INVENTORY OF ON-GOING HIGH TEMPERATURE MATERIALS RESEARCH ACTIVITIES IN EUROPE

SECTION 1 : CORROSION

COMMISSION OF THE EUROPEAN COMMUNITIES
Joint Research Centre, Petten Establishment
High Temperature Materials Information Centre

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SECTION 1 : CORROSION

Coordination : B. Bathe

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Introduction

In the frame of the High Temperature Materials (HTM) Programme of the Commission of the European Communities, carried out at the JRC, Petten Establishment, an Inventory of HTM research in Europe is being established. Inventories facilitate identification of areas where cooperation should be promoted and additional R & D actions be stimulated.

The present volume contains the first section of the Inventory, devoted to HTM-Corrosion. Further sections are under preparation: Section 2 will deal with Mechanical Properties of HTM's.
The report is a revised and enlarged version of the interim survey *), which was published in 1980, comprising information obtained by means of an inquiry carried out in 1979/80 and by personal communication.

This section lists 318 on-going research projects with indication of the performing organisations (91 entries) and the names of the scientists involved in this research. The list is arranged in alphabetic order per country and organisation. Replies in languages other than English have been translated.
Access to specific research activities is facilitated by indexing per type of materials application/technology, type of material, type of research topic and the involved scientists (240).

The JRC, Petten Establishment appreciates the willing contribution of all the organisations and scientists who shared in the realisation of this first section and would welcome support for the preparation of future editions.

*) *EUR 6919 - High Temperature Corrosion Research in Europe - An interim survey. ECSC-EEC-EAEC Brussels-Luxembourg, 1980.*

AUSTRIA

(1) **Osterreichische Studiengesellschaft für Atomenergie GmbH**
Forschungszentrum Seibersdorf, Institut für Metallurgie,
Lenaugasse 10, A-1082-Wien

H.P. Degischer (1)
O. Demel (2 - 4)
H. Konvicka (5)

Projects : (1) Pilot project Nuclear Process heat (PNP) materials testing :
Long term creep tests and corrosion in process-gas between 800 and 950 °C.

(2) Post exposure examination of alloys exposed to HTR helium in the DRAGON reactor.

(3) Post exposure examination of alloys exposed to simulated HTR helium.

(4) Influence of time and temperature on the structural stability of Alloy 800 type steels.

(5) Materials compatibility with liquid metals :
Compatibility of Fe-Cr-Ni-base alloys (between 15 and 70 °/o Ni) with dynamic liquid sodium at 730 °C with special attention to nickel and carbon mass transfer.
Compatibility of austenitic and ferritic steels and refractory metals with liquid lithium at 400 - 600 °C.

BELGIUM

(2) **N.V. Bekaert, Metal Fibre Department**
B - 8550 Zwevegem.

M. De Bondt
R. De Bruyne
I. Lefever

Project : Determination of metal fibre properties (ϕ 4 - 22 μm) made of special stainless steels and nickel-base alloys in hot gases and combustion products.

(3) **C.E.B.E.L.C.O.R.**
Centre Belge d'Etude de la Corrosion
Av. Paul Hèger, Grille 2
B - 1050 Bruxelles

M. Pourbaix

Project : Atlasses of chemical and electrochemical equilibria in the presence of a gaseous phase.

(4) **Centre de Recherches Métallurgiques**
Abbaye du Val-Benoit, Rue du Val Benoit, 69
B- 4000 Liège

A. Davin
D. Coutsouradis
L. Habraken †

Projects : (1) Study of protective coatings (evaporation, sputtering, ion plating) for protection against hot corrosion of iron-, nickel- or chromium-base alloys.

(2) Evaluation of stability of coated and uncoated high-temperature iron-, nickel-, or chromium-base alloys in hot corrosion environments.

(5) **S.C.K.-C.E.N. (Centre d'Etude de L'Energie Nucléaire)**
200 Boeretang
B-2400 Mol

F. Casteels
M. Soenen
H. Tas

Projects : (1) Lithium-corrosion of ferritic and austenitic steels and of nickel-, vanadium- and titanium-base alloys.

(2) Corrosion mechanisms and the deterioration of mechanical properties of ferritic and austenitic steels and nickel alloys in dynamic sodium.

DENMARK

(6) **Risø National Laboratory**
DK - 4000 Roskilde

K. Rørbo

Project : Metallurgical examination of components from steam reformers, ammonia converters, etc. after service.

(7) **University of Copenhagen**
H.C. Ørsted Institute, Department of Physical Chemistry,
Universitetsparken 5,
DK - 2100 Copenhagen, Ø.

P.J. Møller

Projects : (1) Reaction kinetics and thermodynamics of oxidation of copper- and gold-base alloys.

(2) Reaction kinetics and surface structures in the oxidation of iron-and chromium-base alloys.

FRANCE

(8) ***Creusot-Loire***
Centre de Recherches
F - 4270 Firmin Cedex

P. Poyet
C. Pichard

Projects : (1) High temperature oxidation behaviour of cast Fe-Mn-Al-alloys (cf. Entry No. 18)

(2) Corrosion of steels in molten metals like Sn-Pb-Al-Zn.

(9) **E.D.F.**
Electricité de France - *Service du Traitement Individual*
des Résidues Urbains (E.D.F. - T.I.R.U)
43, Rue Bruneseau,
F - 75013 Paris

A. Moreau

Projects : (1) Fireside corrosion of furnace tubes by ash deposits and chlorine-containing combustion gases.

(2) Corrosion and protection of recuperators burning domestic waste.

(10) **Ecole Nationale Supérieure de Chimie de Paris**
Laboratoire de Physicochimie des Surfaces
11, Rue Pierre et Marie Curie
F - 75231 Paris Cedex 05

J. Oudar

Projects : (1) Initial stages of oxidation and sulphidation of iron- and nickel base alloys.

(2) Solubility of sulphur in transition-metals and iron-base alloys.

(11) **E.N.S.E.E.G.**
Ecole Nationale Supérieure - Electrochimie et Electrométallurgie,
Laboratoire d'Adsorption et Réaction de gaz sur solides,
E.R.A. C.N.R.S. No. 368,
B.P. 44,
F- 38401 St. Martin d'Hères

M. Caillet
P. Sarrazin

Projects : (1) Protective coatings for high-temperature application.

(2) Siliconising, vanadium nitride and ion implantation; preparation, properties and oxidation resistance.

(3) Corrosion of electrical contacts by the degradation products of SF_6.

(4) Oxidation of Ni-Al alloys by SO_2.

(12) **E.N.S.E.E.G.**
Ecole Nationale Superieure - Electrochimie et Electrométallurgie,
Laboratoire d'Energétique Electrochimique, L.A. 265,
Domain Universitaire,
F - 38401 St. Martin d'Hères

J.J. Rameau

Projects : (1) Corrosion of steels and stainless steels by molten Na_2S-Na_2CO_3 and hot gases in recovery boilers for Kraft pulp process industry.

(2) Corrosion of steels, stainless steels and superalloys by molten salts (Hitec salt, chlorides, carbonates or hydrogen mixtures).
Application to energy storage in nuclear or solar plants.

(3) Corrosion of nickel, titanium, iron and their alloys by molten borates at 1000 ^{o}C.

(4) Corrosion of nickel, iron, molybdenum and their alloys by molten silicates at 900 ^{o}C.

(5) Corrosion of ionic-conducting refractories by molten chlorides and molten hydroxides.

(13) **E.N.S.M.P.**
Ecole Nationale Supérieure des Mines de Paris
Centre de Matériaux
BP 87
F - 91003 Evry Cedex

G. Pomey
J.P. Henon (1-5)
J. Bienvenu (6)

Projects : (1) Oxidation and corrosion mechanisms of nickel base alloys.

(2) Hot corrosion studies of coatings on nickel base alloys.

(3) Study of cracking and spalling of surface oxide films.

(4) Influence of oxidation at high temperature on creep/ fatigue crack initiation and propagation.

(5) Stress corrosion and corrosion-fatigue crack propagation and mechanisms.

(6) High temperature corrosion of iron-base alloys in sulphidising atmospheres.

(14) **ONERA**
Office National d'Etudes et de Recherches Aéro-Spatiales
29, Avenue de la Division Leclerc,
F- 92 Chatillon-sous-Bagneux.

P. Galmiche

Projects : (1) Development of protective coatings for cooled and un-cooled components in turbo-reactors and power turbines. Conventional refractory superalloys and new materials such as oriented, directionally-solidified eutectics.

(2) Design of new types of structures using at least partly chromium-containing materials such as stainless steels and refractory superalloys, e.g. heat exchangers of turbo-reactors or aero-engine turbine components due to operate at high temperature in corrosive media.

(15) **Université de Technologie de Compiègne**
Division Matériaux et Service d'Analyse
B. P. 233
F - 60200 Compiègne Cedex

G. Béranger
F. Armanet

Projects : (1) Oxidation behaviour of iron- and nickel base superalloys in air/H_2O vapour atmospheres.

(2) Corrosion of titanium-base alloys.

(16) **Université de Dijon - U.E.R. - M.I.P.C -**
Faculté des Sciences - Miranda,
Laboratoire de Recherches sur la Réactivité des Solides,
B.P. 138,
F - 21004 Dijon Cedex

J.C. Colson
M. Lambertin
J.P. Larpin
S. Toesca

Projects : (1) Corrosion of steels and other alloys in sulphidizing and oxidizing atmospheres.

(2) Influence of plastic strain on high-temperature corrosion.

(17) **Université de Limoges**
Centre de Recherches et d'Etudes Céramiques
Equipe de Recherche Associée n° 539 du C.N.R.S.
123, Rue Albert Thomas
F - 87060 Limoges Cedex

M. Billy	(1 - 3)	J.C. Labbe	(3)
D. Bernache	(3)	P. Lefort	(1, 2)
J. Desmaison	(1 - 2)	J. Mexmain	(2)
P. Goursat	(1, 2)	F. Nardou	(1)
J. Jarrige	(2)	F. Raynaud	(1)

Projects : (1) High temperature oxidation kinetics of gas turbine ceramics (nitrides and carbides) in air and O_2, H_2/H_2O, CO/CO_2 atmospheres.

(2) Influence of corrosive atmospheres on mechanical properties (flexure strength, creep, crack velocity).

(3) Corrosion of ceramics in liquid metals.

(18) **Université de Lyon**
Ecole Centrale de Lyon
Département de Métallurgie Physique Matériaux
36, Route de Dardilly
F - 69130 Ecully

P. Guiraldenq

Projects : (1) Materials for nuclear and chemical application (Fe-Cr-Ni and Ni-Cr-alloys): Study of the first stages of de-chromisation in steam by radioactive tracers.

(2) Development of low cost stainless steel (i.e. without chromium and nickel) for electricity generating applications e.g. turbine blades and rotors in steam atmospheres.
(This work is being done in co-operation with Creusot-Loire cf. Entry No. 8)

(19) **Université de Nancy I**
Laboratoire de Chimie Minérale,
Case Officielle No. 140,
F - 54037 Nancy Cedex

B. Roques
B. Dupre

Project : Hot corrosion of aluminized coatings on nickel-base super-alloys.

(20) **Université de Paris-Sud**
Laboratoire de Métallurgie Physique,
Bâtiment 413,
F - 91405 Orsay

Mme A.M. Huntz
P. Lacombe

Projects : (1) Oxidation behaviour of Fe-Ni-Cr alloys and the influence of yttrium additions.

(2) Diffusion processes in mono- and polycrystalline Al_2O_3.

(3) Corrosion of iron- and nickel-base alloys in SO_2/O_2, CO/CO_2 and H_2S/H_2 atmospheres.

(4) Measurement of stress development during oxidation of heat-resistant alloys.

F.R. GERMANY

(21) **Allianz-Zentrum für Technik GmbH**
Krausstr. 14,
D - 8045 Ismaning

P.H. Effertz
D. Wiume

Project : Investigation of mechanisms of failure of boiler tubes in coal and fuel oil fired boilers by high-temperature corrosion.

(22) **Robert Bosch GmbH**
Postfach 30 02 40,
D - 7 Stuttgart 30

H. Pflug

Project : Development of glow plugs for diesel engines, resistant to hot corrosion and with good stress-rupture properties.

(23) **Brown Boveri & Cie AG**
Postfach 351,
D - 6800 Mannheim

H.W. Grünling
K. Schneider
R. Bauer

Projects : (1) Influence of coatings on high-cycle fatigue properties of cast nickel-base superalloys.

(2) High-temperature corrosion of gas turbine materials and coatings with and without mechanical stresses.

(3) Interaction of creep and high-temperature corrosion of nickel-base alloys.

(24) **DECHEMA - Deutsche Gesellschaft für chemisches Apparatenwesen**
Theodor-Heuss-Allee 25,
D - 6000 Frankfurt a/Main 97

A. Rahmel

Projects : (1) Influence of electrode potential on corrosion and creep of superalloys in sulphate melts. (cf. Entry No. 88)

(2) Corrosion behaviour of an Fe-20Cr alloy in $H_2/H_2O/H_2S$ mixtures.

(3) Interaction between corrosion and creep at constant strain rates.

(25) **Deutsche Lufthansa AG -**
Materials and Process Engineering Department,
Postfach 300,
D - 2000 Hamburg 63.

M.P. Malik

Projects : (1) Performance evaluation of high-temperature coatings in transport aircraft gas turbines. (cf. Entry No. 88)

(2) Development of new erosion- and corrosion-resistant coatings.

(26) **Hochtemperatur-Reaktorbau GmbH**
Gottlieb-Daimler-Str. 8,
D - 6800 Mannheim

W. Theymann
Thiele

Projects : Alloys for high-temperature reactor components:

(1) Corrosion behaviour of high-temperature materials in HHT (High-temperature Helium Turbine) - helium.
(2) Corrosion behaviour of high-temperature material in PNP (Pilot project Nuclear Process heat) - helium.
(3) Evaluation of tritium diffusion barriers (coatings) on high-temperature materials.
(4) Development of alloys as protective coatings against carburization and internal oxidation of high-temperature materials.

(27) **INTERATOM - Internationale Atomreaktorbau GmbH**
Friedrich-Ebert-Strasse,
D - 5060 Bergisch-Gladbach 1.

GTH/IA	Gesellschaft für Hochtemperatur-Reaktor Technik /Interat.
BF	Bergbauforschung
HRB	Hochtemperatur-Reaktorbau GmbH
KFA	Kernforschungsanlage, Jülich
RBW	Rheinische Braunkohlenwerke

A. Mittenbühler

Projects : (1) Materials evaluation and development programmes for high-temperature corrosion-resistant alloys in HTR helium in turbines and process heat applications. More specific entries are included under individual organisations listed above.

(28) **Kernforschungsanlage Jülich - Institut für Reaktorentwicklung**
Postfach 1913,
D - 5170 Jülich

R. Hecker
H.D. Röhrig

Projects : Materials behaviour in nuclear process heat systems related to hydrogen and tritium:

(1) Hydrogen permeation in heat-exchanger materials.

(2) Tritium permeation in heat-exchanger materials.

(3) Sorption and diffusion of hydrogen isotopes in HTR materials.

(29) **Kernforschungsanlage Jülich GmbH - Institut für Reaktorwerkstoffe**
Postfach 365,
D - 5170 Jülich 1

A.V. Dean
P.J. Ennis
W.J. Quadakkers
H. Schuster

Projects : (1) Corrosion (oxidation/carburization) of nickel- and iron-base commercial alloys in simulated high-temperature reactor helium and in process gas.

(2) Effect of HTR corrosion on creep-rupture properties and on short-time tensile properties.

(3) Corrosion of wide-range model alloys in HTR helium.

(30) ***Kernforschungszentrum Karlsruhe GmbH -***
Institut für Material- und Festkörperforschung II,
Postfach 3640,
D - 7500 Karlsruhe 1.

S. Leistikow (1, 2)
H.U. Borgstedt (3, 4)

Projects : (1) High-temperature oxidation of Zircaloy in steam under loss-of-coolant and core melt-down conditions.

(2) High-temperature oxidation in steam and impure helium under creep deformation of austenitic stainless steels and nickel-base alloys.

(3) Influence of sodium on properties of materials.

(4) Corrosion of stainless steels and vanadium alloys by liquid lithium.

(31) **Mannesmann Forschungsinstitut GmbH**
Ehinger Str. 200,
D - 4100 Duisburg 25.

P.G. Kalwa
Weber

Project : High-temperature corrosion behaviour of Fe-Cr-Ni and Ni-Cr-base alloys in carburizing environments.

(32) **MAN Neue Technologie - Werkstofftechnik**
Dachauerstrasse 667,
D - 8000 München 50

H. Sprenger

Projects : (1) Interaction of creep/fatigue and oxidation in super-alloys and austenitic steels in solar power plant applications.

(2) Hot corrosion of high-temperature alloys in process gas turbines.

(3) Reduction of deposits in exhaust turbochargers.

(4) Coatings against fretting and corrosion of Ni-Fe-base alloys in reactor circuits.

(5) Oxidation and hot corrosion of high-temperature alloys in diesel engines.

(33) **Max-Planck-Institut für Eisenforschung**
Max-Planck-Str. 1,
D - 4000 Düsseldorf

H.J. Grabke
J. Hemptenmacher
D.S. Williams
R. Möller

Projects : (1) Effect of sulphur and other additives in the gas atmosphere on the carburization of Incoloy 800.

(2) Corrosion processes in complex oxidizing, sulphidizing and carburizing atmospheres.

(3) Interaction of corrosion and creep.

(34) **Posé - Marré - Edelstahlwerk GmbH**
Gerberstr. 26,
D - 4005 Erkrath 1

W. Steinkusch

Projects : (1) Nitrogen pick-up of heat-resistant alloys during service in heat-treatment furnaces and pyrolysis tubes in the petrochemical industry, and related laboratory studies.

(2) Carburization resistance of heat-resistant, cast Ni-Cr alloys.

(35) **Rheinische Braunkohlenwerke AG**
Postfach 41 08 40,
D - 5 Köln 41

Teggers
Theis
D. Schuhmacher

Projects : Materials evaluation for nuclear process heat, esp. coal gasification :

(1) Corrosion testing in process gas atmospheres (H_2O, CO, H_2, CH_4).
(2) Creep testing in process gas atmospheres.
(3) Structural stability of high-temperature alloys in service conditions
(4) Materials testing in coal gasification pilot plants.

(36) **Schmidt and Clemens GmbH and Co.**
Edelstahlwerke Kaiserau,
Postfach 114,
D - 5253 Lindlar

U. van den Bruck
J. Niederau

Projects : (1) Improvement of carburization resistance of high-temperature cast steels.

(2) Improvement of creep resistance in cast high-temperature alloys.

(37) **Stahlwerke Röchling-Burbach GmbH**
Postfach 1980,
D - 6620 Völklingen, Saar.

E.G. Gondolf

Project : Protection of steels against decarburization at high temperatures.

(38) **L. & C. Steinmüller GmbH**
D - 5260 Gummersbach 1

S. Pollmann

Project : Slagging and fouling behaviour of combustion products on boiler tubes.

(39) **Technische Hochschule Darmstadt - Institut für Werkstoffkunde**
Grafenstrasse 2,
D - 6100 Darmstadt

K.H. Kloos
J. Granacher
H. Demus

Projects : (1) Influence of protective coatings and the heat treatments during coating on the creep behaviour of high-temperature nickel-base alloys:

- Creep-rupture strength of materials for gas-turbine blades in static air environment.

(2) Long-term rupture and fatigue strength and hot-gas corrosion of coated and uncoated gas-turbine materials exposed to static and cyclic (0.2 Hz) stress in combustion environments using aircraft fuel JP4, with and without doping, and industrial fuel oil E1, containing S, Na, V, Si as typical corrosive impurities:

- Long-term rupture strength of coated samples.
- Strain-controlled fatigue strength by hot gas corrosion.

(40) **Thyssen Edelstahlwerke AG**
Oberschlesienstr. 16,
D - 4150 Krefeld 1

B. Huchtemann
Schüler

Projects : Alloy development for high-temperature components of the primary circuit of a nuclear process heat system:

(1) High temperature corrosion behaviour of Fe-Ni-Cr and nickel-base alloys in PNP (Pilot project Nuclear Process heat) - helium.

(2) Influence of temperature, gas composition and pressure on the corrosion behaviour as a function of aging time.

(41) **Universität Erlangen-Nürnberg**
Institut für Werkstoffwissenschaften I
Martenstrasse 5,
D - 8520 Erlangen

B. Ilschner
H.G. Sockel
L. Berchtold
H.J. Christ

Project : Carburization and oxidation of IN617, IN713LC and Mo-alloy TZM in impure helium (HHT) and other atmospheres; interaction with creep deformation, especially breakdown of protective surface scales.

(42) **Technische Universität München**
Lehrstuhl für Metallurgie und Metallkunde
Arcisstrasse 21,
D - 8000 München 2

Kh.G. Schmitt-Thomas
H. Meisel
G. Johner
R. Siede

Projects : (1) Metallurgical investigations of coatings to prevent hot gas corrosion of nickel base turbine blades.

(2) Failure mechanism analyses.

(3) Additives to prevent hot gas corrosion of jet engine blades.

(4) Friction welding of nickel base alloys for high performance jet engines.

ITALY

(43) **C.N.E.N. - C.S.N. Casaccia**
Laboratorio Chimica Fisica
S.P. Anguillarese km. 1.300
I - 00060 Casaccia (Roma)

S. Casadio (1)
A. Borello (2, 3)

Projects : Materials Development of the Steam Generators of the Fast Breeder Reactors (FBR), actually 9Cr-2Mo ferritic steel and Alloy 800 :

(1) Liquid sodium corrosion and mass transfer (mainly interstitial carbon and nitrogen) in the secondary systems of the FBR and implication on the mechanical properties.

(2) Water, water-steam and caustic stress corrosion and general corrosion at high temperatures.

(3) Conventional rapid corrosion tests for material characterization and acceptance.

(44) **Centro Ricerche Fiat C.R.F.**
Strada Torino 50,
I - 10043 Orbassano, Torino

A. Belmondo
S. Tosto
H. Walther

Projects : (1) Development surface coating materials.

(2) Surface coating materials phase stability.

(45) **Politechnico di Milano - Institute of Physical Chemistry**
Piazza L. da Vinci 32,
I - 20133 Milano

U. Ducati
P. Cavalotti

Projects : (1) Hot corrosion of metal alloys :

- Hot corrosion of nickel-base superalloys by sulphate contaminants
- Thermogravimetric techniques and evaluation of scale degradation due to volatilization of chromium compounds.
- Electrochemical techniques.

(2) Hot corrosion of stainless steels.

(3) Hot corrosion of nitrogen ceramics :

- Interaction among contaminants, scale and densification promoters.

(46) **Universitá di Padova - Istituto Chimica Industriale**
Via Marzolo
I - 35100 Padova

M. Magrini
U. Principi
E. Ramous

Projects : (1) Water and steam corrosion of steam generator materials.

(2) Mössbauer studies of corrosion products.

(3) Influence of oxidation on structural stability of Ni-base superalloys and high-chromium steels.

THE NETHERLANDS

(47) **Dow Chemical (Nederland) B.V.**
P.O. Box 48,
4530 AA Terneuzen

F.J. Vaes

Projects : (1) High-temperature materials for cracking furnaces.

(2) Investigations of the hot corrosion caused by the use of cheap fuel on gas turbine materials for first stage nozzles and buckets.

(48) **E.C.N. - Stichting Energieonderzoek Centrum Nederland**
P.O. Box 1
1755 ZG Petten

R. Blackstone
B. v.d. Schaaf (1)
P. Back (1)
J.H.N. Verheugen (2)

Projects : (1) Heat exchanger and construction materials for FBC, fluidized bed (coal) combustion, installations.

(2) Materials for MHD-channels and -heat exchangers: Development of ceramic coatings on metallic electrodes.

(49) **N.V. KEMA**
Utrechtseweg 310,
6800 ET Arnhem

W. Huybregts (1)
W. Nagel (1)
J.H.N. Jelgersma (2)

Projects : (1) Corrosion resistance of nickel-base alloys, in particular stress corrosion cracking of Incoloy 800 in NaOH at high temperatures and pressures.

(2) Corrosion of iron-, chromium- and nickel-base superheater materials at 500-700 ^{o}C in combustion gases from heavy fuel-oil.

(50) **Metaalinstituut TNO**
P.O. Box 541,
7300 AM Apeldoorn

Laan van Westenenk 501,
7334 DT Apeldoorn

B.H. Kolster
G.H.G. Vaessen
P.L.F. Rademakers

Projects : (1) Liquid metal corrosion of ferritic steels, austenitic steels, molybdenum and other metals.

(2) Water- and steam side corrosion of ferritic and austenitic steels for steam generators.

(3) Corrosion- erosion of ferritic and austenitic steels and superalloys in fluid-bed coal combustion systems.

(51) **National Aerospace Laboratory (NLR)**
A. Fokkerweg 2
1059 CM Amsterdam

A.J.A. Mom
H.J. Kolkman
G.A. Kool

Projects : (1) Testing and evaluation of high temperature gas turbine coatings.

(2) Investigation of creep and fatigue behaviour of high temperature Ni-alloys in reaction to microstructure and environment.

(3) Fractographic aspects of failed high temperature components.

(4) Materials selection for coal combustion systems.

(52) **Shell Internationale Research Maatschappij B.V.**
Shell Research Laboratories,
P.O. Box 162,
2501 AN Den Haag

J.C.Th. Volkers

Projects : (1) Influence of physical and chemical properties of oxide layers on performance of alloys and composites used for turbine blades, automotive engine valves, superheater tubes, etc.

(2) Material data, performance criteria and calculation methods to aid material selection, design and maintenance of cracker furnace tubes.

(53) **Technische Hogeschool Twente**
P.O. Box 217,
7500 AE Enschede

P.J. Gellings
T. Fransen

Project : Surface working effect of high-temperature corrosion of alloys.

NORWAY

(54) **Central Institute for Industrial Research**
Forskningsveien 1
N - Blindern, Oslo 3

G. Thon
J.K. Solber
Mme M. Seiersten
A. Windfeld
O. Nörholm
L. Nilsen

Projects : High temperature corrosion and mechanical properties of alloys and coatings for directly fired heat engines :

(1) High temperature corrosion and protection of diesel engine components.

(2) High temperature corrosion and creep/thermal shock of selected Ni-superalloys and coatings for gas turbine application.

(3) Development of corrosion resistant exhaust valve alloys.

(4) Development of thermal barrier coatings for heat loaded components for gas turbine application.

(5) High temperature corrosion of selected steels for fluidized bed application.

(6) High temperature corrosion and creep of materials for petrochemical industries.

(55) **University of Oslo - Department of Chemistry**
P.O. Box 1033
N - Blindern, Oslo 3

P. Kofstad

Projects : (1) High-temperature corrosion of chromium.

(2) High-temperature corrosion of nickel and cobalt in SO_2/O_2 atmospheres.

(3) Sodiumsulfate-induced corrosion of nickel and cobalt in SO_2/O_2 atmospheres.

SWEDEN

(56) **FFV Maintenance Division**
S - 581 81 Linköping

Å. Lodén

Project : Cyclic hot corrosion study of materials for Stirling engine.

(57) **Technical University Linköping (LTH)**
Fack, 581 83 Linköping

T. Ericsson
Y. Lindblom

Project : Development of metal oxide ceramic coatings on high-temperature materials. (Joint project of LTH, FFV, Sandvik and Stal-Laval. Sponsored by the National Swedish Board for Technical Development)

SWITZERLAND

(58) **Sulzer Brothers Ltd.**
Ch-8401 Winterthur

H. Beutler
E. Erdös
P. Huber
M. Villat

Projects : (1) Development of an electrochemical test method to investigate the hot corrosion behaviour of superalloys and coatings for gas-turbines (COST-project).

(2) Evaluation of the hot corrosion resistance of superalloys and coatings by means of low and high pressure corrosion test loops (COST-project).

(3) Development of coatings for high temperature corrosion protection of gas turbine blades.

UNITED KINGDOM

(59) **Admiralty Marine Technology Establishment**
Procurement Executive Ministry of Defence,
Holton Heath,
Poole, Dorset, BH16 6JU

J.F. Condé
G.C. Booth
D.J. Godfrey

Projects : (1) Materials evaluation for marine gas turbines:

- Low- and high-pressure rig simulation studies of hot corrosion of nickel- and cobalt-base alloys and coatings.
- High-temperature erosion testing of materials and coatings.
- Study of the mechanisms of hot corrosion/ erosion in the presence of sea salt and sulphur oxides.

(2) Corrosion of materials in high-temperature pressure water:

- Stress corrosion of materials and mechanisms.
- Corrosion fatigue crack propagation and mechanisms.

(3) Improved ceramics for high-temperature engines:

- Selective improvement of the properties of silicon-base ceramics and evolution of a design philosophy for use of non-ductile materials in dynamic engineering applications.
- Evolution of ceramic and cermet coatings for use in aggressive environments.

(60) **Admiralty Underwater Weapen Establishment**
Southwell
Portland, Dorset

J. Bainbridge

Projects : Heat exchanger materials:

(1) Corrosion of austenitic stainless steels by alkali metals and their fluoride and sulphide melts.

(2) Effect of the above environment on the creep rupture properties of stainless steel heat exchanger tube.

(61) **Babcock Power Limited**
Research Centre,
Highstreet,
Renfrew PA4 84W

G.G. Foster
J.W. Taylor

Projects : Materials evaluation for coal processing systems :

(1) Tensile and stress rupture properties of tubular and support materials (Ni-Cr alloys, high nickel alloys, austenitics and high chromium ferritics).

(2) Quantitative assessment of wastage rate and morphology of wastage for tubular and support materials in fluidised bed environment, including erosion wastage/deposition etc.

(3) Software and experimental assessment of the implications of operationally related transients in temperature, stress and environment(s) on the mechanical and corrosion behaviour of materials as in the first programme point above.

(4) Measurement and characterization of softening, sintering, fusion and viscosity characteristics of coal ash materials in relation to fouling behaviour.

(62) **The Brown Firth Research Laboratory**
Attercliffe Road,
Sheffield

K.R. Pirt
P.M. Haigh

Project : Evaluation of the high-temperature corrosion resistance of stainless steels and other highly alloyed materials in a burnt natural-gas environment.

(63) **Central Electricity Generating Board**
Berkeley Nuclear Laboratories,
Berkeley, Gloucestershire GL13 9PB

G.C. Allen (4, 5)	R.C. Lobb (2)	P.M. Tucker (4)
H.E. Evans (2)	R.J. Pearce (3)	R.K. Wild (4)
G.B. Gibbs (5)	K.A. Simpson (3)	D.J. Wood (1)
R.A. Holm (5)	P.W.G. Simpson (2)	

Projects : (1) Determination of the corrosion rate and kinetics of graphite oxidation in CO_2-base gas mixtures at 600 - 700 ^{o}C at 40 bars pressure, including effects of mechanical properties.

(2) Oxidation of stainless steel element cladding for advanced gas cooled reactors :
- Assessment of critical chromium concentration to form Cr_2O_3 in CO_2/CO and $CO_2/CO/COS$ environments.
- Oxidation of 20Cr - 20 Ni steels at high pressure in $CO_2/CO/COS$ environments.
- Studies of localised oxidation in 20Cr - 25Ni steels.
- Influence of a TiN matrix dispersion on oxidation of 20Cr-25Ni-Nb steels.
- Effect of alumina films on oxidation.
- Theoretical assessment of oxidation in a heat flux.

(3) Morphology of reaction products formed in the helium atmosphere of a high-temperature reactor - examination of specimens removed from the Dragon reactor :
- Laboratory oxidation studies of fuel cladding materials for UK advanced gas cooled reactors in simulated reactor coolant (primary CO_2).

(4) High-temperature corrosion of chromium steels in CO_2 atmospheres :
- High-temperature corrosion of binary and ternary alloys in low O_2 partial pressures.

(5) Oxidation of structural steels and fuel cladding in gas-cooled nuclear reactors. Studies of ferritic and austenitic steels and nickel-base alloys in $CO_2/CO/H_2O$ gas mixtures. Effects of carburization, sulphidation and nitridation on oxidation :
- Effect of high-temperature corrosion on mechanical properties of materials, and on behaviour of components and structures in nuclear power plant.
- Spectroscopic studies and oxidizing surfaces: nucleation and early stages of growth of oxides in low oxygen partial pressures and in CO_2, studies by reflectance and Auger spectroscopy. Materials included: iron, chromium, nickel, uranium, various ferritic and austenitic steels and 20Cr-25Ni-Nb fuel cladding.

(64) **Central Electricity Generating Board**
Central Electricity Research Laboratories, Materials Division,
Kelvin Avenue,
Leatherhead, Surrey KT22 7Se

D.R. Holmes (1 - 7)
J.E. Forrest (2)
R. Garnsey (9)
M.I. Manning (1 - 7)
D.B. Meadowcroft (5, 6)
I.L. Mogford (5, 6)
P.C. Rowlands (2, 4, 6)

Projects : (1) High-temperature corrosion of power generation materials in steam.

(2) High-temperature corrosion of gas-cooled reactor materials in high pressure CO_2 and impure helium.

(3) High-temperature corrosion of fast reactor materials in flowing sodium.

(4) High-temperature corrosion of power generation materials in oil and coal combustion products.

(5) Hot corrosion of gas-turbine materials.

(6) High-temperature corrosion of materials for advanced coal conversion plants.

(7) Mechanical properties of oxide scales and oxidation/deformation interactions.

(8) Corrosion fatigue in high-temperature power generation environments.

(9) Stress corrosion in power station environments.

(65) **Central Electricity Generating Board**
Central Electricity Research Laboratories, Chemistry Division
Kelvin Avenue,
Leatherhead KT22 7SE

A.B. Hart
A.J.B. Cutler
R. Garnsey
J.W. Laxton
D.B. Meadowcroft

Projects : (1) High-temperature corrosion of cobalt- and nickel-base alloys in gas turbine combustion products.

(2) Corrosion of steels in high-temperature water.

(3) Stress corrosion in steam and water.

(4) Corrosion of steels in CO_2.

(5) The role of chloride in coal-fired combustion products in relation to corrosion of steels in the range 300 - 700 ^{o}C.

(6) The selection of metals for use as heat transfer surface in reducing gases.

(7) Corrosion in relation to spent nuclear fuel transport.

(66) **Central Electricity Generating Board**
Scientific Services Centre, Scientific Services Department,
Ratcliffe-on-Soar, Nottingham NG11 OEE

D.J. Lees
H.D. Williams

Project : Investigation of the mechanism of fireside corrosion in furnace wall tubes in coal-fired boilers.

(67) **Cranfield Institute of Technology - Department of Materials**
Cranfield, Bedfordshire, MK43 OAL

P.Hancock
J.R. Nicholls

Projects : (1) Rig testing for coal gasification programme of alloys and coatings.

(2) Vanadium corrosion of nickel-base superalloys and high-strength steels.

(3) Salt corrosion of nickel- and cobalt-base alloys.

(4) Influence of inhibitors against hot corrosion attack.

(5) Coatings for high-temperature corrosion resistance.

(6) Erosion of nickel-base superalloys under industrial conditions.

(7) Monitoring of hot corrosion conditions.

(68) **GEC Turbine Generators Ltd**
Cambridge Road,
Whetstone, Leicester

P. Greenfield

Projects : (1) Stress corrosion of turbine materials in steam and water.

(2) Corrosion fatigue of turbine materials in steam and water.

(3) Protective coatings on gas-turbine blading alloys.

(69) **International Research and Development Co. Ltd.**
Fossway,
Newcastle-upon-Tyne NE6 2YD

P. Moorhouse
C. Arthur

Project : Protective coatings by plasma deposition. (cf. Entry No. 88)

(70) **Lucas Aerospace Ltd.,**
Materials Department, Wood Top Works,
Villers Street,
Burnley, Lancashire, BB11 4BP

W.A. Potter
B. Hicks

Projects : Research on high-temperature materials for gas turbines; oxidation, hot corrosion and erosion :

(1) Assessment of oxidation characteristics under isothermal temperature cycling, and dynamic gas-flow conditions in a laboratory burner rig.
(2) Study of effect of test conditions on oxidation behaviour.
(3) Study of oxidation mechanisms.
(4) Assessment of recently-introduced coating systems designed for oxidation protection or as thermal barriers.
(5) Development of novel coating systems.
(6) Evaluation of erosion characteristics of gas-turbine alloys.

(71) **National Coal Board - Coal Research Establishment**
Stoke Orchard,
Cheltenham GL52 4R7, Gloucestershire

B. Robson
N. Hodgkinson

Project : Materials selection for fluidized bed gasification and fluidized bed combustion.

(72) **National Gas Turbine Establishment**
Pyestock,
Farnborough, Hants GU14 OLS

M.G. Cockcroft
J.E. Restall

Projects : (1) Development and assessment of protective coatings for high-temperature gas-turbine components.

(2) Study of corrosion/erosion degradation in gas-turbine components.

(73) **National Physical Laboratory - Division of Materials Applications**
Queens Road,
Teddington, Middlesex TW11 OLW

G.O. Lloyd
S.R.J. Saunders
M.K. Hossain

Projects : (1) Oxidation in complex atmospheres containing sulphurous and carbonaceous gases :

- *Oxide nucleation studies.*
- Detailed microstructural examination of scales.

(2) Hot salt corrosion :

- Development of improved test procedures (COST 50), (cf. Entry No. 88)
- Mechanism of hot-salt corrosion with particular emphasis on the role of chlorides.

(74) **OCTEL - The Associated Octel Company Ltd.**
P.O. Box 17, Oil Sites Road,
Ellesmere Port, South Wirral, Merseyside L65 4HF

W.E. Cowley
R.H. Morris

Projects : (1) Rate/mechanism of corrosion of valve steels in exhaust gas atmospheres and the influence of engine deposits on the corrosion in the temperature range 500 - 1200 ^{o}C.

(2) Effect of lead oxide and SO_2 on the rate/mechanism of corrosion of valve steel and high Ni-Co alloys in the temperature range 500 - 1200 ^{o}C.

(3) Study of the structure and compound (plumboferrite) formation of engine deposits on valve steel and alloys in the temperature range 500 - 1200 ^{o}C.

(75) **Polytechnic of Newcastle-upon-Tyne**
Department of Mechanical Engineering and Materials Technology
Newcastle-upon-Tyne NE1 8ST

K.N. Strafford
P.J. Hunt
P.K. Datta
K. Upadhya

Projects : (1) Optimisation of M-Cr-Al protective coatings.

(2) Studies of sulphur in oxides.

(3) Evaluation of sulphidation behaviour of iron-, nickel- and cobalt-base alloys in atmospheres of low sulphur potential.

(4) Corrosion behaviour of refractory metals and alloys in complex atmospheres of low oxygen potential.

(5) Studies of the interaction of high-temperature corrosion, creep and fatigue processes.

(76) **Rolls-Royce Ltd.**
P.O. Box 3,
Filton, Bristol BS12 7QE

R.G. Ubank

Project : High-temperature burner rig corrosion of superalloys and potential coating alloys with and without salt ingestion.

(77) **UKAEA - AERE - Harwell Corrosion Service**
Building 393, AERE,
Harwell, Didcot, Oxon

B.C. Tofield
N.J.M. Wilkins

Projects : (1) Oxidation and carburization behaviour of stainless steel in CO_2 up to 850 °C.

(2) The development of a new range of ferritic stainless steels containing chromium, aluminium and yttrium (Fe-Cr-Al-Y steels) for use in corrosive environments up to 1300 °C.

(3) The corrosion of materials in environments created in incinerators up to 900 °C.

(4) The corrosion of silicon carbide in a range of high-temperature environments.

(5) The corrosion of 9 °/oCr ferritic steel in superheated steam.

(6) The corrosion of steels in the environments created in sodium/water leaks.

(7) The corrosion of austenitic stainless steels by cesium/tellurium/oxygen mixtures at 350 - 700 °C.

(78) **University of Bath - School of Materials Science**
Claverton Down
Bath BA2 7 AY

B. McEnaney (1 - 4)
V.D. Scott (1, 2)
F.J. Hazlewood (2)
R.G. Cooke (4)

Projects : (1) Effects of ion-implantation on oxidation of iron-chromium alloys.

(2) Effects of silicon on oxidation of iron-chromium alloys in carbon dioxide.

(3) Corrosion of stainless steels in molten alkali metal fluorides and sulphides at temperatures up to 1000 °C.

(4) Effects of thermal corrosion on the strength of nuclear graphites.

(79) **University of Leeds - Department of Ceramics**
Houldsworth School of Applied Science
Leeds LS2 9 JT

F.L. Riley

Project : High temperature oxidation and sulphidation of nitrogen, and related, ceramic materials.

(80) **University of Leeds - Department of Metallurgy**
Leeds LS2 9 JT

J.C. Scully

Project : High-temperature sulphidation of metals.

(81) **University of London - Imperial College - Metallurgy Department**
London SW7 2BP

M.G. Hocking
V. Vasantasvree
P.S. Sidky

Projects : (1) Mechanisms of hot corrosion of marine gas turbine alloys.

(2) Hot corrosion of coal-fired power station heat exchanger tube alloys.

(82) **University of Liverpool - Department of Metallurgy and Materials Science**
P.O. Box 147,
Liverpool L69 3GX

N. Swindells

Projects : (1) Behaviour of metallic coatings at high temperatures :

- High-temperature corrosion of Si-Ti coatings on nickel-base alloys in air plus Na_2SO_4.
- Ternary diffusion in single- and two-phase nickel-base alloy systems.

(2) Oxidation and sulphidation of high-temperature alloys :

- Reaction paths during combined oxidation and sulphidation of iron-base alloys.
- Quantitative analysis by EPMA of oxides and oxidized sulphides in complex nickel- and cobalt-base alloys.

(83) **University of Manchester / UMIST - Department of Metallurgy**
Grosvenor Street,
Manchester M17 H5

R. Rolls (1 - 3)
G. Lorimer (4)
G. Leus (5 - 10)
M. Calvert (5 - 10)

Projects : (1) Influence of oxidation on high-temperature creep of iron-base alloys.

(2) Stress generation and fracture initiation in oxide scales on iron-base alloys.

(3) Effect of inorganic oxide coatings on oxidation kinetics of iron-base alloys in air at elevated temperatures.

(4) Oxidation of chromium steels in high pressure CO_2.

(5) Development and use of charge-particle nuclear techniques for oxidation studies.

(6) Growth mechanisms of Cr_2O_3 scales on chromium.

(7) Oxidation mechanisms of Fe-Cr-Ni alloys.

(8) Growth mechanisms and adhesion of scales on AGR fuel-cladding alloy.

(9) Oxidation mechanisms of Zircaloy.

(10) Effect of yttrium on growth mechanisms of Al_2O_3 scales on a Co-Cr-Al alloy.

(84) **University of Manchester - Institute of Science and Technology - Corrosion and Protection Centre,**
P.O. Box 88,
Manchester M60 1QD

G.C. Wood (1 - 5)
F.H. Stott (1 - 7)
P. Elliott (8 - 11)

Projects : (1) Influence of fine structural, morphological and compositional details on the development of Cr_2O_3 and α-Al_2O_3 scales at high temperatures.

(2) Influence of ion implantation on the high-temperature oxidation of nickel and Ni-Cr alloys.

(3) Internal and intergranular oxidation of alloys.

(4) Diffusional processes and defect structures in oxides and sulphide scales on alloys.

(5) Influence of oxides on high-temperature wear.

(6) High-temperature gaseous corrosion of Fe-Ni-Cr and Co-Cr alloys in environments of high sulphur and low oxygen activities.

(7) Influence of pre-formed oxides on the high-temperature corrosion of Fe-Cr and Fe-Cr-Al alloys in hot gases of low oxygen activities.

(8) Hot corrosion of Ni-Cr alloys in sulphur-containing environments.

(9) Hot corrosion of Ni-Cr alloys in vanadic slags.

(10) Hot corrosion associated with refuse incineration.

(11) Electrochemical aspects of hot corrosion of alloys.

(85) **University of Sheffield - Department of Chemical Engineering and Fuel Technology**
Mappin Street,
Sheffield S1 3JD

C.G. McCreath

Project : The role of filters, transfer ducting, compressor and flame tube in modifying or contributing towards the corrosive/erosive environment experienced by first stage nozzle guide vanes and rotors of gas turbines operated in a marine atmosphere.

(86) **University of Sheffield - Department of Metallurgy**
Mappin Street,
Sheffield S1 3JD

C.W. Haworth
B.B. Argent

Projects : (1) Aluminide coatings on nickel-base superalloys.

(2) High-temperature corrosion of superalloys in complex atmospheres.

(87) **Henry Wiggin and Co. Ltd.**
Holmer Road,
Hereford HR4 95H

C.H. White
K.J. Ball

Projects : (1) Resistance of high-temperature nickel-base alloys to sulphidation in oxidizing (SO_2/Air) and in reducing (H_2S/H_2) atmospheres.

(2) Performance of nickel-base alloys in high-temperature chlorine and hydrogen chloride environments.

(3) Susceptibility of various high-temperature nickel-base alloys to carburization and its effect on mechanical properties.

(88) COMMISSION OF THE EUROPEAN COMMUNITIES
Directorate-General for Research Science and Education (DG XII)
EUROCOP-COST - Concerted Action Metallurgy (COST 50)
Secretariate, Rue de la Loi, 200
B - 1049 Bruxelles

O. Morocutti

Projects (1) : (On-going) High Temperature Materials for Gas Turbines (COST 50 - Round II)

(.01) CMN - IRSIA, Liège, Belgium :

Evaluation of high-temperature corrosion resistance coatings obtained by different methods.

(.02) ONERA, Châtillon, France :

Study of the effects of protection methods and coatings on the creep and fatigue behaviour of superalloys.

(.03) SNECMA, Paris, France :

Study of the corrosion of protective coatings on nickel-based superalloys.

(.04) DECHEMA, Frankfurt, F.R. Germany :

Influence on electrode potential on corrosion and creep behaviour of gas turbine alloys in sulphate melts.

(.05) Deutsche Lufthansa A.G., Hamburg, Germany :

Performance evaluation of high temperature coatings in transport aircraft gas turbines.

(.06) Kraftwerk Union A.G., Mülheim, F.R. Germany :

Longtime corrosion testing with mechanical stress of high temperature alloys for blades of land based gas turbines with high output.

(.07) Motoren- und Turbinen Union, München, F.R. Germany

Strength under hot gas load of turbine blade materials with and without a protective coating.

Vacuum-plasma spraying of coatings to give protection against corrosion by hot gases.

(.08) Thyssen Edelstahlwerke, A.G., Krefeld, F.R. Germany :

Ductility of metallic diffusion type coatings on nickel based alloys.

(.09) C.R. FIAT, Orbassano (Torino), Italy :

High temperature corrosion resistant coatings by surface alloying.

(.10) ELBAR, Lomm, and
University of Eindhoven, The Netherlands :

Study of gas phase coating mechanisms and the behaviour of coatings under simulated practical service conditions.

(.11) Sulzer Brothers Ltd., Winterthur, Switzerland :

Electrochemical methods for testing the corrosion behaviour of gas-turbine blades alloys and protective coatings.

Testing of the corrosion resistance of gas turbine alloys and protective coatings.

(.12) AMTE, Holton Heath, U.K. :

Development of hot corrosion testing procedure for superalloys and coatings.

(.13) CEGB, Leatherhead, U.K.:

The interaction between corrosion and mechanical properties for gas turbine alloys and the corrosion resistance of protective coatings.

Deposition in gas turbines.

(.14) GEC, Gas Turbines Ltd., Leicester, U.K. :

The effect of corrosion resistant coatings on the creep rupture properties of gas turbine alloys.

(.15) International Research & Development Co.,
Fossway, U.K. :

Protective coatings by plasma deposition.

(.16) National Gas Turbine Establishment,
Farnborough, U.K.:

The effects of protective coatings on the mechanical properties and corrosion behaviour of unidirectionally solidified nickel superalloys.

(.17) National Physical Laboratory, Teddington, U.K. :

Test procedures for evaluation of resistance to hot-salt corrosion.

(.18) Rolls-Royce Ltd., Derby, U.K. :

Influence of alloy chemistry and structure on the resistance to hot corrosion and oxidation in several alloys, including high chromium, lower chromium and directionally solidified.

(.19) University of Liverpool, U.K. :

Mechanisms of degradation of protective coatings on gas turbine blading.

(.20) CEC Joint Research Centre, Petten, The Netherlands :

The effect of coatings on the high temperature mechanical properties of nickel-base superalloys.

Projects (2) :
(Started at the beginning of 1981)

High Temperature Materials for Gas Turbines
(COST 50 - Round III)

(.01) CMN - IRSIA, Liège, Belgium :

Property evaluation of hot corrosion resistant coating prepared by sputtering and ion-plating.

(.02) ONERA,
SNECMA,
Université de Nancy,
ARMINES, France :

Corrosion of coated superalloys under successively reducing and oxidizing conditions.

(.03) Brown, Boveri & Cie, Mannheim, F.R. Germany :

Hot corrosion, cyclic properties and metallurgical stability of welded and diffusion bonded superalloys.

(.04) Deutsche Lufthansa A.G., Hamburg, F.R. Germany :

Performance evaluation of high temperature coatings for turbine blades of transport aircraft gas turbines.

(.05) Kraftwerk Union A.G., Mülheim, F.R. Germany :

Hot corrosion and air creep rupture properties of superalloy weldings and brazings.

(.06) Motoren- und Turbinen Union, München, F.R. Germany

Low pressure plasma spraying (LPPS) of hot-gas corrosion resistant coatings and determination of their physical properties.

(.07) ELBAR, Lomm, The Netherlands :

Thermal barrier coatings for turbine blade application.

(.08) National Aerospace Laboratory (NLR), KLM, Emmeloord, The Netherlands :

Effect of fuel quality on coating degradation in aircraft engines.

(.09) Sulzer Brothers Ltd., Winterthur, Switzerland :

Interaction between high-temperature corrosion and creep rupture strength and testing of the corrosion resistance of gas-turbine alloys and protective coatings.

(.10) Linköping University, Linköping, Sweden :

Development of metal-oxide ceramic coatings for high temperature materials.

(.11) AMTE, Holton Heath, U.K. :

Development of hot erosion testing procedure for superalloys and coatings.

Effect of marine environment on high-temperature creep of superalloys.

(.12) CEGB, Leatherhead, U.K.:

Corrosion of gas turbine alloys and coatings in the combustion products of coal gas.

(.13) GEC, Whetstone, U.K. :

The corrosion resistance and protection of repair welds.

(.14) National Gas Turbine Establishment, Farnborough, U.K. :

The effects of protective coatings on the mechanical properties and corrosion behaviour of unidirectionally solidified nickel superalloys.

(.15) NPL, Teddington, U.K. :

The effect of high contents of chloride on hot-salt corrosion in gas turbines burning coal-derived fuels and the development of relevant test procedures.

(.16) University of Liverpool, U.K. :

Dean tests of coated superalloys in simulated combustion atmospheres.

(89) **COMMISSION OF THE EUROPEAN COMMUNITIES**
Directorate-General of Research Science and Education (DG XII)

Division XII/C.1 "Energy Research" -
Production and Utilization of Hydrogen
Programme Coordinator, Rue de la Loi, 200
B - 1049 Bruxelles

G. Imarisio

Projects : Indirect Action Programme "Hydrogen"

(1) CEA - CEN, Fontenay-aux-Roses :

Dependence of corrosion rates at high temperatures upon composition of alloys and composition of aggressive atmospheres containing sulphur compounds.

(2) University of Milan :

Corrosion of metallic materials in sulphuric acid at high temperatures.

(90) **COMMISSION OF THE EUROPEAN COMMUNITIES**
Joint Research Centre, Ispra Establishment
Caselle Postale 1
I - 21020 Ispra (Varèse)

Mme F. Coen-Porisini

Project : Corrosion Research on High Temperature Alloys for Decomposition of Sulphuric Acid.

(91) **COMMISSION OF THE EUROPEAN COMMUNITIES**
Joint Research Centre, Petten Establishment
P.O. Box 2,
1755 ZG Petten (N.H.)

J.B. Marriott
G. Kemeny
J.F. Norton
V. Guttmann

Projects : Behaviour of high temperature alloys in corrosive gases :

(1) The corrosion behaviour of iron and nickel base alloys exposed to carburising environments.

(2) Inhibitive treatments and their effect on materials behaviour in carburising atmospheres.

(3) The corrosion behaviour of iron base alloys in mixed carburising/oxidising environments.

(4) The effect of sulphur upon the corrosion behaviour of iron and nickel base alloys in binary and complex component environments.

(5) The influence of static stress on the carburisation of iron base austenitic alloys.

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