux G. P.
 Département de Recherches Avancées
 141 Rue Michel Carré
 95 Argenteuil
 Syre
 Molinier
 Research Areas:
 2.1
37. Université d'Amiens
 College Scientifique
 18 Place St. Michel
 80 Amiens
 F. Marion
 Programs:
 1.1, 1.3

38. Université de Lyon
 69 Lyon
 Uzan
 Research Areas:
 1.3
39. Université de Marseille
Laboratoire de Chimie Generale
 Lab. de Cristallographie
 13 Marseille
 M. Lafitte
 Dreschler
 Research Areas:
 1.1, 1.3, 2.3
40. Université de Nancy
 Laboratoire de Chimie Minérale
 13 Place Carnot
 54 Nancy
 Vigne
 Research Areas:
 1.3, 2.2, 2.3
41. Université d'Orleans
 Labor de Chimie des Solides
 21 Rue Saint-Etienne
 45 Orleans-la-Source
 J. Bardolle
 Research Areas:
 1.1, 1.3
42. Université de Paris
 Lab. de Chimie
 47 Rue des Ecoles
 Paris 5^e
 J. Benard
 J. Oudar (See also #27)
 Research Areas:
 1.1, 1.3
43. Université de Poitiers
 Laboratoire de Chimie
 5 Cité de la Traverse
 Poitiers
 G. Valensi
 Research Areas:
 1.1, 1.2, 1.3
44. Université de Tours
 Laboratoire Chimie Generale et Minerale
 1 bis Boulevard Tonnellé
 37 Tours
 P. Belin
 Research Areas:
 1.1, 1.3
- GERMANY
45. August Thyssen-Hütte AG
 41 Duisburg-Hamborn
 Kaiser-Wilhelm-Str. 100
 Ch. Strassburger
 Research Areas:
 2.3
46. Babcock-Werke
 Forschung und Entwicklung
 42 Oberhausen
 Postf. 34/35
 H. Jahn
 H. Büskens
 Research Areas:
 2.3
47. Battelle-Institut e.V.
 6000 Frankfurt/Main 90
 Postschliessfach 900/60
 H. Ahlborn
 Programs:
 1. Oxidation resistance of high-temperature alloys containing special additions
48. Berliner Kraft- und Licht-AG, BEWAG
 1 Berlin 30
 Stauffenbergstr. 26
 K. Wickert
 Research Areas:
 1.3, 1.5, 3.1
49. Brown, Boveri & Cie
 Zentralstelle für Werkstofftechnik
 68 Mannheim 1
 Postfach 351
 H. Möller
 Research Areas:
 1.1, 1.3, 2.2, 2.3, 3.1, 3.4
50. Dechema-Institut
 6 Frankfurt
 Rheingau-Allee 25
 Dr. A. Rahmel
 Programs:
 1. High-temperature oxidation of iron and steels
 2. Electrochemical studies of corrosion in alkali-sulfate and V₂O₅ melts.
51. Deutsche Edelstahlwerke AG
 415 Krefeld
 Oberschlesienstr. 16
 Dr. K. Bungardt
 Dr. G. Lennartz
 Research Areas:
 1.3, 2.2, 2.3
52. Edelstahlwerk Witten AG
 581 Witten
 Postfach 1369
 J. Bruch
 Research Areas:
 2.1, 2.3
53. Forschungsvereinigung Verbrennungskraftmaschinen
 6 Frankfurt-Niederrad 1
 Lyoner Strasse
 F. Umland
 W. Möller
 Research Areas:
 1.1, 1.3, 2.1, 2.3, 3.1, 3.4
54. Hamburgische Elektrizitätswerke
 2 Hamburg 1
 Gerhart-Hauptmann-Platz 48
 Pfeiffer
 Research Areas:
 1.1, 1.2, 1.3, 2.3
55. International Nickel Deutschland GmbH
 4 Düsseldorf
 Kreuzstr. 34
 R. Ergang
 W. Herder
 Research Areas:
 2.3
56. Kraftwerk Union AG
 433 Mülheim (Ruhr)
 Postfach 1420
 H. Schieferstein
 Research Areas:
 2.2, 2.3, 3.4

57. L. u. C. Steinmüller GmbH
 Mat.-Prüfanstalt
 527 Gummersbach
 S. Pollmann
 Research Areas:
 1.3, 1.5, 2.2, 2.3
58. Mannesmann-Forschungsinstitut GmbH
 41 Duisburg-Wanheim
 Schwenk
 Research Areas:
 1.2, 1.3, 2.3
59. Max-Planck-Institut für Eisenforschung
 4 Düsseldorf
 Max-Planck-Str. 1
 Bohnenkamp
 Research Areas:
 1.2, 1.3, 2.3
60. Max-Planck-Institut für Physikalische Chemie
 34 Göttingen
 Bunsenstr. 10
 Prof. Carl Wagner
 Research Areas:
 1.1, 1.2, 1.3
61. Max-Planck-Institut für Metallforschung
 7 Stuttgart 1
 Seestr. 75
 Dr. H. J. Engell
 H. J. Grabke
 Research Areas:
 1.1, 1.2, 1.3, 2.1, 2.2, 2.3
62. Stahlwerke Südwestfalen AG
 Hüttental
 5903 Geisweid/Kr. Siegen
 W. Wesseling
 F. W. Frantes
 Research Areas:
 2.1, 2.3
63. Technischer Überwachungsverein Bayern e.V.
 8 München 23
 Kaiserstr. 14
 K. Köhler
 Baumann
 Research Areas:
 2.2, 2.3
64. Technischer Überwachungsverein Essen e.V.
 43 Essen
 Steubenstr. 53
 Baatz
 Hermann
 Research Areas:
 2.2, 2.3, 3.1
65. Thyssen Röhrenwerke AG
 Metallurg. Abteilung
 4 Düsseldorf
 Höherweg 271 a
 E. Kranz
 Research Areas:
 1.1, 2.1, 2.3
66. Universität Bonn
 Mineralogisch-Petrologisches Institut
 53 Bonn 1
 Liebfrauenweg 3
 A. Neuhaus
 N. Gebhardt
 Research Areas:
 1.1, 1.3, 2.2, 2.3
67. Universität Dortmund
 Institut für Physikalische Chemie
 46 Dortmund
 August-Schmidt-Strasse
 H. Rickert
 Research Areas:
 1.1, 1.2, 1.3
68. Universität Karlsruhe
 Institut für Chemische Technik
 75 Karlsruhe
 Kaiserstrasse 12
 Dr. E. Fitzer
 Programs:
 1. Formation of SiO₂ glass layers by oxidation of WSi₂, MoSi₂, SiC and Si₃N₄; kinetics of the oxidation and the oxygen diffusion through the glass as the controlling step
 2. Kinetics of the reactions of the silicon-donors with base alloys; diffusion of silicon in Me₅Si₃-phases; diffusion of basic alloy components to the oxide-forming layers. The following diffusion couples are studied: MoSi₂/Mo, MoSi₂Nb, MoSi₂/Ta, NbSi₂Mo, NbSi₂Nb, WSi₂/Mo, WSi₂/Nb, WSi₂/W, Mo₅Si₃/Ta₅Si₃, Mo₅Si₃/Nb₅Si₃, W₅Si₃/Nb₅Si₃, Ta/Cr, Nb/Cr, Ta/NiCr, Nb/NiCr
 3. Applied research on the formation of Si-donors on high temperature alloys (for example hot pressing, vapor plating)
 4. Basic research on reactions of refractory silicides with nitrogen; exploration of such compounds as diffusion barriers on Cr-alloys against nitrogen absorption
 5. Mechanical properties and recrystallization behavior of SiO₂-forming compounds at high temperatures
 6. Compatibility of SiO₂ and Si-donors with oxides of the basic alloys; modifications of SiO₂-forming compounds by borides and germanides; oxidation kinetics and sintering mechanisms; transport mechanisms in such complex oxides
69. Universität Münster
 Institut für Metallforschung
 Lehrstuhl für Anorganische Analytische Chemie
 44 Münster
 Schlossplatz 2
 F. Umland
 Th. Heumann
 Research Areas:
 1.1, 1.2, 1.3, 2.3, 3.1
70. Verein Deutscher Eisenhüttenleute e.V.
 4 Düsseldorf
 Breite Str. 27
 W. Schlüter
 Research Areas:
 1.1, 1.2, 2.1, 2.2, 2.3
71. Vereinigung der Grosskesselbetreiber
 43 Essen
 Kurfürstenstr. 27
 H. Kirsch
 Research Areas:
 2.3, 3.1
72. Vereinigte Kesselwerke AG
 4 Düsseldorf
 Werdener Str. 3
 Steller
 Research Areas:
 2.3, 3.4

ITALY

73. Ansaldo Meccanico Nucleare
 Piazza Carignano 2
 Genoa
 B. Boselli
 Research Areas:
 1.2, 1.3
74. Centro Sperimentale Metallurgico S.p.A. sede legale
 Via di Castel, Romano
 Roma
 G. Bando
 Research Areas:
 1.1, 1.2, 2.1, 2.2, 2.3
75. ENTE Nazionale Per l'Energia Elettrica
 Via Giovan Battista Martini
 Roma
 P. Sturla
 Research Areas:
 2.2, 2.3, 3.1, 3.4
76. Istituto Metalli Leggeri-Comitatuto Corrosioni
 Via S. Giovanni sul Muro n. 9
 Milano
 Rossi
 Research Areas:
 2.3
77. Laboratorio FIAT
 Stabilemento Grandi Motori
 Corso G. Agnelli 200
 Torino
 G. Simonetti
 Research Areas:
 2.3
78. SNAM Progetti
 Laboratorio Rinuti Studi e Ricerche
 S. Donato Milanese
 Milano
 C. Verga
 Research Areas:
 2.3
79. Università di Bologna
 Istituto di Metallurgia
 Viale Risorgimento, 4
 Prof. Paolo Spinedi
 Programs:
 1. Oxidation of metals in dry oxygen by means of spectrometric and thermogravimetric methods
80. Università di Pisa
 Istituto di Chimica Industriale e Applicata
 Pisa
 M. Baccaredda
 Research Areas:
 1.3

NETHERLANDS

81. Laboratory for Thermal Power Engineering
 Group Combustion Technology and Steamboilers
 Rotterdamseweg 139A
 Delft
 H. van Staa
 Programs:
 1. Studies of the formation and suppression of V₂O₅-corrosion in fuel-oil fired steamboilers

82. N. V. tot Keuring van Electrotechnische Materie- alien (N. V. KEMA)
 Arnhem
 J. H. N. Jelgersma
 A. J. Elshout
 Research Areas:
 1.1, 2.3, 3.1

83. Technische Hogeschool Twente
 PO Box 217
 Enschede
 P. J. Gellins
 Research Areas:
 1.1, 1.3, 2.3

NORWAY

84. Norges Tekniske Hogskole - NTH
 Dep. of Metallurgy
 Trondheim
 A. B. Winterbottom
 Research Areas:
 1.1, 1.3
85. Sentralinstitutt for Industriell Forskning - SI
 Blindern
 Oslo 3
 Forskningsveien 1
 P. Kofstad
 J. Kvernes
 Research Areas:
 1.1, 1.2, 1.3, 2.1, 2.2, 2.3

SPAIN

86. Celulosas De Huelva, S.A. Madrid
 M. R. Ortega
 Research Areas:
 2.3, 3.1, 3.4
87. Compania Iberica Rafinadora De Petroleos, S.A.
 Madrid
 Research Areas:
 2.1, 2.3, 3.1, 3.4
88. Esso Petroleos Espanoles, S.A.
 Madrid
 L. A. Lopez
 M. A. Quintana
 Research Areas:
 2.1, 2.3, 3.1, 3.4
89. La Maquinista Terrestre y Maritima, S.A.
 Barcelona
 Research Areas:
 2.3, 3.1, 3.4

UNITED KINGDOM

90. Admiralty Materials Laboratory
 Holton Heath
 Poole
 Dorset
 BH16 6JU
 J. F. Conde Lytchett Minster 711
 Programs:
 1. Study of the phenomenon and mechanism of high temperature sulfidation corrosion in marine gas turbines
 2. Studies of alloys and coatings using a low pressure combustion rig
 3. Kinetic and other basic investigations

91. Associated Octel Co. Ltd.
 Research and Engineering Dept.
 P. O. Box 17
 Ellesmere Port
 Cheshire
 W. E. Cowley
 Research Areas:
 2.1, 2.3
92. Atomic Energy Research Establishment
 Harwell
 Didcot
 Berks
 Dr. J. E. Antill Abingdon 4141 Ext. 4454
 Programs:
 1. Kinetics of the corrosion of metals and ceramics by gases. Particular interests include carburization phenomena and generation of stress by corrosion.
 1.1, 2.1, 2.3
93. Babcock, Wilcox (Operations) Ltd.
 High Street
 Renfrew
 Scotland
 G. G. Foster
 Research Areas:
 2.3
94. Berkeley Nuclear Lab., C.E.G.B.
 Materials Div.
 Berkeley
 Gloucestershire
 P. P. Jennings
 Research Areas:
 1.1, 1.2, 1.3, 2.1, 2.2, 2.3
95. British Steel Corp.
 Midland Group, Research and Development Dep.
 Swinden Laboratories
 Moorgate,
 Rotherham
 A. Nicholson
 A. M. Edwards
 Research Areas:
 1.1, 2.3
96. Brown-Firth, Research Lab.
 Attercliffe Road
 Sheffield S 4 7VY
 J. E. Truman
 Research Areas:
 2.3
97. Central Electricity Research Lab., C.E.G.B.
 Kelvin Avenue
 Leatherhead
 Surrey
 A. B. Hart
 D. de G. Jones
 D. R. Holmes
 W. D. Halstead Leatherhead 4488
 Programs:
 1. Thermodynamic studies of high temperature corrosion processes
 2. Vapor and decomposition pressures of alkali metal sulfates; their vapor and condensed phase reactions. Also those of Fe, Cr, and Ni sulfates, sulfides, V oxides, and mixed sulfates of the type $\text{Na}_3\text{Fe}(\text{SO}_4)_3$.
 Research Areas:
 1.2, 1.4, 1.5, 2.1, 2.2, 2.3, 3.4
98. The City University
 St. John Street
 London EC 1
 A. C. C. Tseung
 Research Areas:
 1.3, 2.3
99. Cranfield Institute of Technology (Ex. Glasgow University)
 Department of Materials
 Cranfield
 Bedfordshire
 Dr. P. Hancock 0234 51551
 Programs:
 1. Mechanical properties of surface oxides
 2. Influence of surface scales on mechanical properties of underlying metals
 3. Effect of gaseous contamination on scaling
100. Fulmer Research Institute Ltd.
 Stoke Poges
 Buckinghamshire
 M. A. P. Dewey Fulmer 2181
 Programs:
 1. Development of oxidation and sulfidation resistant cobalt and nickel alloys
 2. Mechanism of sulfidation attack
 3. Physical chemistry of sulfidation
101. Henry Wiggin & Co. Ltd.
 Hereford
 Dr. J. Heslop Hereford 6461
 Programs:
 1. High-temperature alloy development
 2. Gaseous corrosion
102. Hirst Research Centre, G.E.C. Ltd.
 East Lane
 North Wembley
 Middlesex
 D. S. Evans
 Research Areas:
 1.1, 1.2, 1.3, 2.1, 2.3
103. International Combustion Ltd.
 Derby, DE 2, 9 GT
 Ashley
 Research Areas:
 2.1, 2.3
104. International Nickel Ltd.
 Research and Development Lab.
 Wiggin Street
 Birmingham 16
 E. G. Richards
 Henry Lewis
 R. A. Smith 021-454-4871
 Programs:
 1. Development of new alloys resistant to high-temperature corrosion
 2.3
105. University of Leeds
 Dep. Metallurgy
 The Houldsworth School of Applied Science
 Leeds 2
 J. C. Scully
 Research Areas:
 1.3
106. University of Liverpool
 Dep. Metallurgy and Materials Science
 P. O. Box 147
 Liverpool L693BX

- Prof. John Stringer 051-709-6022
 Programs:
 1. Oxidation of tantalum, niobium, and dilute alloys based on these metals
 2. Oxidation and sulfidation of cobalt-base superalloys
 3. Scale fracture mechanisms
 4. Morphologies of oxide scales
 5. Stress generation and relief in growing oxide scales
107. University of Manchester
 Institute of Science and Technology
 Chem. Eng.
 P. O. Box No. 88, Sackville St.
 Manchester M60 1QD
 T. K. Ross
 G. C. Wood 061-236 3311
 I. A. Menzies 061-236 3311
 Programs:
 1. Kinetics, nucleation and growth; structure of oxide scales
 2. Oxidation under wear conditions
 3. Stress and hardness measurements
 4. Cyclic oxidation
 5. Cr and Al diffusion coatings
 6. Mechanical properties of oxides
 7. Sulfidation of Ni-based alloys
108. University of Manchester
 Institute of Science and Technology
 Metallurgy
 P. O. Box No. 88, Sackville St.
 Manchester M60 1QD
 R. Rolls
 Research Areas:
 1.3, 2.2, 2.3
109. Marchwood Eng. Lab., C.E.G.B.
 Marchwood
 Southampton
 Hants
 P. J. Jackson
 Research Areas:
 2.3, 3.1
110. Midlands Region, C.E.G.B.
 Scientific Services Department
 Hams Hall
 Birmingham
 L. H. Toft
 Research Areas:
 2.3, 3.4
111. National Gas Turbine Establishment
 Pyestock
 Farnborough
 Hants
 A. Burwood-Smith
 J. E. Northwood
 M. J. Weaver
 Programs:
 1. Effect of alloy composition and micro-structure on oxidation
112. National Physical Laboratory
 Teddington
 Middlesex
 G. O. Lloyd 01-977 3222
 Programs:
 1. Microstructural studies of breakaway oxidation on chromium-iron alloys
 2. Hot salt corrosion of nickel-based super-alloys
113. University of Newcastle Upon Tyne
 Dep. Metallurgy
 Newcastle-upon-Tyne, 1
 R. F. Tylecote
 D. Maxwell
 Research Areas:
 1.3
114. Nuclear Design and Construction Ltd.
 Cambridge Road
 Whetstone
 Leicester
 D. Goodison
 Research Areas:
 1.3, 2.2, 2.3, 3.1, 3.4
115. N. W. Region, C.E.G.B.
 Scientific Services Department
 825 Wilmslow Road
 East Didsbury
 Manchester
 M. Fountain
 Research Areas:
 1.2, 2.2, 2.3, 3.1
116. Rolls Royce Ltd.
 Bristol Engine Division
 P. O. Box 3
 Filton
 Bristol
 G. Llewellyn
 D. W. Hall
 Research Areas:
 2.2, 2.3
117. University of Sheffield
 Dep. Metallurgy
 St. George's Square
 Sheffield S13JD
 Dr. N. Birks 78555
 Programs:
 1. Oxidation of metals and alloys in complex alloys
118. Shell Research Ltd.
 Thornton Research Centre
 P. O. Box 1
 Chester
 R. W. Wilson
 Research Areas:
 1.2, 1.3, 2.2, 2.3, 3.1, 3.4

UNITED STATES

119. Aerospace Research Laboratories
 Metallurgy and Ceramics Research Laboratory
 Building 450 (ARZ)
 Wright-Patterson Air Force Base, Ohio 45433
 Dr. N. M. Tallan (513) 255-4402
 Dr. H. C. Graham
 Programs:
 1. Oxidation of ZrB₂, ZrB₂-SiC, and ZrB₂-SiC-Cr compositions
 2. Oxidation of dispersion-strengthened Ni-Cr alloys
 3. Oxidation/vaporization of Cr₂O₃
 4. Effect of rare earth additions on oxidation of Ni-Cr-Al alloys
 5. Oxidation of coated columbium-based alloys
 6. High temperature oxidation of alloys containing Mo and/or W
 7. Sulfidation and hot corrosion
 8. Diffusion in oxide scales.

120. AiResearch Manufacturing Company of Arizona
 Division of The Garrett Corp.
 402 South 36th Street
 Phoenix, Arizona 85034
 M. S. Roush (602) 267-2650
 Programs:
 1. Evaluation of seven commercial protective coatings for resistance to hot corrosion
 2. Investigation of repair of diffusion coatings on turbine components
 3. Investigation of the relative hot-corrosion resistance of uncoated and coated IN-738, IN-792, MAR-M 432, MAR-M 509, as compared with IN-100 and Alloy 713LC
121. Air Force Institute of Technology
 Civil Engineering School
 Wright-Patterson Air Force Base, Ohio 45433
 Dr. James R. Myers (513) 255-3569
 Programs:
 1. Coatings for superalloys in gas turbine engines
 2. Oxidation of ultra-pure cobalt at selected oxygen pressures over the temperature range 950 - 1250 C
 3. The oxidation of René 41 and thoriated nickel filaments
122. Avco Corporation
 Systems Division
 Materials Sciences Dept.
 Lowell Industrial Park
 Lowell, Massachusetts 01851
 Dr. Warren C. Steele (617) 452-8961
 Programs:
 1. Kinetics of gas-surface reactions (Reactions of refractory metals or coated metals with high temperature air species)
 2. Graphite oxidation
123. Avco Lycoming Division
 Materials Laboratories Dept.
 550 So. Main Street
 Stratford, Connecticut 06497
 Dr. William R. Freeman, Jr. (203) 378-8211
 Programs:
 1. Evaluation of promising sulfidation resistant nickel-base superalloys
 2. Effect of time, sulfur content, NaCl content, temperature, and alloy composition on depth of attack
 3. Effect of vanadium and NaCl on corrosion rate
124. Battelle Memorial Institute
 Columbus Laboratories
 505 King Avenue
 Columbus, Ohio 43201
 Dr. R. I. Jaffee (614) 299-3151 Ext. 1536
 E. S. Bartlett (614) 299-3151 Ext. 2873
 Dr. B. A. Wilcox (614) 299-3151 Ext. 2360
 Programs:
 1. Oxidation of superalloys, particularly cobalt-base alloys, and dispersion strengthened nickel-base alloys, such as TD NiC and TD NiCrAl
 2. Studies on the effects of ThO₂ and rare earth metals and their oxides on oxidation mechanisms in nickel and cobalt alloys
 3. Diffusion studies of metals in oxides and alloys. Cr⁺³ in NiO and NiCr and Al⁺³ in TD NiCrAl alloys
 4. Creep in oxides
 5. Plasticity in scales
 6. Oxidation of tantalum, columbium, and their alloys
 7. Evaluation of coated refractory materials
8. Degradation and reuse of radiative thermal protection system materials for the space shuttle (includes study of tolerance of columbium alloys for coating defects; e.g., oxygen contamination/mechanical property degradation kinetics, coating/substrate oxidation interaction, and catastrophic oxidation)
125. Bell Telephone Laboratories
 Dept. of Metallurgical Engineering
 Room 1A-106
 Murray Hill, New Jersey 07974
 Dr. J. H. Swisher (201) 582-4601
 Programs:
 1. Internal oxidation as a means of dispersion strengthening alloys for high-temperature cations
 2. Surface oxidation of Ni-Fe alloys containing small Si and Mn additions. Controlled surface oxidation required for electrical contacts
 3. Corrosion in thin film metallization
126. Bendix Research Laboratories
 Materials and Processes Dept.
 10-1/2 Mile Road
 Southfield, Michigan 48075
 S. K. Rhee (313) 352-7630
 Programs:
 1. Oxidation of commercial high-temperature alloys
127. Bureau of Mines
 Materials Science Projects
 Albany Metallurgy Research Center
 P.O. Box 70
 Albany, Oregon 97321
 Dr. Arne Landsberg (503) 926-5811
 Dr. Laurance L. Oden (503) 926-5811
 Programs:
 1. Chlorination of gold
 2. Chlorination of platinum
 3. Chlorination of tungsten, molybdenum and their binary alloys
 4. Materials for construction of high temperature chlorinators (under which title the corrosion of the alkaline earth fluorides in typical industrial chlorination environments was investigated)
128. Cabot Corporation
 Stellite Division
 Technology Dept.
 1020 W. Park Avenue
 Kokomo, Indiana 46901
 Dr. S. T. Wlodek (317) 457-8411 Ext. 624
 Programs:
 1. Development of high strength Ni- and Co-base alloys with good oxidation/hot corrosion resistance
 2. Evaluation of commercial Ni- and Co-base alloys in oxidation/hot corrosion
 3. Development of alloys for carbonizing/oxidizing service
 4. Processing techniques for highly alloyed oxidation resistant compositions
129. Clemson University
 College of Engineering
 Clemson, South Carolina 29631
 Dr. James S. Wolf
 Programs:
 1. The role of self-generated scale stresses in the high-temperature oxidation of metals

130. Connecticut, University of
 Department of Metallurgy
 Storrs, Connecticut 06268
 Dr. O. F. Devereux (203) 429-3311 Ext. 1273
 Prof. N. D. Greene (203) 429-3311 Ext. 1273
 Programs:
 1. Effect of oxide contaminants on oxidation of silicon
 2. Oxidation of lanthanide metals
131. Curtiss-Wright Corporation
 Materials Engineering Dept.
 One Passaic Street
 Wood-Ridge, New Jersey 07075
 Dr. Sam Wolsin (201) 777-2900 Ext. 2709
 Programs:
 1. Evaluation of diffusion coatings for Udimet 700
 2. Evaluation of diffusion coatings for IN-100
 3. Evaluation of the relative oxidation-hot corrosion resistance of selected nickel- and cobalt-base superalloys
 4. Development of improved diffusion coatings for nickel- and cobalt-base superalloys
132. Dayton, University of
 Research Institute
 High Temperature Materials Engineering Group
 Dayton, Ohio 45409
 Dr. Dennis Gerdeman (613) 229-2517
 Programs:
 1. Creep of coated and uncoated Ta-222(current)
 2. Repairability of slurry silicide coatings (inactive)
133. Delaware, University of
 Department of Chemical Engineering
 Newark, Delaware 19711
 Prof. C. E. Birchenall
 Programs:
 1. Diffusion of Fe⁵⁵ in Cr₂O₃
 2. Self-diffusion of iron in ferrous sulfide
134. Denver, University of
 Metallurgy and Materials Science Division
 Denver Research Institute
 University Park
 Denver, Colorado 80210
 Dr. Albert S. Yamamoto (303) 753-2621
 Programs:
 1. Development of Ni-Cr-W alloys with emphasis on improved oxidation and sulfidation resistance (recently completed)
135. Florida, University of
 Dept. of Metallurgical and Materials Engineering
 Center for Applied Thermodynamics and Corrosion
 Gainesville, Florida 32601
 F. N. Rhines (904) 392-1451
 E. D. Verink (904) 392-1451
 Programs:
 1. Oxidation of nickel
 2. Surface films
136. Ford Motor Company
 Materials Development Dept.
 Turbine Operations
 20000 Rotunda Drive
 Dearborn, Michigan 48121
 Yesh P. Telang (313) 32-31612
 Warren A. Rentz (313) 33-75316
 Programs:
 1. Development of high-temperature nickel- and cobalt-base alloys and determination of their properties
 2. Improved sulfidation resistant coatings for nickel-base alloys
137. General Electric Company
 Materials and Processes Laboratory
 Schenectady, New York 12305
 Dr. Chester T. Sims (518) 374-2211
 Ext. 5-3079, 5-9223
 Gerald Wasielewski
 Programs:
 1. Development of nickel- and cobalt-base alloys for industrial gas turbines
 2. Correlation of oxidation/corrosion test data with service life for superalloys and steels
 3. Development of hot-corrosion resistant alloys for marine gas turbines (Navy/MEL)
 4. Study of fuel treatments for residual fuels
 5. Materials developments for hot-stage use in residual fuel marine industrial turbines
138. General Electric Company
 Material and Process Technology Laboratories
 Thomson Laboratory
 1000 Western Ave.
 Lynn, Massachusetts 01905
 Dr. M. Kaufman (617) 594-5156
 E. J. Beltran
 Programs:
 1. Hot corrosion behavior of nickel- and cobalt-base superalloys and protective coatings in simulated marine and industrial environments
139. General Electric Company
 Oxidation/Corrosion Laboratory
 Materials Development Engineering
 Gas Turbine Department #53-337
 Schenectady, New York 12305
 Harvey von E. Doering (518) 374-2211
 Ext. 54311
 Programs:
 1. Development of high temperature (1400 - 2000 oxidation data for design properties
 2. Evaluation of nickel- and cobalt-base alloys and coatings in crude and residual fuels
 3. Evaluation of nickel- and cobalt-base alloys and coatings in hot corrosion
 4. Evaluation of corrosion inhibiting additives for vanadium bearing fuels
140. General Electric Company
 Research and Development Center
 Metallurgy and Ceramics Laboratory
 P.O. Box 8
 Schenectady, New York 12301
 Dr. C. S. Tedmon Jr. (518) 346-8771
 Dr. H. S. Spacil (518) 346-8711
 Dr. Alan U. Seybolt (518) 346-8771
 Programs:
 1. Thermodynamics and kinetics of corrosion of gas turbine alloys burning impure fuel
 2. Research on mechanisms of hot corrosion
141. General Electric Company
 Materials and Process Technology Laboratory
 Aircraft Engine Group
 Building 500-M87
 Cincinnati, Ohio 45215
 Dr. William C. Hagel
 C. S. Wukusick
 Programs:
 1. Hot corrosion and oxidation of superalloys
142. General Electric Company
 Materials and Processes Laboratory
 Aircraft Engine Group
 Evendale, Ohio 45218
 Dr. R. E. Allen (513) 243-6738

Programs:

1. Strengthening of FeCrAlY oxidation resistant alloys
2. The influence of high velocity (Mach 0.5-1.0) gases on surface stability in high-temperature alloys
3. Oxidation resistance and coating development for high strength Cr alloys
4. Coating development for TD NiCr
5. The influence of small quantities of rare earth elements on the oxidation resistance of Ni-base superalloys

143. IIT Research Institute

Metals Division
 10 West 35th Street
 Chicago, Illinois 60616
 Dr. V. L. Hill (312) 225-9630

Programs:

1. Development of oxidation-resistant hafnium-base alloys (current)
2. Investigation of refractory metal composites for liquid rocket engines (oxidation-corrosion in O₂, F₂, HF, BF₃ and their combinations) (current)
3. Ductile claddings for dispersion-strengthened nickel-base alloys (oxidation of Ni-Cr-Al-Y, Ni-Cr-Ta-Y, and Fe-Cr-Al-Y Alloys) (Completed)

144. The International Nickel Company, Inc.

Paul D. Merica Research Laboratory
 Materials Systems Section
 Sterling Forest
 Suffern, New York 10901
 Dr. J. W. Schultz (914) 735-2761

Programs:

1. Improved test methods for hot-corrosion and oxidation
2. Effects of alloy composition on hot corrosion and oxidation resistance of nickel-base alloys

145. Little, A. D., Inc.

R&D Division, Materials Section
 Cambridge, Massachusetts 02140
 Dr. Joan B. Berkowitz (617) 864-5770 Ext. 2913

Programs:

1. Effects of electric fields on hot corrosion in conducting flames

146. Lockheed Missiles & Space Company

Palo Alto Research Laboratories
 Metallurgy and Composites, D/52-31, B/204
 3251 Hanover Street
 Palo Alto, California 94304
 Dr. T. E. Tietz (415) 324-3311 Ext. 45678
 R. A. Perkins (415) 324-3311 Ext. 45740
 C. M. Packer (415) 324-3311 Ext. 45286

Programs:

1. Stability characterization of refractory materials under high velocity flight conditions (Air Force)
2. Nitridation resistant chromium alloys (NASA)
3. Coatings for tantalum alloys (NASA)
4. Environmental stability of high temperature alloys (IR&D)

147. Los Alamos Scientific Laboratory

Group N-1
 P.O. Box 1663
 Los Alamos, New Mexico 87544
 Dr. R. J. Fries (505) 667-6322

Programs:

1. Chemical diffusion coefficients of carbon in the Group VI refractory metals as determined from carbide layer growth rates
2. Carbide layer growth rates of W/Mo and W/Re alloys
3. Evaporation rates of refractory metals

148. Manlabs, Inc.

21 Erie Street
 Cambridge, Massachusetts 02139
 Dr. L. Kaufman

Programs:

1. Stability characterization of refractory materials under high velocity atmospheric flight conditions
2. Development of boride composites for oxidation resistant components

149. Massachusetts Institute of Technology

Corrosion Laboratory
 Room 8-202
 Cambridge, Massachusetts 02139
 Prof. Herbert H. Uhlig (617) 864-6900 Ext. 3313

Programs:

1. Initial oxidation of single crystal copper (150-250 C)

150. Michigan, University of

Department of Chemical and Metallurgical Engineering
 Ann Arbor, Michigan 48104
 Prof. Lawrence H. Van Vlack (313) 764-2385

Programs:

1. Oxide subscales in binary iron alloys
2. Scale and subscale formation in alloys of iron with Group VIB elements

151. NASA-Lewis Research Center

Coating Section, 49-1
 21000 Brookpark Road
 Cleveland, Ohio 44135
 Salvatore J. Grisaffee (216) 433-4000 Ext. 393

Programs:

1. Pack and slurry coatings for superalloys and dispersion strengthened materials
2. Alloy claddings for superalloys and dispersion-strengthened metals
3. Oxidation behavior of coatings and metal claddings
4. Characterization of coatings and metal claddings
5. Development and evaluation of slurry coatings for refractory metals
6. Coatings for high performance rocket engines
7. Hot corrosion of alloys

152. NASA Lewis Research Center

Oxidation and Refractory Compounds Section, 49-1
 21000 Brookpark Road
 Cleveland, Ohio 44135
 Dr. H. B. Probst (216) 433-4000 Ext. 267

Programs:

1. Oxidation of TD Nickel-Chromium
 Surface preparation effects
 Velocity effects
 Pressure effects
 Scale topology
 Hot corrosion
2. Oxidation mechanisms and kinetics in the Ni-Al, Ni-Al-Cr, Ni-Al-Ti, and Ni-Al-Si systems
3. Simulated turbine engine oxidation of commercial cast Ni-base superalloys
4. Vaporization of protective scales

5. Cyclic oxidation of Cr_2O_3 and Al_2O_3 forming alloys
 6. Properties of spinels
 7. Coating and cladding studies
153. National Bureau of Standards
 Corrosion Section
 Washington, D. C. 20234
 Dr. J. Kruger (301) 921-2094
 Programs:
 1. Surface reactions and initial film formation
154. Naval Air Development Center
 Mechanical Metallurgy Branch (MAMM-4)
 Metallurgical Division
 Aero Materials Department
 Warminster, Pennsylvania 18974
 Robert G. Mahorter (215) 672-9000 Ext. 2808
 Programs:
 1. Analyses of parts from engines subjected to naval aircraft service to determine the extent and severity of oxidation/corrosion problems
 2. Studies of surface reaction kinetics with the objective of minimizing scale formation on heat resisting alloys
 3. Development of NDT methods for detecting incipient hot corrosion
155. Naval Ship Research and Development Laboratory
 Metals and Composites Division
 Code A815
 Annapolis, Maryland 21402
 Walter L. Wheatfall, Sr. (301) 268-7711
 Ext. 8205
 Programs:
 1. Hot corrosion behavior of recently developed nickel-base alloys in combustion products from diesel fuel
 2. Oxidation behavior of nickel-base superalloys
 3. Development of dispersion-strengthened cobalt-base alloys
 4. Effect of fuel additives on hot-corrosion behavior of materials in combustion products of vanadium-bearing fuels plus ingested sea salt
 5. Effect of alloying elements on hot-corrosion behavior of nickel-base alloys
 6. Mechanism of hot corrosion
156. New York, State University of
 Dept. of Materials Science
 College of Engineering
 Stony Brook L. I., New York 11790
 Prof. L. Seigle
 Programs:
 1. Mechanism of oxidation of Ni-Al alloys
157. North American Rockwell Corp.
 Science Center
 Thousand Oaks, California 91360
 Dr. Neil Paton (805) 498-4545
 Programs:
 1. Oxidation of thoria-dispersed nickel-base alloys
 2. Hot salt stress corrosion of superalloys
158. Northwestern University
 Department of Materials Science
 The Technological Institute
 Evanston, Illinois 60201
 Prof J. Bruce Wagner, Jr.
 Programs:
 1. The diffusion of sulfur and also the diffusion of chlorine in single crystals of oxides
159. The Ohio State University
 Dept. of Metallurgical Engineering
 116 W. 19th Avenue
 Columbus, Ohio 43210
 Prof. Robert A. Rapp (614) 293-6178
 Programs:
 1. Oxidation of Ni-Cr-Al alloys at 1000-1200 C
 2. Solubility and diffusivity of oxygen in solid nickel
 3. Diffusion of chromium in nickel oxide
 4. Control of oxygen activity in gaseous environments
160. Olin Corporation
 Metals Research Laboratories
 91 Shelton Avenue
 New Haven, Connecticut 06511
 Dr. M. J. Pryor
 Programs:
 1. High-temperature oxidation of copper-base alloys
161. Pennsylvania State University
 Metallurgy Section
 M. I. Building
 University Park, Pennsylvania 16802
 Prof. G. Simkovich (814) 865-3351
 Programs:
 1. Sulfidation of binary and ternary iron-base alloys
 2. Oxidation of chromium-base alloys
 3. Oxidation of cast irons
 4. Oxidation and sulfidation of pure metals
 5. Oxidation and simultaneous carburization of pure metals and alloys
 6. Effect of gas solubilities in scales upon kinetics of oxidation and sulfidation
162. Pennsylvania, University of
 School of Metallurgy and Materials Science
 Philadelphia, Pennsylvania 19104
 Prof. W. L. Worrell (215) 594-8592
 Programs:
 1. Kinetics of dissociation of $\text{H}_2\text{S}(\text{g})$ on iron sulfide (FeS) at elevated temperatures
 2. Nitridation of titanium at temperatures between 1200 and 1500 C
 3. High-temperature corrosion of chromium and chromium-nickel alloys in SO_2/O_2 atmospheres
163. Phillips Petroleum Company
 Research and Development Dept.
 Phillips Research Center, Bldg. C-7
 Bartlesville, Oklahoma 74003
 R. M. Schirmer (918) 336-6600 Ext. 48-573
 Programs:
 1. Effect of sulfur in JP-5 fuel on hot corrosion of turbine blade materials in marine environment
 2. Evaluation of protective coatings for resistance to hot corrosion
 3. Effect of smoke-abatement additives in JP-5 fuel on hot corrosion of turbine blade materials
 4. Development of turbine simulator for hot corrosion studies
 5. Inhibition of hot corrosion of superalloys by fuel additives
 6. Effect of pressure on hot corrosion of superalloys
 7. Effect of vanadium in fuel on hot corrosion of superalloys
 8. Effect of lead in fuel on hot corrosion of superalloys

164. Pratt & Whitney Aircraft
 Division of United Aircraft Corp.
 Advanced Materials Research and Development
 Laboratory
 Middletown, Connecticut 06457
 Dr. F. S. Pettit (302) 347-4401 Ext. 3189
 Dr. G. W. Goward (302) 347-4401 Ext. 3189
 Pratt & Whitney Aircraft Div.
 East Hartford, Conn.
 Dr. D. H. Boone
 Programs:
 1. Oxidation and hot corrosion (Na_2SO_4 , etc.) of nickel- and cobalt-base alloys--development of more resistant alloys
 2. Protective coatings for nickel- and cobalt-base alloys
 3. Oxidation of uncoated and coated columbium-base alloys
165. Purdue University
 School of Materials Science and Metallurgical Engineering
 Lafayette, Indiana 47907
 Prof. Richard E. Grace (317) 749-2601
 Programs:
 1. Transition kinetics during linear to parabolic oxidation of chromium (recently completed)
 Oxidation-sulfidation kinetics of iron (current)
166. Solar Division
 International Harvester Company
 Process Research Dept. (Mail Zone R-1)
 2200 Pacific Highway
 San Diego, California 92112
 A. R. Stetson
 Programs:
 1. Castings for dispersion strengthened alloys--NAS3-14312
 2. Fused slurry silicide coatings for Ta reentry heat shields--NAS3-14315
 3. Evaluation of coatings for cobalt- and nickel-base superalloys--NAS3-9401
 4. Silicide coatings for tantalum and columbium alloys--NAS3-9412 and NAS3-7276 (NASA CR-72519 and NASA CR-54529)
 5. Hot corrosion of coated superalloys in a gas turbine environment, Contract No. N00019-68-C 0532 (Naval Air System Command AIR 53674)
167. Stanford Research Institute
 Materials Sciences Laboratory
 Menlo Park, California 94025
 Dr. Daniel D. Cubicciotti (415) 326-6200
 Programs:
 1. Volatilization of metal oxides and thermodynamics of oxides
 2. Hot salt corrosion
 3. Reactions with salts and oxides
168. Stanford University
 Mineral Engineering Dept.
 Stanford, California 94305
 Prof. R. W. Bartlett (415) 321-2300 Ext. 4470
 Programs:
 1. Solubility and diffusion of oxygen in platinum and the effect of other metals in platinum alloys on both internal oxidation and oxygen transport. The end applications are related to high temperature coatings based on platinum group metals. (current)
169. Sylvania Electric Products, Inc.
 Chemical and Metallurgical Division
 High Temperature Composites Laboratory
 70 Cantiague Road
 Hicksville, New York 11802
 Lawrence Sama (516) 931-3500
 Programs:
 1. Development of protective coatings for columbium alloy gas turbine blades
 2. Scale-up of fused silicide coatings for columbium alloy reentry heat shields
170. Systems Research Laboratories, Inc.
 Physical Sciences Division
 7001 Indian Ripple Road
 Dayton, Ohio 45440
 Dr. W. C. Tripp (513) 426-6000
 Programs:
 1. Electrical behavior of ceramic materials at high temperatures (includes study of defect structure and high temperature oxidation of metals and alloys)
171. TRW, Inc.
 Equipment Group
 23555 Euclid Avenue
 Cleveland, Ohio 44117
 Dr. J. V. Peck (216) 383-2967
 Dr. R. J. Quigg
 Programs:
 1. Aluminide coatings on superalloys
 2. Non-aluminide coatings for superalloys
 3. Coatings for columbium
 4. Basic corrosion of superalloys
 5. Development of production manufacturing techniques for coating TD Ni
 6. Development of repair and reprocess coating for Ni-base alloy turbine blades
 7. Development of improved coatings for Ni- and Co-base alloys
 8. Manufacturing techniques for W/Si-W coated tantalum
172. United Aircraft Research Laboratories
 High Temperature Materials Research
 400 Main Street
 East Hartford, Connecticut 06108
 Dr. Michael A. DeCrescente
 N. Bornstein
 Programs:
 1. Sulfidation mechanisms
 2. Mechanism of vanadium accelerated corrosion
 3. High temperature oxidation
173. United States Steel Corporation
 Applied Research Laboratory MS-16
 P.O. Box 38
 Monroeville, Pennsylvania 15146
 Dr. W. E. Boggs (412) 372-1212
 Dr. E. H. Phelps
 Programs:
 1. Investigation of the reactions between hot sulfur-containing gases and iron base alloys (current)
 2. The modification and inhibition of oxide formed on steel in slab reheat furnaces (current)
 3. Effects of alloying elements on the formation of protective oxide films on heat resistant steels (terminated 1970)
 4. Evaluation of high-temperature oxidation performance of ferrous alloys
 5. Development of coatings for oxidation resistance
174. United States Steel Corporation
 Physical Chemistry Section
 Edgar C. Bain Laboratory for Fundamental Research
 Research Center
 Monroeville, Pennsylvania 15146

Dr. Howard W. Pickering (412) 351-3100

Programs:

1. Transition from internal to external oxidation in binary and ternary alloys
2. Preferential attack of one component of binary alloys by an aggressive gas

175. University of California at Los Angeles

Materials Department

6531 Boelter Hall

Los Angeles, California 90024

Prof. D. L. Douglass (213) 825-1622

Programs:

1. Zirconium oxidation mechanism
2. Role of oxide plasticity on oxidation
3. Influence of rare earth metals on oxidation
4. Resistance of Ni-20Cr and Ni₃Al

176. Vanderbilt University

Dept. of Materials Science and Metallurgical Eng.
Nashville, Tenn. 37203

Prof. B. D. Lichter (615) 322-2415

Programs:

1. Hot corrosion mechanisms in Ni-Cr alloys and superalloys
2. Effect of rare-earth oxide additions on hot corrosion of Ni-Cr alloys

177. Westinghouse Electric Corp.

Astronuclear Laboratory

Metals Science Section

P.O. Box 10864

Pittsburgh, Pennsylvania 15236

Dr. R. C. Svedberg (412) 892-5600

Programs:

1. Investigation of the possibility of modifying the defect structure of parent oxides to enhance oxidation protection (NASC No. N00019-70-C-0148) (current)
2. Reactivity of some vanadium alloys with the interstitials oxygen, nitrogen, and carbon at low partial pressures (AEC Contract AT(30-1)-3791 (completed))
3. Evaluation of mechanical properties, oxidation resistance and structure of slurry-silicide coated T-222 (NASA-CR-72713) Contract No. NAS3-12410 (completed)
4. Development of ductile oxidation resistant columbium alloy (AFML-TR-69-64) Contract No. AF33615-67-C-1689 (completed)

178. Westinghouse Electric Corporation

Westinghouse Research Laboratories

Churchill Borough

Pittsburgh, Pennsylvania 15235

Dr. Earl A. Gulbransen (412) 256-3475 or 3482

Programs:

1. Vaporization chemistry in the oxidation of Cr, Si, Mo and Cb
 2. Thermochemistry and the high temperature oxidation of Si and SiC
 3. Thermochemistry and the reaction of metals with S and O gases
 4. High temperature oxidation of refractory metals
 5. Thermochemistry and the combustion of aluminum and zirconium
-

TABLE 2. CATEGORY INDEX

Category*	Code*	Organization (Number from Table 1)	Total
Thermodynamics, phase diagrams, reaction equilibria	1.1	1,3,5,6,13,14,19,20,22,26,27,31,32,37,39,41,42,43,44,49,53,54,60,61,65,66,67,69,70,74,82,83,84,85,92,94,95,97,99,100,102,106,107,119,124,129,130,135,147,152,155,156,159,167,168,171,172,173,174,175,178	61
Electrochemical problems	1.2	1,14,20,23,28,43,50,54,58,59,60,61,67,69,70,73,74,85,94,97,102,115,118,145	24
Reaction kinetics and diffusion processes	1.3	2,3,5,6,9,10,11,13,14,15,17,19,21,26,28,30,31,32,37,38,39,40,41,42,43,44,48,49,51,53,54,57,58,59,60,61,66,67,68,69,73,79,80,83,84,85,90,92,94,97,98,99,100,102,105,106,107,108,112,113,114,117,118,119,121,122,124,125,127,130,133,135,140,141,142,144,147,149,150,152,153,154,155,156,158,159,161,162,165,167,171,172,173,174,175,177,178	97
Aerodynamic factors (mechanism of deposition)	1.4	97,146,148,152	4
Rheological investigations (viscosity of the melts)	1.5	48,57,97	3
Development of corrosion-resistant materials	2.1	2,18,22,24,32,36,47,52,53,61,62,65,70,74,85,87,88,91,92,94,97,100,101,102,103,104,106,107,111,119,124,128,134,136,137,142,143,146,148,155,176,177	42
Surface protection of materials	2.2	5,6,7,8,15,16,19,22,24,27,29,30,32,33,34,35,40,49,51,56,57,61,63,64,66,68,70,74,75,85,90,94,97,107,108,114,115,116,118,119,120,121,124,131,132,136,138,139,142,143,146,151,152,163,164,166,168,169,171,177	60
Material Behavior under corrosion	2.3	2,3,4,5,6,8,11,12,13,14,15,16,17,19,22,24,25,33,39,40,45,46,47,49,50,51,52,53,54,55,56,57,58,59,61,62,63,64,65,66,69,70,71,72,74,75,76,77,78,81,82,83,85,86,87,88,89,90,91,92,93,94,95,96,97,98,99,101,102,103,104,106,107,108,109,110,111,112,114,115,116,117,118,119,120,121,123,124,126,127,128,131,137,138,139,140,141,143,144,146,150,151,152,154,155,157,159,160,161,162,163,164,166,170,171,174,175,176,177	119
Additives	3.1	48,49,53,64,69,71,75,82,86,87,88,89,109,114,115,118,139,163	18
Surface treatment of pipes, supports, and other parts of furnaces, boilers, turbines, etc. exposed to high temperatures	3.4	2,7,49,53,56,72,75,86,87,88,89,97,110,114,118	15

*The categories and code numbers were selected to conform to those of the European Federation of Corrosion survey.

TABLE 3. NAME INDEX

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