EUR 8526 EN

Commission of the European Communities

Multiannual Programme
of the Joint Research Centre
1980-1983

1982
ANNUAL STATUS REPORT

HIGH-TEMPERATURE MATERIALS

EUR 8526 EN

Commission of the European Communities

Multiannual Programme of the Joint Research Centre 1980-1983

1982 ANNUAL STATUS REPORT

HIGH-TEMPERATURE MATERIALS

Published by the
COMMISSION OF THE EUROPEAN COMMUNITIES

Directorate-General

Information Market and Innovation

Bâtiment Jean Monnet
LUXEMBOURG

Printed in Holland

ISBN 92-825-3580-0
Catalogue number: [redacted]

High-Temperature Materials 1982

Research Staff:	**38 persons**
Budget:	**4,394 Mio ECU**

Projects:

1. **High Temperature Materials Information Centre**
2. **Materials and Engineering Studies**
3. **High Temperature Materials Data Bank**

Programme Manager: M. Van de Voorde
Commission of the European Communities
Joint Research Centre
Petten Establishment
P.O. Box 2
1755 ZG PETTEN,
The Netherlands

1. Introduction

The High Temperature Materials Programme is executed at the JRC, Petten Establishment and has for the 1980/83 programme period the objective to promote within the European Community the development of high temperature materials required for future energy technologies.

The strategy of this programme is a combined approach to survey technology and industrial requirements in order to identify future needs, to establish and perform research projects in selected key areas (coal conversion and related processes) and finally to build and maintain multilateral communications with manufacturers, users and also with the research and development sector involved in these materials.

The programme contributes to the public service and the "central nature" roles of the JRC by provision of scientific and technical information and expertise and also by acting as a focal point for co-ordination.

2. Results

2.1. Information Centre

The objectives of this project are the provision of information service functions to the European HTM community and the encouragement of co-operative actions.

In order to meet these objectives, the Information Centre has undertaken three separate activities, i.e.

- Information Exchange and Transfer, organising conferences, symposia, colloquia, seminars and courses,
- Information Collection, executing inquiries, surveys and studies,
- Information Storage, establishing inventories on on-going research and implementing a computerised information base on HTMs R&D programmes, organisations and experts.

The results obtained are presented in **Figure 1.**

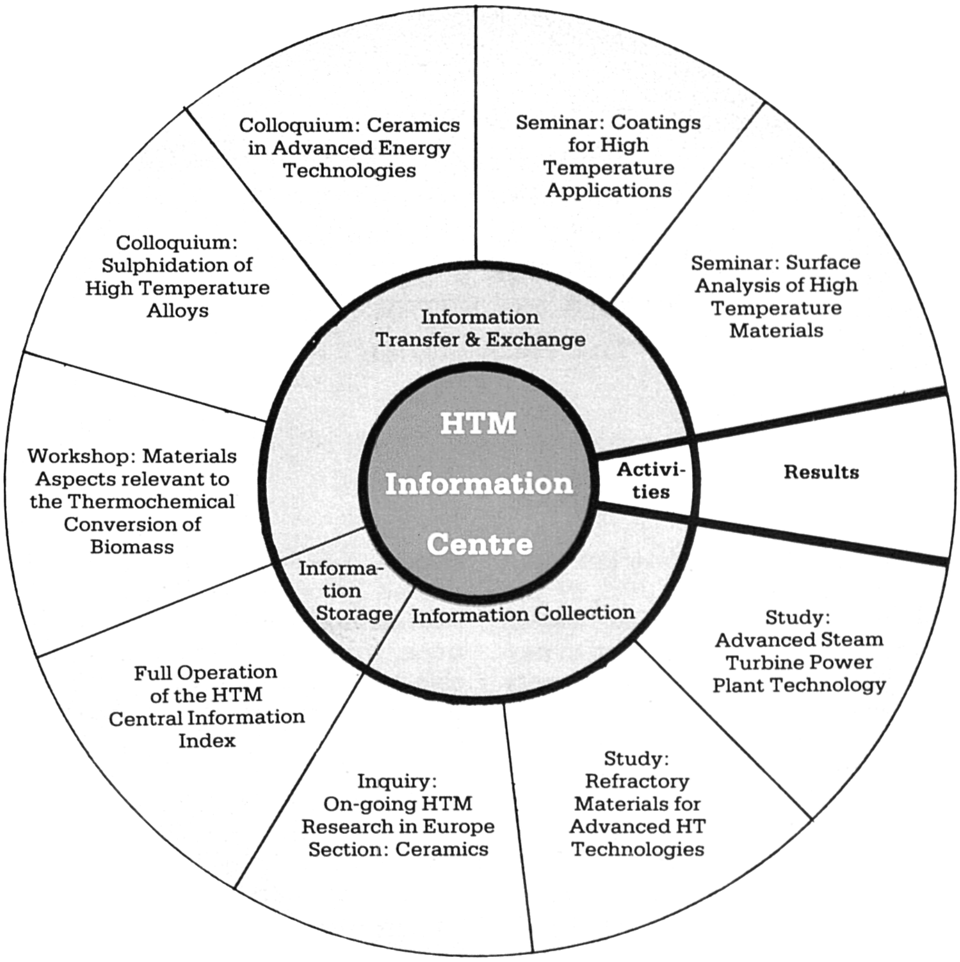


Figure 1: Information Centre, Activities and Results

2.2. Materials and Engineering Studies

Continuing analysis of industrial needs has demonstrated the critical dependence of many processes upon the development of improved or new materials. Future industrial development will equally depend strongly on the availability of materials with improved or even novel properties.

Technical areas dependent upon these materials developments include:
- the energy sector, power generation and utilisation,
- petrochemical processing and allied industries,
- automotive and gas turbine industries,
- nuclear engineering, etc.

The overall technological requirements to be met by the constructional materials include:
- increased efficiency through higher process temperatures,
- improved reliability, thus increasing plant availability,
- safety, both for operators and the local population,
- longer design lives, thus spreading the capital needs,
- tolerance of the increasingly corrosive environments arising from changes in process parameters or the use of lower grade fuels.

Satisfaction of these requirements enables improved design concepts to be prepared for the necessary higher operating temperatures.

To achieve these targets, research on materials for service at high temperature (above 600^{0}C) is a key factor and studies have shown that the area having greatest impact on the industrial scene involves austenitic steels, nickel-base superalloys and special coating materials. The information required concerns:
- the mechanical property and corrosion behaviour of existing materials in corrosive environments,
- the development of improved materials for high temperature processes,
- the behaviour of components under particular industrial conditions.

The general approach in the Materials & Engineering Studies project is to provide behavioural patterns of materials in specimen and component form for application in the advanced energy technologies. Work to explore the mechanisms by which corrosion proceeds in industrially simulative low oxygen bearing environments is an important part of the programme; the conclusions provide information on expected life and on the steps necessary to develop more resistant alloys. A further line of attack on the problem explores the development of coatings, their application technology, and their succes in preventing corrosion of the constructional materials. When corrosion data suggest that the bare, or coated, alloy has a reasonable life expectancy, information is needed on the effect that exposure has on the mechanical properties. Data have then to be obtained to charaterise the alloy and components made from it for creep and fatigue behaviour in the environments concerned in order that reliable design information may be derived.

The types of environments being used typify those found in various petrochemical, biomass conversion, HTR and some coal conversion processes.

In these applications the special life limiting problems concern carburisation of the material or the effects of interaction between different corroding reactions such as oxidation with carburisation or sulphidation. Because of its importance to these applications, the range of temperatures used for the test programme is 700 to 1000°C.

The alloys under test are, for the most part, the heat resistant steels which are typical or candidate structural materials for fossil fuel conversion processes. They fall into two groups with representatives in each of wrought and centrifugally cast products:

25% Cr - 20/25% Ni
e.g. Type 314, HK40,

22/25% Cr - 33/35% Ni
e.g. Alloy 800H, HP40Nb.

The aims of this project have been paralleled to some extent by those of the latest European collaborative programme on materials, i.e. COST 501 *), which is concerned with high temperature materials for conventional systems of energy generation and conversion using fossil fuels. As a result the HTM programme has been deeply involved in preparing the action. During 1982 more than 150 preliminary proposals were studied by a small team of experts in which JRC participated and following their advice about 120 detail project proposals were submitted by 13 collaborating countries in addition to those of JRC. Close examination and discussion of the intermeshing nature of the various pieces of work has led to a strong internationally integrated action. The HTM programme is taking part by contributing 6 clearly identified parts of the programme. Five of them are in the Materials and Engineering project, and deal with corrosion, protection, creep and fatigue. The sixth work package involves the Data Bank project in the management of data arising from all collaborators in the action.

*) COST: Cooperation in the domain of scientific and technical research - European Concertation.
COST 501: High Temperature materials for conventional systems of energy generation and conversion using fossil fuels.

Corrosion without Load

Environmental parameters such as temperature and the chemical activity of carbon (C), oxygen (0) and sulphur (S) are varied systematically and different alloy compositions are used so that a more scientific basis can be formulated for the selection and the continuing development of new materials to satisfy the demands of the service applications.

Intermittent weighing of the specimens during the periodic interruption of tests conducted in autoclaves at temperatures between 750 and 1050°C ensures that the kinetics of the corrosive reactions are monitored. The mechanisms by which the corrosive degradation proceeds are elucidated by detailed examination of representative specimens using surface and cross-sectional structural analysis techniques, e.g. X-ray diffraction, optical microscopy, electron-microscopy, and electron spectroscopy.

The kinetics of carburisation and the mechanisms involved have been established for a range of austenitic steels and nickel base alloys between 825 and 1050°C in the absence of other corrosion reactants. Improved resistance within the upper part of this temperature range has been shown to be dependent on the nickel and tungsten contents. Structural and surface finish effects are also of importance. Knowledge of the early stages of corrosion is however necessary to enable the picture to be completed. It has been found from a series of short duration exposures that during heating of the autoclave to temperature, before carburisation takes place, oxidation reactions occur between reactive elements in the alloy (Cr, Mn, Si) and oxygen bearing impurities in the H_2/CH_4 gas. Calculations have shown that these oxides are stable in the selected atmospheres at temperatures between 600 and 825°C. Observation has shown that, for example, a primary chromia scale, formed at preferential positions during heating has tranformed to a chromium carbide after only 300 min at 825°C. This in-situ tranformation from oxide to carbide helps to explain the morphology of the carbides which persists for long times **(Figure 2).**

When there is suficient oxygen present to form and maintain a stable surface scale at the test temperature, the resulting interaction of carburising and oxidising mechanisms leads to a more complex situation. Comparison on tests between the well known commercial alloy HP40Nb and an equivalent pure FeCrNi model alloy illustrate this situation. The model alloy is found, when exposed at 1000°C for 2000 h to develop an oxide scale of chromia which effectively prevents carbon penetration. By contrast the commercial alloy which contains small quantities of elements such as Mn and Si is found to form a spinel type oxide containing both chromium and manganese. This is present as a less uniform, defective, scale which allows carbon to permeate through to the alloy surface where it causes carburisation **(Figure 3).**

It is well known that carburisation can be reduced by "poisoning" the atmosphere with a sulphur bearing species, such as H_2S. Experiments at 1000°C have shown that the level of H_2S is rather critical. There is a large reduction in carburisation kinetics but to achieve the maximum effect it is neces-

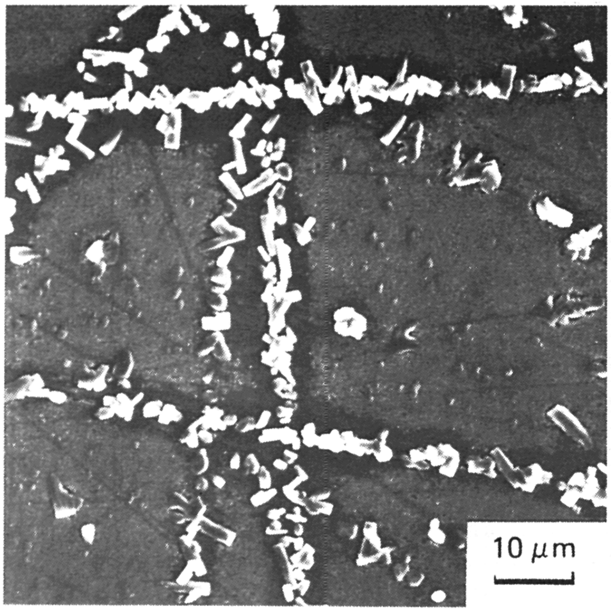


Figure 2: SEM micrograph of the electropolished surface of a 25Cr - 33 Ni model alloy exposed for 300 mins at 825°C in H_2-CH_4 gas with a carbon activity of 0.8 transformation of a primary Cr_2O_3 scale formed during heating up, has transformed to chromium carbide mainly along scratches on the original metal surface.

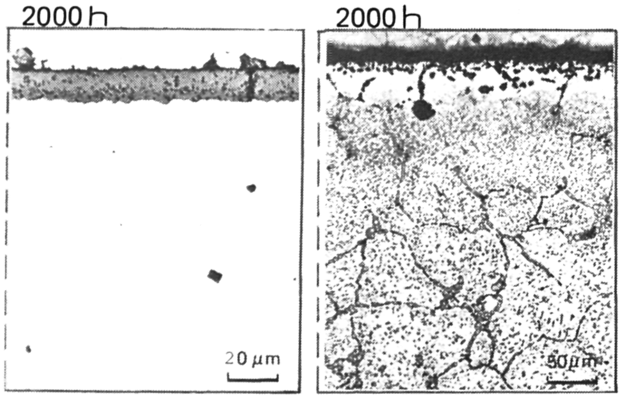


Figure 3: Kinetics of corrosion of 25Cr-35Ni alloys exposed to a carburising/oxidising environment (Po_2 = 4 . 10^{-20} atmos., a_c = 0.3) at 1000°C and resulting microstructural changes (electropolish condition).

sary for the conditions to be close to the thermodynamic boundary for the formation of a stable sulphide which, in this case, chromium sulphide. If sufficient H_2S is present to cross this boundary, sulphidation of the alloy proceeds with potentially disasterous consequences for the component.

The report for 1981 described work carried out on the kinetics and mechanisms of sulphidation by which nickel containing austenitic alloys degraded in H_2/H_2S gas mixtures in which the sulphur potential was controlled at two levels i.e. 10^{-11} and 10^{-6} bar. This earlier work at 825°C was extended during the present period to 750° the lower sulphur potential. It is frequently found that time dependent processes are also temperature dependent and in the corrosion field this is well documented for oxidation and carburisation. However the effect of lowering the reaction temperature from 825 to 725°C upon sulphidation resistance was found to be insignificant. These results in different types of sulphur bearing atmospheres illustrate the complex situation which exists in many petrochemical and coal conversion processes.

Corrosion under Load

Previous investigations have shown that there is an effect of stress on the kinetics of carburisation but the reduction is sufficiently small (~5%) to be ignored in practical situations. Tests have continued with one of the steels, HK30 in carburising/oxidising atmospheres. Evaluation of the results obtained so far has not revealed any significant difference in the kinetics or mechanisms of the mixed oxidising and carburising reactions between stressed and unstressed samples. Metallographic observation of samples exposed to the H_2/CO atmosphere has shown that from the surface inwards there is a thin layer of oxide, a carbide free layer containing internal oxides, a carburised layer and the uncarburised matrix core.

Mechanical properties under static loads

When corrosion data suggest that an alloy has a reasonable life expectancy in a particular type of environment, more information is needed concerning the effect of exposure to that environment, on the mechanical properties. One of the principal factors in the design of high temperature components is the resistance to creep. Unfortunatly, the only data available for use in design codes are those obtained by testing in air. Therefore the major experimental approach has been to determine the effect of exposure to aggressive environments on the creep strength, ductility etc. of selected alloys. The uniaxial creep testing is performed using commercial creep machines equipped with specially developed environmental chambers which contain the test gas, H_2/CH_4,H_2/CO etc. The design of these chambers is such that there is no interference with the sensitive equipment used for the continuous measurement of creep strain.

Tests on the centricast tube material HP40Nb have confirmed earlier work with the well established centricast alloy HK40 that the creep behaviour in a carburising environment is very complex as a result of the change of structure and consequent creep response with increasing carbon content in the sample and also as a result of the stresses induced by the carbon ingress.

Some of these effects persist throughout the test and considerably reduce the creep rupture strength in a carburising environment. In one test serie the reduction brought the creep rupture strength to values similar to those recorded for 1% creep strain on the same cast in air. These results are helpful for the efficient design of components operating in such environments.

Tests conducted in a carburising/oxidising environment show that the oxide layer may be defective and so, not fully protective. In this case, carburisation occurs. The effects on creep are then similar to those seen in a purely carburising environment, though the magnitude may be different. With a defective scale of this type, the presence of sulphur in the environment in addition to carbon may be expected to lead to sulphidation. The penetration of sulphur into the sample is likely to affect its creep and fracture behaviour. Equipment has been prepared to enable these complex tests to be conducted.

Mechanical Properties under dynamic loads

The materials in many industrial components are subjected to periodic stress cycles, either imposed at constant temperature by changes in the mechanical loading or caused by temperature cycling.

A reasonable level of knowledge already exists concerning the behaviour of many materials under static loads in oxidising environments. However, with regard to the varying load situation which results in fatigue, the level of understanding is much lower. The introduction of aggressive environments complicates the situation even more and the resulting situation is characterised by a multitude of simultaneously operating processes in the material which may or may not mutually interact.

During the year under review considerable effort has been put into the development of the special test equipment required to investigate low cycle fatigue behaviour under complex environmental conditions. The test chamber has been designed, manufactured and mounted on a fatigue testing machine in such a way that test operation can be controlled by the plastic straining of the gauge length of the high frequency heated specimen. Because the experimental techniques and equipment for fatigue testing are different from those for creep testing, trials had to be made to establish that the desired environments could be attained at the specimen surface. These trials have involved the determination of the behaviour of various materials under controlled high frequency heating conditions followed by assessment of the results in terms of thermodynamics. It was concluded that at 1000°C a gas containing H_2 and CO reacted to form the equilibrium components and that the kinetics of the metal/gas reactions were sufficiently rapid for the oxides and carburisation appropriate to a mixed carburising/oxidising environment with $Po_2 = 10^{-18}$ bar and $a_c = 0.3$ to be observed. Testing in air on the austenitic steel Alloy 800H started as planned and in advance of the requirements for the latest European collaboration programme COST 501. Technique development for the study of crack initiation and crack growth in Alloy 800H has progressed sufficiently for testing to commence.

At the same time analysis of the data obtained on gas turbine materials in the earlier collaborative programme, COST 50, has continued. It appears from this analysis that presently accepted crack growth models grossly overestimate the time required for cracks to grow to the onset of final fracture. This conclusion is of great importance since the intervals between inspections of operating plant require assumptions to be made about the growth of pre-existing crack like defects during that period. Reasons for the observed high rates of crack growth have been determined but reasons for the failure of the model will require additional data to be obtained on various materials. **(Figure 4).**

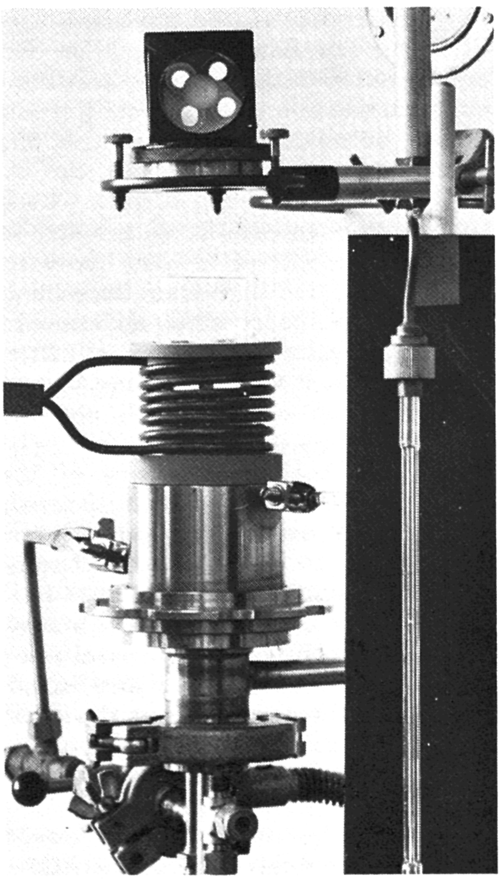


Figure 4: Experimental set-up used to determine the oxygen and carbon activities at the surfaces of samples heated by means of high-frequency induction. The cylindrical samples are visible in the viewing prism at the top.

Surface Protection - Scales and Coatings

The use of all metallic materials for applications at high temperatures in aggressive environments requires the formation and preservation of a protective surface oxide layer or scale to act as a barrier to corrosion.

In several engineering applications the strength requirements involve the use of materials which do not develop a protective oxide scale in the environment concerned. Hence coatings able to withstand the conditions seen in service have to be used. The protective action of these coatings against corrosion is related to the development of their natural scales. Provided the coating does not react with the substrate alloy, then mechanical data obtained in a benign atmosphere can be used for design purposes. However, it is known that in some cases reactions occur between coating and substrate alloy which can detrimentally affect the protective ability of the coating and also the mechanical properties of the composite material.

Under the conditions applying to many coal conversion and utilisation processes, damage to the scale by mechanical erosion can be significant. This leads to accelerated corrosion attack and hence more rapid consumption of the coating. For this reason a thick coating or cladding, applied perhaps by a co-extrusion process has to be considered. The corrosion behaviour of the material (e.g. Fecralloy) used for these thick layers can be examined without the presence of a substrate. Tests have shown that when exposed at 1000°C in an environment of high carbon activity and very low oxygen partial pressure the Fecralloy still forms a protective oxide scale.

Minor additions of other elements to the alloy are found to affect the detail composition and morphology of the scale but penetration of carbon into the alloy is effectively prevented. If a preliminary treatment is given to the sample to form an oxide scale before the exposure to the corrosive environment, the sample becomes almost inert according to weight change measurements. Detail surface examination reveals that small morphological changes are occuring, showing that there is a dynamic process involved. This very protective type of behaviour is due to chemical and physical properties of the highly stable alumina scale.

Samples of SiO_2 coated steel were exposed in the same high carbon/low oxygen potential atmosphere because it is known that under oxidising conditions silica can be protective. However, the silica was thermodynamically unstable at 1000^{0}C and offered no protection to the underlying metal. M_7C_3 carbides formed on the surface and carbon penetrated into the alloys. **(Fig. 5).**

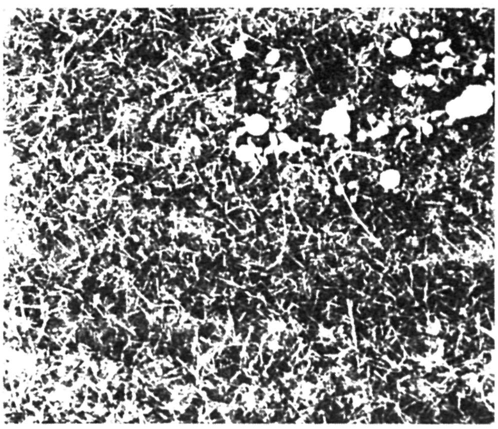
Many coated industrial components are subjected to fluctuating temperatures due to start up/shut down, changes in power demand etc. For this reason a thermal cycling test is appropriate for the examination of the mechanical behaviour of the scale, and coating. The thermal fatigue test is a very searching, and complex test of the behaviour of a coated sample and of the effect of any interaction between coating and substrate. Study of the behaviour of coatings applied to IN738LC, a popular alloy for industrial gas turbine blades shows that coatings will only provide extended lives at strain levels which are low enough not to cause cracking in the coating. Under these conditions corrosion is the controlling mechanism.

Creep of Tubular Components in Corrosive Environments

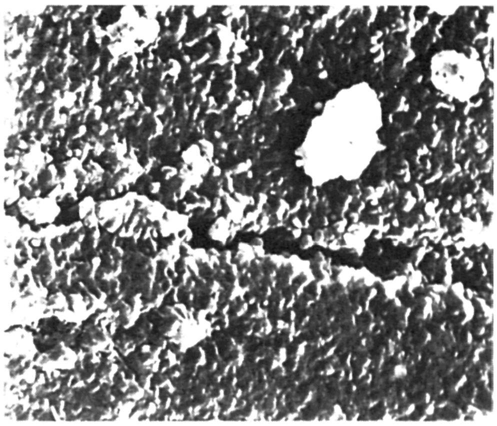
The goal of this engineering activity is to make the mechanistic understanding and data gained from laboratory tests transferable to industrial design and operation of plant; its experimental part is related to the testing of tubular specimens for which the construction of a facility is going on and has reached the operation phase. The prototype experimental test point of this 4-cell facility has produced first test results, and a computer-controlled control system has been designed and ordered. The construction of the second pressuring system has commenced in preparation for installation in a second cell where a unixial creep testing machine will be used in combination with pressuring to control the multiaxial loading parameters.

Considerable attention has been paid to identifying and putting into practice suitable in-situ creep deformation measurements methods. Whereas conventional extensometry utilising transducers placed both, diametrally and axially could be readily conceived, the determination of potential non-uniform deformation of tubes 250 mm in length, 25 mm internal diameter and 4.5 mm wall needs a different technique and has therefore initiated the search for additional measurement methods. The usefulness of applied inert marker grids for post-test evaluation has been confirmed and both X-ray and gamma-ray radiography have shown significant promise to warrant further investigation for continuous in-situ measurement of non-uniform deformation.

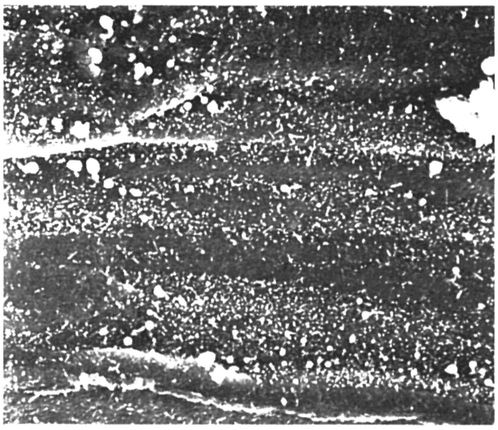
The experiments carried out during the



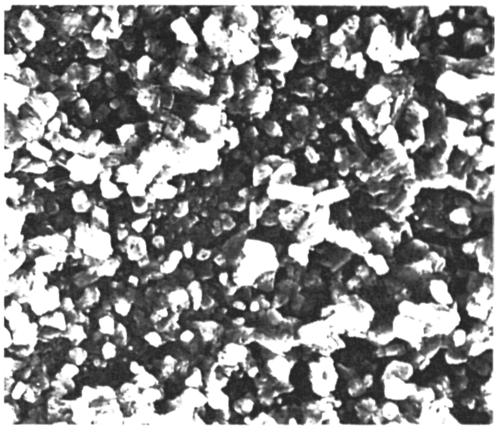
A02: Fe Cr Al Y



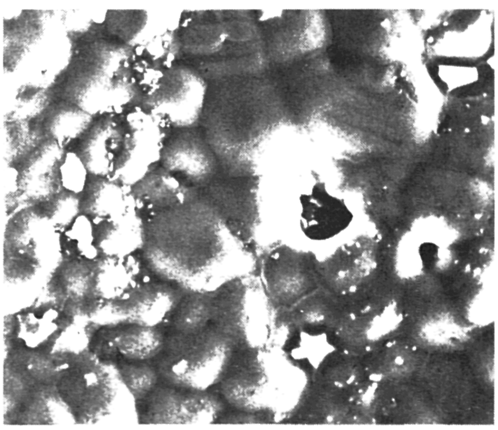
A1: Fe Cr Al Y, pre-oxidized



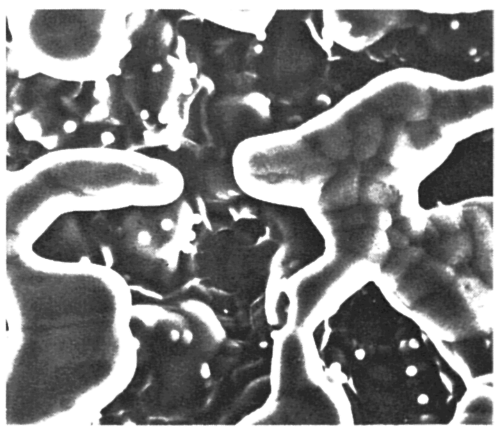
Bo2: Fe Cr Al Y + Ti



B1: Fe Cr Al Y, pre-oxidized



C01: alloy 800H + SiO_2 - COATING



D01: HP 40 Nb + SiO_2 - COATING

Figure 5: Surface morphology of alloys/coating exposed to carburising environment, x3000 SEM.

year have concentrated on the following:

a) Completion of a series of nine internal pressure tests on tubes at 900°C and 1000°C carried out under external contract.

b) Internal pressure tests using the prototype system in the first operative cell.

c) The final series of uniaxial tubular tests at the same temperatures as the pressure tests which are required for comparison and as reference data.

With regard to stress rupture behaviour, the uniaxially tested tubes follow closely conventional specimen behaviour as do the internally pressurised tubes where the hoop stress to cause rupture is the strength parameter considered. The few test results from the first operating cell also fit well with the other data; and an apparent isotropy in stress rupture behaviour of the wrought Alloy 800H tube can be confirmed from examining all the test results.

As evidenced by measurements of elongations to failure, all tubular tests, whether uniaxial or internal pressure, exhibit inferior ductility to the conventional specimens. This is currently thought to be due to the comparatively large tubular specimen which has a characteristically non-uniform strain distribution and a failure mode influenced differently by the constraints rendered by material around the propagating creep cracks. The potential contribution due to metallurgical differences between tubes and conventional specimens is to be checked by machining conventional specimens from the tube walls.

However, as in plant design deformation at failure is often less important than creep rate, attention will in future be more strongly focussed on continuous in-situ deformation measurements rather than data established post-test.

2.3. The High Temperature Materials Data Bank

The High Temperature Materials Data Bank follows in its conceptional lines the outcome of an investigation made to establish the European requirements for an information system on high temperature materials. The project defined for the period 1980-1983 has the objective to set up a pilot data bank containing mechanical properties and those of primary concern being tensile, creep and fatigue test results with emphasis on 600 - 1000°C test temperature and C-O-H environments for alloys covered by the specifications on the "Alloy 800" group. The data bank is developed and operated in collaboration with the computing centre of the Ispra Establishment to which a Petten terminal is linked via Euronet. The use of the Euronet system as the data transmission system between Petten and Ipsra gave the JRC an early opportunity to acquire on-line experience.

The developed data collection procedure has been further tested in practice and can now be considered as complete and operative. An improved manual of the procedure together with a directory of the data collection fields has been assembled. It enables external data bank partners to perform correct and compatible data collection and formatting ready for input. The present status of the data bank content is shown in **Figure 6.** Current data input increases at present the data quantity rapidly.

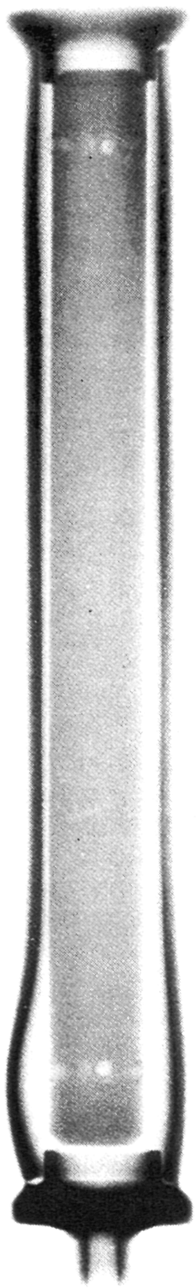


Figure 6: Post test radiograph of tube creep tested at 900°C under internal argon pressure.

A significant improvement of the communication between Petten and the HTM data bank files in the Ispra computer was obtained by the introduction of full synchronous (X-25) connection using a leased telephone line between the Petten terminal and the EURONET multiplexer in Amsterdam. The new multiplexer at the Petten site permits the connection of up to 8 different terminals, plotters or printers, thus enabling more efficient work with the data files. Transmission speed is now at a rate of 2400 bit/s, and transmission errors are practically eliminated; both features are essential requirements for the transfer of signals for graphic display.

Since data input is largely in its operation and consolidation phase, the majority of the software development could be devoted to the design of programmes and procedures for the output and presentation of data in tabular and graphical format. A report programme was introduced to produce a report about the data bank content for a "source document" from which the data were extracted. This programme uses batch mode operation. As part of the planned application programmes for the forthcoming data evaluation activities, so-called standard evaluation programmes have been implemented by a contractor which enable the evaluation and graphic presentation of material properties in relation with stored physical and computed statistical parameters.

The approach to the generation of a first "Data Bank Demonstration Book" was split into two lines: a "demonstration book" containing only a few processed examples will be prepared during the first half of 1983, while a more comprehensive "Alloy 800 data report" will be assembled from data bank output by an external contractor.

3. Conclusions

The HTM programme contributes to developments in the new energy conversion field through the provision of improved knowledge on materials science and technology. Its activities were executed in close contact with universities, industries and governmental bodies.

The experimental activities and facilities of the programme are of great interest for the new concerted European action (COST 501) on high temperature materials for conventional systems of energy generation and conversion using fossil fuels. Consequently, considerable effort has been devoted to the formulation of a strong action containing well integrated international projects. Five clearly identified pieces of work in the Materials & Engineering Studies project have been incorporated into COST 501 together with the use of the HTM Data Bank for efficient management of the data arising throughout the action.

The Information Centre project was successful in supplying information on materials R&D and developing close contacts with industrial and energy programmes, making use of high temperature materials. Greater emphasis was placed on activities concerning ceramics and refractories. The computerised information base on HTM relevant organisations, experts and research programmes became fully operational.

Dependable materials performance is critical for the operation of advanced energy technologies. The programme contributes to the satisfaction of the requirements by studying behavioural patterns of materials in specimen and component form which involve the use of the unique facility for high temperature testing in toxic and explosive atmospheres which represent those found in industrial applications.

The results obtained have increased the understanding of materials behaviour, assist in the selection of high temperature materials for plant design and contribute to the development of new materials.

A satisfactory number of tube test results have become available from internal pressure tests carried out by a contractor, low pressure tests with axial loading made in ETL, and the first results produced by the new high pressure test installation. All these results have permitted to draw first conclusions on the basis of a correlation with uniaxial data; however more multiaxial experiments must be completed before the objective of the project, i.e. the reliable transfer of uniaxial data to component conditions, is fully achieved. Particular effort has therefore further been expended on the construction of the needed facility, the design and assembly of its complex safety and control system and the investigations which are necessary to put into practice the most suitable deformation measuring method for these extremely difficult conditions.

The data bank project has tested and proved in practice the data collection and input stage. The main development of this stage is now completed, and a "data collection manual" has been issued. The quantity of data stored has increased from 2000 records at the end of 1981 to about 6000 records now. The acquisition and processing of additional input is continuing.
The work on the "Data Bank Demonstration Book" revealed shortcomings at the output side and the need for qualitative and quantitative consolidation.

It was therefore decided to issue a demonstration book which will present a few processed examples and to make a comprehensive Alloy 800 data report after this consolidation is achieved. It is planned that this Alloy 800 data report will be made by an outside contractor.

The data management task of this project in the COST 501 programme leads to the collaboration with various involved institutions which provide data formatted for the input to the data bank. The main purpose of the data management by this facility is the consistent evaluation of the mechanical property data which are generated by the various projects of this collaboration.

TYPE OF TEST RESULT	Number of Test Results
Tensile Test	
· strength	826
· proof stress	2584
· yield stress	53
· elongation	756
· reduction of area	705
· stress strain curve	25
Creep Curve	101
Creep Strength	249
Creep Rate	212
Creep Rupture Strength	1815
·elongation	886
·reduction of area	664
Cyclic Stress Strain Curve	15
Isothermal SN Test	638
Thermo-Mechanical SN Test	40
Fatigue Crack Growth	79

Figure 7: Status of Data Bank Content
File "Test Results"
December 1982

Specific efforts concentrated on the preparation of the JRC multiannual programme for the period 1984/87. The proposed programme aims to satisfy industrial needs in the area of materials long term service in high temperature aggressive environments by the promotion, coordination and conduct of studies to evaluate materials behaviour under conditions relevant to the critical areas of important industrial processes.

Five closely connected projects are proposed for execution in order to achieve the stated aims:

- Studies on Steels and Alloys: concentrate on selected HTM for their suitability for service in aggressive environments.
- Studies on Sub-Components: verify experimental methods for applying specimen data to tubular sub-components, operating under complex industrial conditions.
- Studies on Engineering Ceramics: aim at exploiting the advantages of ceramic components in high temperature corrosive structural applications.
- The HTM Data Bank: will be made available on-line and covers mechanical properties of a range of important HTM;
- The HTM Information Centre: aims to encourage information exchange, to collect and disseminate HTM information, to indentify and evaluate future R&D requirements and to promote research collaboration.

Salg og abonnement · Verkauf und Abonnement · Πωλήσεις καί συνδρομές · Sales and subscriptions
Vente et abonnements · Vendita e abbonamenti · Verkoop en abonnementen

BELGIQUE / BELGIË

Moniteur belge / Belgisch Staatsblad

Rue de Louvain 40-42 / Leuvensestraat 40-42
1000 Bruxelles / 1000 Brussel
Tél. 512 00 26
CCP/Postrekening 000-2005502-27

Sous-agents / Agentschappen:

Librairie européenne / Europese Boekhandel

Rue de la Loi 244 / Wetstraat 244
1040 Bruxelles / 1040 Brussel

CREDOC

Rue de la Montagne 34 / Bergstraat 34
Bte 11 / Bus 11
1000 Bruxelles / 1000 Brussel

DANMARK

Schultz Forlag

Møntergade 21
1116 København K
Tlf: (01) 12 11 95
Girokonto 200 11 95

Underagentur:

Europa Bøger

Gammel Torv 6
Postbox 137
1004 København K
Tlf. (01) 15 62 73
Telex 19280 EUROIN DK

BR DEUTSCHLAND

Verlag Bundesanzeiger

Breite Straße
Postfach 10 80 06
5000 Köln 1
Tel. (0221) 20 29-0
Fernschreiber:
ANZEIGER BONN 8 882 595

GREECE

G.C. Eleftheroudakis S.A.

International bookstore
4 Nikis Street
Athens (126)
Tel. 322 63 23
Telex 219410 ELEF

Sub-agent for Northern Greece:

Molho's Bookstore

The Business Bookshop
10 Tsimiski Street
Thessaloniki
Tel. 275 271
Telex 412885 LIMO

FRANCE

Service de vente en France des publications des Communautés européennes

Journal officiel

26, rue Desaix
75732 Paris Cedex 15
Tél. (1) 578 61 39

IRELAND

Government Publications

Sales Office
GPO Arcade
Dublin 1

or by post

Stationery Office

Dublin 4
Tel. 78 96 44

ITALIA

Libreria dello Stato

Piazza G. Verdi, 10
00 198 Roma
Tel. (6) 8508
Telex 62 008
CCP 387 001

Licosa Spa

Via Lamarmora, 45
Casella postale 552
50 121 Firenze
Tel. 57 97 51
Telex 570466 LICOSA I
CCP 343 509

Subagente:

Libreria scientifica Lucio de Biasio - AEIOU

Via Meravigli, 16
20 123 Milano
Tel. 80 76 79

GRAND-DUCHÉ DE LUXEMBOURG

Office des publications officielles des Communautés européennes

5, Rue du Commerce
L-2985 Luxembourg
Tél. 49 00 81
Télex PUBLOF - Lu 1322
CCP 19 190-81
CC bancaire BIL 8-109/6003/300

NEDERLAND

Staatsdrukkerij- en uitgeverijbedrijf

Christoffel Plantijnstraat
Postbus 20014
2500 EA 's-Gravenhage
Tel. (070) 78 99 11

UNITED KINGDOM

H.M. Stationery Office

P O Box 569
London SE1 9NH
Tel. (01) 928 69 77 ext 365
National Giro Account 582-1002

Sub-Agent:

Alan Armstrong & Associates

Sussex Place, Regent's Park
London NW1 4SA
Tel. (01) 723 39 02

ESPAÑA

Mundi-Prensa Libros, S.A.

Castelló 37
Madrid 1
Tel. (91) 275 46 55
Telex 49370-MPLI-E

PORTUGAL

Livraria Bertrand, s.a.r.l.

Rua João de Deus
Venda Nova
Amadora
Tél. 97 45 71
Télex 12709-LITRAN-P

SCHWEIZ / SUISSE / SVIZZERA

FOMA

5, avenue de Longemalle
Case postale 367
CH 1020 Renens - Lausanne
Tél. (021) 35 13 61
Télex 25416

Sous-agent:

Librairie Payot

6, rue Grenus
1211 Genève
Tél. 31 89 50
CCP 12-236

SVERIGE

Librairie C.E. Fritzes

Regeringsgatan 12
Box 16356
103 27 Stockholm
Tél. 08-23 89 00

UNITED STATES OF AMERICA

European Community Information Service

2100 M Street, N.W.
Suite 707
Washington, D.C. 20 037
Tel. (202) 862 95 00

CANADA

Renouf Publishing Co., Ltd.

2182 St. Catherine Street West
Montreal
Québec H3H 1M7
Tel. (514) 937 3519

JAPAN

Kinokuniya Company Ltd.

17-7 Shinjuku 3-Chome
Shiniuku-ku
Tokyo 160-91
Tel. (03) 354 0131

NOTICE TO THE READER

All scientific and technical reports published by the Commission of the European Communities are announced in the monthly periodical **'euro-abstracts'.** For subscription (1 year: BFR 2.000) please write to the address below.

ECU	BFR	UKL	IRL	USD
3.40	150	2.10	2.30	3.50

[redacted]

ISBN 92-825-3580-0

9 789282 535806

OFFICE FOR OFFICIAL PUBLICATIONS
OF THE EUROPEAN COMMUNITIES

Boîte postale 1003 - Luxembourg

CDNA08526ENC