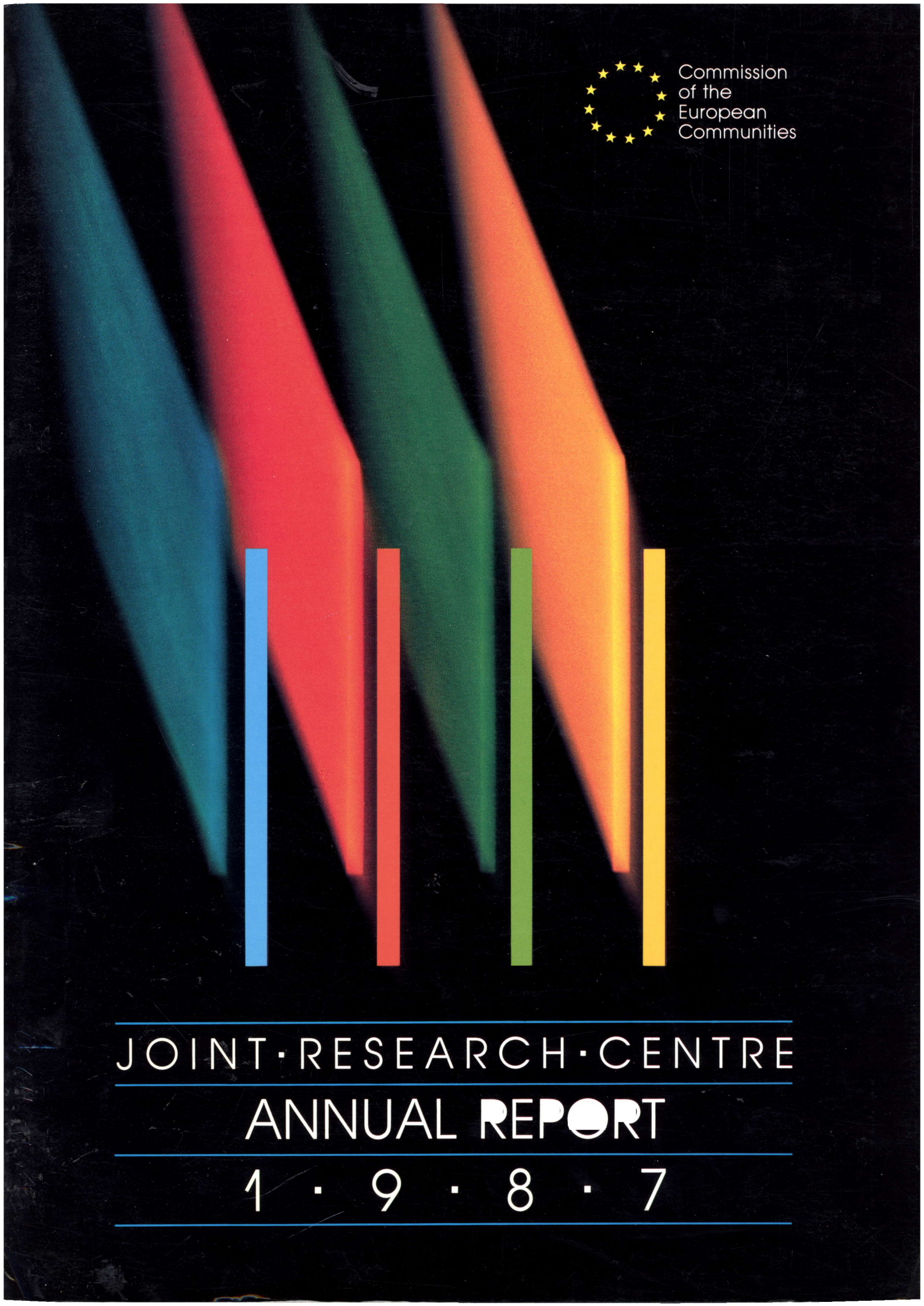
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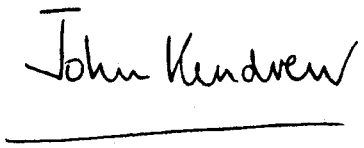
Foreword

This 1987 annual report on the Joint Research Centre is the last of those covering the multiannual programme 1984-1987 and highlights the year's scientific and technical achievements.

1987 has been a particularly difficult year characterized by a scarcity of means and by a pressing need for changes. At the same time, the management has been heavily involved in initiating the modifications needed to fit the JRC to meet the challenges of the 1990's in the Community. Proposals for such changes have been presented by the Commission to the Council of the European Communities; they had been discussed by the JRC Board of Governors. It is foreseen that enhanced responsibility will be delegated to the scene of scientific action, more precisely, to the new scientific institutes, and that more power will be given to the Board of Governors of the JRC; furthermore, bureaucratic administrative burdens will be shed where possible.

It is intended to refresh the scientific spirit by measures to introduce a higher proportion of young researchers, made possible by an early retirement scheme. Mobility among scientists will be increased by opening new avenues for making available research grants and for encouraging visiting scientists, together with new recruitment schemes. Scientific vitality will be enhanced through exploratory research and a more down to earth approach will be insured by augmenting work for third parties.

The Board of Governors is fully aware of these challenging tasks. The Board is confident that with earnest participation by staff and management, the difficulties of the past will be overcome, and that the JRC will enjoy a bright scientific future in the service of the Community.



Sir John Kendrew
Chairman of the Board of Governors

CONTENTS

INTRODUCTION

1987 was a watershed year for the JRC. It was the last year of the JRC's multiannual programme for 1984 - 1987; and a year in which much thought was given to the Centre's future. In October 1987 the Commission published "A New Outlook for the Joint Research Centre" (1) which proposed radical changes to be made to the JRC's operation, management and methods of financing.

One of the key changes under consideration is the opening up of the JRC's work to the outside world. Under the new proposals the Centre would remain an integral part of the Community R&D strategy and in this capacity maintain its institutional role of scientific and technical support for the implementation of Community policies. But it is equally clear that to play a stronger role in the overall European R&D system, the JRC must begin to work for other clients.

This implies that the JRC will be encouraged to place its specialised, neutral and independent scientific potential at the disposal of national organisations or industries in the Member States by means of research contracts, service work, cooperative projects, industrial clubs and so on. Exploratory research will also be encouraged in order to promote the pursuit of scientific excellence in a world of continuous scientific and technical change.

The ideas contained in the Commission's proposals were influenced not only by the results of a substantial evaluation of the JRC programme performed early in 1986, but also by the findings of a Panel of Senior Industrialists who were asked by the Commission to advise on the future mission of the JRC. These proposals have already been considered by the Council of Ministers, the European Parliament, the Economic and Social Committee, the Euratom Scientific and Technical committee, and the Committee on Scientific and Technical Research (CREST). A final decision on the future of the JRC will be taken by the Council of Ministers during 1988.

Clearly the most far-reaching changes to the JRC have yet to take place, but 1987 saw the introduction of a number of modifications in its scientific and technical work that should help to pave the way for the major reforms by increasing the JRC's appeal to potential new clients. These modifications included a strengthening of the High Temperature Materials Programme with a new project on advanced materials and structures. The European Parliament also allocated an additional 2 million ECU to the JRC in order to promote research into industrial technologies. These funds were used to install a new Surface Engineering Laboratory at Ispra.

Following the Chernobyl accident, a new project on Radiation Evaluation and Monitoring was launched within the JRC's Environmental Protection Programme. The programme for the Application of Remote Sensing Techniques was also stepped up in 1987, to take account of the latest developments. This work should favour the growth of commercial value-added services in the application of data from space satellites (Agriculture and land-use, and marine monitoring).

This report describes work carried out under the 1984-1987 multiannual programme, including details of the management of resources, programme execution, and the results obtained. The following milestones are particularly significant, and should give the reader some idea of the kind of scientific and technical services which the JRC is already able to provide, even before the new changes take place.

Industrial Technologies

- Improvement of standard neutron data in the fission of ^{235}U and ^{252}Cf as requested for the INCD/NEANDC Standard File.
- First trial within the Interlaboratory Measurement Evaluation Programme (IMEP) to compare test on blood serum as performed by several clinical laboratories.
- Installation of new equipment to prepare standardised samples of marine fish, for use in heavy metal trace elements analysis (Support to Community Reference Bureau).
- Completion of the first phase of a study of the corrosion of silicon nitride materials by corrosive products of burning diesel fuel.
- Construction and application of a model for establishing the boundaries of deformation mechanisms in steel tubes subjected to multiaxial stress.
- Formation of an Interest Club, involving ENEL (I), LABORELEC (B), CEGB (UK), MPA (FRG) and JRC Ispra for the development of an expert system for safety assessment of pressure components in non-nuclear power plants.
- Determination of the thermodynamic properties of high temperature superconductors (of type YBa2 Cu3 06,5 + x) so that characterization procedures could be improved.

Nuclear Fission

- Conclusion of a reliability benchmark exercise on the Human Factor in Probabilistic Safety Analysis. This exercise, coordinated by the JRC, included the participation of several European teams and of specialists from the National Research Council in the US.
- Integration of results obtained through the Project for Inspection of Steel Components (PISC) in the activities of codes and standards organizations, as well as in the work of Inspection and Licensing Authorities.
- Completion and test of a transportable instrument for non-destructive analysis of plutonium in alpha contaminated waste.
- Organization of the first training course for IAEA and Euratom inspectors in the Pre-Perla facility for testing nuclear safeguards.
- Start of the irradiation phase, in the PHENIX reactor at Marcoule (F), of an experiment to convert long-lived "minor actinides" in nuclear waste into short-lived fission products.
- Development of a new concept for safeguards analysis in reprocessing plants; this allows the use of smaller samples, down to the nanogram scale, which facilitates shipment.
- Demonstration of aerosol agglomeration by acoustic waves; this opens up new possibilities for managing toxic or radioactive aerosols.

Environmental Protection and Satellite Remote Sensing

— Implementation of the Radioactivity Environment Monitoring (REM) data bank, which collates effects of the Chernobyl accident.

— Publication of the final version of the European Inventory of Commercial Chemical Substances (EINECS); this version is available on-line, on the main Ispra Computer.

— Fully automatic classification and mapping of land use for the whole Department of Ardèche (F) - 560.000 ha - using mono-temporal Landsat-TM data.

Non-Nuclear Energy

— Development of a new methodology for monitoring solar buildings.

Exploitation of the High Flux Reactor (HFR) Petten

— Increase of the average utilization of the High Flux Reactor to 84% of maximum occupation, for customers in the Netherlands, Federal Republic of Germany, the JRC programme and others.

This list highlights only some of the most significant achievements. Important work was also done in many other projects and programmes during the year, as reported in detail in Chapters 3 and 4.
As in previous years, JRC work was supported by several in-house services (workshops, hot cells, special laboratories, informatics services, etc.). As it was the last year of the approved multiannual programme the Centre did not in 1987 make significant new investments in these important services.

Much of the work was conducted in close collaboration with numerous national bodies, firms and organizations from inside and outside the Community. It is a pleasure to acknowledge this interest and collaboration. It is through these many joint activities that the Commission is insured of the proper transfer of knowledge from the JRC to the broader Community. In Annex A this report records other such transfers from the JRC during the year such as publications, the organization of Ispra courses, the evaluation of results and participation by the JRC in exhibitions and fairs.

In summary 1987 was a dynamic year for the JRC. Much progress was made in line with established plans; but it was above all, the year where the many thoughts on the role of the laboratories crystallized into formal proposals and solid plans for the future of the Joint Research Centre.

JRC ANNUAL REPORT 1987

FINANCIAL AND HUMAN RESOURCES

FINANCIAL AND HUMAN RESOURCES

Expenditures committed to the Programme in 1987 and the Multiannual Programme 1984-87.

The commitments for the execution of the Programme (Common Programme and Supplementary Programme for the High Flux Reactor at Petten) were fixed by the Budgetary Authority at the level of 212,1 MioEcu, taking into account transfer and savings plan of previous years. The JRC moreover had available commitment credits for the execution of support to other Commission services, bringing the total to 218,7 MioEcu.

Details about 1987 commitments for the execution of the various programmes (industrial technologies, thermonuclear fusion, nuclear fission, non-nuclear energies and environment) as well as for the execution of the Supplementary Programme (exploitation of the HFR reactor) are given on table 1.

Table 1: Commitments for programme execution 1987 (Rounded figures, MioEcu)

	Personnel	Other Expenditures	Total
Industrial technologies	17.3	13.5	30.8
Thermonuclear Fusion	10.3	7.7	18.0
Nuclear Fission	55.8	33.0	88.8
Non-Nuclear Energies	6.3	2.8	9.1
Environment	20.2	9.7	29.9
Subtotal	109.9	66.7	176.6
Exploitation HFR Reactor	4.5	16.0	20.5
Total	**114.4**	**82.7**	**197.1**

Difference between available credits and expenditures for the common and supplementary programmes represents 15 MioEcus which are nearly exclusively due to outstanding personnel credits awaiting a decision of the European Court of Justice on the multiannual revision of the evaluation of the cost of living.

An account can also be drawn of the effective expenditures over the four year period 1984 - 1987. The expenditure commitments estimated necessary originally by the Council decision for the execution of the four-year research Programme 1984-1987 amounted to 700 MioEcu, divided into 398.8 MioEcu for personnel expenditures - this amount to be automatically reevaluated by the Budgetary Authority - and 301,2 MioEcu for specific credits, the expenditure of which was to be referred to the Council. Following the implementation of a savings plan, the Commission undertook to limit the four year increase in expenditures for specific credits to 25 MioEcu. The actual figures are as shown in table 2.

Table 2: Annual and total expenditures (rounded figure in Mioecu) 1984-1987 JRC Research Programme

	1984	1985	1986	1987	Total
Personnel credits	102	109	113	114	438
Specific credits	76	89	78	83	326
Total	178	198	191	197	764

Human Resources

Staff

The JRC authorized staff amounts to 2260, including both the scientific-technical category and the administrative category as illustrated in figure 1.

Employees are governed by the staff regulations for employees of the European Communities. For many years the JRC has only recruited staff as temporary agents under the conditions of the Staff Regulations; at present 53% (51.4% in 1986) of the total staff are temporary agents and 47 % are officials in the scientific-technical and administrative categories.
During the four years of the 1984-1987 programme, 361 agents left the JRC.

During the same period 208 agents have been recruited as temporary agents and 35 transferred from other services of the Commission.

Visiting Scientists and Fellows

The JRC trains high-level specialists through a programme of fellowships, which is applicable to three different categories of candidates:

— undergraduate students;

— postgraduate students preparing a master's or a doctoral degree

— post-doctoral fellows.

Fellows are given a grant lasting from one to three years.

Table 3 shows where these fellows worked in the various JRC establishments during 1987.

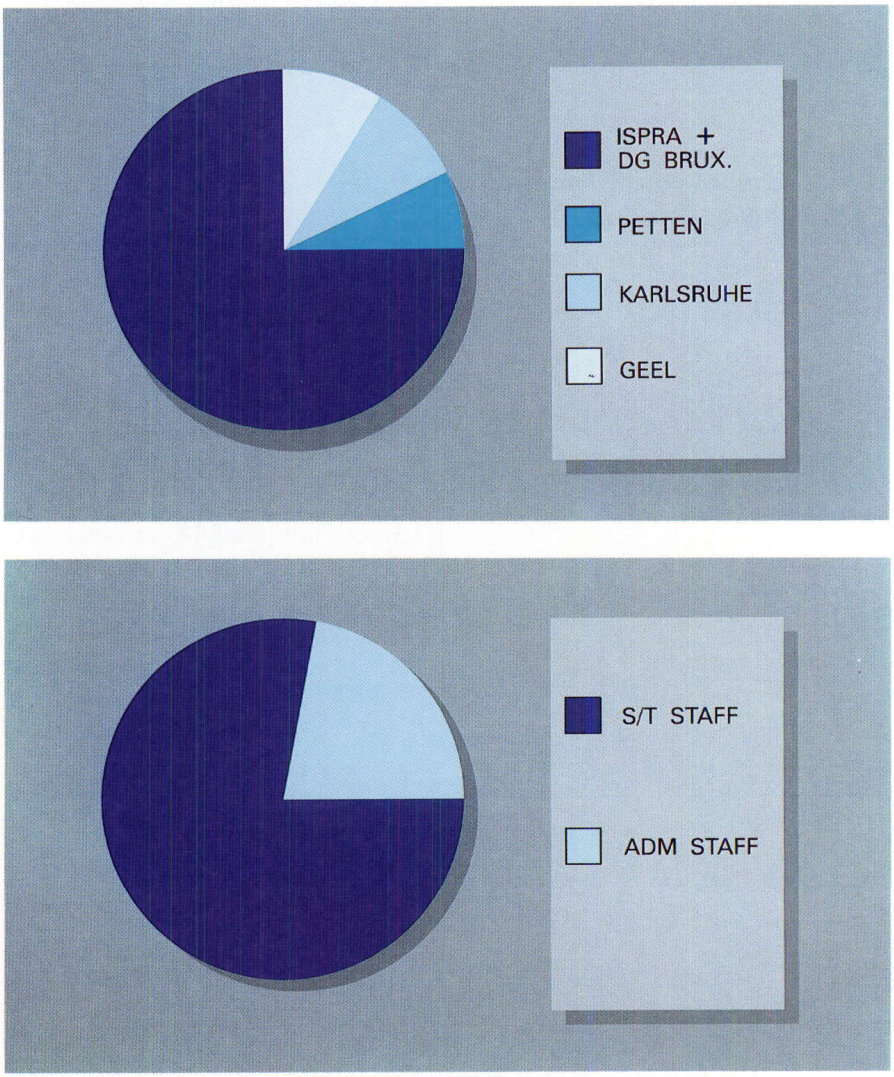
Table 3: Fellows by place of work and by categories

	Ispra	Karlsruhe	Petten	Geel	Total
Post-doctoral fellows	6	1	2	2	11
Post-graduates	65	6	11	4	86
Undergraduates	86	-	-	17	103
Total	157	7	13	23	200

Besides this type of fellowship, the JRC hosts visiting scientists, mostly professors on sabbatical leave and senior scientists; they are appointed for one year. In 1987, 55 visiting scientists (Ispra 40, Geel 9, Karlsruhe 5, Petten 1) resided in the JRC.

The visiting scientists and fellows total 255 individuals.

Figure 1: JRC staff by places of work and by categories



JRC ANNUAL REPORT 1987

SCIENTIFIC AND TECHNICAL ACHIEVEMENTS

INDUSTRIAL TECHNOLOGIES

This programme comprises research related to Nuclear Measurements and Reference Materials, implemented at the Geel Establishment; Materials and Structure, implemented at the Ispra Establishment; and High Temperature Materials, implemented at the Petten Establishment.

Nuclear Measurements and Reference Materials

The Central Bureau for Nuclear Measurements (CBNM), established by the Euratom Treaty and located at Geel has the important mission of promoting European standards and the harmonization of reference methodologies and materials. The work must meet the high standards required for the preparation of reliable reference materials. The standardised measurements must be laid out in a stepwise fashion so the final result can be obtained with a highly repeatable degree of accuracy.

Nuclear measurements

Nuclear measurements are mostly done according to the needs expressed by international organizations such as IAEA, NEA, BIPM; some are performed at the request of national institutions.

a. Nuclear Data

Nuclear Data for Standards - Widths of total kinetic energy-and mass-distributions in the fission of ^{235}U as a function of neutron energy, and of the resonances and their quantum numbers, have been successfully described on the basis of a three-exit channel fission model (H.H.Knitter et al., Z. Naturforsch. 42a (1987)786; F.J. Hambsch, Dissertation, D-17, Darmstadt 1987). Measurements of the spontaneous fission of ^{252}Cf show that most of the fission neutrons are emitted from fully accelerated fragments. A new value was obtained for the emission probability of the 60 keV γ-ray in the ^{241}Am decay.

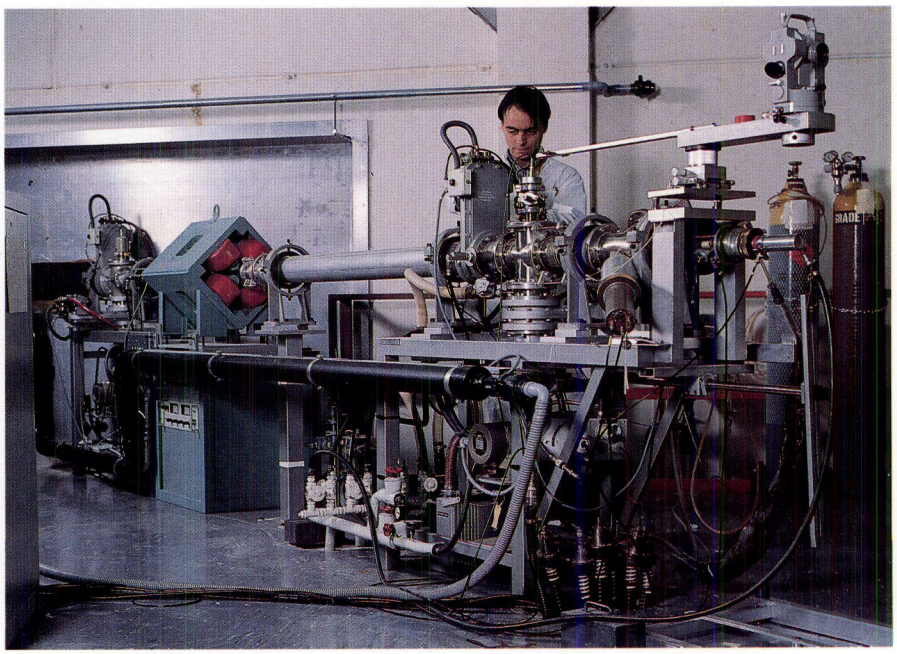


Figure 2: Beam line at the Van de Graaf accelerator serving as intensity - and energy - variable neutron source

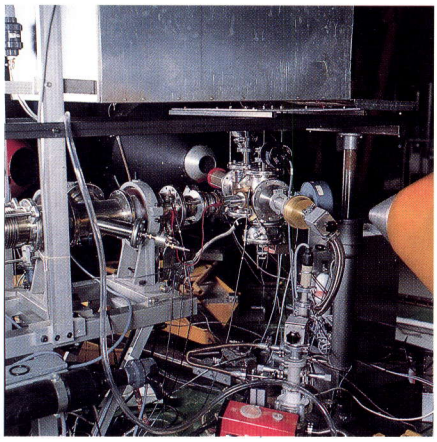


Figure 3: Close up of the Detection chamber for helium induced by neutron bombardment at the Van de Graaf accelerator

Nuclear Data for Fission Technology - Measurements previously reported for η (the number of fission neutrons emitted per neutron absorbed) in ^{235}U at subthermal neutron energy were corrected for multiple scattering. First fission cross-section measurements were performed at the Very Cold Neutron Source at the Institute Laue-Langevin, Grenoble. An experimental method for the determination of efficiencies and response functions of capture detectors, when applied to neutron capture measurements, successfully reproduced the transmission results of the 1.15 keV resonance in ^{56}Fe, and resolved the discrepancy which initiated the NEANDC Task Force.

Nuclear Data for Fusion - At the request of the EC Task Force on Fusion Neutronics in support of the Next European Torus (NET), measurements were made of the double-differential neutron emission cross-sections of ^{7}Li, and of the tritium production cross-section for ^{9}Be. The results of these experiments provide data for the calculation of neutron transport in the blanket of the fusion reactor, which contains lithium as tritium breeder material.

b. Nuclear Metrology

Radionuclide Metrology - A method was developed that improves the accuracy of peak analysis in high resolution spectrometry of complex alpha spectra (G.Bortels et al., Int. J. Appl. Radiat. Isot. ^{38}A (1987) 831). An ionization chamber was made operational on-line for activity measurements. Geel participated in an international comparison of activity-concentration measurements of a ^{125}I solution (organized by BIPM).

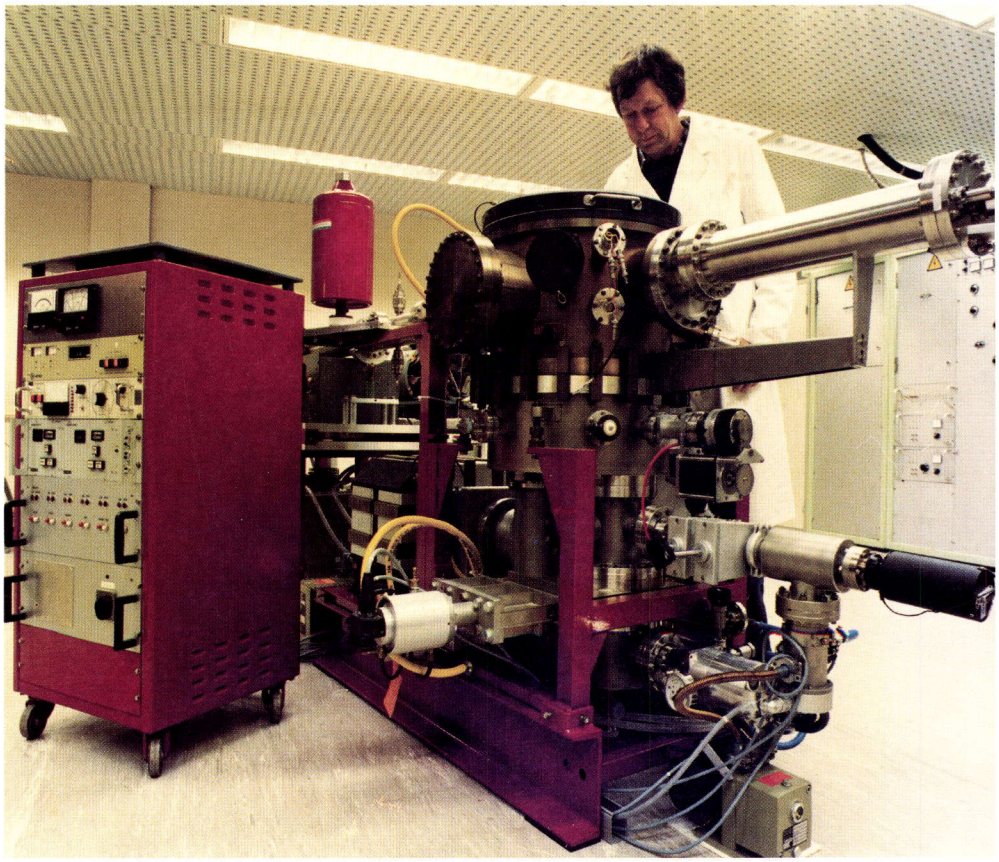


Figure 4: Scattering chamber for Rutherford Backscattering experiments at a beam line of the 3.7 MV Van de Graaf accelerator.

Metrology of Neutron Fluence and Dose - Geel participated in a comparison organized by BIPM to find out whether the two-spherestechnique can be used to measure neutron fluence at neutron energies of 2.5 and 14.7 MeV. Absorbed dose was determined by ionometric techniques in the course of neutron irradiations for the Radiobiology Department of SCK/CEN Mol.

Reference Materials

Reference materials are prepared according to established needs: nuclear reference materials for industries, safety or safeguards requirements, and non-nuclear reference materials in the frame of the Bureau Communautaire de Reference, BCR (DG XII Shared-Cost Action).

a. Nuclear Reference Materials

Actinide Reference Materials - Reference materials of uranium minerals and ores (EC-NRM 111-116) were prepared by sampling and conditioning and by testing analytical methods to produce stable and homogeneous materials. A batch of 250 g of purified PuO_2 is now in the process of characterization (EC-NRM 210). The procedure for certifying reference materials with $^{233}U/^{235}U/^{238}U$ (EC-NRM 199) was verified. Certification procedures for several plutonium spike materials were developed using Isotope Dilution Mass Spectrometry (IDMS). Ten sets of PuO_2 samples of different isotopic composition for measuring isotope abundance by γ-ray spectrometry were ordered by and delivered to laboratories in Europe and the USA.

The Regular European Interlaboratory Measurement Evaluation Programme (REIMEP) related to actinide measurements that was initiated by Geel continued with increasing interest from other laboratories.

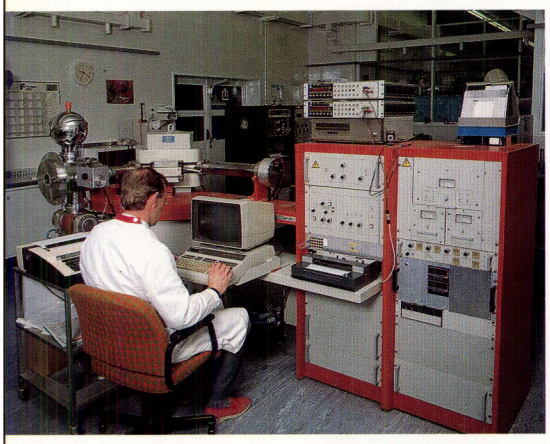


Figure 5: Mass spectrometer with supply-electronics and data acquisition system

Reference Materials for Reactor Neutron Dosimetry - The work on a series of reference materials for neutron dosimetry in reactors proceeded as planned. Although the characterization procedures are still going on, seven of these materials have already been made available for sale. Nickel (EC-NRM 521) and ^{238}U oxide (EC-NRM 501) have been submitted to the EC Nuclear Certification Group, after the draft reports had been approved by the participating laboratories and the experts' working group in 1986.

Samples and Targets for Nuclear Measurements - A total of 425 special, commercially unavailable samples and targets (thin deposits, foils, powder pellets or metal sheets or wires, quantitative alloys) were prepared, characterised and delivered to customers in national organizations, industries and universities. The amount of activity required for sample preparation depends not only on the number of samples requested but is largely determined by the specifications demanded by the customers.

Figure 6: General view of the preparation unit for synthetic uranium isotope mixtures

b. Non-nuclear Reference Materials

Reference Materials for Biological Applications - Isotope Dilution Mass Spectrometry was used for the certification of boron traces in rye grass. The same method was used to determine reference values for lithium in human blood serum. The characterized serum samples were submitted to a first Interlaboratory Measurement Evaluation Programme (IMEP) test in which six clinical laboratories participated.

Support to the Community Reference Bureau - Geel contributed, in several ways to the shared-cost action programme of the Community Reference Bureau in DG XII. In total, 1770 reference materials, including 180 non-ferrous metals and alloys, were sold and shipped in 396 orders. For analytical comparisons 921 samples, 530 of them non-ferrous, were distributed to 123 laboratories. Standardised material from marine fish, to be certified for heavy metal trace elements, was prepared, with new equipment able to treat quantities of up to 200 kilogrammes of fresh fish. The freeze-drying of fruit juice concentrate to produce similar reference material was tested.

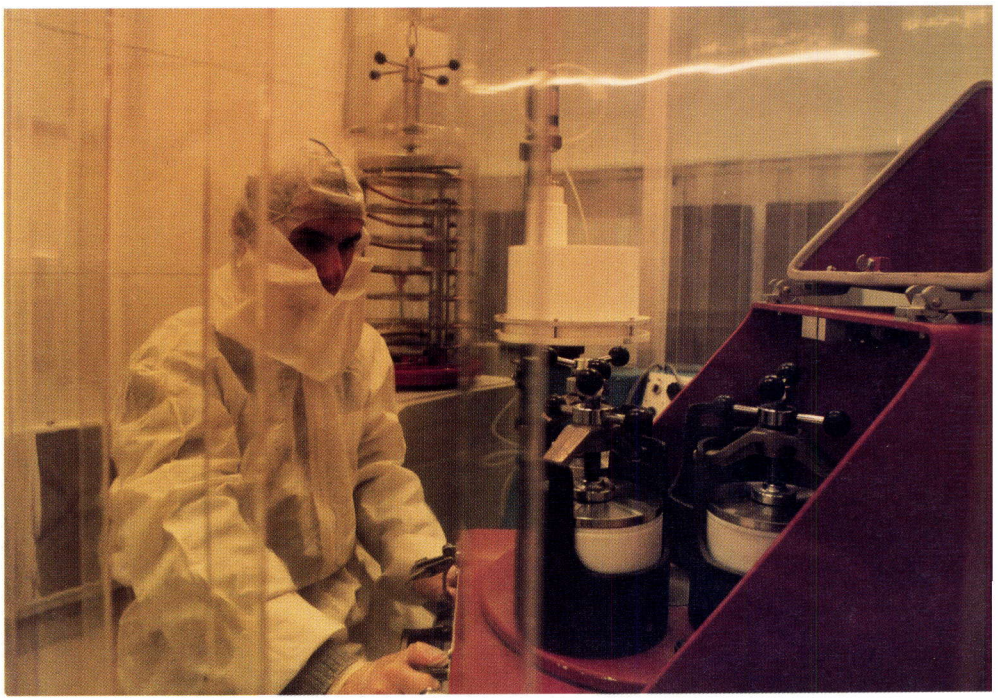


Figure 7: Experimental room for treatment of reference materials prepared in support to BCR

High Temperature Materials (HTM)

The programme aims to stimulate the development and industrial utilization of advanced materials for high temperature applications in the European Community. The programme results are of a generic nature, in order to benefit a range of technologies useful in several industries (automative, chemical, power, etc). The programme includes five projects : Steels and Alloys, Sub-Components, Engineering Ceramics, HTM Databank and HTM Information Centre.

Steels and Alloys

Conditions were identified, under which high temperature steels in coal conversion systems, with metal temperatures of 600-800°C, form oxide scales. This permits the measurement of a steel's resistance to corrosion by sulphidising species in gaseous environments. Techniques were developed to apply condensates and/or deposits of specific morphological types to steel, for subsequent studies of corrosion. The experience gained in conducting these programmes has been applied to industrial failure analysis and the improvement of materials.

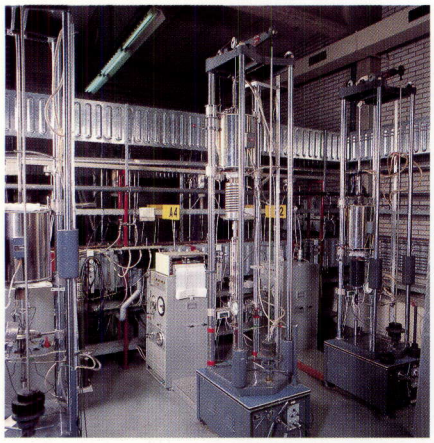


Figure 8: High temperature creep testing of heat resisting steels

The corrosion of several coatings, of Fe-Cr-Al-type composition, applied to different high-temperature steels, was assessed in complex gaseous environments with and without superimposed mechanical stress.

It was shown that internal carburisation of material undergoing creep in the low-oxygen atmosphere of coal-conversion systems is critical. Results show that creep rates are not worsened by the formation of internal carbides, as much as is the case for stress rupture strength and ductility. The creep behaviour of an advanced oxide dispersion-strengthened super-alloy has been characterized at high temperature (to 1050°C) as part of an integrated international programme.

The low-cycle fatigue behaviour of an advanced alloy was determined, including crack initiation, micro-crack and macro-crack growth. Identification of the active mechanisms for deformation and environmental attack made it possible to express mathematically the behaviour. Pre-normative investigations have been made, with industrial backing, in the areas of creep crack growth, techniques for testing low-cycle fatigue and thermo-mechanical fatigue.

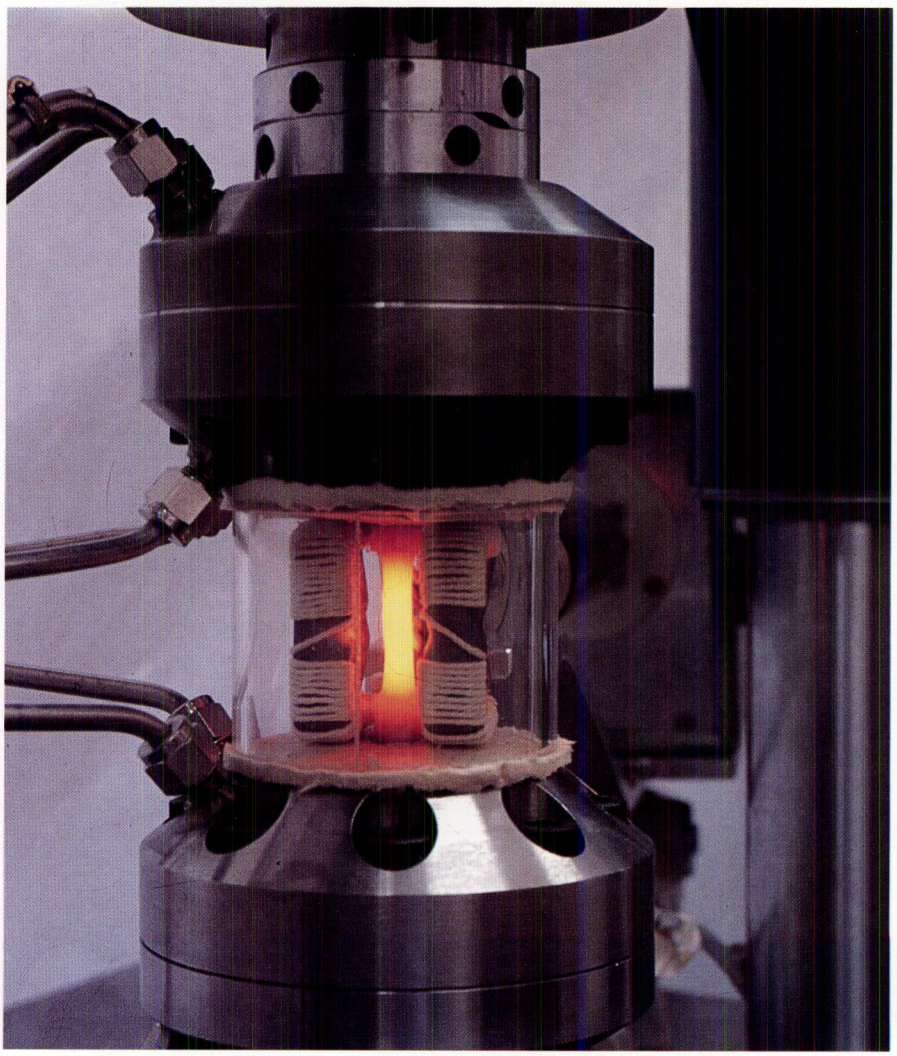


Figure 9: View of an induction heated specimen in a low cycle fatigue test rig

Alloys sub-components

A recent model for predicting the creep behaviour of tubes under multiaxial stress was employed in a series of complex experiments. These demonstrated that the mechanism controlling rupture in tubes of Alloy 800 under multiaxial stress is different for low stress (long life) and high stress (short term) conditions. The location of this difference in terms of operating parameters (temperature, stress, environment) is crucial to the prediction of component lifetime in service.

Continuing work with major German and British engineering companies, as part of the BRITE shared cost programme, is aimed at developing methods for predicting the behaviour of an advanced stainless steel, and a low-alloy ferritic steel, under simulated plant operating conditions combining creep and fatigue. In collaboration with a major Dutch petrochemical manufacturer, ferritic tubes have been subjected to hydrogen at pressures up to 200 bar and temperatures up to 650°C to evaluate conditions leading to hydrogen embrittlement in chemical reactors.

New testing techniques have been developed for continuous measurement of circumferential strain, and for measuring the growth of cracks in tubes undergoing creep.

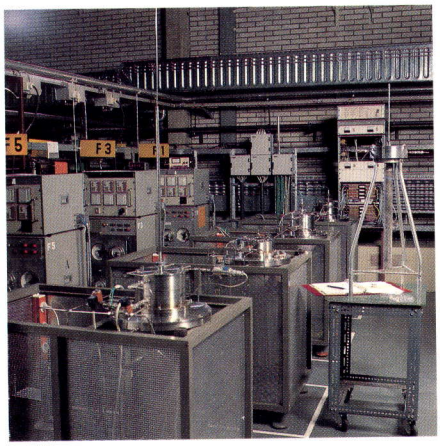


Figure 10: Corrosion testing in simulated industrial environments

Engineering ceramics

Studies of the influence of processing parameters on the microstructures and properties of silicon nitride have shown that:

- Optimizing powder characteristics leads to a significant gain in the mechanical strength of slip cast material.
- Carbon, often a contaminant in industrial processing; can influence the sintering efficiency and mechanical behaviour of sintered ceramics.

Corrosion rigs for measuring long-term changes in mass and for studying corrosion kinetics under aggressive industrial environments, (primarily a combination of sulphidizing and oxidizing gases), have been developed and commissioned. Experiments were focused on the degradation of silicon nitride in environments simulating diesel combustion gases at temperatures up to 1400°C.
Silicon carbide materials from three different methods of fabrication are now being tested in similar environments. Early results show that silicon carbide has superior corrosion resistance to silicon nitride under oxidizing conditions.

The influence of oxidizing environments on lifetime and creep behaviour of hot pressed silicon nitride has been investigated at temperatures up to 1500°C.

Creep testing in the tensile mode is costly and technically difficult. Testing in the flexural mode is more attractive, but results in non-linear stress conditions, which makes standardized testing more difficult. A facility for tensile testing up to 1500°C has been commissioned to correlate creep behaviour in flexural and tensile stress modes. A crack growth measurement facility has been set up which will permit direct measurement of the crack growth process at temperatures up to 1500°C. This will be used to further study the environmental influences on the growth process.

High temperature materials (HTM) data banks

The scope of the HTM Databank has been extended from a single alloy type (Alloy 800) to take into account a number of the more important steels used in power engineering. The data originates from COST and BRITE projects. Attention has been focused on lifetime prediction, and methods for extrapolating computer-aided assessments of component service behaviour, to behaviour under stress at high temperature.

The option of extending the data bank to ceramic materials has been investigated.

The data handbook on Alloy 800, containing 200 data sheets, has been published and circulated to contributors in more than 50 industrial and research organisations. Data originating from COST sources were restricted to authorized participants.

Contributions were also made to international standardization activities in the framework of VAMAS, ASTM and CODATA.

High Temperature Information Centre

The Centre has concentrated on preparing for the 1988-1991 Programme Projects which reflect this emphasis, including workshops, studies and meetings on prenormative and technological research requirements to support needs for high-temperature materials in industry.

Materials and Structures

The programme was initiated at the Ispra Establishment late in the first half of 1987. It is intended to perform preliminary studies on advanced materials during the transition to the 1988-1991 JRC Programme. The programme includes these subprojects : structural reliability, mechanical properties of steel, assessment of characterization methods for advanced materials; development of physical characterization methods.

The European Parliament allocated two million ECU to the Joint Research Centre in order to promote research useful to European industrial technology. These funds were used to install a Surface Engineering Laboratory at Ispra. This laboratory will be a modern installation for work in this field performed in close cooperation with laboratories and industries of the Member States.

The feasibility of a Reaction Wall Unit has been studied. This facility, to be built at Ispra in the 1988-1991 periods, would be used to study the non-linear response of large concrete and steel structures, and would permit the development of building and safety codes.

Structural Reliability

In this project, advanced non-destructive diagnostic methods and damage evaluation procedures, as well as codes for predicting the lifetime of components are developed. The work is a continuation of earlier work on the early detection of failures in nuclear vessels and reactor components, performed as part of the Reactor Safety programme. In 1987, an effort was made to adapt these methodologies to other industrial sectors and to new materials.

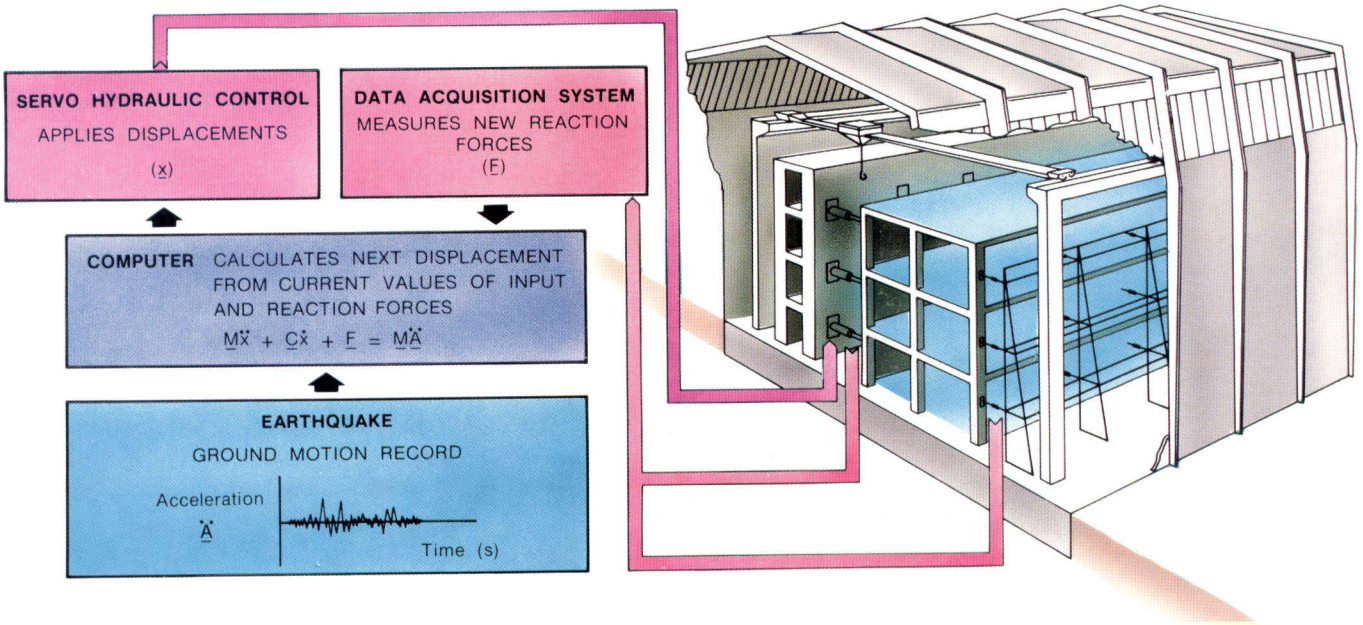


Figure 11: Pseudo-dynamic testing of pre-fabricated building using a reaction wall

The experimental methods investigated are acoustic and thermal emission, laser holography and interferometry. The activity has attracted great attention from the industrial press. Progress made in 1987 includes:

- An Interest Club set up among electric utilities for the development of an expert system aiming at the assessment of the lifetime of steamheaters subject to creep damage.
- A BRITE project, prepared with seven companies in four countries, which is scheduled to start in January 1988. It will last 3 years and lead to the development of an expert system for enhancing the inspection and maintenance of industrial structures, using methods based on reliability assessments.

The possibility that creep in components may be monitored by measuring the resulting emission of heat is, in principle, a very powerful method, not only for metallic but also for non-metallic materials. Recent results have shown that measuring thermal emission allows a qualitative identification of different levels of damage in different specimens.

Mechanical Properties of Steel

During the last years, new austenitic stainless steels were developed in Europe, in which the nickel is partly or totally replaced by manganese, and part of the chromium is replaced by silicon or aluminum. This was done in view of potential difficulties in nickel and chromium supply. These steels should also present some advantages in comparison with conventional 18 Cr - 10 Ni stainless steels (AISI 300 series). In particular, a better time-independent (plastic) mechanical behaviour and a better resistance to corrosion in water should result.

This project aims to study the deterioration of materials in structural components under stress, at high temperature in very critical environments.

Figure 12: SEM backscattered electron image of Vickers hardness indentations in an Fe - Cr - Mn alloy; the light bands are ϵ martensite

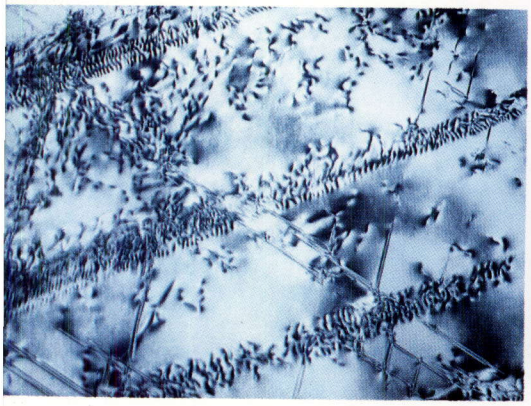


Figure 13: A bright field TEM image of planar array of partial dislocations after 10% deformation at 373 K

In 1987 activity concentrated on the preliminary characterization of these alloys.

- The microstructure at five temperatures of Fe-Cr-Mn alloys was characterised as received from the producer, UNIREC of France.
- The weldability and welding properties at one temperature was assessed using an electron beam procedure. The results showed a good weldability of the alloy, due to manganese.
- Corrosion understress has been tested in saturated $MgCl_2$ solution at the boiling point (154°C). The manganese steel appears to have a behaviour intermediate in between the two nickel base alloys, AISI 304 and 316.
- Contacts have been initiated with stainless steel producers and users in order to form an Interest Club for this class of materials.

Development of Physical Characterization Methods

In this project, advanced characterization methods for surfaces, subsurfaces and interfaces are investigated. Corrosion processes in metals and ceramics as well as the characteristics of deposited layers (e.g. for protective purposes) are at the centre of these investigations. The aim is to develop a set of measuring techniques suitable for a wide range of users. These techniques will also help analyse the results obtained in the Surface Engineering Laboratory at Ispra. In the same project, successful, albeit limited research was performed on high-temperature ceramic superconductors. The aim of the research is to help understand the conditions for preparing, and the methods needed to characterise this important new class of materials.

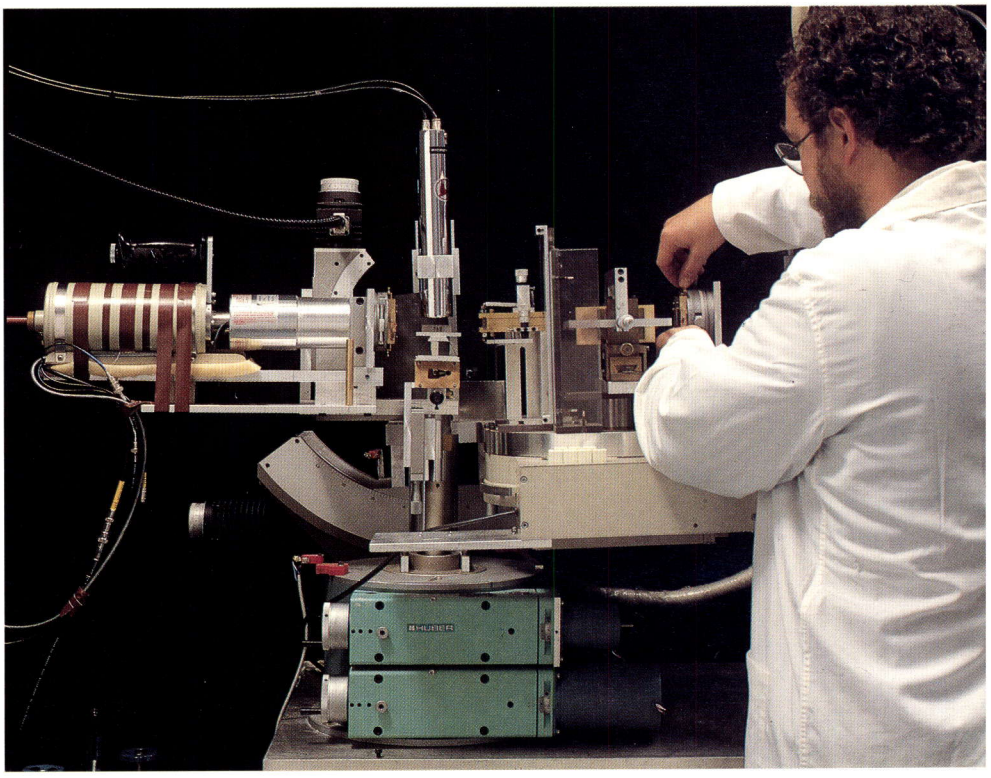


Figure 14: Aligning the prototype glancing angle x-ray spectrometer recently constructed in the Physics Division at Ispra for surface studies of advanced materials

In 1987:

- collaboration was initiated with the Petten Establishment for studies of corrosion processes. Oxidation at the surface of stainless steel was investigated by glancing angle X-ray absorption spectroscopy. The aim was to evaluate this technique as a means of corrosion analysis.

  By firing X-rays at a sample at a glancing angle, the penetration of X-rays into the surface is limited to the top layers (typically 50 Angstroms). Using a synchrotron radiation source - in this case the Daresbury Synchrotron Radiation source, UK - an EXAFS (Extended X-ray Absorption Fine Structure) spectrum may be taken by measuring reflected intensity at each wavelength. The spectrum obtained contains only surface information. This spectrum may then be analysed by comparing it with reference compounds.

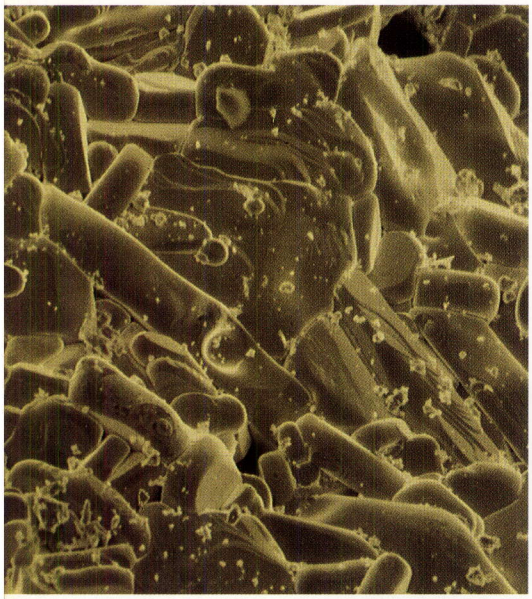


Figure 15: Scanning Electron Micrograph of a sintered pellet of YBa_2 Cu_3 O_{7-x} showing its micrystalline structure

The problem with studying corrosion using this technique is the deterioration of the surface flatness caused by the corrosion, leading to lower reflectivity and less surface sensitivity. The aim of this study was to ascertain whether relevant information about corrosion layers could be obtained despite this. For the experiments, several samples of stainless steel were subjected to a variety of corrosion treatments. The results indicated that the transition from metallic phase to corrosion compound could be observed; and that the chemical nature of the corroded layer could be determined.

Close collaboration with researchers from the University of Strathclyde and Daresbury was crucial for the success of this work

- An investigation was initiated on high-Tc ceramic superconductors of the type(YBa2CU3)Oz. The aim of the research is to identify the thermodynamic conditions of stability in these compounds (oxygen equilibrium pressure, enthalpy and eutropy of oxygen solution) in the range of oxygen contents at which the compound shows superconducting properties ($6.5 \leqslant z \leqslant 7$), and in the temperature range in which the superconductor is prepared and conditioned.

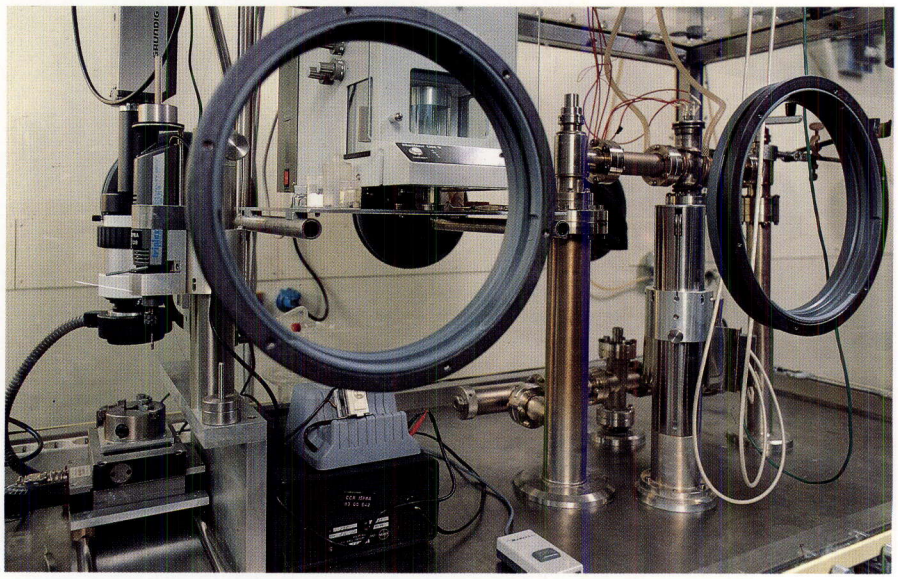


Figure 16: A detail of the solid electrolyte emf apparatus for work on small amounts of radioactive material or on non-active samples

An electrochemical solid state cell is used. Three second order transitions which depend on oxygen content have been identified and tentatively interpreted. These are : 1) at 600-700°C, a tetragonal/othorhombic transition; 2) at 500-600°C, an accumulation of oxygen vacancies in the Cu-O basal plane of the orthorhombic structure; 3) at $T < 500$°C, a further transition, possibly occurring in the basal plane. Two articles on the subject have been submitted for publication (Nature, Phys.Rev. Letters) as well as a contribution presented at the Interlaken (Switzerland) High Temperature Superconductors Symposium.

It is suggested that the transition at 500-600°C, responsible for ordering the oxygen sublattice, is the reason for the prolonged heating in this temperature range that is deemed necessary to obtain a superconducting compound.

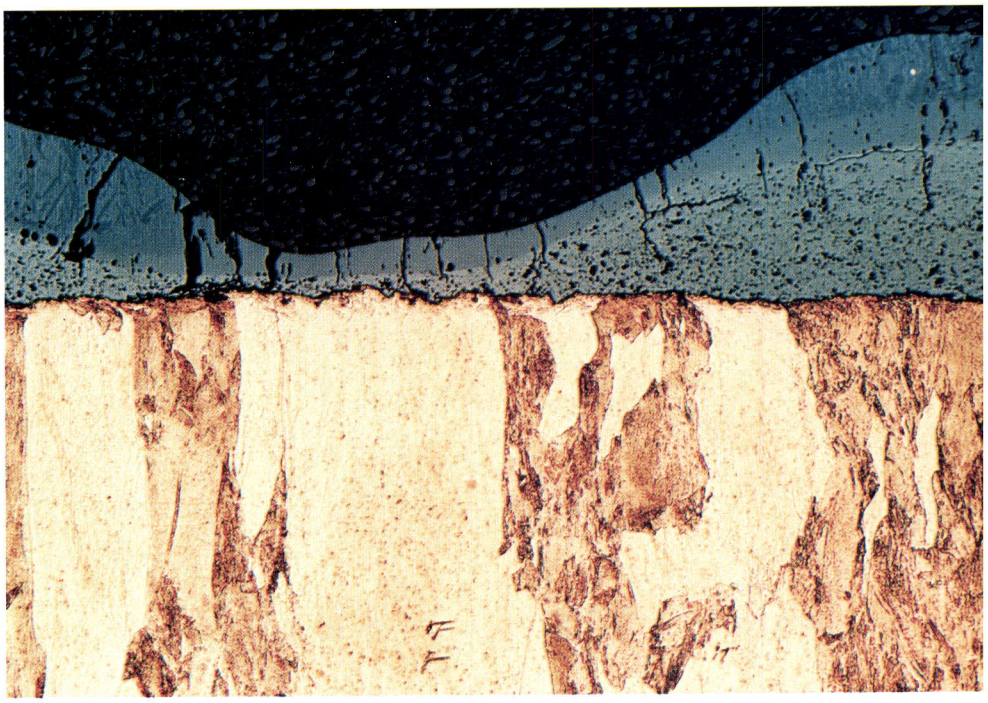


Figure 17: A micrographic section of a divertor plate made up of copper acting as a heat sink with a tungsten/Rhenium alloy armour produced by plasma spray coating. The image shows the effects of plasma disruption

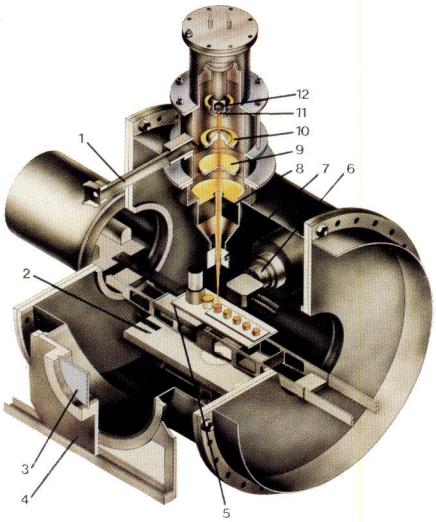


Figure 18: An exploded view of the electron beam gun facility (10 kW) used for simulating disruption phenomena currently under study as part of the Fusion research programme

Surface Engineering Laboratory at Ispra

The properties of the surfaces of most solid materials can be influenced by energy beams. As an example one may choose the resistance of a steel surface to oxidation. In normal life one protects steel by paints. A similar but more effective protection can be obtained by bombarding the surface with ions; the protective layer does not peel off as is the case with paints. Other properties, which can be improved are the hardness, the wear resistance and the friction between solid parts. Methods of this type are applied to different technological components, such as bearings which have to work in corrosive environments, dies for fiber drawing, human joint replacement components,and so on.

The application of energy beams for the tailoring of specific surface properties of technological components is an expanding field. At present, Europe does not have a facility which allows the combined application of different techniques. An enquiry conducted in materials research laboratories and in the industrial press has shown that such a facility would receive a widespread interest.

The laboratory will thus offer, to interested industries, the possibility of becoming acquainted with new techniques for surface treatments. It will offer the execution of prototype experiments and put at their disposal the know-how of its staff. In the frame of the programme on advanced materials it will standardize and develop control methods for improved surfaces.

In December 1987, the ion implantation, laser and film deposition facilities as well as a high lateral resolution AUGER microscope have been ordered (total : 2.3 million ECU). The laboratory is expected to be fully operational at the end of 1988.

FUSION

This programme is centered on "Fusion Technology and Safety" and implemented at the Ispra and Petten Establishments. The JRC is fully integrated with the technological work carried out by the European Associated Laboratories in the frame of the European Fusion Programme 1985-1989.

Reactor Studies

The project to design the NET reactor has focused on identifying what is needed to produce various plasma configurations inside the same basic machine. The size and geometry of the internal segments facing the plasma have been established and the corresponding maintenance procedures have been set-up. Some tests on typical components to be remotely operated have been carried out.

Three-dimensional, thermo-mechanical analyses of the NET first wall segments during standard operation have been pursued, taking into account the detailed geometry of the cooling channels. In parallel, the electro-mechanical effects of plasma disruption have been evaluated. The need of increasing the stiffness of the wall facing the plasma was recognized. A display system to visualize the behaviour of the first wall segments during this electromagnetic transient has been developed.

A new concept of the internal segments including the divertor plates has been proposed. It consists of multilayer panels covering the inboard region of the reactor, with stainless steel cooling channels embedded in a copper matrix protected by tungsten or graphite tiles on the side towards the plasma.

The design of the blanket, including Pb-17Li as liquid breeder and water as coolant, has been optimized in keeping with the latest experimental data, and has been integrated in the overall reactor configuration.

Figure 19: Engineering studies of the fusion reactor NET (Next European Torus) by means of computer aided design

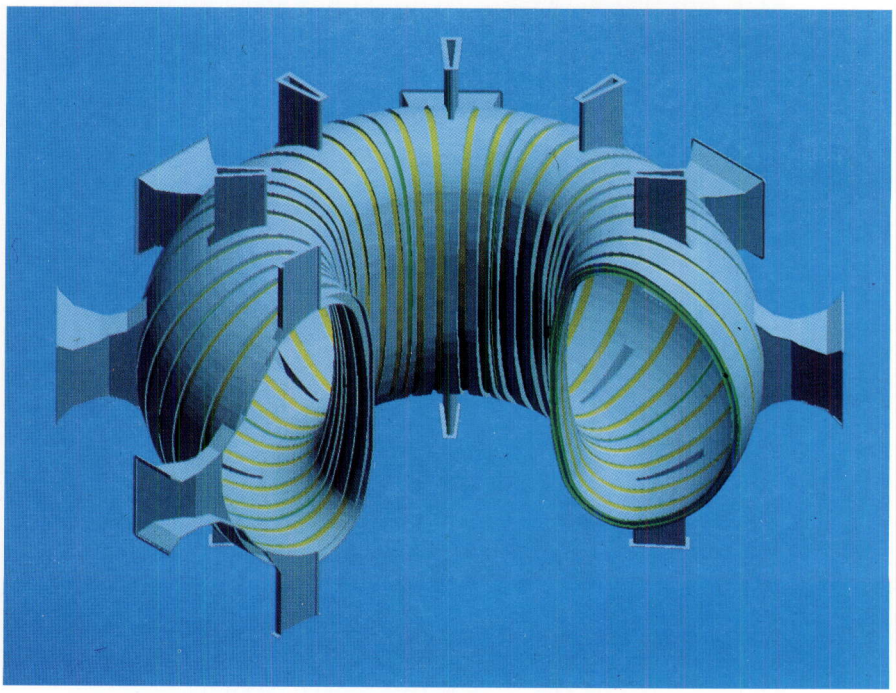


Figure 20: An example of a computer aided design illustrating, in this case, the vessel of the fusion reactor JET (Joint European Torus)

Breading Blanket Technology

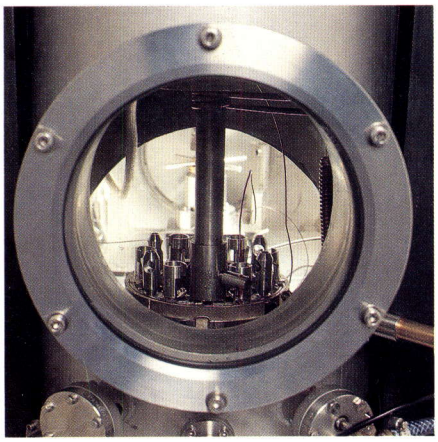


Figure 21: A detail of the device for testing tensile specimens in Pb-17Li under inert atmosphere or vacuum conditions

As in previous years, experimental work has been concentrated on the liquid breeder Pb-17Li.

A first set of in-pile tritium extraction experiments at HFR-Petten has been carried out. The purpose of these irradiation experiments is to measure the on-line tritium release from Pb-17Li capsules in different conditions, namely static, with helium sweeping and bubbling. The capsules are enclosed in stainless steel. The irradiations will continue through the first months of 1988.

A facility to study the desorption of hydrogen from Pb-17Li has been constructed and put in operation. The breeder, fed in a saturator with hydrogen at different concentrations, circulates in a chemical reactor with a counter-current of helium. The hydrogen desorbed by the helium stream is continuously monitored. During preliminary tests an unexpected hydrogen permeation rate through the probe used for the measurement of hydrogen pressure was found. In order to understand this, the dependence of reaction rates on the hydrogen concentration has been investigated.

Corrosion tests in Pb-17Li with stainless steel have shown that the presence of oxygen increases the depth of ferritic corrosion and causes a depletion of cromium within this layer. It has been shown that such an increase cannot be due to increased nickel solubility caused by the change in composition of the alloy, and that cromium may interact with oxygen to form a ternary oxide. In long duration corrosion tests with a constant load (390 MPa) at 450°C, no relevant stress effects were found.

Structural Materials Studies

A facility for investigating the thermo-mechanical behaviour of first wall panels of NET under pulsed operation has been successfully used for calibration measurements and for clean-geometry experiments (tubes). Two NET first wall panels, developed at Ispra and by the NET-team at Garching, are being constructed by European companies and will be tested in the facility starting in the first part of 1988.

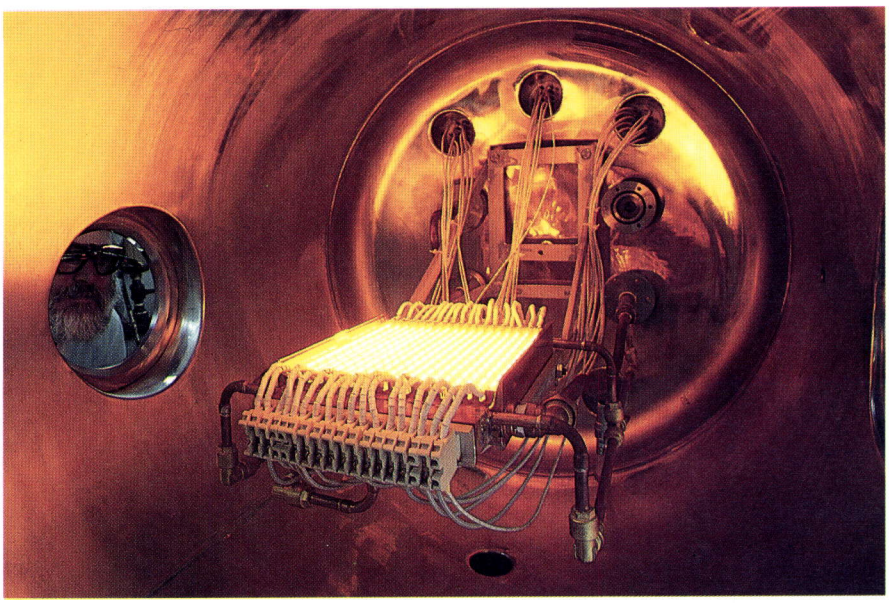


Figure 22: A testing facility for thermal fatigue and life-time evaluation of the NET first wall; Interior of the vacuum chamber showing the heating element

A comprehensive analysis has been carried out of the tensile behaviour of type-316 stainless steels irradiated in the HFR Petten and in the Oak Ridge HFIR reactors up to a displacement level of 10 dpa. The results were analysed in order to determine the role of chemistry, neutron spectrum, mechanical and thermal history and temperature in deformation behaviour.

Further irradiation experiments of 316-stainless steels and manganese-cromium (Mn-Cr) steels have been performed at HFR-Petten up to displacement levels of 5 dpa and in the Ispra cyclotron. Fatigue crack-growth tests on specimens irradiated with protons in the Ispra cyclotron have been extended to the case of helium-particle implantation. It was found that light-ion irradiation has only a slight influence on fatigue crack growth at 500°C in 316-stainless steel.

Microstructural evolution due to post aging helium-implanted Mn-Cr steels was investigated, and intergranular precipitation was observed.

Safety Studies

The analysis of neutron induced radioactivity in structural and breeder materials was continued. With regard to waste disposal, a table was set-up which gives for each element the maximum tolerable concentration for shallow land burial or for recycling. These studies are also relevant for reducing the radioactive impact of accidental releases.

A model of the effects of tritium release was evaluated with experiments conducted by national laboratories.

The behaviour of the in-vacuum structures of NET under the influence of decay heat in different fault conditions of the cooling system has been further investigated, taking into account radiation, conduction and natural convection. As a result, it was shown that the cooling circuits can be designed to allow a cooling capacity by natural convection sufficient to maintain the machine in an inherently safe state, if a generalized loss-of-flow accident occurs.

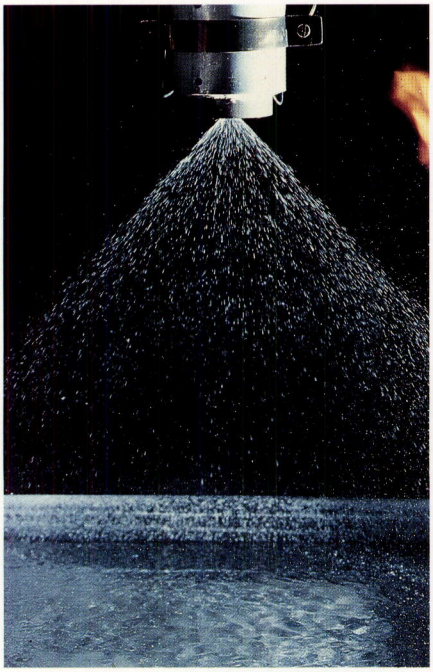


Figure 23: Reactivity experiments with the Pb-17Li alloy; the Pb-17Li spray under pressure (40 bars) at 800°C. The alloy shows a lower reactivity than lithium

Experiments simulating plasma disruption, using electron beams on plain and helium implanted metallic specimens, revealed that the main phenomena affecting the behaviour of first wall materials, are the melting-resolidification speed, crack formation and helium aggregation into bubbles.

Promising results have been obtained in fabricating metallic and ceramic protective coatings with high melting points, high porosity and low thermal conductivity.

Complementary information on the effects of abnormal heat loads on structural components was obtained from experiments in progress under collaboration with INEL-USA where the fractional evaporation of manganese steel components is assessed at different temperatures.

Experiments on the interaction of cooling water with Pb-17Li, Li Pb and Li have supplied new data on reaction kinetics, melt-water mixing and conversion of chemical energy into mechanical work. A large scale test facility has been completed and scooping test shave already been performed. This facility allows breeder (Pb-17Li)-water interaction experiments in realistic blanket conditions.

Tritium Laboratory Studies

The European Tritium Handling Experimental Laboratory (ETHEL) in construction at Ispra is intended to help address the safety problems resulting from the presence of large Tritium amounts in fusion reactors. The laboratory already has the precise objective of demonstrating the feasibility of minimising the release of radioactivity to the environment.

A turn-key contract has been signed with NNC (UK) at the end of 1986 for a total amount of 14.8 Mecu's. It is structured in four parts:

Stage 1: Detailed Design and Safety Analysis
Stage 2: Civil Work, Infrastructures
Stage 3: Associated Laboratory Systems
Stage 4: Remaining Supplies and Commissioning

Work related to stage 1 has been performed during 1987 and it will be completed by Spring 1988, while construction of the Laboratory will start in May 1988 and be completed by 1990. For all items included in stages 2 and 3, the most relevant are:

— building,
— heating-ventilation,
— electrical supply,
— large caisson,
— gasous and liquid waste buffer/storage tanks,
— glove boxes,

NNC has stipulated sub-contracts for executive design, construction and mounting in Italy, France and UK on the basis of call for tenders performed on a European Community countries level. The call for tender procedures for all remaining items will be concluded as soon as stage 4 will be released (July 1988).

Contacts with the Italian licensing authority have also progressed according to schedule.

In parallel, the preparation of the first experiments to be carried-out in ETHEL has been pursued. These concern air detritiation systems, advanced methods for tritium re-work, management of tritiated wastes and measurement of the outgassing rate of tritium interacting with the first wall. Concerning the last point, a hydrogen/deuterium neutral source with the appropriate flux and energy parameters is under construction. The first experiments are scheduled for middle of 1988.

Reactor Safety

One part of the research is performed directly by the JRC Ispra; the other part of the programme is executed through Shared Cost Actions (SCAs) cofinanced by the Commission and national laboratories. The SCAs, which started in 1985, were designed to be closely integrated with the JRC activities; therefore Shared Cost Actions have been launched in almost all the areas described below. Information on contracts begun in 1987 are summarized in table 4.

Almost all the SCA contracts are still under way and will end in 1988. Only some of the PISC parametric studies and a benchmark exercise on Probabilistic Safety Analysis were finished in 1987 and the final reports are being published.

Reliability and Risk Evaluation

This project is subdivided into three main areas:

— European Reliability Data System - ERDS.

— Probabilistic Safety Assessment models and procedures.

— Man-machine interaction studies

In the area of ERDS, efforts were made during 1987 to consolidate the structure of the data banks, starting with analysis of their content. The following achievements may be noted:

— finalisation of the past events transcoding of the AORS - Abnormal Occurrences Reporting System.

— expansion of the CEDB - Component Event Data Bank. Data suppliers will include Spain, which has decided to adopt the CEDB scheme to collect data in its nuclear power plants.

New data treatment methods have been tested, with the aim of providing a feedback from the operating experience of nuclear power plants to the nuclear industry.

In the area of Probabilistic Safety Assessment (PSA), the main achievement has been the Reliability Benchmark Exercise on Human Factors. This exercise involved 12 teams from the European Community, in addition to Sweden,

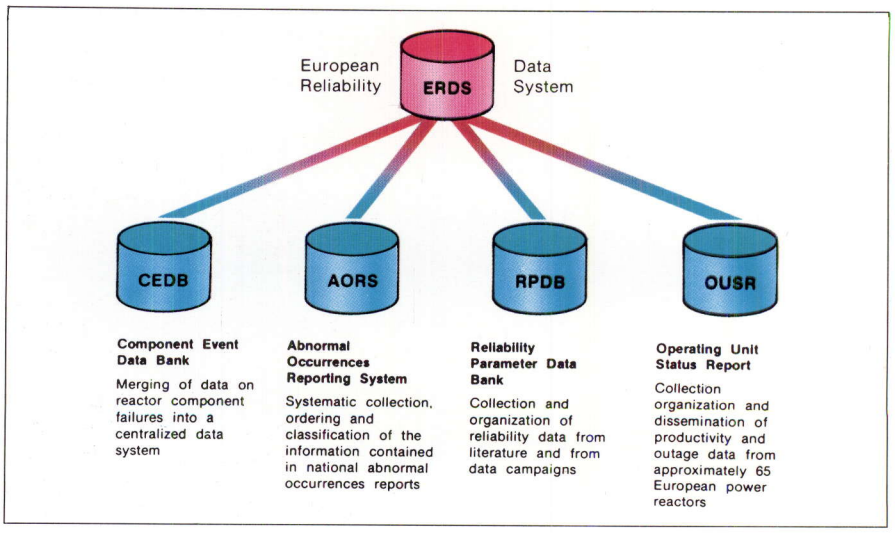


Figure 24: The European Reliability Data System (ERDS) collects and processes different types of data from abnormal occurrences to full or partial outages of nuclear power plants in Europe

Table 4: Shared Cost Actions engaged in 1987 (Reactor Safety)

Research Area	Activity	Scientific Objectives	Participants	Allocated Budget (KECU)
1. Reliability and risk evaluation	Event sequence reliability benchmark exercise	To compare different aspects of PSA methodologies and contribute to their harmonization	Thirteen organizations From I, UK, F, FRG, DK, B, NL	427
4. Study of abnormal behaviour of LWR	Analysis of experimental data on LWR LOCA and EEC	Assessment of system codes utilized and developed in Europe for analysis of experimental data	Seven organizations from I, NL, FRG, B, UK, F	243
5. Source term	Preparatory studies of in-pile tests on FP transport in severe accidents	Review of FP and aerosol instrumentation of relevance to the Phebus-FP project	Three organizations from FRG and UK	210
Source term	Preparatory studies of in-pile tests on FP transport in severe accidents	Review of capability of the Phebus-FP facility to simulate phenomena and parameters typical for severe accidents in European NPP's	Ten organizations from UK, FRG, I, E, NL	645
Source Term	Containment studies	Survey of analytical capability for predicting structural response of NPP containments to severe loading	Five organizations from UK, DK, I, E	126
6. LMFBR accident modelling	In-pile tests on local subassembly accidents (MOL--7C)	Demonstration that local cooling disturbances will not cause clad and fuel melting beyond the subassembly concerned	Two organizations from B and FRG	93

Finland and USA. It was done in two steps: the human factor in maintenance and testing, and during management of an incidental emergency. Both have shown how methods used in human reliability analysis lack completeness and accuracy when compared to other analytical aspects of PSA, such as system reliability analysis or common cause failure.
Concerning fault-tree analysis it is worth mentioning that the computer code SALP has also been made available in a version for personal computers (SALP - PC).

In the area of man-machine interaction studies, the work on the System Response Analyser (SRA) has continued focusing on the further development of the cognitive model of the operator. The previously-developed Low Level Decision Model is now superseded by a first version of the High Level Decision Model in which tasks such as detection, diagnosis and planning have been modelled using various representation schemes of operator knowledge and different memory recall mechanisms and heuristics. In the SRA context an original approach to the quantitative model of a system (steam generator) has been developed.

In parallel, fast simulation models of transient behaviour of PWRs have been implemented and the second version of the DYLAM-2 code, which is the driver in the SRA, has been completed.

As a complement to the SRA, multivariate stochastic dynamic models have been developed to support the operator in diagnostic decisions. The application of the model to a reactor steam generator confirmed the efficiency of the method in representing linearor quasi-linear behaviours, and in aiding diagnosis by the operator using on-line state indicators.

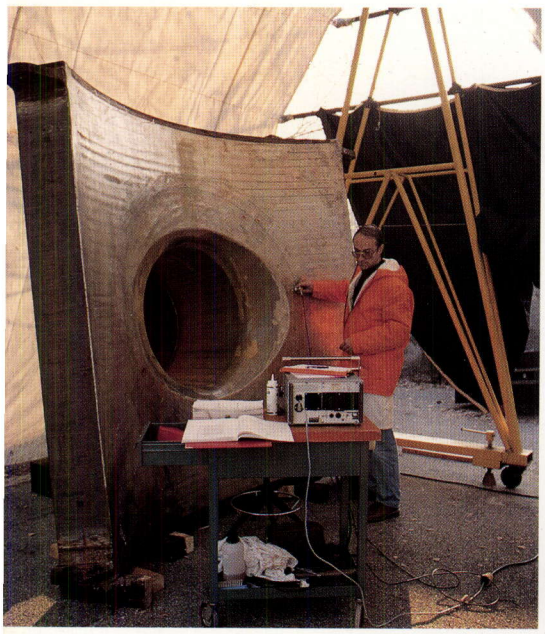


Figure 25: Non-Destructive Testing (NDT) of steel components using ultrasonic techniques

PISC (Project for Inspection of Steel Components).

1987 was the decisive year for the start of the PISC III project. Most of the technical details of its seven projects were defined, mock-ups were designed, and samples of structures containing real defects were gathered and conditioned at JRC Ispra.

Round Robin Tests have been prepared on four themes:

- exercises on full scale pressure vessel components,
- inspection of safe-ends of different reactor types,
- inspection of primary pipe sections and assemblies,
- tests of steam generator tubings.

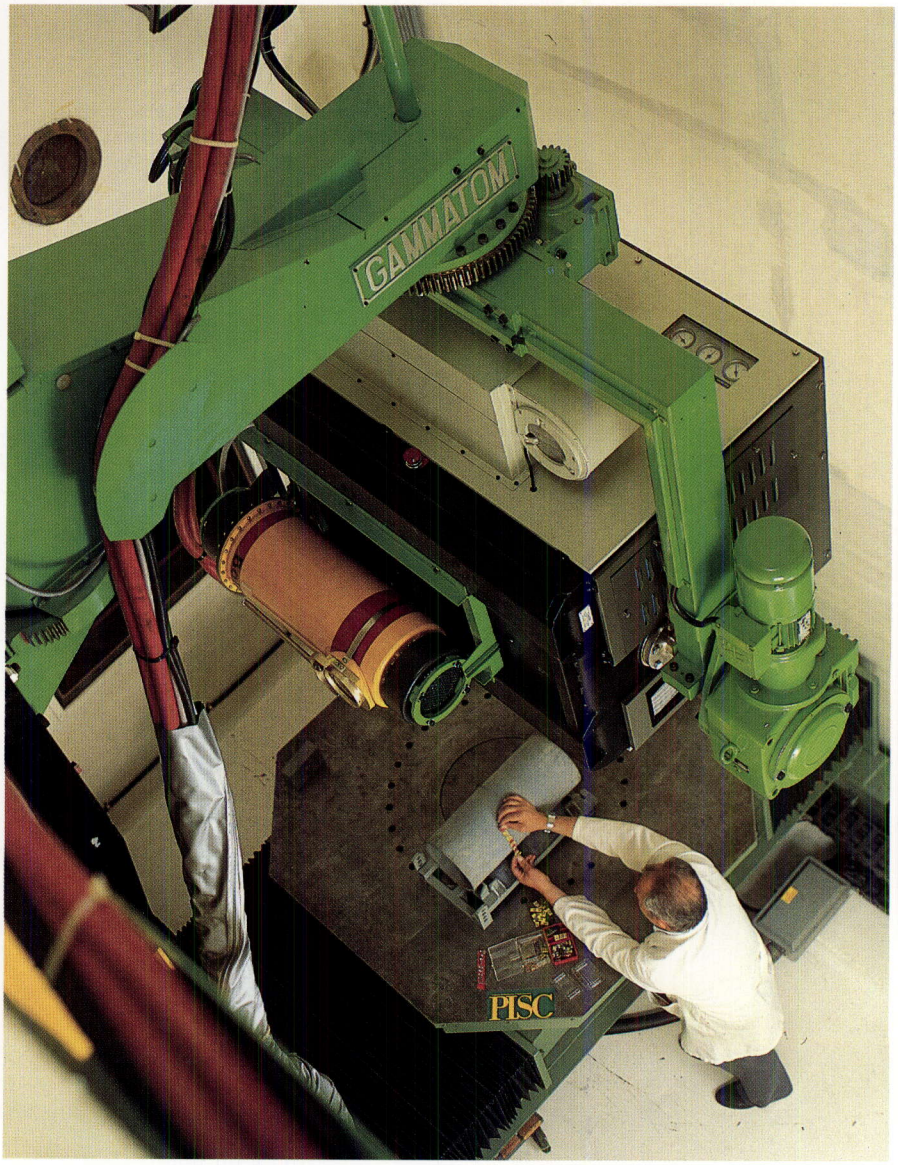


Figure 26: Non-Destructive Testing of steel components using high energy X-rays, carried out as a part of a Round-Robin exercise to identify flaws in reactor structures

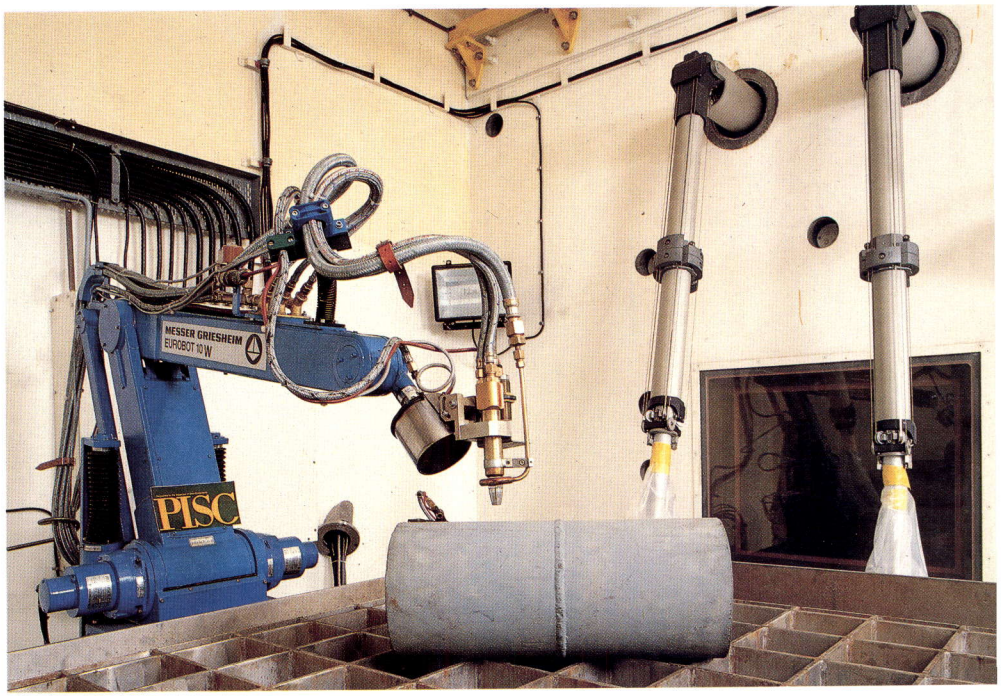


Figure 27: Expertise by destructive examination of reactor structures for the full characterisation of service induced defects

Calls for participation in these Round Robin Tests were sent out in mid 1987 and statements of intent to participate were received at the end of 1987. The present situation is that PISC III will involve more than 60 inspection teams in Europe, USA and Japan.

During 1987 the parametric studies of PISC II funded by Shared Cost Action contracts were terminated as well as the screening phase concerning the PISC III inspection exercise on centrifugally cast austenitic steel welds of primary circuits.

Results from parametric studies quantify several qualitative results of the PISC II Round Robin Tests and indicate effective limitations in detecting conservative defects. The test of cast stainless steel has shown the extent of the problems that must be solved during the inspection of primary circuit pipes. Results were published as a PISC/NRC report.

1987 was also the year:

- of presentation of PISC II results and PISC III plans at large conferences: NDE in Nuclear Industry (Orlando USA), SMIRT 9 (Lausanne), 3rd European NDE Conference (London);
- of implementation of these results by Codes and Standards bodies and by inspection and licensing authorities. ASME in particular has gone from the modification of Section XI (In Service Inspection) to Section V (overall NDT requirements).

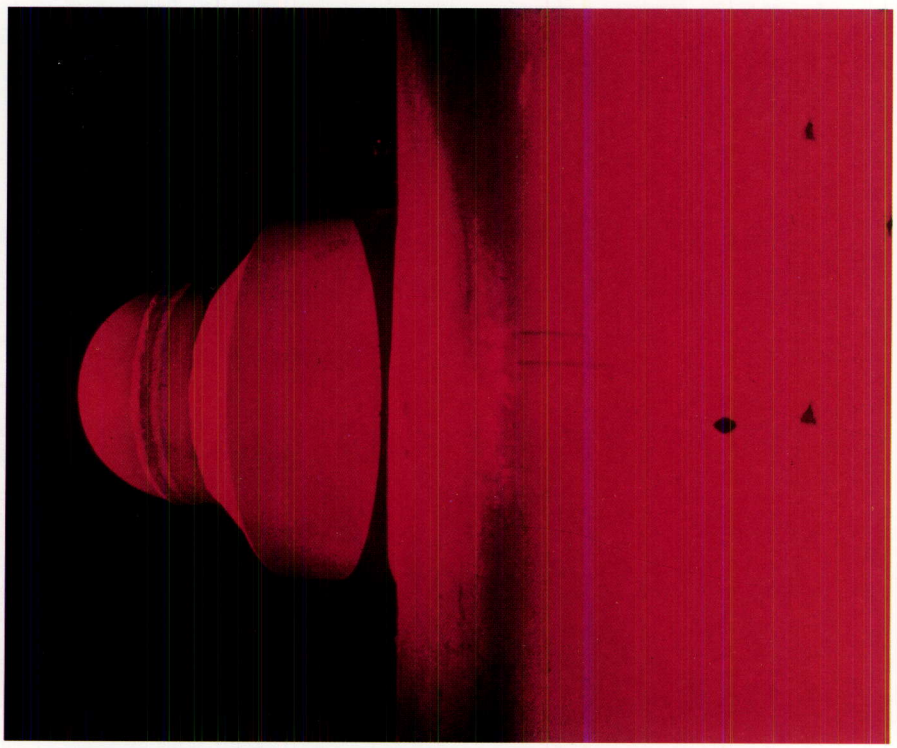


Figure 28: Vessel nozzle corner inspection using He-Ne laser light techniques

LWR Primary Circuit Life Prediction

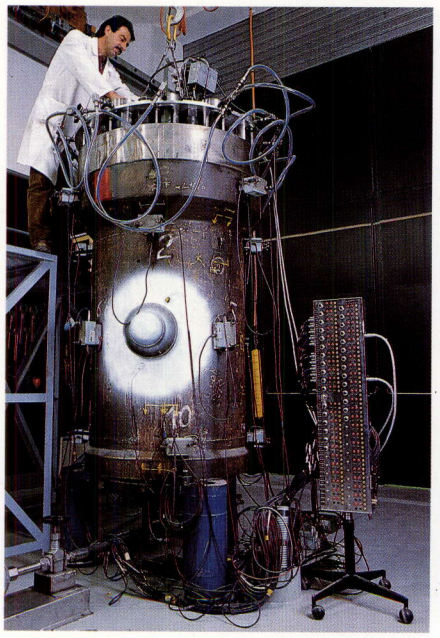


Figure 29: Computer controlled test rig for fatigue tests on 1/5 scale models of pressure vessels

The objective of the project is the development of a comprehensive methodology (entailing inspection and monitoring techniques, structural analysis, uncertainty modelling and for analytical tools for reliability assessment) for the prediction of the residual lifetime of primary circuit components.

To this end, theoretical activities are backed by experimentation including:

1. fatigue testing on 1/5-scale models of pressure vessels;
2. pressurized thermal shocks on nozzle corners and safe-ends.

The main outcomes related to fatigue testing can be summarised as follows:

- modelling: the prediction of residual lifetime (cycles to failure), produced by the COVASTOL code, was in agreement with experimental evidence;
- non destructive testing: data from the periodic test were rather scattered; better information was obtained by acoustic emission monitoring and by ultrasonic continuous monitoring of critical areas;
- fracture mechanics: the efficiency of the J-integral approach for assessing the safety and reliability of pressure vessels was confirmed.

As far as the Pressurized Thermal Shock (PTS) tests are concerned, all the preliminary analyses have been completed and the test rig is almost ready.

During the coming test, artificial intelligence tools will be used to control the experimentation and to offer a real time aid to decision during the course of the experiment.

Figure 30: The LOBI experimental facility used for integral tests on loss of coolant accidents in Light Water Reactors

Abnormal Behaviour of LWR Cooling Systems

The objective is to produce experimental data on thermohydraulic phenomena and to use these data to assess and improve large system codes used for LWR safety analysis.

The main results during 1987 were the execution of 7 tests of the LOBI(*)-MOD2 Programme (three-small-break, loss-of-coolant tests, three special transient tests and one natural circulation test), with analysis and documentation.

(*) LOBI is a large experimental facility available at the JRC for investigating thermohydraulic behaviour of reactor cooling systems during transient or loss-of-coolant accidents.

The LOBI test facility is an approximately 1:700 scale model of a four-loop 1300 MWe PWR and has two primary loops, the intact loop representing one loop of the reference PWR. Both primary loops contain a coolant circulation pump and a steam generator. The simulated core consists of an electrically heated 64-rod bundle housed in the pressure vessel model. Nominal heating power is 5.3MW. An extensive measurement system and a specially tailored data acquisition system are used to monitor and record the main thermohydraulic parameters prior to and during each test.

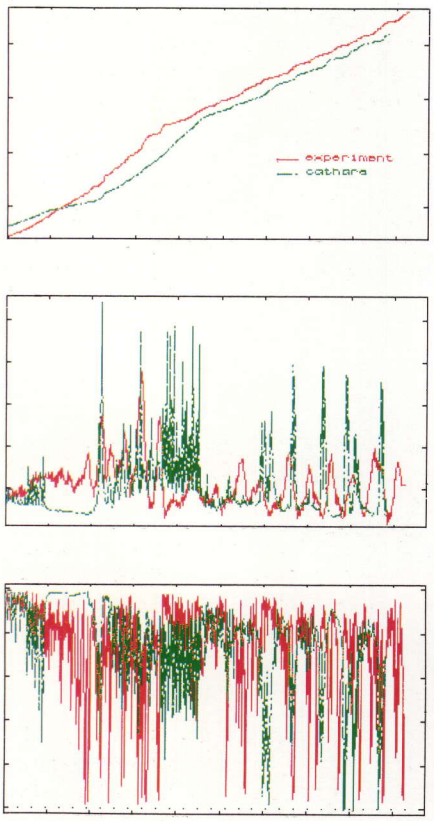


Figure 31: Mass lost out of the break, the flow rate and the upstream void as measured in a LOBI 3% break experiment and calculated by the CATHARE code

The European thermohydraulic codes CATHARE (F) and DRUFAN (FRG) were assessed in close collaboration with the national code development teams at CEN Grenoble and GRS Garching respectively. The codes have been assessed on LOBI experiments simulating small-break, loss-of-coolant accidents.

In close connection with this, code assessment work has also been intensively pursued in the frame of SCA contracts, thus allowing close working contacts between JRC and national teams using the above mentioned codes. JRC has also participated with these codes in basic benchmark tests during an international workshop held in March 1987 in the USA.

Source Terms

The objective is to investigate and model the phenomena underlying the release of radioactive material from LWR under hypothetical severe accident conditions. Another major effort of the JRC in 1987 was devoted to the study of fission products and aerosol behaviour in a PWR containment system and in particular on code and model assessment.

The LACE (LWR Aerosol Containment Experiment) project, in which the JRC is one of the co-sponsors, was successfully completed in February 1987. LACE investigated in a large scale test facility the aerosol behaviour in a containment building following a severe accident. Analysis of results and reporting have continued during 1987. In particular, the JRC has carried on the benchmark exercise on the LACE LA-4 test with participation of organizations inside and outside the Community. As agreed to by the contract, the JRC distributes test results to the organizations (safety bodies, research centres etc.) of EC Member Countries not directly participating in the LACE project.

Two experimental programmes, at KFK-Karlsruhe and UKAEA-Winfrith, financed through SCA contracts, have been carried on and preliminary results produced. The KFK-Karlsruhe programme deals with resuspension of aerosol from sump water due to pool flashing; the AEE-Winfrith programme deals with the effect on the volatility of fission products of various mechanisms such as flow regime, high temperature, hydrogen, etc.

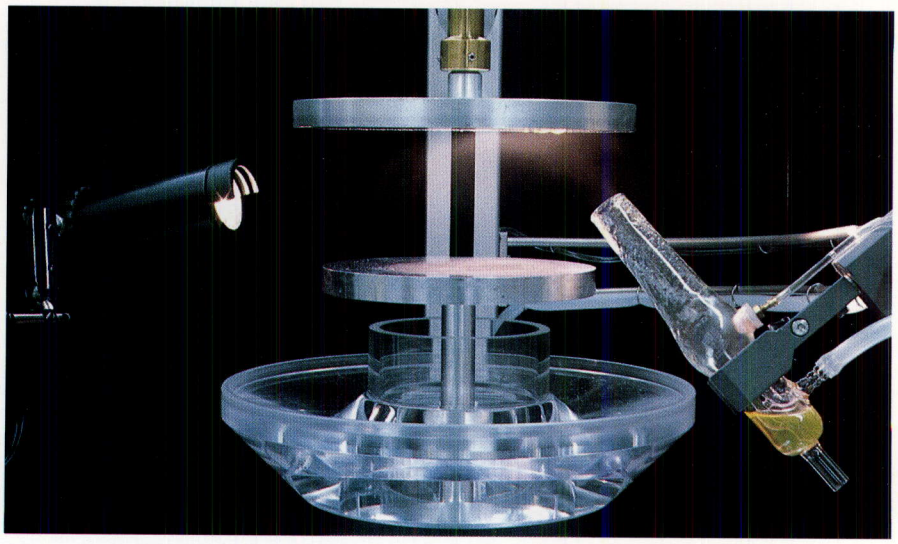


Figure 32: Coagulation of a water aerosol by an ultrasonic field

In 1987 the Commission undertook some preliminary studies in support of the French Phebus Fission Products project, in which the Commission will participate in the next multiannual programme 1988-91. The aim of this project is to investigate, in an in-pile test facility, some typical severe accident sequences. Two types of SCA contracts were launched. The first one is a study of the capability of the Phebus Fission Products installation to represent the phenomena believed to take place during a severe accident. The second one is devoted to the analysis of existing instrumentation and to the assessment of possible advanced instrumentation to be utilized in Phebus Fission Products. Several groups of European experts are working on these two topics. Both studies should be completed by mid-1988.

LMFBR Accident Modelling

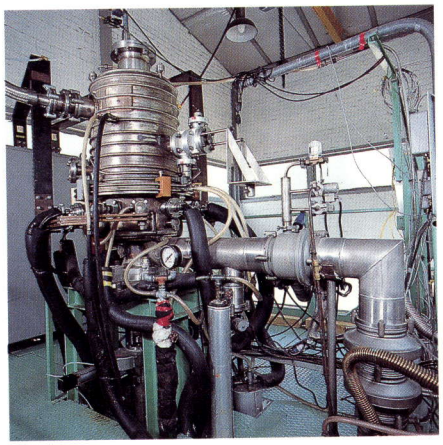


Figure 33: FARO project; back-up test facility showing the radiation furnace which can operate up to 3000°C

The objective is to investigate phenomena relevant to very low probability accidents involving partial or total core damage in an LMFBR and to develop models and codes for the analysis of such accidents.

The European Accident Code (EAC) is being developed for the analysis of the Initiation Phase of low -probability whole -core accidents in LMFBRs. In 1987 the EAC1 code was finished and the development of the more detailed benchmark-type code EAC2 continued. The further development of EAC2 up to the end of 1989 received the full support of experts from the member countries.

The EAC2 version utilizes the same informatics and thermohydraulics as EAC1, but new advanced modules for pin dynamics, fission gas, fuel movement after cladding failure, and neutronics, now being developed, will be integrated in the system.

The FARO facility is in operation at the JRC Ispra. It studies, using real reactor materials, the melting of large fuel masses and investigates phenomena such as fuel jet penetration and fragmentation in sodium, the response of structures to fuel jets and fuel freezing, and plugging in channels and subassemblies.

In 1987 the problems of controlled UO_2 melting and release of the melt from the furnace into the test section have been solved. The first part of the test programme concerning the erosion of steel plates exposed to 100 kg molten UO_2 has been successfully completed. The seven experiments performed during 1987 include mock-up tests for the large mass UO_2/sodium interactions test programme (TERMOS). The first experiment in this series including the real test section is planned for early 1988.

The associated modelling activity includes the development of a FARO furnace simulator computer code (SMURF), and the modification and improvement of the computer codes for UO_2 jet/structure interaction and for UO_2 jet penetration.

In general, the computer codes that have been developed, have satisfactorily reproduced the experimental results.

The thermohydraulic tests comparing single and two-phase flow in grid-and wire-spaced tube bundles have been terminated successfully. Data were obtained on pressure drops in single and two-phase flow, heat transfer in two-phase flow, dry-out and mixing. These tests allow the comparison of the hydrodynamic behaviour of two bundle designs. Evaluation and analysis are in progress.

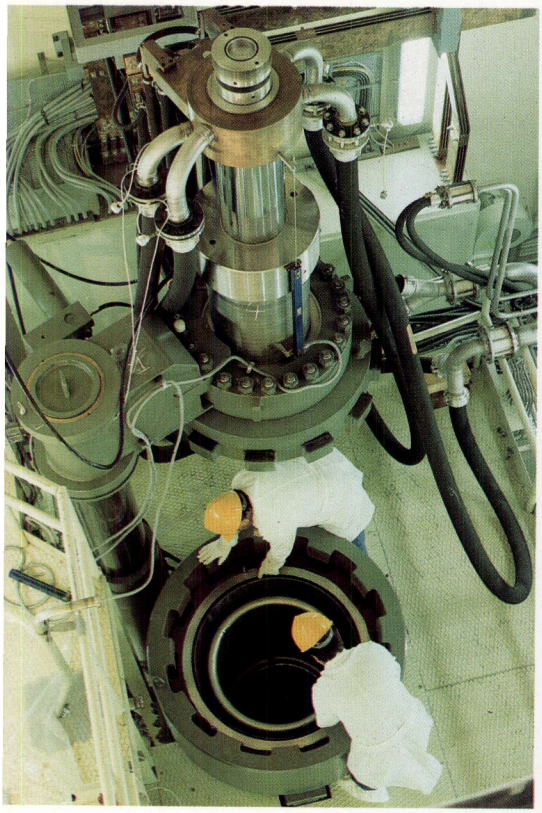


Figure 34: FARO facility; checking the UO_2 level in the high temperature melting furnace after loading

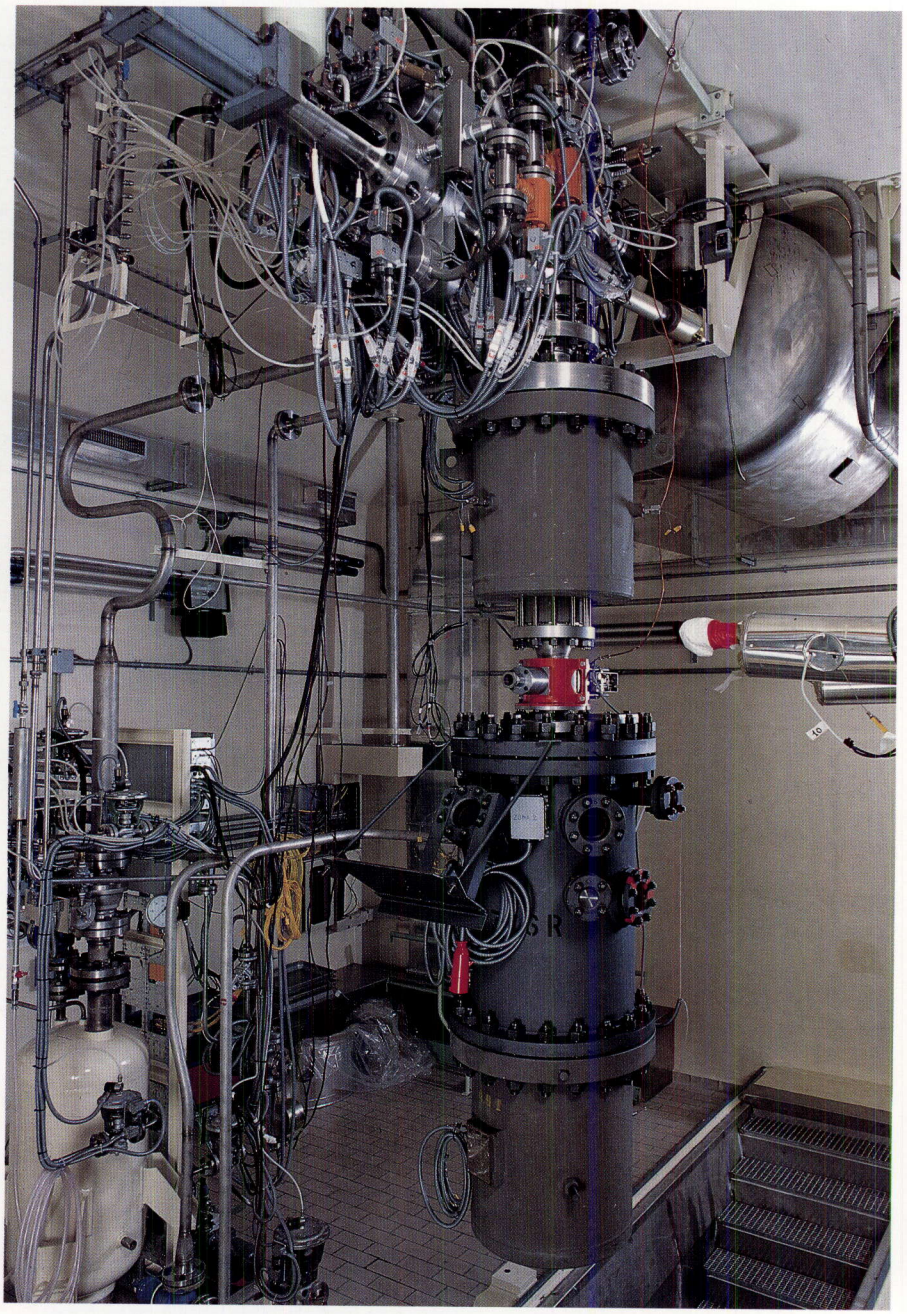


Figure 35: FARO facility; view of the BLOKKER test section used for perforation studies

Concerning the study of local subassembly accidents and their potential propagation to the whole reactor core, the Commission has continued to participate, through the SCA, in the in-pile programme SCARABEE (F) and MOL-7C (B/FRG).

Two SCARABEE in-pile tests have been successfully performed during 1987. The experience gained with the execution of eight SCARABEE tests in four years has increased the understanding of physical phenomena during accidents that lead to fuel melting in a fast reactor subassembly.

At the end of 1987 the SCARABEE test matrix was reviewed and priority was given to the study of propagation of molten materials to neighbouring subassemblies and to the behaviour of pre-irradiated fuel rods. The JRC has contributed to test precalculations and to analysis of the reactor physics in the SCARABEE experiments.

The JRC has contributed to an extension of the MOL-7C programme for the measurement of fission products transferred to the sodium coolant from the molten fuel during the execution of the next in-pile tests of the programme.

PAHR (Post Accident Heat Removal) In Pile

This project addresses the ability to cool a bed, formed by UO_2 and stainless steel particles in sodium, which is assumed to be deposited on horizontal structures in case of LMFBR core melting. The project focusses on in-pile tests where different types of bed composition, particle size, temperatures and boundary conditions are investigated.

The in-pile experiment executed in the Melusine reactor in early 1987 has not given the expected results, due to the premature failure of high-temperature thermocouples, although one ultrasonic thermometer operated successfully up to 2200°C. In agreement with CEA/CENG the experiment, in which a mixed UO_2-SS particle bed is heated until the UO_2 melts, will be executed in the BR-2 reactor at CEN-Mol.

On the basis of knowledge acquired from the Sandia and the European in-pile tests, and from the out-of-pile tests executed at the JRC Ispra, a new test matrix for the remaining three in-pile tests has been defined with the contribution of national experts.

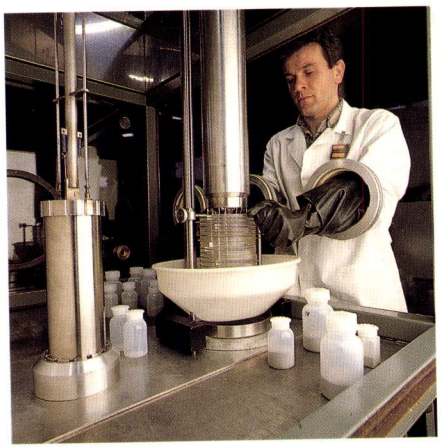


Figure 36: Examination of the particle distribution on a debris bed carried out as part of the PAHR in-pile tests

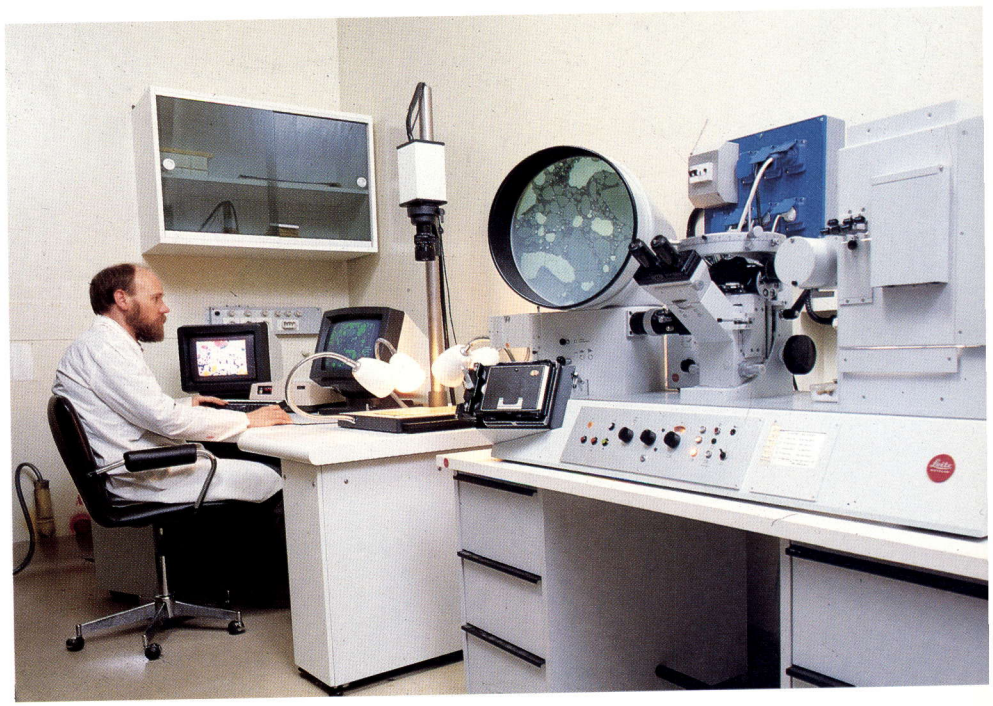
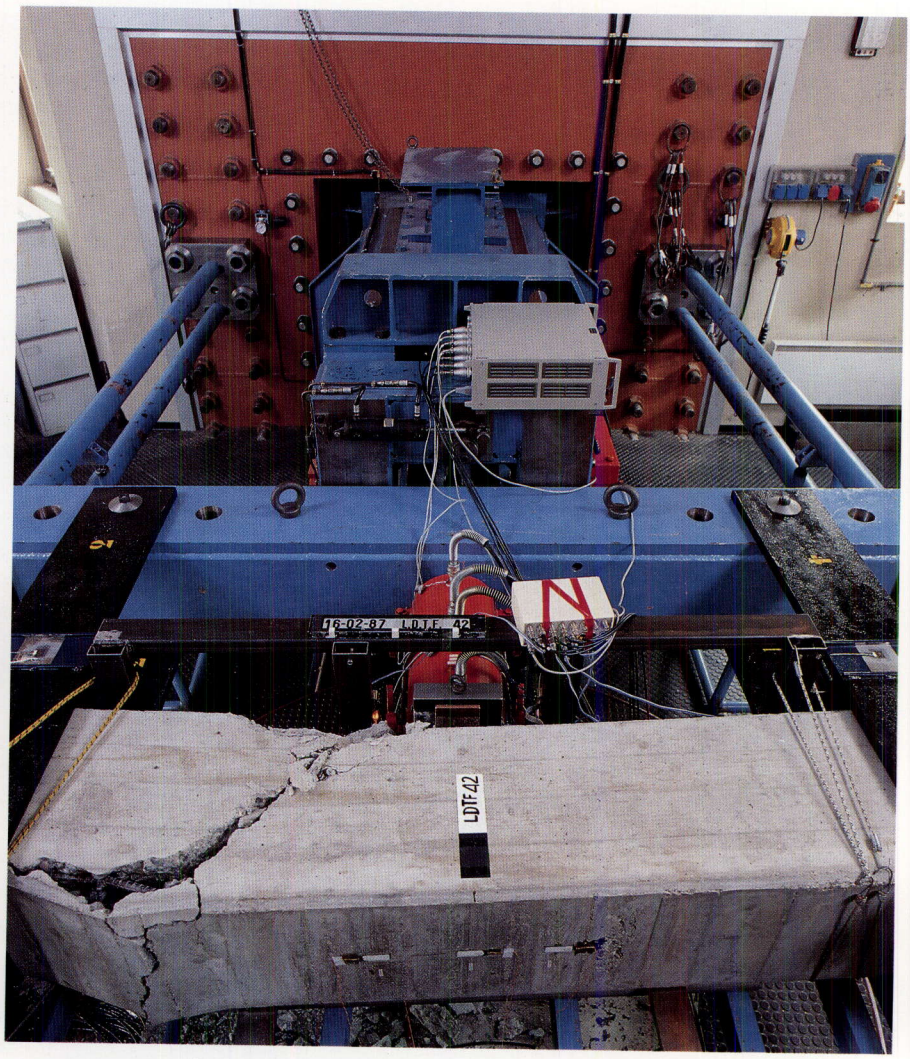


Figure 37: An analytical laboratory of the study and research hot laboratory at Ispra showing an optical microscope and an image analysing system

Figure 38: Dynamic testing on a reinforced concrete beam performed in the Large Dynamic Test Facility (LDTF)



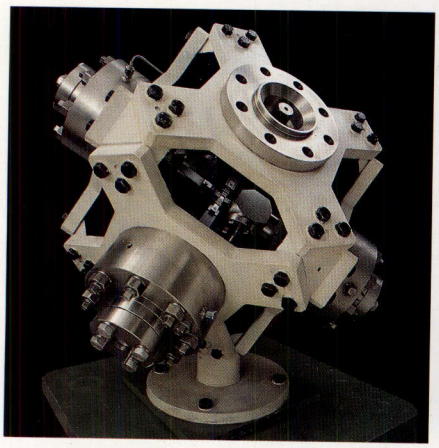


Figure 39: Biaxial dynamic testing device

LMFBR Material Properties and Structural Behaviour

The object of this research is to investigate the properties of austenitic steels used for LMFBR components and to establish constitutive laws describing the steel, both as damaged during reactor life, and when submitted to dynamic loading in case of severe accidents.

A large experimental programme has been under way for several years which has shown how mechanical properties are modified by different damage processes.

In the future, other materials of interest for other industrial plants will also be considered. With this aim, in 1987 a series of tests on concrete specimens has been started on the Large Dynamic Test Facility.

Work on dynamic structural code development has also been continued in collaboration with CEA-Saclay

Radioactive Waste Management

JRC activities have a double objective:

- to assess the risks linked to waste disposal in geological formations;
- to minimize waste arising in future fuel cycle installations.

These objectives are also common to the shared-cost action programme on radioactive waste management, and both programmes are closely coordinated among themselves and with national activities.

The JRC activities are carried out both at the Ispra and at the Karlsruhe establishments.

Waste Management and the Fuel cycle

The project aims at proposing modifications to the fuel cycle, which minimize waste and improve waste quality for final disposal. One activity pursued with this goal in mind is the setting-up of a facility named PETRA. This facility is presently being installed in three of the available hot cells of the ADECO laboratory which form part of the ESSOR reactor complex at Ispra. The process will treat batches of high burn-up fuel material containing six kilogrammes of uranium, under Purex type conditions. A consortium comprising an international group of one German and two Italian companies are involved in a turn-key contract for the delivery of the facility.

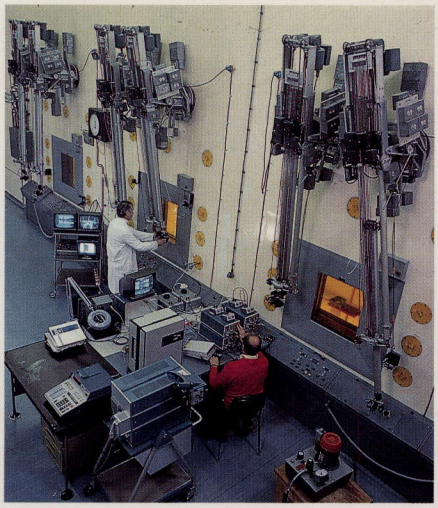


Figure 40: A view of the hot cells of the ESSOR complex. Three of the cells have been modified to host radiochemical facilities for waste management studies

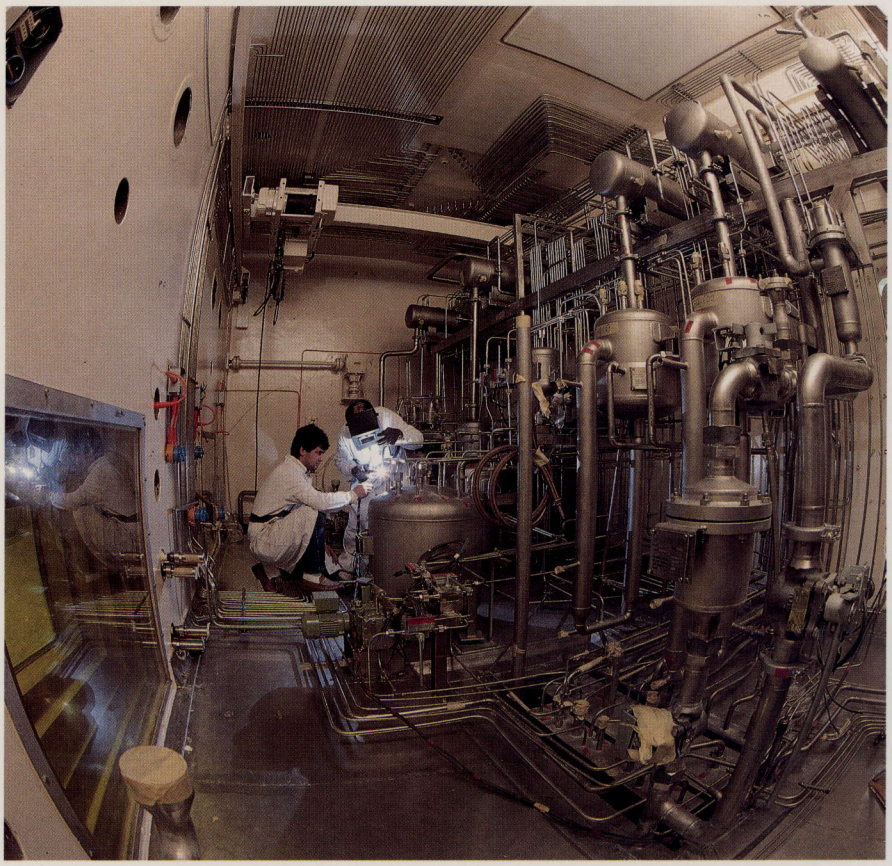


Figure 41: An internal view of one of the hot cells accommodating the PETRA plant nearing the phase of mechanical component installation. Commissioning of the plant will start in May 1988 and cold functional testing will get under way in September 1988.

Figure 42: The high efficiency He^3 detector head for measurement of Pu contaminated 200 l waste barrels by analysis of the detected spontaneous fission neutron pulse train

During 1987, the mechanical installation of all components and connected pipework in the cells has reached 90% completion. As recently requested by the italian Nuclear Licensing Authority the building structure and the extraction system have to be seismicly qualified. This back fitting work is scheduled to be completed by the middle of 1988.

Commissioning of the facility by the consortium will start in May whilst cold functional testing is scheduled for September 1988.

The Users' Group, which was formed to define the detailed programming of the facility, met twice in 1987 and recommended a series of activities to be carried out in PETRA. A few of them can already be implemented during hot commissioning of the facility. The proposals are being evaluated and ranked following criteria recommended by the group.

The PETRA facility has attracted the interest of the Italian Nuclear Authority (ENEA) who is negotiating a financial participation in a multi-annual research collaboration contract for operational work in PETRA. An interest in the facility has also been expressed from Germany on the use of PETRA as a test facility for independent verification.

A second activity pursued under this project and closely connected to the nuclear waste problem, is the non destructive assay (NDA) of plutonium. The NDA method is based on the analysis of spontaneous fission neutron emission, a method for which has been developed at the JRC Ispra. This method can be employed for both mg and kg quantities of Pu and can be complemented with alpha gamma spectrometry for the determination of the isotopic composition.

A fully transportable instrument for non-destructive measurement of plutonium in alpha contamined waste has been tested both at the Ispra establishemnt and at the Casaccia Establishment, ENEA, in a collaboration for the study of instrumentation for in-field testing of an alpha-contamined waste.

Figure 43: High sensitivity segmented γ scanner for determination of the Pu-isotope composition of waste barrels

Safety of waste disposal in continental geological formations

This project includes both theoretical assessments and experiments to provide the necessary database. These activities are carried out in joint projects with the shared-cost action programme.

Theoretical studies have led to the development of a risk assessment code (named LISA) which is distributed through the NEA and IAEA data banks. A commercial version (release No 4) can be obtained from JRC, which incorporates the TROUGH code describing actinide migration in geological media. Release No 4 is 10 times more time-efficient on the computer than release No 3 and it is fully documented. The JRC is also contributing:

- to the coordination and the execution of the Community Project PAGIS (Performance Assessment of Geological Isolation Systems), which is to be completed in 1988.
- to the international coordination of the development of probabilistic safety assessment codes, in the frame of an ad-hoc working group of NEA.

The experimental activities aim at studying the interaction of waste and surrounding materials in the repository, and the migration of actinides and fission products in the geosphere.

The study of the influence of thermal gradients on the corrosion and leaching of waste materials was initiated in 1987. The first results indicate a diminished corrosion rate of mild iron containers in such gradients, due to formation of a protective crust rich in iron, silicate and calcium. Such a crust is not formed in isothermal conditions.

Figure 44: Laboratory simulation experiments on geochemical migration of radionuclides using groundwaters and geological materials typical of the different disposal options considered

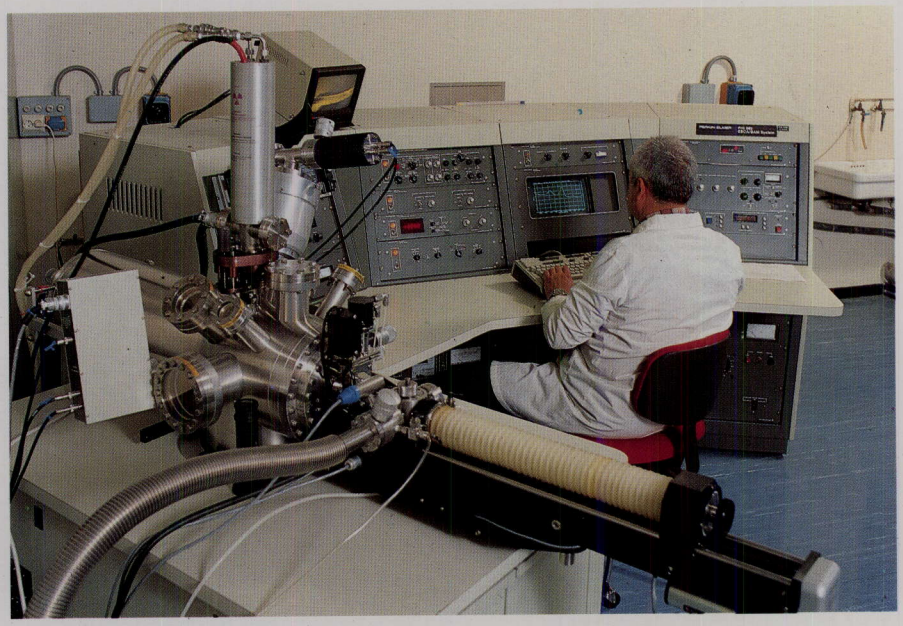


Figure 45: Surface analysis system employed for the study of radioactive waste glass and metal corrosion

The study of alternative waste matrices has proceeded, including development of silico-titanate glasses for the solidification of sodium-rich waste. The JRC holds a patent on these materials.

Experiments were carried out to identify the controlling parameters of the migration of actinides and long-lived fission products in natural systems. Synthetic and natural groundwaters and materials overlying candidate geological formations for high-level waste repositories in Europe were studied.

Although in general, the existence of reducing conditions was found to retard radionuclide migration, a constant column breakthroughof Np 237 (20% of the input activity) was detected in natural groundwater under reducing conditions. Slow kinetics of absorption reactions and migration of unretained microcolloids may account for the Np release; these processes are being investigated.

The retention properties of backfill materials to be used for a repository in a salt dome were also studied, with columns prepared by pressing crushed salt from the Asse mine. The hydrodynamic parameters of the columns were determined from the shape and delay of the elution curves of tritiated brine. The retardation factors of actinides, measured under oxidizing conditions at room temperature, indicate that backfilling with crushed salt may retard migration.

Natural humic substances were characterised as part of the MIRAGE project coordinated by the Commission. The reliability of analytical methodologies for the composition and the structural chemistry of humic acids was assessed. Commercial and site-specific humic compounds were used as reference products.

The possibility of using laser spectroscopy for the quantitative determination of chemical equilibria in very dilute aqueous solutions was explored by studying the hydrolysis and the formation of complexes between uranium and carbonates. The results obtained indicate that laser spectroscopy is sufficiently sensitive to study chemical equilibria of actinides at concentrations approaching those of natural systems.

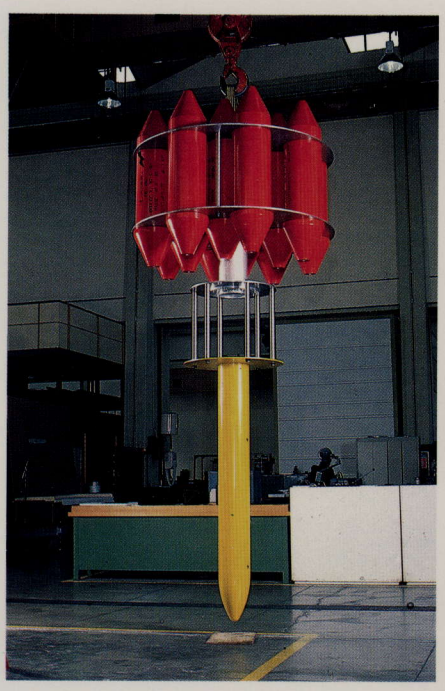


Figure 46: Recoverable "Soft Lander" for deployment on the floor of the deep ocean. This penetrating device is designed to measure in-situ sediment properties

Feasibility and safety of geological disposal in deep oceanic sediments

This project is reaching termination, in line with opinions expressed by the NEA Seabed Working Group. The final report is presently being assembled, and laboratory experiments are being completed.

The results show that disposal into seabed sediments could be a viable option for both feasibility and safety. Several important unknown factors remain, particularly the oceanographic parameters, which may possibly form the objective of long-term international research.

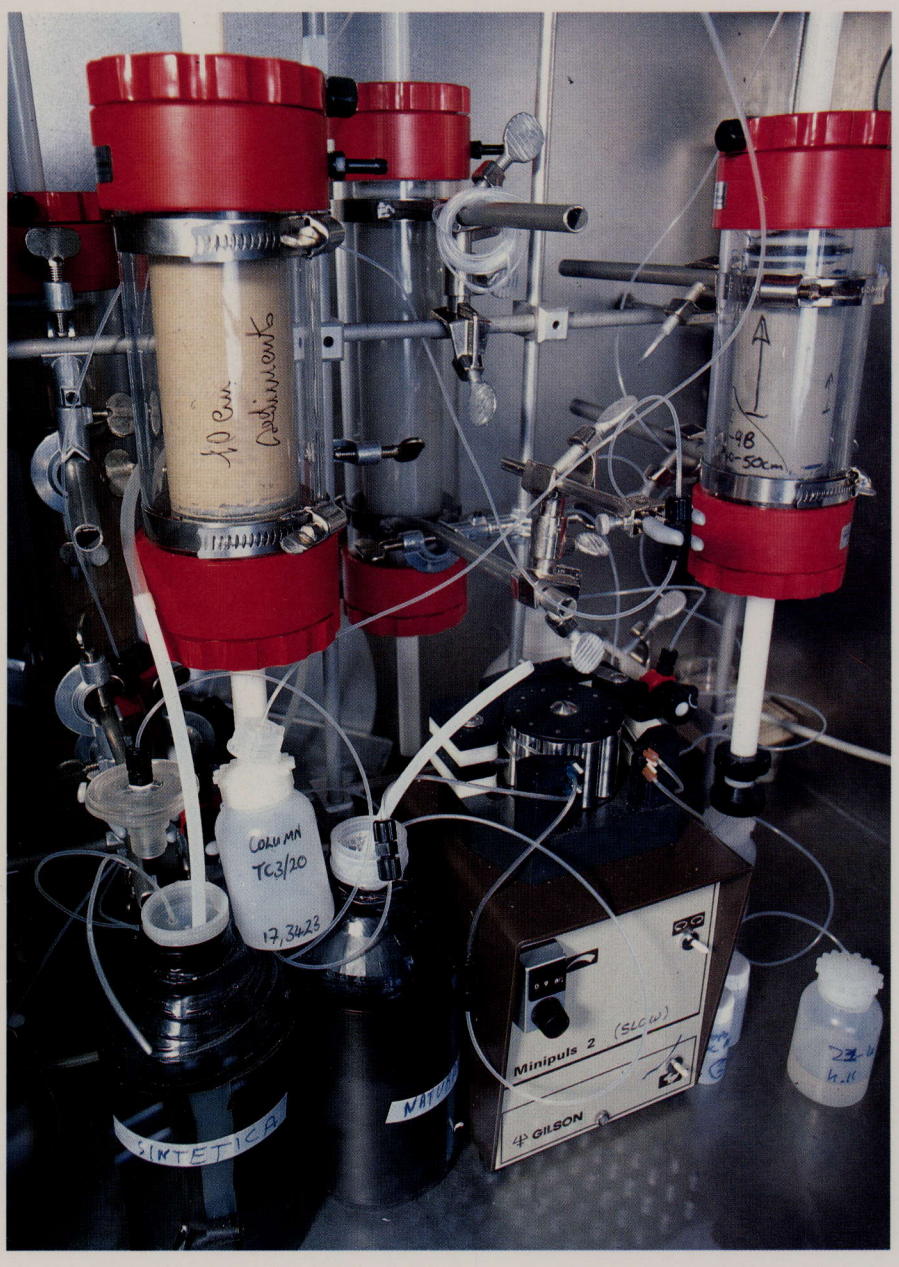


Figure 47: Column migrating experimental set-up in redox controlled glove box employed for the measurement of radionuclide mobilities in deep ocean sediments

Safeguards and Fissile Materials Management

In the European Community, safeguards of fissile materials are implemented in the framework of the EURATOM and Non Proliferation Treaties and of Supply Agreements with third countries (Australia, Canada and USA).

The general objectives of these activities are twofold:

- on the one hand, to provide basic knowledge as a background for effective support to the Safeguards Directorate of the Commission (Luxembourg) and of the IAEA;
- on the other hand, to develop new safeguards techniques which might improve operating procedures.

The R&D activities are subdivided into three areas; many of these activities are performed in cooperation with national R&D organisations of the Community through the European Safeguards Research and Development Association (ESARDA).

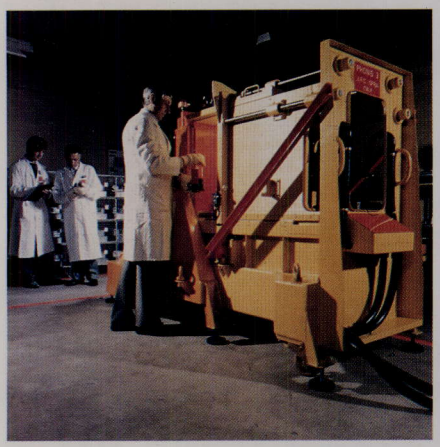


Figure 48: PHONID; a photo-neutron interrogation device to monitor plutonium and uranium bulk samples employed in European plants since 1974

The first one is the **development and assessment of performance under field conditions of analytical techniques, non destructive assays and sealing systems**

Many systems for measuring fissile materials in fuel fabrication plants, reprocessing plants and storage areas have been developed or adapted for specific requirements.

- The "PRE-PERLA" facility at JRC Ispra can handle bulk quantities of highly enriched uranium. In June a calibration campaign of fifteen instruments for non-destructive assay, from the Euratom Safeguards Directorate, IAEA, Los Alamos and JRC, took place. The results of this campaign were used as input to a two-week exercise in Physical Inventory Taking held in PRE-PERLA in July, for eight IAEA and Euratom inspectors. This was the first full scale training course in PRE-PERLA.

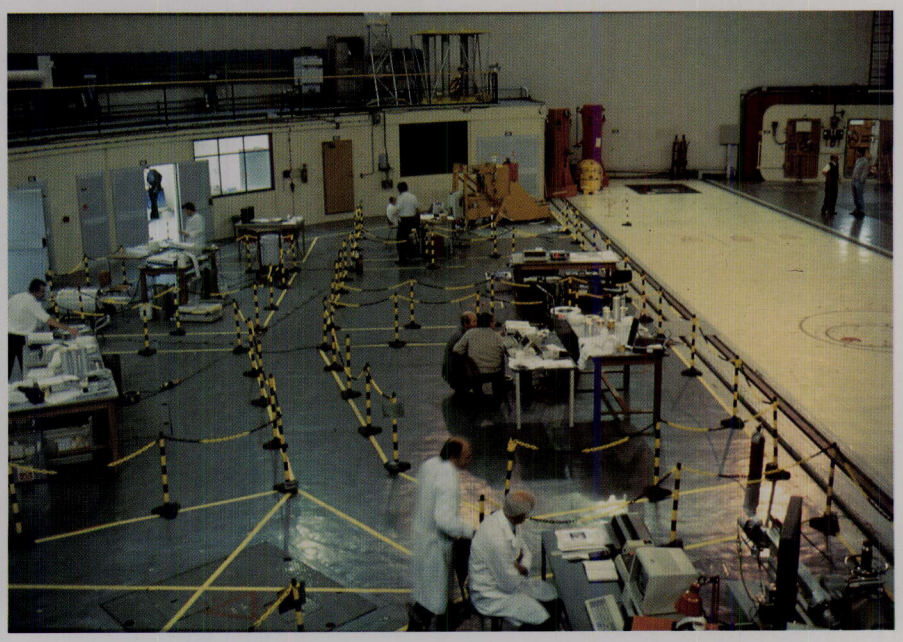


Figure 49: PRE-PERLA laboratory during a training course given to EURATOM and IAEA inspectors

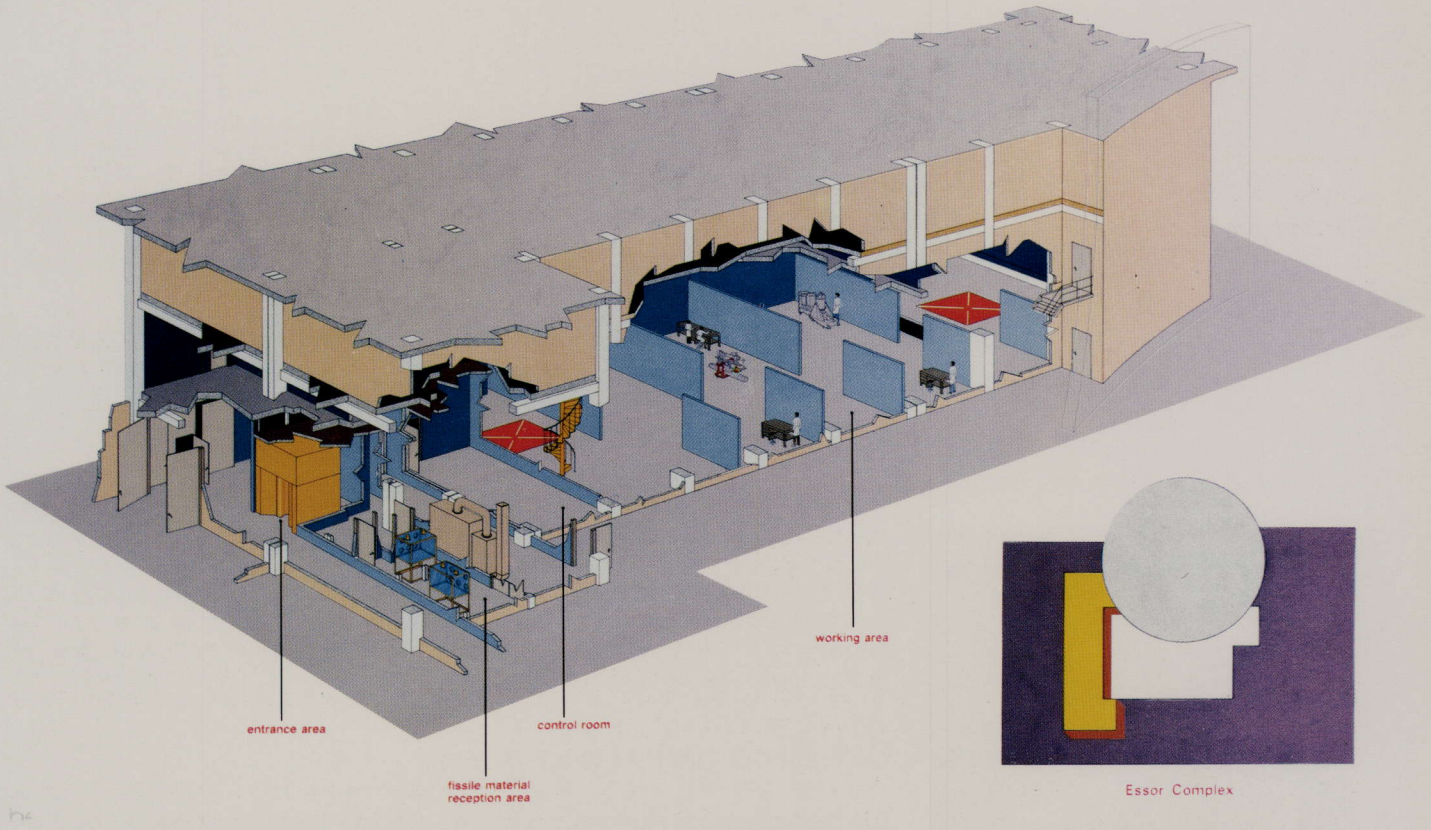


Figure 50: An exploded view of the future NDA bulk facility presently under realisation and due for completion towards the end of 1988

- The physical, chemical and isotopic characteristics of fifty PERLA standards for plutonium were defined; the preparation of these standards in a fabrication plant was carefully monitored and destructive analysis of samples, taken during fabrication, was organized with external laboratories.
- A new way to check the analysis of inputs to reprocessing was developed at JRC Karlsruhe. The sample is conditioned on-site by an analytical robot and sub-nanocurie samples of uranium and plutonium are shipped to a safeguards laboratory for analysis by mass spectrometry.

Figure 51: The computer vision system for reviewing images obtained during optical surveillance. The pictures are grabbed by the TV camera, processed by the computer and displayed on the TV monitor

The second area of R&D is to the **processing, transmission and evaluation of data produced by non-destructive assay methods and surveillance techniques.**

Three projects provide results of direct use to inspectors, and are useful for the design of more advanced surveillance techniques.

- A prototype for reviewing, by computer, images obtained during optical surveillance, has been installed at the IAEA headquarters for more extensive performance tests. The system processes views, recorded on videotape, of different facilities, including spent fuel storage ponds;
- A new modular system for video surveillance was developed in 1987. It is designed for multiple TV-camera recording systems, and has powerful self-diagnostic capability and data retrieval. The system can be integrated with other sensor types like seals or motion detectors. It is a starting point for the design of integrated containment and surveillance systems.
- In 1987 the design of a new prototype of a laser surveillance system (called LASSY) was started, primarily for use in spent fuel pools. Two beams of light scan an area above or under the water. The system detects the position of fuel assemblies in the area.

The third area of R&D is the **study of computerized accountancy systems and plant modelling**

The design and evaluation, in a simulated environment, of safeguards systems, is an important part of this research.

A simulator, based on visual programming, was designed and implemented. This software package is now being adapted for different users e.g. IAEA, EURATOM, plant operators. This package is possibly the first example of simulation based on artificial intelligence in the safeguards area.

Nuclear Fuels and Actinide Research

The Nuclear Fuels and Actinide Research Programme takes place at the European Institute for Transuranium Elements, the Karlsruhe Establishment of the JRC. Its objectives are threefold: improvement of the safe use of fuel in nuclear reactors with fast or thermal neutron fluxes; investigation of safety-related aspects of the nuclear fuel cycle (actinide formation, handling of radioactive material, reprocessing of nuclear fuel); and basic actinide research.

Figure 52: A view of the facilities used for preparing fuel samples

Operational Limits of Nuclear Fuels

This project aims to improve the technical performance and safety of nuclear fuel. It is concerned with the optimisation of advanced fuels and with the investigation of the physical properties of nuclear fuel, especially at high temperatures, which are of interest for safety evaluations.

Optimisation of Dense Fuels

Mixed uranium-plutonium nitride is a strong candidate for the optimized fast breeder fuel cycle.

In 1987, the database on fission product migration and release during operational transients was extended to high burn-ups, reaching 53 MWd/kg. The cooperation with the Risø Fission Gas Project with international participation of industry and national research institutions was continued and first results were obtained on MOX fuel, i.e. LWR fuel containing about 3% plutonium.

The specifications for a joint JRC-CEA nitride irradiation experiment (NIMPHE 1) in the Phenix reactor in Marcoule were worked out. Five pins of the fuel bundle to be irradiated were fabricated at the Institute and the irradiation was started in October. A second fast flux experiment to compare the performance of carbide and nitride fuels is being prepared.

Study of Properties of Nuclear Materials at High-Temperature

Development and testing of equipment for measuring thermophysical properties of nuclear fuel up to very high temperatures continued during 1987. A laser-heated autoclave for measuring the specific heat of solid and molten uranium dioxide was tested under high pressure and with acoustic sample levitation up to 4500°K.

The apparatus for measuring of the thermal conductivity of liquid UO_2 was further improved by increasing the speed of the data acquisition and the precision of the temperature measurements.

The above studies were performed in order to furnish data needed for safety considerations in fast and light water reactors. In the same context the in-pile experiment PAHR-Celia 1, performed in the Melusine reactor at Grenoble, was equipped with an ultrasonic thermometer conceived and built at JRC Karlsruhe, which monitored successfully the temperature rise in a simulated debris bed up to 2200°C. Ultrasonic temperature sensors were also prepared and delivered to CEN Cadarache for the SCARABEE-BF3 in-pile experiment.

The fuel pin performance code TRANSURANUS developed at JRC Karlsruhe was further improved by the introduction of a new in-pile motion module (URADYN) and fitted into the European Accident Code (EAC) system under development at JRC Ispra.

Transient Behaviour of Oxide Fuels

The aim of the project is to investigate possibilities of increasing the lifetime of light water reactor fuel rods by studying the transient fuel and fission product behaviour at high levels of burn-up, and finding out how fission gas and

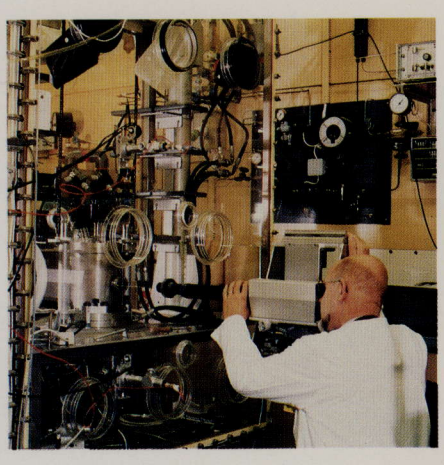


Figure 53: An installation for thermal conductivity measurements on molten UO_2

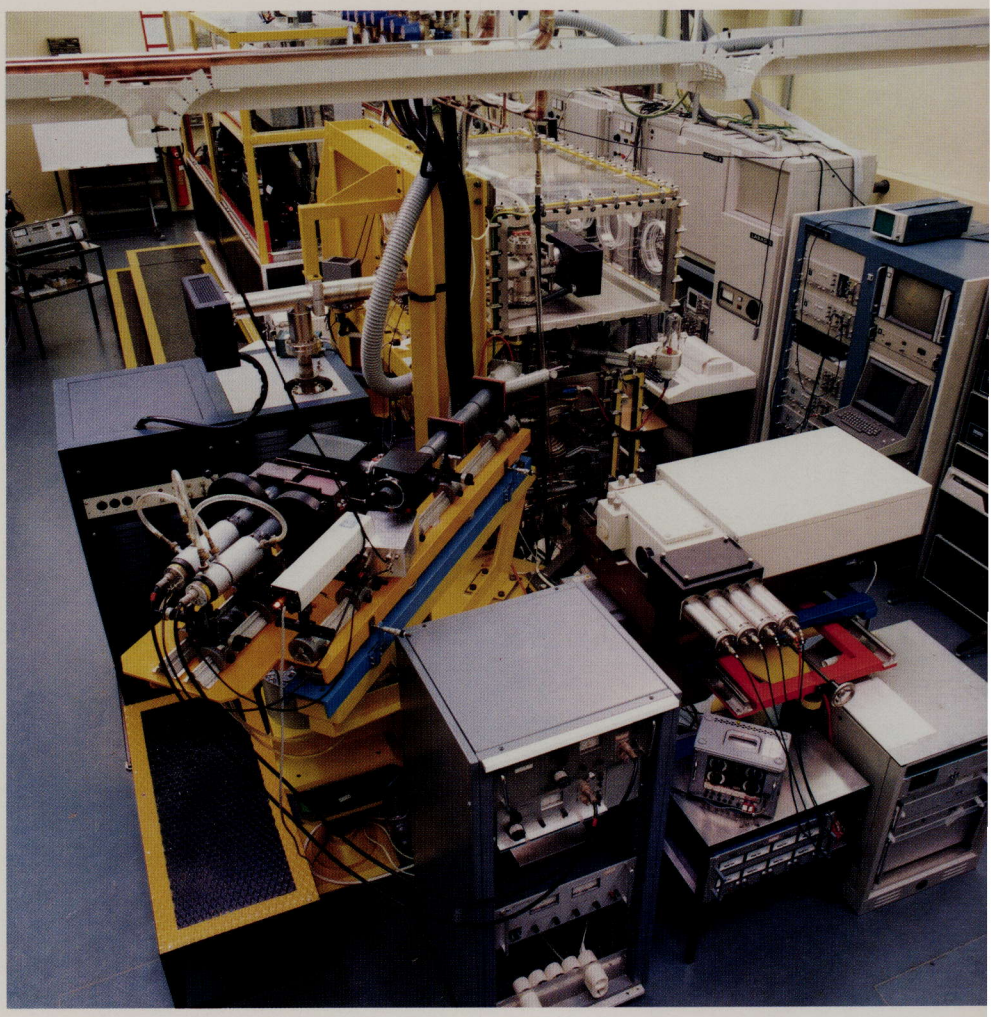


Figure 54: An installation for vapour pressure measurements on nuclear fuel samples up to very high temperatures (5000 K) by laser pulse heating

volatile fission products are released from the fuel matrix. The fuels under study are of commercial type, and have been irradiated in currently operating power reactors to various burn-up levels. Laboratory experiments provide the necessary basic data for extensive modelling calculations.

In 1987, the database on fission product migration and release during operational transients was extended to high burn-ups, reaching 53 MWd/kg. The cooperation with the Riso Fission Gas Project with international participation of industry and national research institutions was continued and first results were obtained on MOX fuel, i.e. LWR fuel containing about 3% plutonium.

These are some of the principal observations made in 1987:

- Laboratory experiments showed that significant fractions of Rb and Te can occupy substitutional sites in UO_2. First measurements of thermal solubilities of rare gases in UO_2 were obtained and the temperature range for venting of pressurized pores in UO_2 on heating and cooling was determined.
- UO_2 fuel with a simulated burn-up of 3% was produced, and the release of volatile fission products was found to be very similar to that of irradiated fuel. This facilitated considerably the execution of release experiments.
- The results of the first irradiations with transient-tested high burn-up UO_2, plus central thermocouples, made it possible to extend the fuel rod performance code TRANSURANUS, for steady states and transient integrals from fission product migration to central, temperature calculations.
- The code FUTURE for the mechanistic behaviour of fission product was applied to new hot cell annealing tests with high burn-up UO_2.
- A third code, MITRA, was developed to include short-lived fission products and decay chains into release calculations for steady state and transient conditions. All three codes are available for external users.

Actinide Cycle Safety

The project comprises the investigation of actinide formation in-pile, improvements in handling conditions of radioactive material, and investigations of key aspects of nuclear fuel reprocessing.

Formation of Actinides In-Pile

The aim of this activity is to evaluate and, if possible, reduce the risk associated with the presence of actinides in the fuel cycle by measuring actinide formation in light-water reactors and fast breeders and by studying the effects of recycling minor actinides in a fast breeder reactor.

Fuel samples which had been irradiated in the KNK II fast flux test reactor and which contain U, Np, Pu, and Am have been analysed for their isotopic concentrations. The results are being compared with reactor physics calculations based on neutron dosimetry, in collaboration with KfK Karlsruhe and CEN Mol.

In the same context, eight U and/or Pu fuel oxide pins containing Am and Np as mixed oxides are being irradiated in the French PHENIX reactor.

For the isotope analysis, a novel mass spectrometric technique has been developed which can be used for analyzing nanogram samples of plutonium. Since the sample is completely evaporated in this procedure, any disturbing effects due to isotope fractionation average out. With the new technique, the

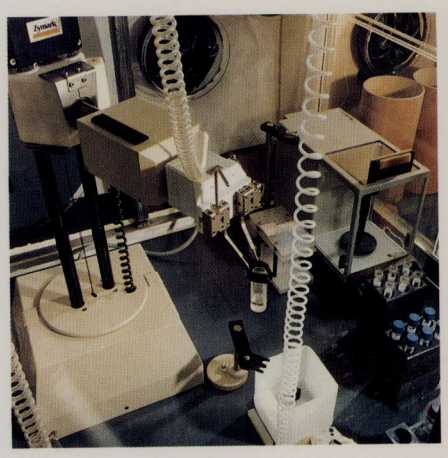


Figure 55: Safeguards Analysis; detail showing a robot used for fuel sample preparation

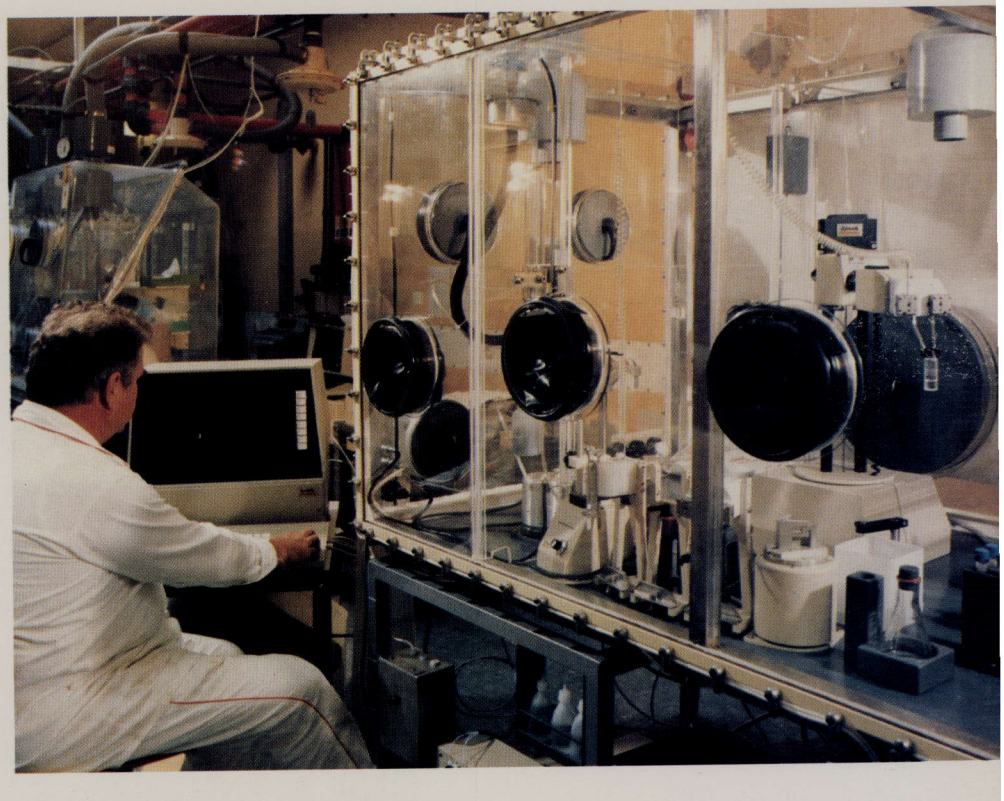


Figure 56: Safeguards Analysis; glove box containing robots for fuel sample preparation

time necessary for making an analysis is reduced by a factor of five, while only 10-2 of the usual sample size is required (S. Franzini, L. Koch, M. Romkowski, Mass-Spectrometric Analysis of Sub-Nanogram Amounts of Uranium and Plutonium, Proc. 9th Annual Symposium on Safeguards and Nuclear Materials Management, London, May 12-14, 1987). This analytical technique is particularly interesting for nuclear safeguards analyses, since it could facilitate sample shipment procedures.

Sample conditioning is done by robots which not only reduce the radiation dose to the operators, but also decreases the amount of time necessary to perform an analysis.

Safe Handling of Nuclear Fuels

This is mainly the study of the formation and dispersion of plutonium-bearing aerosols under normal and off-normal operating conditions.

It was found, in small scale fires of plexiglass contaminated with (U,Pu)O2, that about 1,5% of the contaminants were transported to the outlet filters, in agreement with the results from large scale fires involving simulated (non-radioactive) aerosols. This demonstrated the validity of simulation experiments for predicting radioactive aerosol dispersion during accidents in nuclear installations.

The kinetics of aerosol particle agglomeration was studied by numerical simulation, using the concept of "fractal dimension". Within the range of parameters investigated it was observed that the decrease in concentration and the increase in median particle size during agglomeration were nearly identical exponential functions of time and the exponents involved were found to be independent of the initial particle concentration.

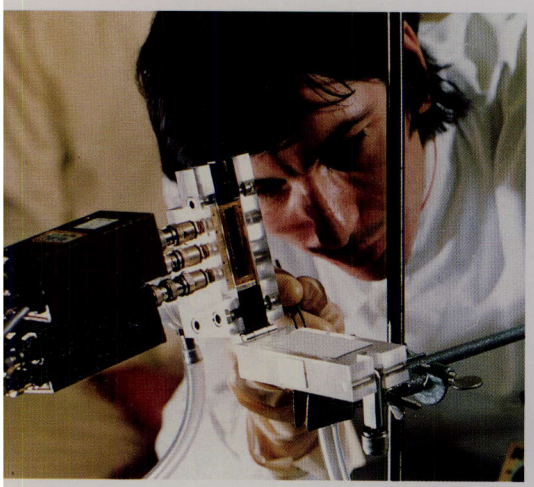


Figure 57: Inertial spectrometer for characterisation of nuclear aerosols

In view of possible consequences for the safety of nuclear installations, a study was launched in order to clarify possible causes for the occasionally observed increase in filter penetration by active alpha particles. A preliminary conclusion from the experimental results obtained so far is that fitters are penetrated only when the nuclide ejected in the disintegration process is radon, an inert gas with low sticking coefficient.

Reprocessing of Nuclear Fuels

Two main subjects are treated under this heading: a) studies of reprocessing procedures for fast breeder fuels, to see how well they fit into the classical back-end of the fuel cycle and b) the development of methods for the recovery and purification of actinides from waste and fuel solutions of different origin and composition.

One drawback in the use of nitride fuel is the nuclear transmutation of natural nitrogen into radioactive ^{14}C. This problem could be eliminated if the fuel contained essentially ^{15}N. For the purpose of evaluating the implications of the use of ^{15}N at the reprocessing stage, we have carried out dissolution experiments of uranium nitride in nitric acid highly enriched in ^{15}N, to investigate the secondary exchange reactions taking place between the various reaction products during the dissolution process.

Figure 58: A view of an α, β, γ cell of the hot cell facilities used for non destructive analysis in the dissolution of spent fuel samples

For the separation of the individual actinides the final version of the combined extraction chromatographic columns (TBP/ion exchange) was tested. The separation of rare earths and actinides was improved by a preconcentration of these elements on a small additional ion exchange column.

As a contribution to investigations on accidental leaching of underground waste repositories, the formation of plutonium colloïds in aged solutions was measured as a function of acidity and time.

The OXAL process, which is part of the research area "Radioactive Waste Management and the Fuel Cycle", is aimed at obtaining "alpha-free wastes". The process has been tested in a hot cell with a process waste solution of intermediate activity.

Actinide Research

The aim of this project is to understand the properties of actinide-containing solids in terms of the electronic structure of their constituents and of the contribution of 5f-electrons to the chemical bond. Selected properties of, especially, intermetallics and binary actinide compounds, with emphasis on the less-known elements Pa, Np, Am, Cm, Bk, and Cf, the so-called minor actinides are investigated experimentally and theoretically. This requires well characterized samples, often single crystals, of known composition, crystal structure, and impurity content.

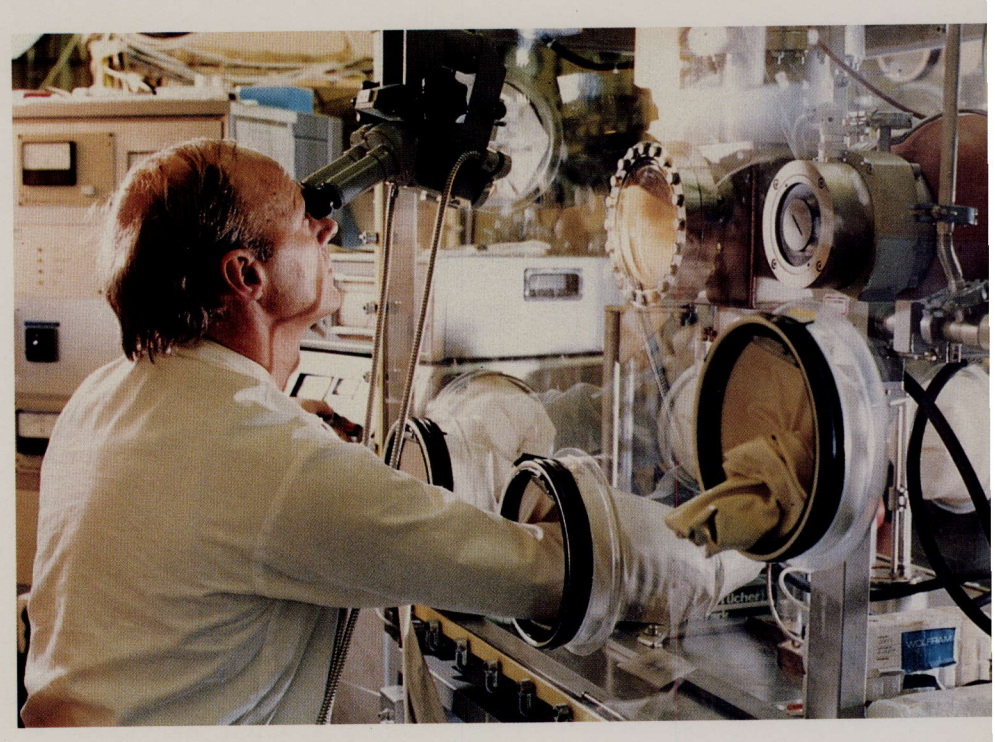


Figure 59: The preparation in glove box conditions of actinide single crystals

During 1987, the mineralization technique developed for single-crystal growth of uranium and plutonium compounds was applied to grow crystals of neptunium compounds. Single crystals of NpP were obtained for the first time and the search continues for optimum growth conditions.

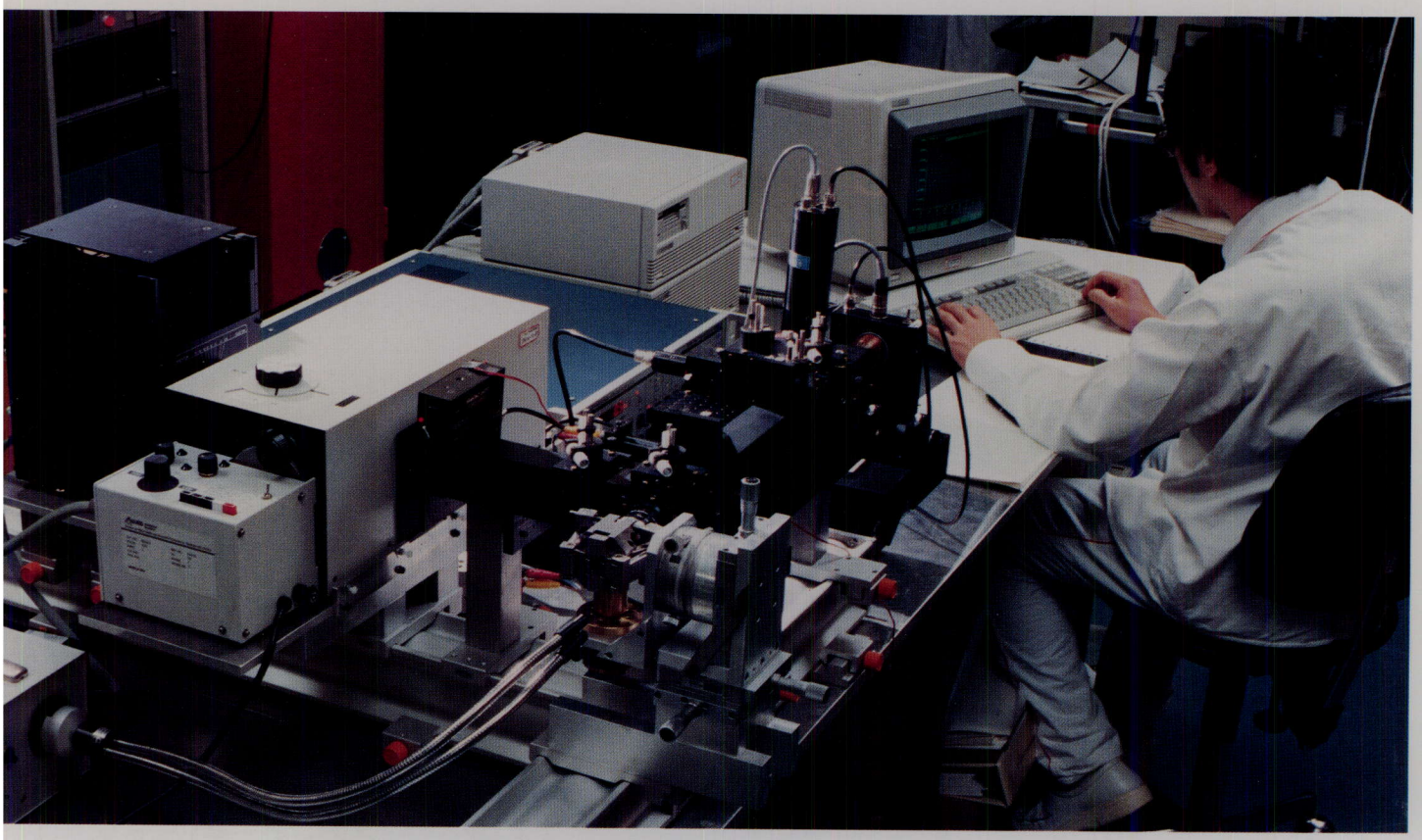


Figure 60: The facility for optical measurements (absorption and reflection) under very high pressure conditions

In a new effort involving the miniaturization of this technique, small single crystals of compounds of transplutonium elements (AmBiand AmTe) for solid state physics studies were fabricated for the first time.

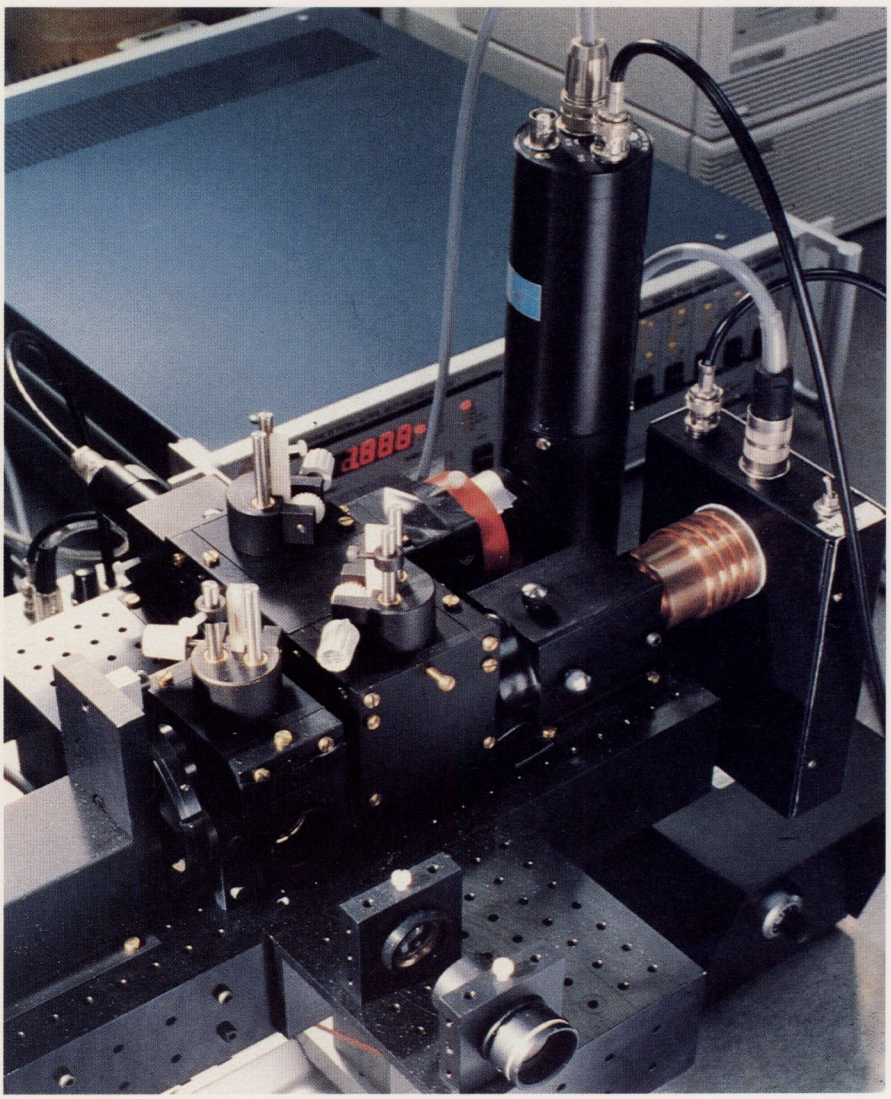
Single crystals of $PuFe_2$ and UFe_2, produced at the Institute, were studied by neutron diffraction and magnetization measurements; these systems are particularly interesting because they show strong hybridization between the 5f- and 3d-electrons. This hybridization is also the subject of a considerable theoretical effort involving electronic band structure calculations. These investigations were carried out in close collaboration with national laboratories in Risø and Grenoble.

In search of new materials with interesting magnetic or superconducting properties, new ternary or pseudo-ternary compounds were prepared and characterized such as $NpRh_2Si_2$, $NpRuRhSi_2$, $Np(RuxTc1\text{-}x)_2Si_2$ with $x=0.2$ and 0.4.

In the frame of our study of actinide metals and alloys under pressure a phase transition in a-plutonium metal at about 45 GPa has been identified. X-ray absorption spectroscopy at high pressures has been implemented as a corollary to the hitherto applied X-ray diffraction technique.

A new installation to measure optical reflectivity under high pressure, was set up in collaboration with scientists from the Max-Planck-Institut für Festkörperforschung at Stuttgart. First tests with uranium and thorium compounds were successful.

Figure 61: A detail showing the detector used for optical measurements under very high pressure conditions



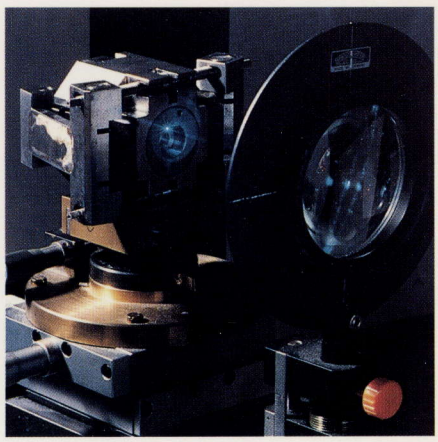


Figure 62: An Argon laser light for fluorescence measurements in determining pressures in high pressure cells

Photoelectron spectroscopy continues to be an essential tool for the study of the surface behaviour and the reactivity of actinide metals. The initial reactions of uranium surfaces with oxygen and carbon dioxide have been extensively studied. In the case of neptunium a compound of the form Np_2O_3 was discovered, a composition which is not stable in the bulk material.

The effectiveness of the project on basic actinide research is enhanced by extensive collaborations with laboratories in Europe and collaborative connections with a number of institutions in the United States. The importance of the Institute as an international focal point is underlined by the editing at Karlsruhe of "Actinide News Letters" with a world-wide distribution, and the annual "Journées d'Actinides" meeting. The unique capability of JRC Karlsruhe to produce high purity actinide samples, including single crystals, gives this Institute a key role in international actinide research. In 1987, more than 20 laboratories throughout the world carried out structural and physico-chemical investigations with specimens from JRC Karlsruhe.

NON NUCLEAR ENERGIES

The programme on non nuclear energies is limited to solar energy (photovoltaic and thermal conversion) and to energy management in buildings. These activities are implemented at the Ispra Establishment and are coordinated with the Shared Cost Actions managed in this field by DG XII in Brussels.

Testing Solar Energy Systems

The testing programme is based on a unique ensemble of test facilities at ESTI (European Solar Test Installation), both for photovoltaic and thermal solar devices. This enables the JRC to play an important role for the development of European technologies and the preparation of norms and standards in an emerging industrial sector.

Photovoltaic Devices and Systems

The project on photovoltaic (PV) conversion comprises pre-normative studies in calibration and qualification testing of photovoltaic devices, tests and monitoring of PV plants, research in photovoltaic semiconductor materials and contributions to standards writing organizations.

Main results achieved in 1987 may be summarized as follows:

Solar cells

The calibration facilities were used to calibrate about 60 solar sensors and reference devices coming from industry and other organizations. The outdoor calibration facility has been equipped with new hardware and software in order to react faster to suitable weather conditions. A study contract was set

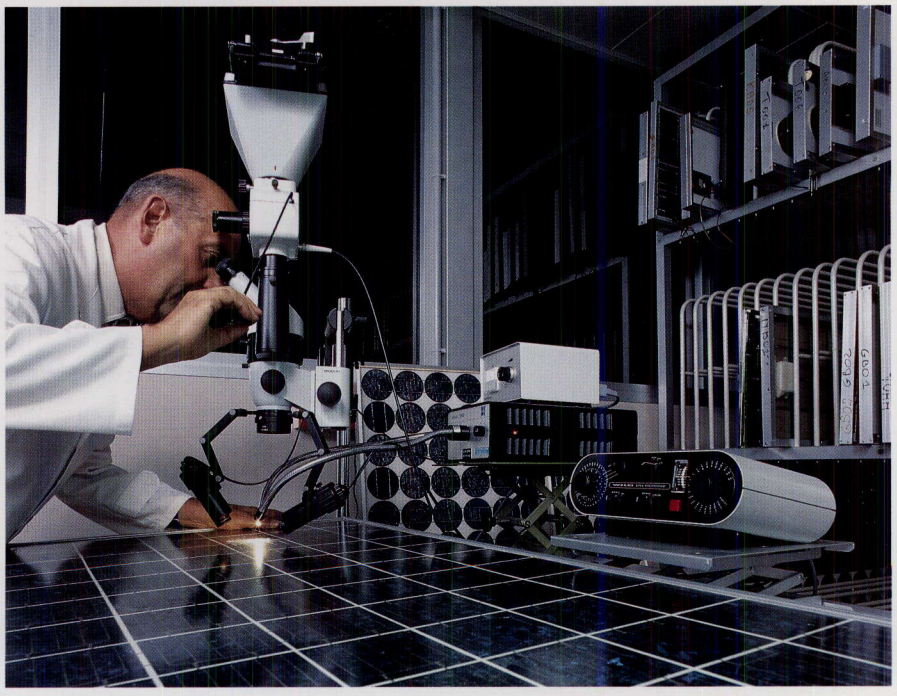


Figure 63: Visual inspection of PV modules - the qualification and certification of PV-modules comprises various accelerated, ageing tests. In between these tests a thorough inspection is performed in order to evaluate possible defects which could limit the lifetime under natural exposure

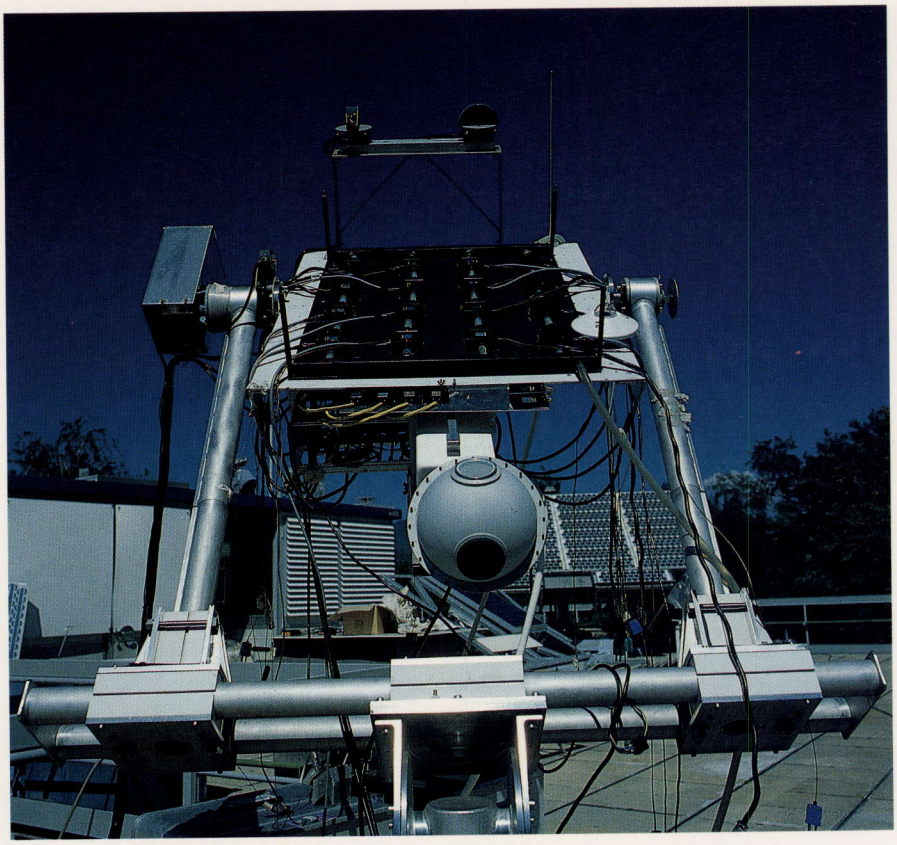


Figure 64: A precision calibration facility - a part of the European Solar Testing Installation (ESTI)

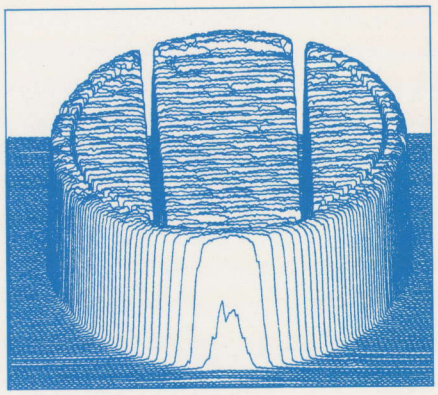


Figure 65: ESTI. An example of an horizontal and vertical laser beam scan. The induced current is recorded and the resulting image gives precise information about the internal structure of a solar cell

up with CIEMAT (Spain) for external parameter measurements on amorphous devices.

The LASER scanning facility has been installed and provides for light induced current measurements at different wavelengths onphotovoltaic devices up to 15 x 15 cm^2 area.

Module qualification and performance rating

During the year about 86 modules of 23 different types have been tested compared to 18 types tested last year. A collaboration contract with CEN Cadarache (France) was established in the field of amorphous module degradation measurements.

System studies

An innovative concept for the determination of the state of charge of accumulators used in photovoltaic plants was tested. It showed significant improvements compared to conventional methods.

Plant tests and data monitoring

The elaboration of PV plant data has been extended and now includes those coming from the demonstration projects of DG XVII (Energy).

A portable instrumentation package for testing Pt arrays has been finalized for prototype production at a solar electronics company.

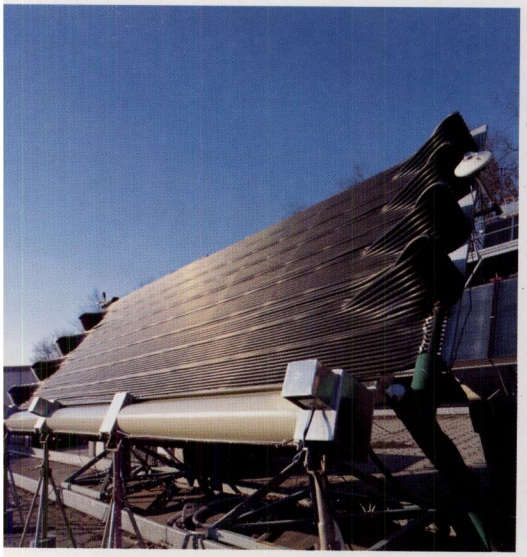


Figure 66: A test facility for thermal performance measurements of solar collectors, for validation of test methods under development

Thermal Conversion

The thermal conversion project develops test methods for predicting the performance and evaluating the durability of solar components and systems. This activity is mainly carried out within the European Solar Collector and Systems Testing Group (CSTG), which is managed and financed by JRC. The execution of the concerted programme of this Group, which is composed of 22 national laboratories, is now in its final phase with the preparation of six documents of recommendations based on experimental and theoretical work carried on within the respective laboratories and the JRC test facilities.

- In Greece where there already exists a well established industry for solar water heaters, the documents of the CSTG will be taken as the basis for the Greek standard test procedures. A collaboration has been set up between JRC and Demokritos, the institution responsible for these standards. On request from the FAO (Food and Agriculture Organization of the United Nations) the JRC has been also invited to participate in drafting guidelines on "Solar Water Heating for Rural Areas" to be discussed at Naxos in June 1988.
- Studying the aging of solar absorbers by measuring surface optical properties has been extended to an external collaboration, with the Instituto Nacional de Technica Aerospacial, Madrid. Due to the interest which is developing in this field a workshop on optical property measurement techniques was held at Ispra in October, 1987 with the participation of over 40 European and non-European experts, and representatives from industry, including the glass manufacturing industry and instrument manufacturers.
- A prototype solar cooling box for use in hospitals in developing countries was tested for the UN World Health Organisation.
- Tests of the corrosion of solar absorbers by sulphur dioxide in the atmosphere have been pursued, in collaboration with Leuven University. The tests showed the need to adapt DIN 50018 Standard to that purpose.

Figure 67: 11 different commercial Solar water heating Systems under test as part of an activity for the development of a test procedure in determining the long term thermal performance

- In the International Standardization Organization, where the JRC has been chosen as a technical expert, a test method developed at Ispra for predicting the performance of solar water heating systems is under discussion to become part of an ISO Standard.

Collaboration

A collaboration has been established with ENEA, Italy to study aging of solar collectors, passive solar technologies and seasonal storage of solar energy. Mixed teams of investigators have been set up at Ispra.

Energy Management in Buildings.

Energy consumption in the residential and commercial building sector represents about 35% of total EC energy consumption. It is also the sector which has been recognized as the most important in terms of possible energy saving, which could significantly reduce pollution. The JRC participates in the elaboration of common methodologies for the evaluation of building performance including monitoring technologies for an optimal utilization of thermal energy in buildings.

Figure 68: The recently modified Solar Laboratory at the Ispra establishment showing the large new sunspace

Figure 69: A closer view of the newly built sunspace showing the shading system on the windows

Figure 70: One of a group of passive solar test cells which make up the extensive test facility installed at the Ispra establishment

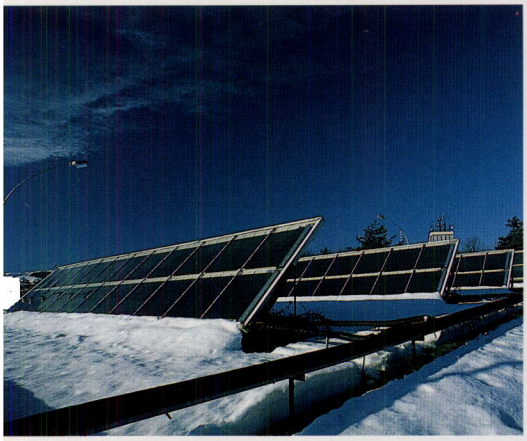


Figure 71: An array of solar collectors used for seasonal storage

Solar Passive Technologies

The introduction of solar passive technologies into modern architecture is particularly interesting because of its important energy saving potential; but it requires the development of new design tools and adequate new norms and standards.

- as part of the participation of the JRC in the PASSYS project of the Cost Shared Action of the DG XII, a test methodology for the thermal behaviour of a solar passive test cell, based on parameter identification techniques through ARMA (Auto Regressive Moving Average) has been developed and tested at Ispra. The same method has also been applied with success to a solar building with a mixed active and passive system.
- The problems of solar architecture in Mediterranean climates have been addressed at a workshop held at Ispra in June 1987 with the participation of the Southern European Member States. Areas of possible concerted programmes have been identified and a collaboration has been set up for the testing of solar passive components with the Politecnico di Milano.

Energy auditing

This includes the development and comparison of various methodologies for the evaluation of energy consumption and identification of energy saving measures in buildings.

- A "benchmark exercise" of various European energy audit schemes has been carried out at Ispra on different types of building. A detailed analysis of data completed in 1987 showed important discrepancies in the results due in part to different national approaches to the problem. This work received a public award at the ICBEM 87 Lausanne Conference (International Conference on Building Energy Management).

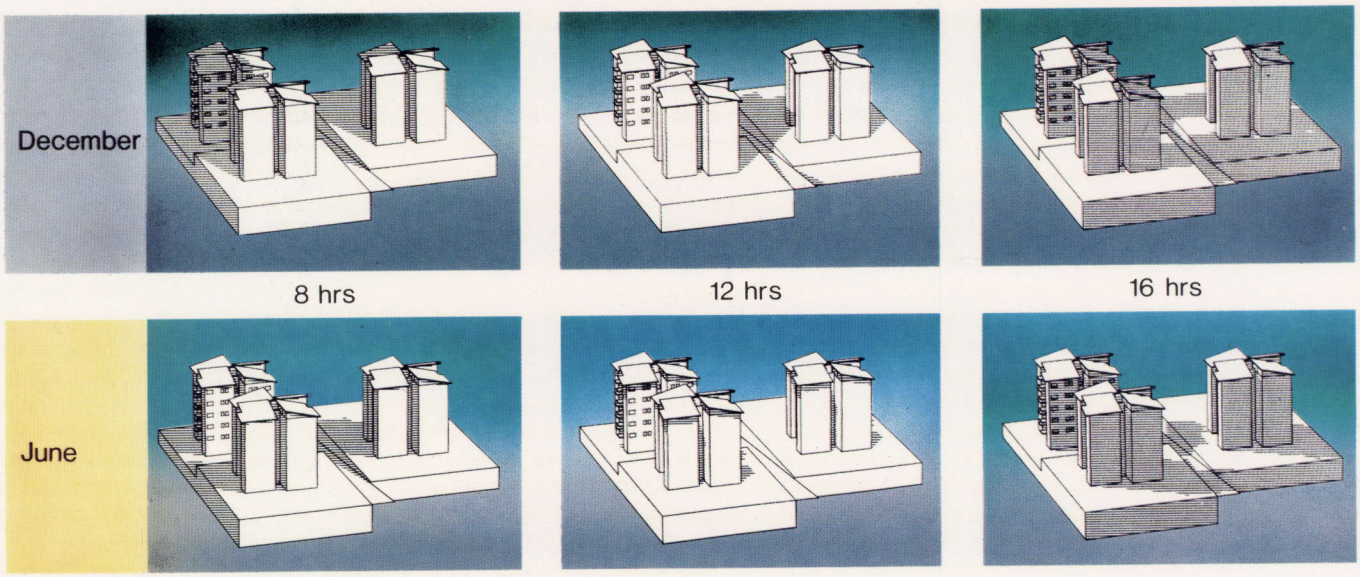


Figure 72: The drawing above is an example of the graphic output from SHADOW PACK, a 3-D modelling package, developed at Ispra. In this case it is being used to study solar gains in some of the buildings in the "Benchmark Experiment"

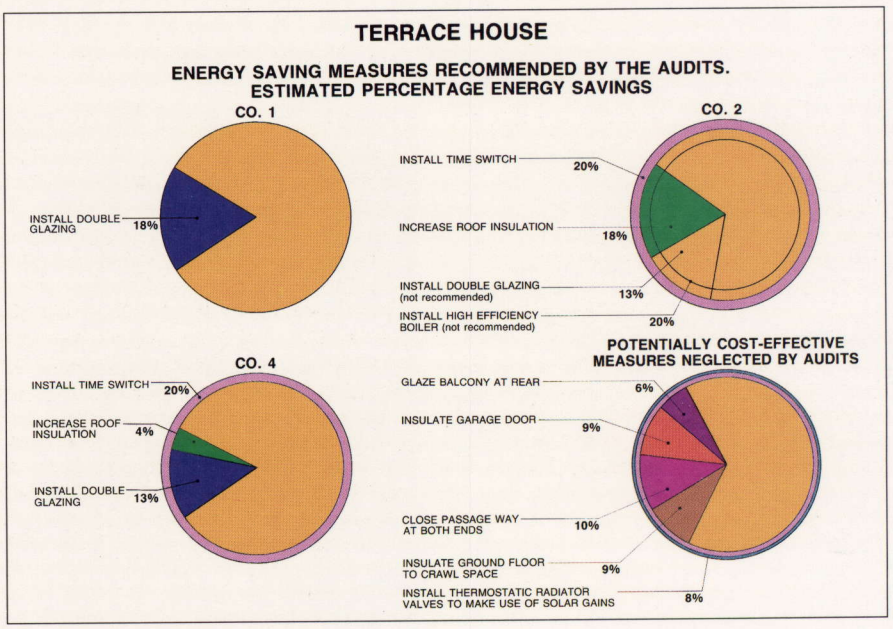


Figure 73: The pie charts show the limited nature of the auditors' recommendations for a house. In all, only 3 energy saving measures were recommended, whilst a whole series of potentially cost-effective measures were completed neglected

- The "Source Book for Energy Auditors" has been published by IEA, with the participation of the JRC acting as task leader. The Regione Lombardia has asked the JRC to help implement some of the new methods presented in this document.
- Auditing companies and the UK Building Research Centre are showing great interest in the software developed at Ispra for image processing of buildings, and have made requests to use it.
- JRC has contributed to the activities of DG III in its preparation of a EUROCODE for Rational Use of Energy in Buildings and to the activities of DG XVII concerning the Energy Labelling of Buildings.

ENVIRONMENT

Environmental Protection

Starting in 1987, the programme has been focused on five research areas: Environmental Chemicals, Atmospheric Pollution, Water Quality, Chemical Waste and Radioactive Environment Monitoring. The programme also supports the EC environmental policy established by Directorate General XI, "Environment, Consumer Protection and Nuclear Safety".

Environmental Chemicals.

The ECDIN (Environmental Chemicals Data Information Network) databank coverage has been extended by the incorporation of the BIG data base (Belgian Fire Brigade Information Centre on Dangerous Substances). Information on first measures in case of road accidents involving chemical substances is now available.

The number of users of ECDIN is increasing, due to increasing interest from the USA, Japan and Australia.

Preliminary contacts have been made with the US National Science Foundation to involve ECDIN in establishing a Biotechnology Environmental Release Database (BERD).

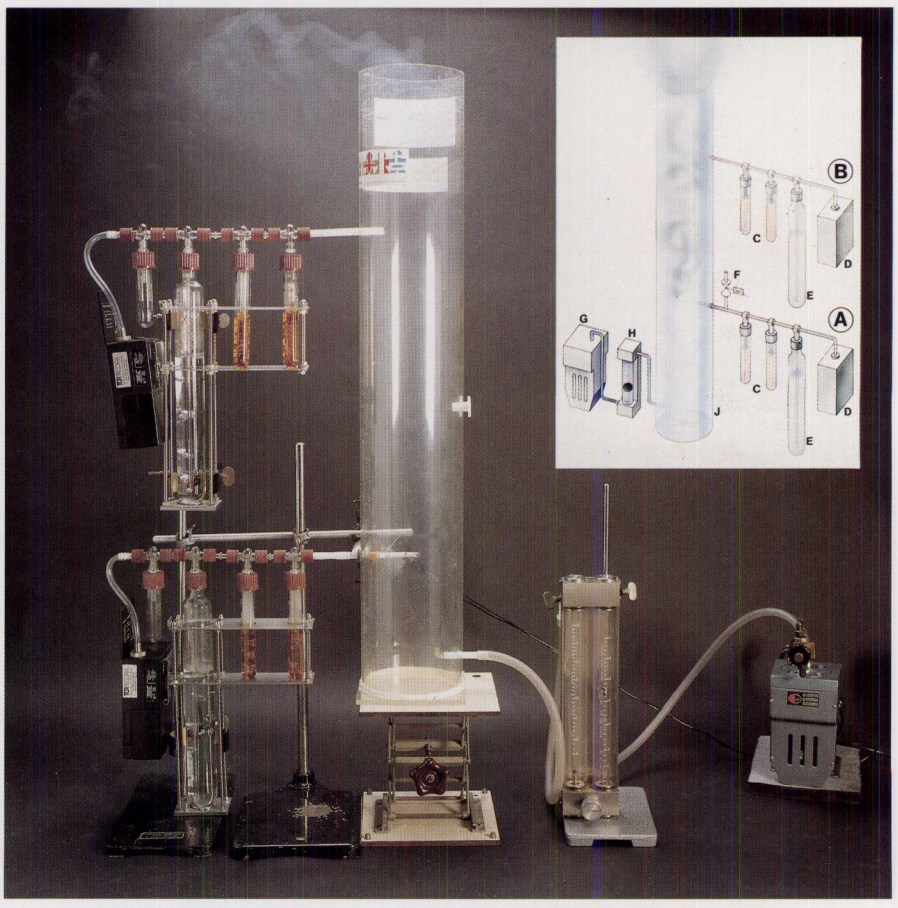


Figure 74: Experimental set-up for the determination of carbonyl compounds in mainstream (MS) and sidestream (SS) cigarette smoke. A - sampling train for MS smoke, B - sampling train for SS smoke, C - impinger bottles, D - constant flow personal pumps, E - water traps, F - bypass valve, G - bellows pump, H - flow meter, J - plexiglass tube

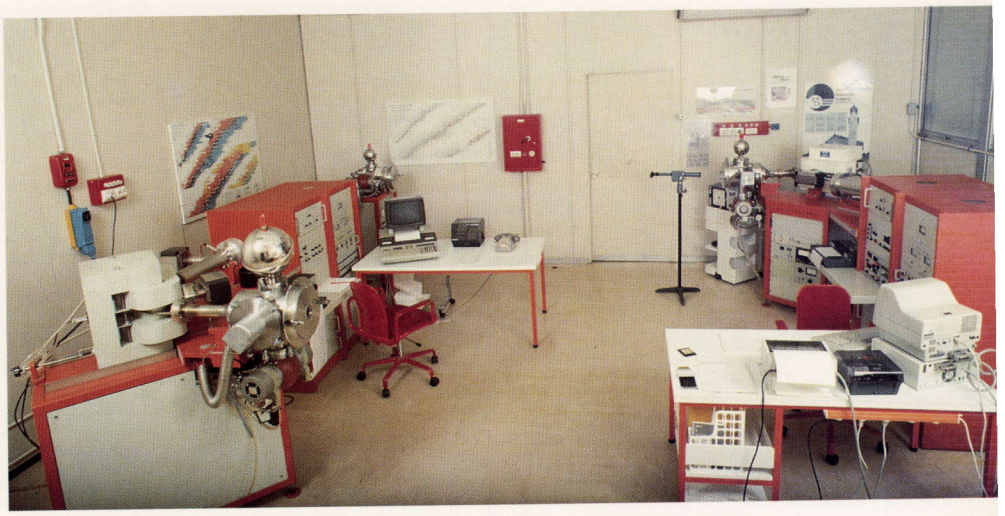


Figure 75: Laboratory containing inorganic mass spectrometer used for trace determination and isotopic measurements

The COST concerted action "Indoor Air Quality and its Impact on Man", led by JRC, has established its initial working programme: preparation of guidelines for formaldehyde emissions, investigation of problem buildings and measurement of indoor pollutant levels.
The experimental activities of JRC were presented at three international fairs where measurement of carbonyl compounds in active and passive cigarette smoke were performed. It was shown that more than 90% of the total pollutant mass is contained in passive smoke. On request of the European Parliament, indoor air quality has been assessed during three measurement campaigns in the Parliament buildings at Strasbourg, Brussels and Luxembourg.

Figure 76: Environmental pathway of trace metals; laboratory leaching experiments on fly ashes by radioactive tracers

In the project on exposure and health effects of trace metals, further results have been obtained on the distribution of different trace metals in human blood and on the dose-effect relationships of inorganic arsenic compounds in cell cultures. Systematic work on the determination of trace metals in lung tissues, blood and urine of the general population continued in order to establish baseline reference values. Neutron activation analysis was used to study clinical case reports and to diagnose lung diseases induced by trace metal.

In the project on environmental pathways, work began on the characterization of soil and soil-pollutant interaction. Experiments with soils sampled at the Ispra site and interacting with different trace metals demonstrated the potential of radioactive tracer methods. A finite element model was applied to the trace metal mobilization in ground-water from a coal fly-ash repository. The model predicted that the arsenic concentration in ground-water 20 metres beneath the repository will persist for 60 years above the maximum permissible concentration level, as defined in EC 80/778 Directive on drinking water quality.

Atmospheric Pollution (Acid deposition)

The role of naturally emitted substances, like terpenes and pinenes in chemical and photochemical transformation of air pollutants to acidic compounds was further investigated. The reaction of ß-pipene with ozone in presence of sulphur dioxide leads to sulphur containing particulate matter, of which at least 75% is sulphate. This finding is similar for dark and sunlit conditions. In similar ex-

Figure 77: Teflon bags used to study photo chemical reactions of air pollutants under simulated atmospheric conditions

periments with natural terpene mixtures a rapid oxidation of sulphur dioxide to sulphate was found.
To contribute to the understanding of the role that NO_3 radicals play in the night-time chemistry of atmospheric pollutants, reactions between NO_3 radicals and unsaturated organic hydrocarbons of biological origin were studied using FT-IR (Fourier Transform-Infrared Spectroscopy) and GC-MS (Gas-Chromatography-Mass Spectrometry). Under laboratory conditions, the main products are nitrate, pernitrate and carbonyl functional groups.

On request of the Greek Ministry for the Environment, in September the JRC mobile laboratory for remote sensing of air pollution performed extended air pollution measurements in Greece (Athens and Thessaloniki). Especially high values of SO_2 were observed. Data evaluation will continue as soon as meteorological data are available.

A new dual-trap tracer analyser with a detection limit of 0.01 ppt for perfluorocarbons was purchased and tested. The mobile laboratory for "in-field" release, sampling and analysis of atmospheric tracers is now assembled and ready for field campaigns.

Figure 78: An interior view of the mobile unit used for in-field analysis of atmospheric pollutants

Figure 79: A 450 l gas reaction chamber instrumented with advanced spectroscopic analytical facilities (IR-FT spectrometer IR-diode laser spectrometer, UV-VIS assay spectrometer), used for laboratory studies of night time atmospheric chemistry

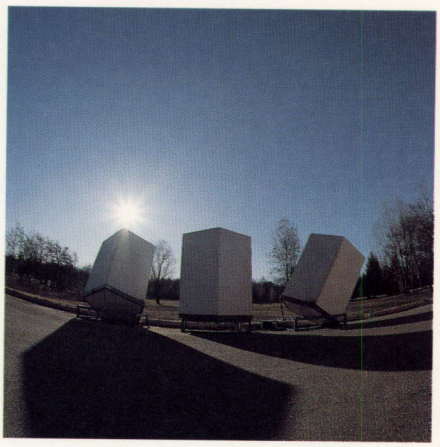


Figure 80: A side view of the three antennas of the SODAR experiment which measures vertical wind profiles

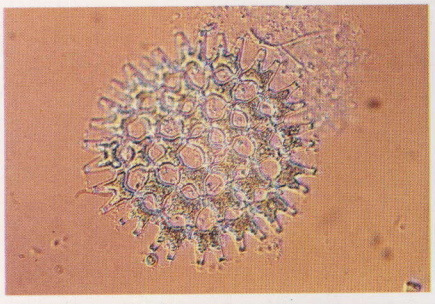
A 3D-Doppler acoustic radar (SODAR), to determine vertical wind vector profiles, has been purchased and works now at the Ispra site on a continuous routine basis. Another meteorological instrument, a 3D sonic thermo-anemometer coupled with a fast-response NO_2 analyser has been successfully tested in a joint exercise with the Fraunhofer Institute for Atmospheric Research near Raisting (Bavaria) for dry deposition measurements.

The JRC contribution to the COST concerted action 611 "Physico-chemical behaviour of atmospheric pollutants" has continued and JRC scientists have been involved in the definition phase of the EUREKA environmental project EUROTRAC.

Laboratory work for extending the ISPRA MARK 13A process for flue gas desulphurisation to a combined desulphurisation/denoxing process continued. Electrolytic reduction of nitrous oxide via an iron-EDTA (Ethylendiamine tetraacetic acid) complex gave promising results. Preliminary experiments showed a reduction of nitrous oxide at the cathode compartment of the electrolytical cell. At the same time, at the anode compartment of the same cell, bromine to be used for oxidising sulphur dioxide to sulphuric acid could be regenerated from the hydrobromic acid formed in the existing ISPRA MARK 13A process.

Figure 81: The Ispra Mark 13A Pilot Plant near completion at the SARAS Refinery complex in Sardinia. The plant is expected to be operational in the latter half of 1988

Figure 82: Laser diffraction flow cytometry for measuring the evaluation of the algal biomass in a fresh water ecosystem



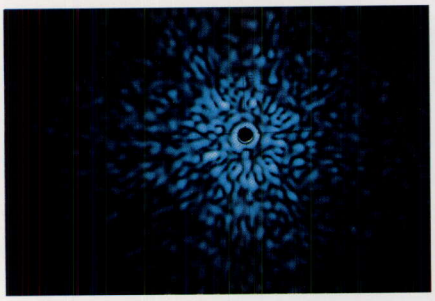


Figure 83: Two images of the Pedicestrum duplex algae
a) as seen using conventional light microscopy
b) seen as a diffraction ''fingerprint'' using laser illumination

Trace Metal Pollution

In enclosure experiments on Lake Comabbio in northern Italy, a shallow lake with periodical mass mortality of fish during critical stratification periods, the physical, chemical and biological effects of artificial oxygenation were followed. For testing the ecotoxicity of nickel at low concentrations (50 μg/1) the mortality and reproduction rate of the water flea, Daphnia magna, proved to be a valuable bioindicator. Further refinements of the flow cytometric method developed at Ispra made it possible to identify algal classes by photopigment autofluorescence and to quantify number and size of cells within populations. This can be used to assess water quality in an objective and comparable way. To model the recovery of Lake Orta in northern Italy, a highly polluted lake, a systematic inventory of trace-metals (Cu, Cd, Pb, Cr, Ni, Zn) in dissolved, particulate and sediment phases was performed.

Chemical Waste.

To study the fate and environmental pathways of highly toxic compounds contained in chemical waste, analytical procedures for extraction and analysis of polyhalogenated aromatic compounds from environmental samples were developed. These methods were further verified by use of ^{14}C radiolabelled dioxins and polychlorinated biphenyls (PCB). Risk assessment for human exposure to these compounds, contained in soot, incinerator fly ash, polluted soils and industrial wastes, was performed by assigning toxicity equivalent fac-

tors to each compound and including factors for source composition and bioavailability.

The Chemical Emergency Management (ChEM) decision support system has been further developed. The first module is now operating and can identify the levels of threat related to the most common types of accidents involving PCBs.

Radioactivity Environmental Monitoring (REM)

Figure 84: REM: Interrogation of the data bank, in this case, to obtain the measurements of the radioactive levels in areas of France

After the Chernobyl accident, numerous measurements have been performed in the different countries affected by the accident.

The necessity of storing the numerous results of these measurements on an international basis led the JRC to create the REM database.

During the reporting period the data base has grown to a size of about 200,000 radioactivity measurements, mainly from member countries of the EEC. Particular care has been devoted to the menu-driven enquiry procedure, which is fully transparent and user-friendly.

The measurements were obtained from national offices and from universities, small laboratories, etc. They have been introduced into the database from different supports, such as magnetic tapes, floppy disks or simply copying data from official papers.

A user's group, created to assist the JRC in developing and checking the database, met in the middle of the year.

As a complement to the radiological data, meteorological and rainfall data were also gathered for the period of interest, 26th April to 15th May, 1986.

The data-set of meteorological measurements, such as wind velocity and direction, sky-cover, humidity, temperature, pressure, and turbulence, was then mathematically treated to obtain fine-mesh grid values for pressure and wind fields. From this information it is easy to obtain plume trajectories at different altitudes.

The rainfall data include precipitation values for almost all the EC countries on a daily basis. There are more than 1,000,000 data points. In order to obtain useful information for area-averaged deposition, advanced statistical fitting techniques such as fractals are being successfully employed.

The large set of information available and the possibility of running at Ispra long-range transport computer models (MC-LAGPAR, MESOS, acquired in this period) has led us to support the participation of the European Commission in the model comparison launched by the IAEA and WMO.

At the same time, an effort to improve and harmonize the measurement methodologies among the countries in order to increase the validity, accuracy and comparability of the results has also started. In this frame, a workshop has been organized at Ispra with the participation of many researchers in the field.

The database is being extended to cover the period before the Chernobyl accident back to 1984, using the data obtained by DG V, Health and Safety in compliance to Art. 35-36 of the Euratom Treaty. These data will be used to prepare the EC periodical reports on radioactivity levels in the EC.

Application of Remote Sensing Techniques

1987 was marked by a significant growth in this activity, with the start of two new projects, microwave remote sensing, and agricultural statistics, the latter being a support requested by the Directorate General for Agriculture and the Statistical Office of the EC. All the projects were guided by the need to develop practical applications of space satellite data for the needs of end users, principally the Commission Services (six Directorates General are currently concerned). The work should also favour the growth of commercial "value-added" services in the application of data from space satellites.

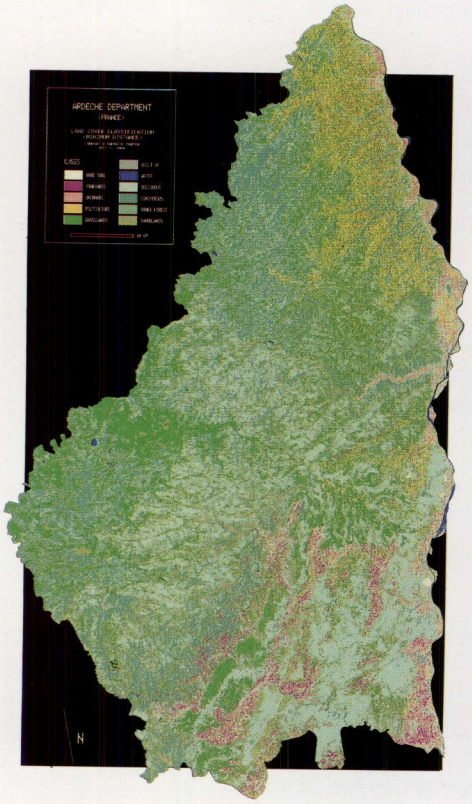


Figure 85: Land cover map over the Ardèche region (F) obtained by automatic classification

Agriculture and Land Use

Within the project "Land Use Planning in European Marginal Areas", the main results during 1987 were the inventory and mapping of soil occupation (agriculture and forestry) over the Department of Ardèche (F) by automatic classification methods, using data from the Thematic Mapper (TM) (30 m resolution) of the Landsat-5 satellite.
The first classification and mapping was obtained for the whole department (560.000 ha) using monotemporal TM data. The vegetation categories as defined by the French Ministry of Agriculture, are rather broad, but very important from the economic and environmental point of view: vineyards, orchards, mixed crops, permanent grasslands, shrublands and moorlands, forests (deciduous,coniferous, mixed). The total areas of vegetation categories calculated from satellite images compare very well with the official inventory of the French Ministry of Agriculture for the Ardèche department.

Improvement of the results and especially the mapping accuracy at local level, requires the use of multitemporal data and the development of per-field/per-segment methods to take local spatial information into account. Two important packages were developed and tested as part of the movement towards the use of multitemporal per-segment methods

a) relief information was introduced into the geometric registration of images taken at different times, by using a digital elevation model for the whole department (maximum registration error 0.5 to 1 pixel over the whole of Ardèche);

b) A multiband, multidate automatic segmentation method was developed based on a global clustering and cluster mapping of the data. The method was found to work satisfactorily.

Figure 86: Radiometric measurements made over a sunflower crop by means of a radiometer with the same spectral bands as the Thematic Mapper Satellite

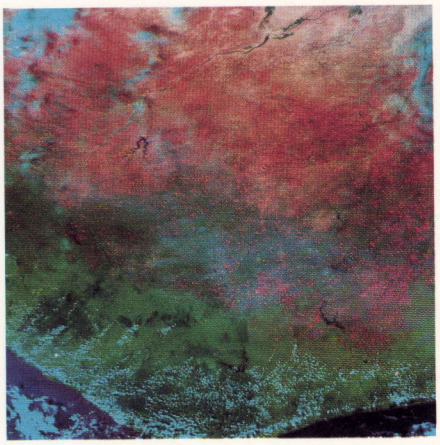


Figure 87: The AVHRR instrument carried on board the NOAA satellites provides regional views of resource distribution on a nearly daily basis. The image shown here is used to study the seasonal development of vegetation and the role of fires (red dots) as an agent of environmental degradation

As a complement to JRC support for the management of the "less favoured areas" (LFA), the "Collaborative Programme", consisting of a series of joint projects (see table 5) executed by a network of 25 national institutes or laboratories in Europe, entered an active phase. The main studies use remote sensing for the monitoring and management of land-use, agriculture, forestry, pasture land and soil moisture in typical test-sites of European marginal areas. Thematic Mapper and SPOT data were delivered to the project teams and their processing is in progress. A special effort is being made to integrate different national databases and information gathered from remote sensing satellites by using geographical information systems (GIS).

JRC staff visited all the participating institutes, to consolidate and orientate the programme. The network established within the Collaborative Programme will have an important role in strengthening European development of remote sensing methods and computer packages adapted to the highly divergent regional and local problems related to the management of LFA.

The project "Surveillance of Renewable Resources in Africa", in support of DG VIII and governmental agencies of western African countries, has been restructured around three topics which have as a common theme the study of vegetation dynamics in the tropical area:

— Monitoring of rainfed foodcrops: a stratification procedure for agricultural areas was proposed. It involves the integration of different remote sensing sources and aims at providing a space-based framework for agricultural surveys. The method is being tested in pilot projects by the statistical services of the countries involved in the project. At a more detailed level, results of radiometric measurements over experimental fields in Mali allow better correlation between the vegetation index and biomass production.

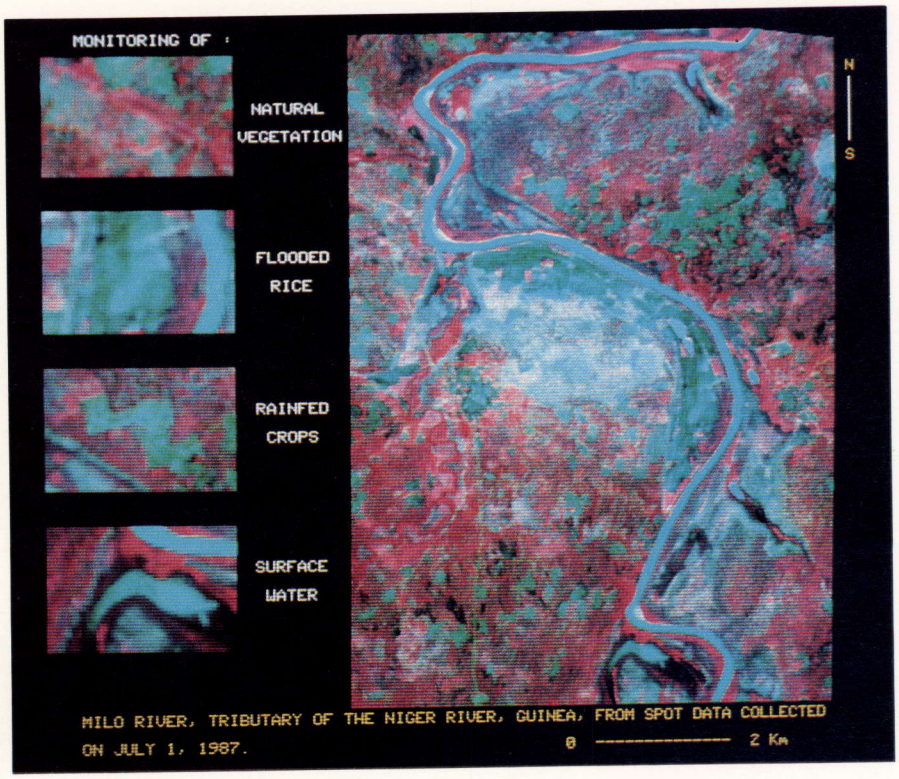


Figure 88: Analysis of SPOT satellite data in a multistage sampling scheme to study the role of vegetation in the hydrology of the Upper Niger watershed of Guinea

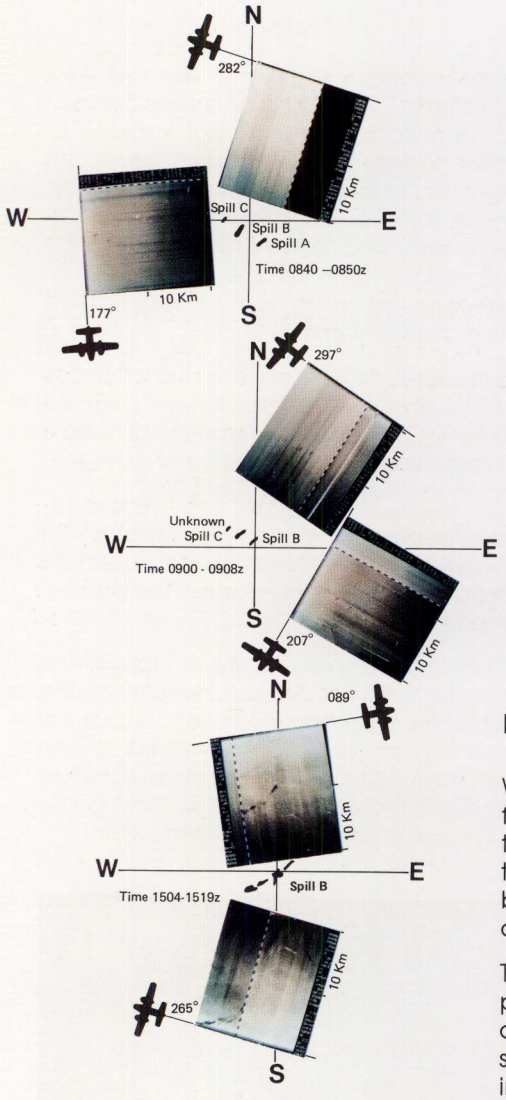


Figure 89: ARCHIMEDES II - a schematic indication of the flight paths over a test area giving position and direction of aircraft relative to the oil spill

— Study of the Upper Niger watershed in Guinea: the vegetation cover over specific catchment areas was characterised. For each catchment area a vegetation index (one value per area) was computed from Landsat-MSS imagery during the dry seasons of 1975, 1985 and 1986. The comparison of the three situations allowed the catchment areas to be classed according to the degradation of the vegetation. On the basis of this diagnosis, priority areas for protection have been selected and proposed to the Directorate General for Development which is involved, with the Guinean Government, in a development programme on the Upper Niger watershed in Guinea.

— Study of tropical deforestation: 1 and 4 km resolution AVHRR data in the southern part of West Africa was used, mainly to observe southern Guinea. So far, the study has shown how the vegetation index coupled with thermal data, leads to a better understanding of the dynamics of the savanna-forest interface. Fires identified on the AVHRR images were interpreted in terms of deforestation activities. This research is aimed at a classification of vegetation (especially forest-nonforest) and an analysis of the seasonal-multiannual dynamics of large areas considered ecologically sensitive. The information will be integrated into development proposals by the Directorate General for Development.

Monitoring the Marine Environment

Within the Archimedes Project (remote sensing of hydrocarbons and biogenic films at sea) the JRC and the University of Oldenburg (FRG) organized the international colloquium "Remote Sensing of Pollution of the Sea", March 31 to April 3, 1987, at the University of Oldenburg. The proceedings were edited by the JRC and Oldenburg and the JRC was responsible for their publication and distribution.

The global report on the Archimedes II experiment (November 1985) was published by the JRC at the end of 1987. The experiment has improved the analysis by remote sensing of hydrocarbons and of biogenic thin films on the sea surface. A small complementary exercise (Archimedes IIa), aimed at filling the gaps in Archimedes II, will take place in April 1988; test sites have been chosen on the Dutch continental shelf.

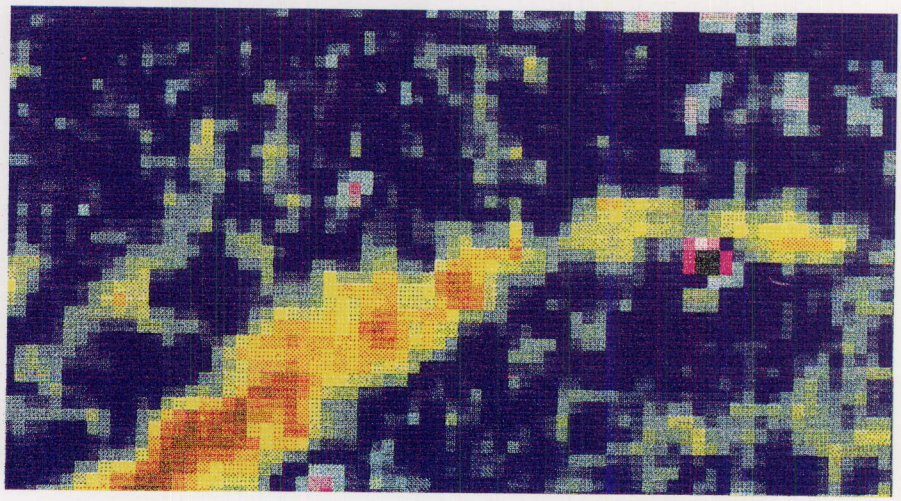


Figure 90: ARCHIMEDES II - an oil spill described here as linearly scaled coloured levels of back scattered radar signal power (SARSCAT)

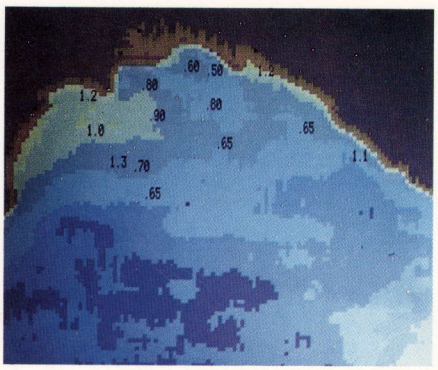


Figure 91: A map of chlorophyll concentration (mg/m^3) of the coastline facing the Naples harbour (I). The image was derived from TM data of Nov. 11. 1987 and a comparison with contemporary in-situ measurements

Pollution of the sea by dangerous substances other than hydrocarbons will become the subject of the current Archimedes Project. This was tackled by gathering lists of priority dangerous substances from different agencies, followed by a preliminary examination of their known properties.

In project "Coastal Transport of Pollution", Thematic Mapper (TM) scenes of polluted coastal water were interpreted. An experiment was carried out around the Gulf of Naples in collaboration with several Italian institutes. Chlorophyll and suspended sediments, surface temperature and spectral irradiance were measured directly in the sea, and combined with TM image processing, to assess the possibility of monitoring the water quality in an area characterized by heavy urban and industrial loads. TM appears to be only slightly inferior for this purpose to the "Coastal Zone Colour Scanner" (CZCS), images taken by a now defunct satellite, and to be a valid substitute in turbid coastal waters.

Modification of codes for CZCS data elaboration at low sun angles have been performed at Ispra while about 40 CZCS scenes were processed to study the evolution in time of phytoplankton and total suspended matter along the Adriatic coast of Italy. A computer code for the superposition of single and time averaged CZCS thematic scenes with bathigraphic maps was developed.

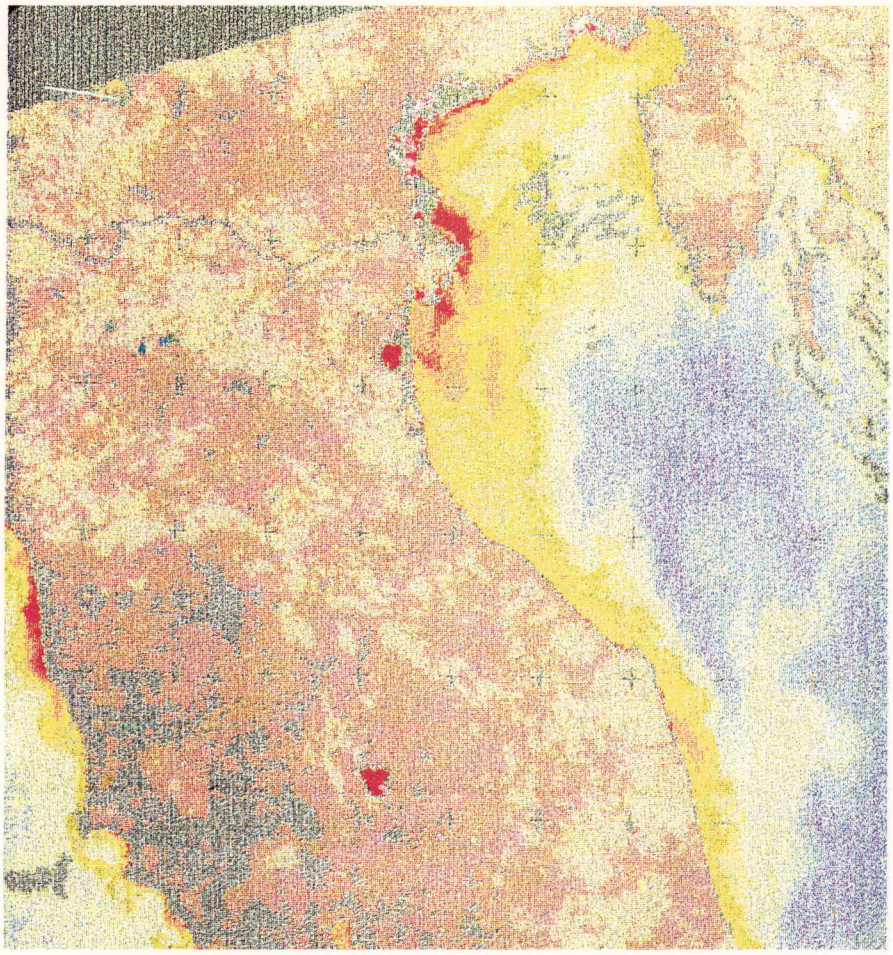


Figure 92: A chlorophyll concentration map of the north Adriatic coastline of Italy derived from CZCS data. High chlorophyll concentrations are denoted here in red with the lowest concentrations in the predominantly blue area

Figure 93: Deployment of the spectroradiometer during an exercise in the Bay of Naples, Italy

A field radiometer with high spectral resolution was tested in the sea environment and the software necessary for the analysis and interpretation of the data is being developed. A method for atmospheric corrections of airborne scanner data is being developed under an ad-hoc contract.

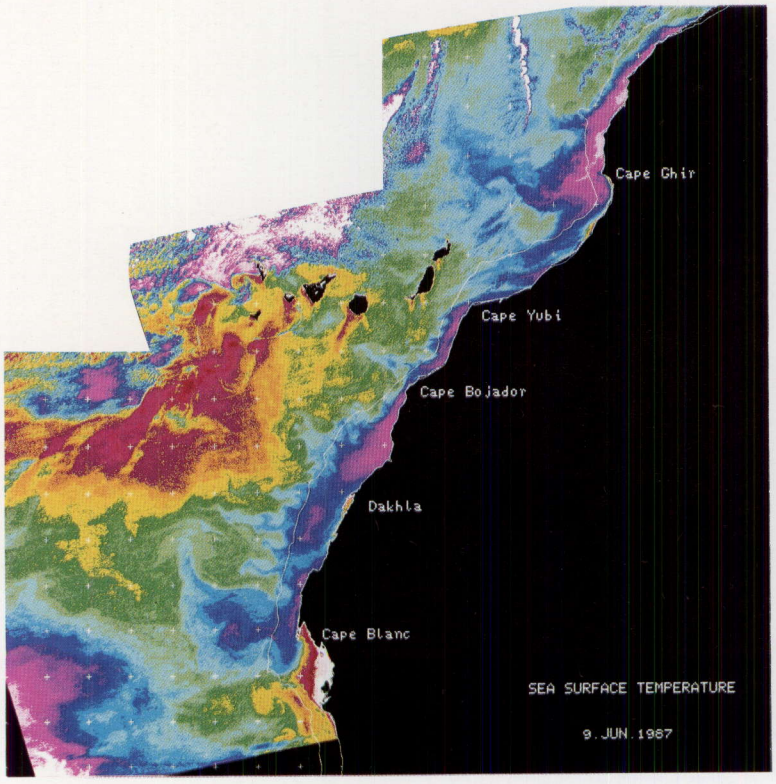
The transient 3-dimensional hydrodynamic circulation model of the Adriatic Sea was implemented on the Amdahl 5050 computer as far as the inclusion of the passive constituents.

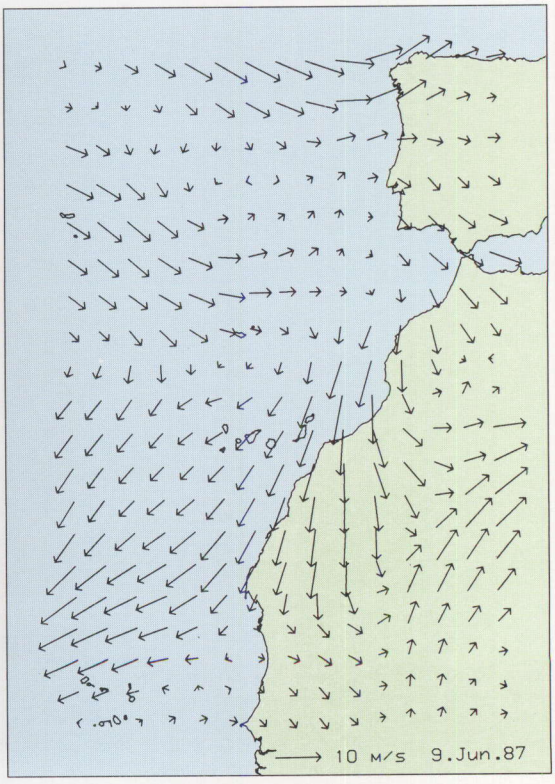
Optical and in-situ measurements of yellow substances and chlorophyll in the German Bight have been analyzed. The results will be compared with airborne scanner data and LIDAR measurements.

For the study of the West African coastal upwelling, maps of chlorophyll-like pigment concentrations and sea surface temperature derived from CZCS and AVHRR historical data from US Nimbus-7 and NOAA satellites have been compared with past conventional measurements at sea. These measurements have led to a description of the large scale seasonal oceanographic variations at the sea surface of Northwest Africa. Special attention has been paid to quasi-permanent plumes representing local fluxes of biological production from the upwelling shelf into the open ocean, which were practically unknown until now.

Figure 94: Sea surface temperature map, derived from remote sensing AVHRR data, of the northwest African upwelling area for 3 June 1987, and the map of the wind field for the same day. Coastal upwelling characterised by low water temperatures, is caused by the trade winds persistently blowing towards the equator

For a temporal description of the upwelling in 1987, bi-monthly AVHRR images and relevant meteorological daily data were collected and processed. The necessary procedures were derived for processing AVHRR images to geometrically corrected maps of sea surface temperature. The final software will be developed under contract as part of the ERDAS software system. The procedure and the software will be available for other users.





Advanced techniques

Within the project "Development of Laser Fluorosensing Techniques", the final configuration of the airborne fluorosensor has been laid down by the contracting company and a large part of the apparatus has been assembled, using a mode-locked Nd-YAG laser base on a single oscillator configuration. This laser is capable of operating at a 10 Hz repetition rate, providing light at 355 nm for oil fluorescence excitation and at 532 nm for chlorophyll measurement. In this technique a laser beam is used to induce fluorescence in thin films of organic substances on the surface of water. Characteristics of the fluorescence permit the identification of the substance and the measurement of the film.

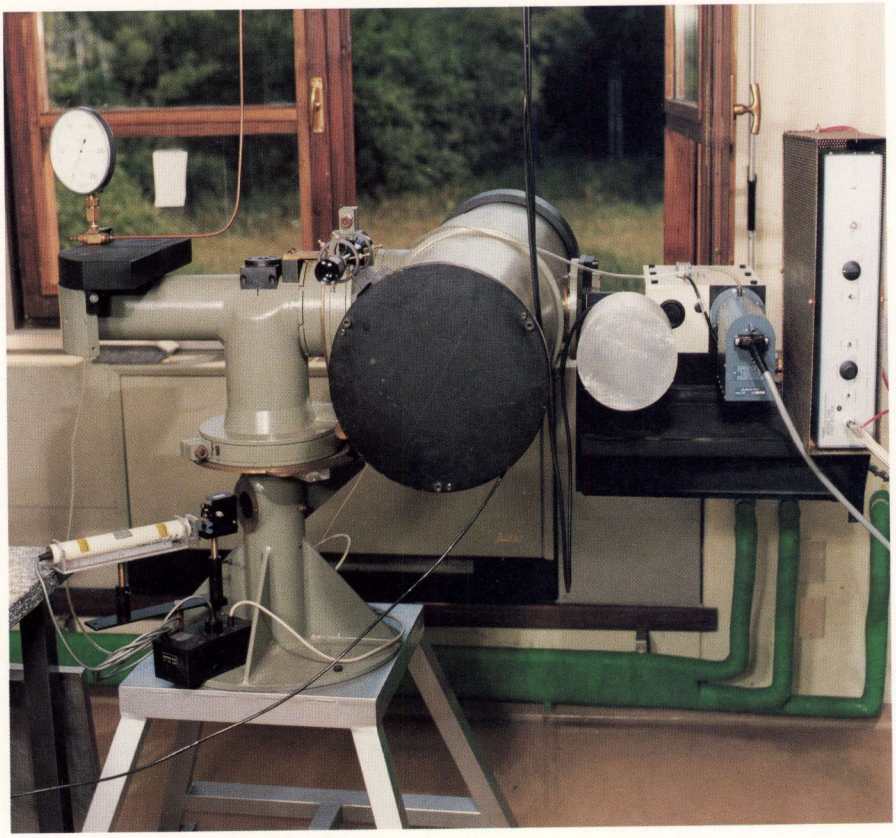


Figure 95: A remote sensing simulation facility developed at the JRC Ispra, for remote spectral and time characterisation of laser induced fluorescence

A system was devised at Ispra to reproduce calibrated oil films for testing the fluorosensor. This has allowed us to verify the feasibility of measuring the thickness of oil films by fluorescence using two excitation frequencies. Inconclusive results were obtained by the "water Raman attenuation" method due to non-reproducible and unpredictable spreading of the oils under test on the water surface.

The remote sensing simulation facility has been upgraded to match as far as possible the performance of the airborne fluorosensing apparatus. Following the implementation of a streak camera for the multispectral temporal analysis of the fluorescent pulse, the presently available laser source was modified to narrow the pulse width to 0.5 ns.

A meaningful correlation of oil fluorescence efficiencies with various parameters of the fluorescence, such as decay time and spectral characteristics, was obtained for a representative number of crude oils. Normalization against calibrated measurements on a standard (quinine bisulphate) allowed the spectral conversion coefficient "to be obtained".

A formal agreement has been established with three Italian Departments (Environment, Merchant Navy and Civil Protection) aimed at cooperative field-testing of the airborne fluorosensor. As a first step of a testing programme ranging from ground-based to in-flight conditions, a project has been drawn up for the operation of the laser fluorosensor as a mobile unit installed in a van.

A market study for the airborne fluorosensor done by a Dutch contractor, revealed considerable interest in the JRC instrument among sea water surveillance bodies in Europe. They particularly expressed interest in using the fluorosensor for scientific studies preliminary to the development of operational systems, for monitoring such things as chlorophyll and chemical pollution.

The "Microwave Remote Sensing" project was started in 1987. Three preparatory steps, were initiated: signature research, airborne experiments and demonstration projects. Most of the work was performed under contract.

Two studies in signature research were placed with leading European research institutes. Both concerned the analysis of the major scattering centres of plants. Small coniferous trees were selected as model targets. The studies produced a number of new results which will have a considerable influence on future modelling of the interaction of the electromagnetic wave target, in future signature measurements, and in the interpretation of radar image data.

The airborne experiments, came in two major parts. One was the continuation of the AGRISAR 86 experiment. After a quality check of the images it was decided to reprocess most of it in order to provide the users with reliable inputs for their investigations. The preliminary results were presented during a workshop at the end of the year. The positive reactions resulted in a recomandation that the data evaluations be continued.

Figure 96: Ground data being collected at the Feltwell (UK) Test Site for the AGRISCATT Campaign. Comprehensive and well documented ground data are essential for signature research and for EURACS

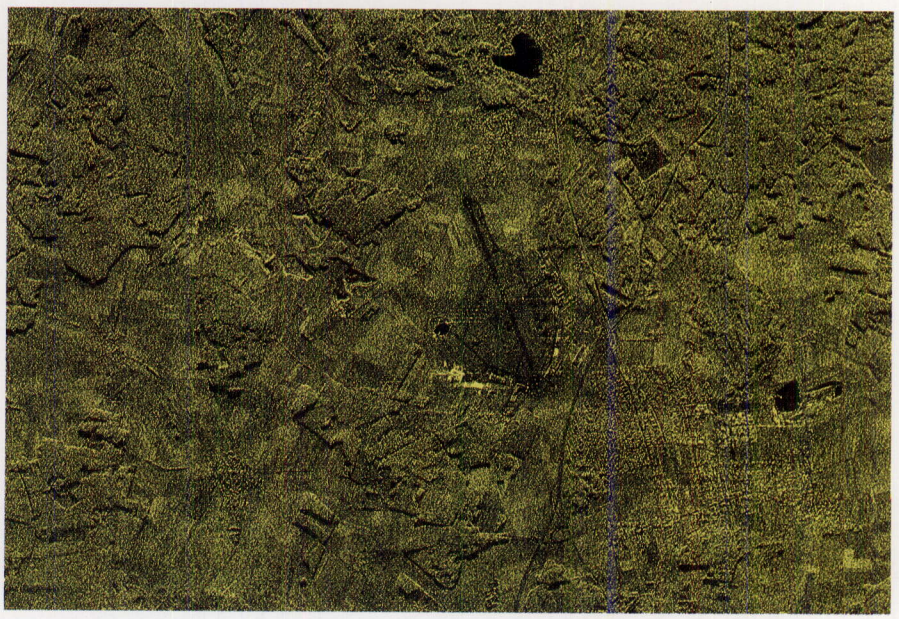


Figure 97: An X-band airborne synthetic aperture radar image acquired with the French VARAN-S system for the AGRISCATT Campaign. The image is of the Oberpfoffenhofen Test Site in Germany. The DFVLR airfield is shown in the centre of the image

Considerable effort was put into the joint ESA/JRC AGRISCATT campaign and flights were made over four European agricultural sites (essentially the same as for AGRISAR) with one scatterometer and Synthetic Aperture Radars. The JRC participated in this airborne experiment by developing, together with external experts, a catalogue of standard ground data parameters to be collected in parallel with the flights. A number of contracts were placed which assured the requisite collection of ground data. The data quality is now being evaluated.

To transform these efforts into a useful tool for microwave remote sensing, the JRC also initiated a first attempt to create a radar cross section database, EURACS. This data set will contain standard ground parameters as well as calibrated, verified radar cross sections. This was a first feasibility study on the structure of such a database.

The third activity was the preparation of a demonstration project within the US/German-Italian SIR-C/X-SAR Shuttle experiment. The proposal is placed by the JRC within the framework of the planned ERS-1 pilot-project. The selected application was to forestry.

Table 5: National and International Projects in the Collaborative Programme for LFA

Title of the project	Area	Institute responsible and collaboration
Management Models using Remote Sensing and GIS in Land Use and Forestry	Denmark, Greece and France	Bureau of Land Data, Vejle Denmark, France, Greece, Ireland.
Land Use monitoring (forestry, grass-land)	Central Ireland	University College Dublin, Trinity College Dublin et al.
Land Resources Management in Uplands	Northerm Wales, UK	Institutes and Agencies in Wales - Institute for terrestrial ecology, Bangor, UK.
Soil Water Management for agricultural area	Netherlands, Greece, France	Institute for Land and Water Management Res. Wageningen, Netherlands, France, Greece
Development of Land Information System using SGEOS (forestry, grassland, agricultural land use)	Transitional test-site Ardennes-Eifel-Limburg-Lorraine-Luxembourg	Eaux et Forêts/CEPS-INSTEAD, Luxembourg, Germany, France, Belgium and Netherlands
Remote Sensing and Agrohydrology	Famenne southern Belgium	Lab. d'Hydraulique Agricole, Gembloux - B.
Identification of ecological-economic changes in fragile mountain zones	Central France	CNRS Paris, France
Study by RS of the effect of decline in agriculture and natural environment in Uplands	Central France	RS Unit, Ministry of Environment, Neuilly, France
Inventory of Vegetation Coverage and soils	Ardèche, France	Ministry of Agriculture, Paris, France
Development of and operational model for crop inventory and land potential	Tuscany, Italy	IATA, Florence, Italy
Use of physical socioeconomic indicators for less favoured areas buy the use of SGEOS data	Puglia, Italy	Aquater, S. Lorenzo, Italy
Information system for land use planning using SGEOS data	Axios plain, Northerm Greece	School of Agriculture, Thessaloniki, Greece, France, Uk.
Land Use in LFE (stress due to moist cond., olives, cereals, heathlands)	Messina province, SW Peloponnes, Greece	Laboratory of Geography, University of Athens, Greece Greek Institutes and organisations, France, UK, Belgium.

Industrial Hazards

The Industrial Hazards research programme has been better defined. These activities complement the shared-cost multiannual programme in the field of Major Technological Hazards and support the regulatory actions of DG XI within the frame of the EC directive on "Major Accident Hazards of Certain Industrial Activities".

Accident Prevention

The Benchmark Exercise on Major Hazards Analysis (BE-MHA), which aims to compare risk studies independently performed by different expert teams on the same subject, has been finalized. The BE-MHA aims at establishing a state-of-the-art review of procedures, methods, models and databases for risk analysis of chemical facilities; at assessing corresponding uncertainties and limitations and at contributing towards common approaches for analysis. The subject was an ammonia storage facility with under sea and underground pipelines connecting it to a sea terminal and to in-plant storage facilities.

The project is partly funded by the shared-cost multiannual action programme (DG XII) on Major Technological Hazards, by DG XI (Environment, Consumer Protection & Nuclear Safety) and by the JRC. The JRC ensures the coordination of the project and will perform the evaluation of the results (expected by mid 1989).

The project involves 13 European teams representing about 20 organizations from 10 European countries and belonging to industry, governmental bodies, research institutes and specialized consultant groups.

Whereas industrial and research bodies such as SNAM Progetti (I), ENICHEM (I), and GRS (FRG) showed interest in the informatic tools already developed for reliability analysis, significant progress has been achieved towards the

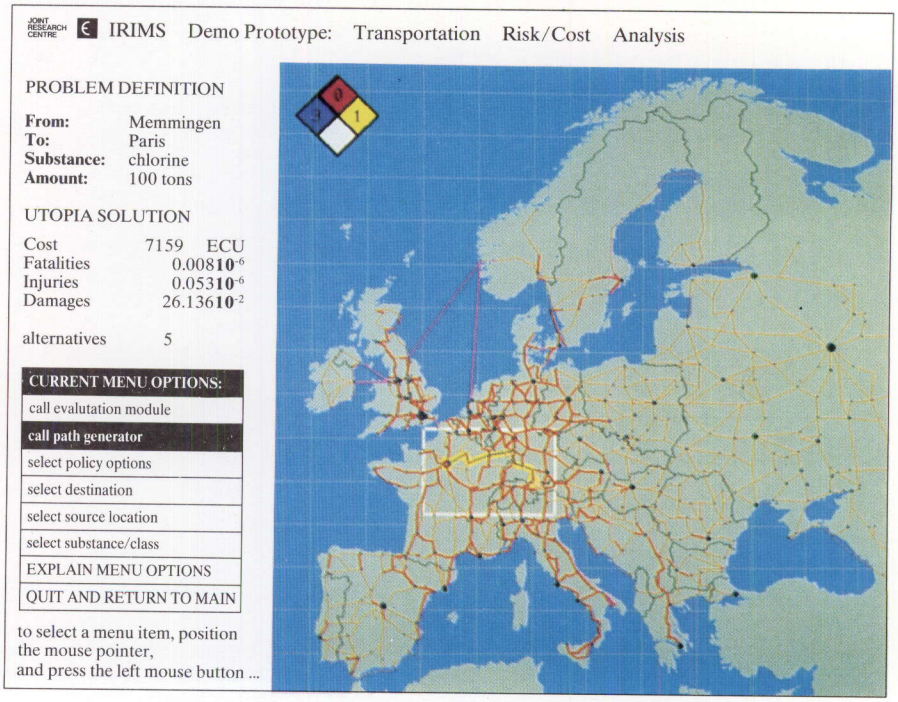


Figure 98: Ispra Risk Management Support Systems (IRIMS); an example of data output describing the road network in Europe and generation of different paths from Menningen to Paris. The cargo transported is 100 tons of chlorine whose HAZCHEM code can be seen in the left top corner of the map

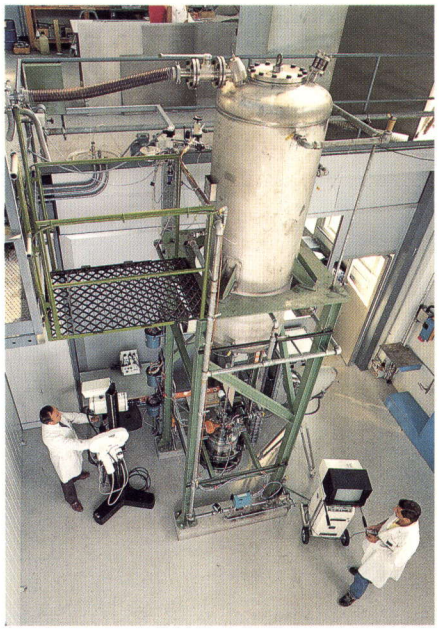


Figure 99: A small scale multiphase - multicomponent fluid flow test facility installed at the JRC Ispra

development of an expert system, STARS (Software Tool for Advanced Reliability and Safety analysis), in collaboration with RISO (DK) and towards tools based on the DYLAM (Dynamic Logic Analytical Methodology) approach for evaluating incident scenarios.

The MARS (Major Accident Reporting System) accident database is fully operational in agreement with DG XI in accordance with the Seveso directive. Accidents reported by the Member States have been recorded, and their analysis has begun.

In collaboration with the Dutch Ministry for environmental affairs, the integrated Ispra Risk Management Support (IRIMS) software system is being developed to produce comparative risk scenarios for the production, transport and use of chlorine in the Netherlands. The system now includes a 3-dimensional model allowing risk analysis for heavy gas diffusion and crisis management.

Accident Mitigation and Control

JRC research activities on the chemical and thermodynamic behaviour of runaway reactions include, the construction of the experimental facility FIRES (Facility for Investigating Runaway Events Safety). The facility is mostly intended to validate specific numerical codes for control of industrial chemical processes, such as polymerization and nitration, and to assess early warning systems. FIRES consists of standard chemical reactor (100 litres, provided for pressures of 16 bar) housed in a bunker, with control and data acquisition systems and auxiliary equipment. Bunker basement, chemical laboratory and control room have been built, while reactor and auxiliary equipments are ready for installation.

Complementary research in multiphase-multicomponent (MPMC) fluid flow has been performed by the improved small scale MPMC-facility. This has included phenomenological studies on the influence of geometry and physical properties on two-phase fluid flow regimes, depressurization tests and parametric studies to assess the application of the SAFIRE code on predicting flow behaviour inventing systems.

Collaboration with the DIERS (Design Institute for Emergency Relief Systems) users group has been continued with the analysis of the DIERS group's improved SAFIRE code.

JRC activities on runaway reactions are discussed and reviewed by the European Contact Group on Runaway Reactions which includes industrial partners (Rhône Poulenc and Roussel UCLAF (F), Hoechst (FRG), ICI (UK), DSM (NL) and governmental and research institutions (University College-Dublin (IRL), TNO (NL), ENEA-DISP and University of Pisa (I), HSE and Polytechnic of the South Bank- London (UK).

EXPLOITATION OF THE HIGH FLUX REACTOR

In 1987 the reactor routine operation was uneventful apart from a minor incident with an isotope production facility which resulted in the loss of two days reactor operation.

Routine maintenance of the reactor and modification activities (including the upgrading of the new primary heat exchangers) were carried out in the main stop periods in March/April and July 1987. Other general activities such as assembly, testing and commissioning, operation, dismantling, neutron radiography, etc., which are connected with HFR irradiation projects, progressed in the normal way.

During 1987 the HFR supported research and development programmes of amongst others KFA Jülich (FRG), KWU Erlangen (FRG), KfK Karlsruhe (FRG), ECN Petten (NL), Interatom (FRG), IRE Fleurus (B) and CEC programmes. The individual projects were in a number of important areas, such as:

- Safety aspects of nuclear fission energy.
- Irradiation of materials for controlled fusion applications.
- Neutron activation analysis for geological and environmental studies.
- Fundamental research with neutron beams.
- The production of radioisotopes.
- Non-destructive testing by neutron radiography.

Activities of the HFR programme may be highlighted as follows:

- Among the various irradiations performed in the HFR, one experiment is in support of the High Temperature Gas Cooled Reactor (HTR) and concerns the long term irradiation of instrumented HTR spherical fuel elements. In 1987 the experiment completed 600 full power days and the accumulated data, unique for the HTR designer, include measurements of temperature fields as a function of neutron fluence and burn-up for spherical fuel elements.

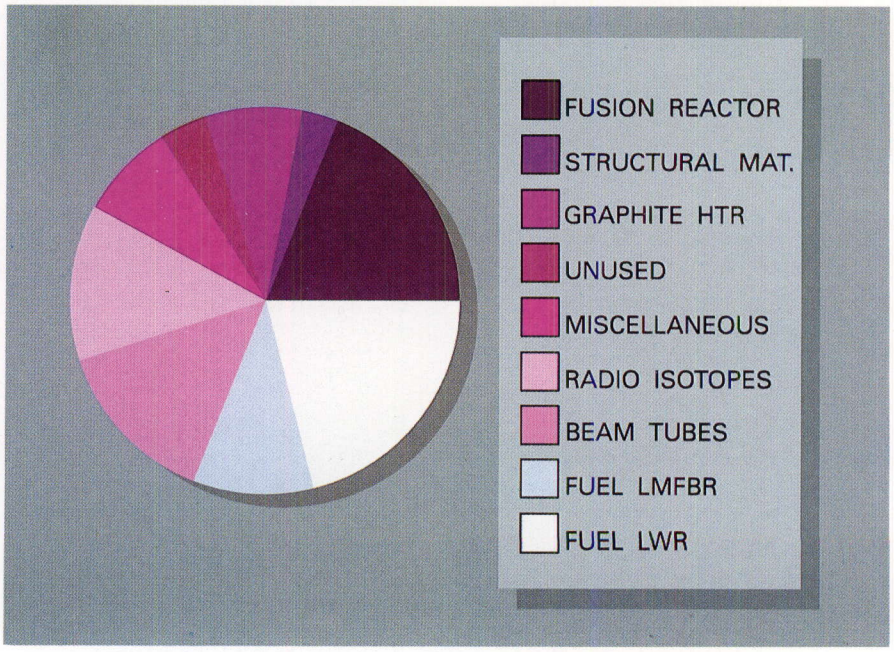


Figure 100: HFR Utilisation - theoretical percentage HFR occupation based on a tariff for the period 1986-1990

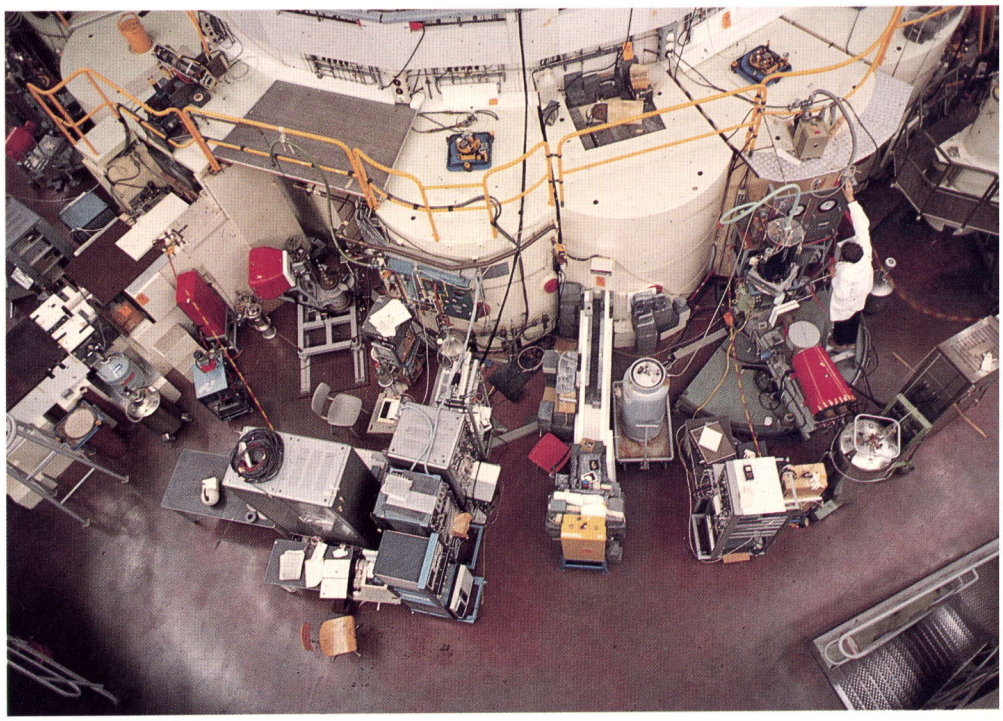


Figure 101: View of some of the experimental equipment situated around the reactor pool, in use for irradiations in the HFR

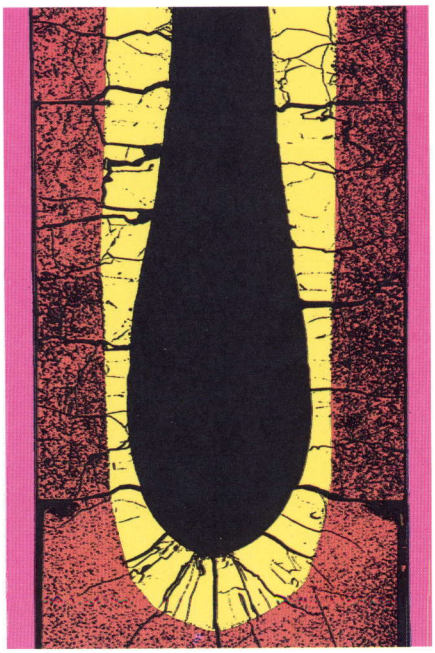


Figure 102: Detail from an Epithermal neutrograph of mixed oxide fuel pins in the HFR experiment POTOM, indicating melted fuel region

Also in the frame of the German HTR development programme another irradiation carried out in the HFR studies the behaviour of graphite designed for use in the HTR reflector. The target fast neutron fluence of $2.6.10^{22}$ cm^{-2} (EDN) was reached during the year,following a total irradiation time of about 4 years.

Two other irradiations belong to the group of experiments within the Fast Breeder Reactor (LMFBR) programme. The first experiment, named RELIEF, consisted of six months of irradiation and four special transients simulating operational transients in a typical LMFBR. The experiment is equipped with a specially designed (and patented) sensing system, consisting of a concentric series of miniature steel bellows which are adjusted by gas pressure, such that the fuel and cladding displacement of the fuel pin can be measured during a transient. It is intended to demonstrate that the effect of the fuel displacement on the reactivity of the reactor is less severe than anticipated in conservative safety analyses, hence giving "relief" to reactor operators.

The second experiment, named POTOM, is the fifth in series of short irradiations which deliberately cause partial melting in the fuel. The aim of the experiment is to determine the linear fissile power at which fuel melting first occurs and also to study the effect of continued operation with melted fuel. For the latter, it was successfully demonstrated by the irradiation of 2 partially melted fuel pins (melting confirmed by neutron radiography) for one whole reactor cycle that the continued irradiation of a partially melted fuel pin would have no detrimental effect to the continued operation of a power reactor.

The LWR irradiation programme of the HFR primarily addresses fuel irradiation experiments with pre-irradiated fuel rod segments (pre-irradiated in commercial power reactors).

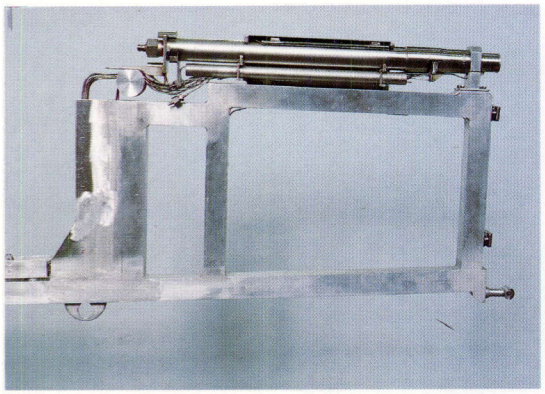


Figure 103: In-pile section of an ISOLDE radiation device for the HFR Petten

The major topics of LWR fuel irradiation experiments completed in 1987 or continuing in 1988 are: power re-ramping for the investigation of the postulated memory effect, extended burn-up behaviour of MOX fuel rods, power ramping behaviour of BWR fuel rods (and subsequent return to a power reactor for additional burn-up accumulation), power ramping behaviour of PWR fuel rods having standard and/or advanced design, transient fission gas release and iodine release under simulated in-pile loss-of-coolant accident (LOCA) conditions.

The previously mentioned iodine release experiment (ISOLDE), which had a high priority in 1987, is now approaching its final stage and the planned test series will quantify under controlled conditions the iodine release from a fuel rod damaged by over heating during the course of a LOCA. The tests were initiated by the findings in connection with the "Three Mile Island" accident, which led to an iodine release into the biosphere which were orders of magnitude lower than expected.

- In the field of controlled fusion reactor development two projects should be reported. One experiment, which was started in 1987, will provide the first irradiation data for a liquid breeder material. A part from tritium extraction methods, rates of tritium permeation through reference wall material are being studied using an existing out-of-pile installation (Tritium Measuring Station).

  In the frame of another irradiation dealing with superconducting material, the recently developed "high temperature" superconducting material $YBa_2Cu_3O_7$ has been irradiated in the HFR. This is to our knowledge the first time in the world that this has been carried out. First measurements show that the most interesting material properties, i.e. critical temperatures and critical current density, are not noticeably altered by a fast neutron fluence of between 10^{16} and 5.10^{19} cm^{-2}.

- In 1987 the production of radioisotopes increased. For example 224^{235}U targets (compared to 183 in 1984) were irradiated and transported to the customer for reprocessing. The objective of these irradiations is the recovery of 99Mo for the manufacture of tracer radioisotopes for medical applications. New promising contacts were made with other interested organisations in Belgium, Hungary and the United Kingdom.

- With respect to the industrial use of non-destructive testing of materials by neutron radiography (scheduled to start in 1988/89) an essential extension towards subthermal neutrons of the existing beam tube facility ILONCA was completed.

- The average utilization of HFR reached 84% of the practical limit of occupation.

The large number of existing irradiation projects will ensure a high occupation of the HFR in 1988 and in the following years.

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SCIENTIFIC AND TECHNICAL SUPPORT TO OTHER COMMISSION SERVICES

SCIENTIFIC AND TECHNICAL SUPPORT TO COMMUNITY POLICIES

The JRC scientific and technical expertise is made available to various Commission departments for the formulation and the implementation of Community policies. This scientific and technical support covers several types of activity:

- theoretical studies or laboratory work
- assistance in management of research projects or contracts
- scientific and technical expertise and elaboration of elements of Council directives or recommendations.

During 1987, these activities are representing only 3% of the annual turnover of the JRC; this share is nevertheless foreseen to be increasing in the future.

An illustration of this support to the various Community policies is given in figure 3.

The most significant achievements of 1987 are briefly mentioned in the next pages.

General Support to Cooperation and Mutual Assistance in Case of Disaster

The JRC Ispra assisted the General Secretariat in preparing a communication by the Commission to the Council in the field of Civil Protection.

The JRC is also providing technical assistance for the preparation of the VADEMECUM of Civil Protection in the European Community and the set up of the inventory and the interconnection of data banks on natural and man made disasters in the European Community.

JRC Support for International Cooperation and for Development

Nuclear Safeguards

In the framework of the political and technical cooperation of the Com-

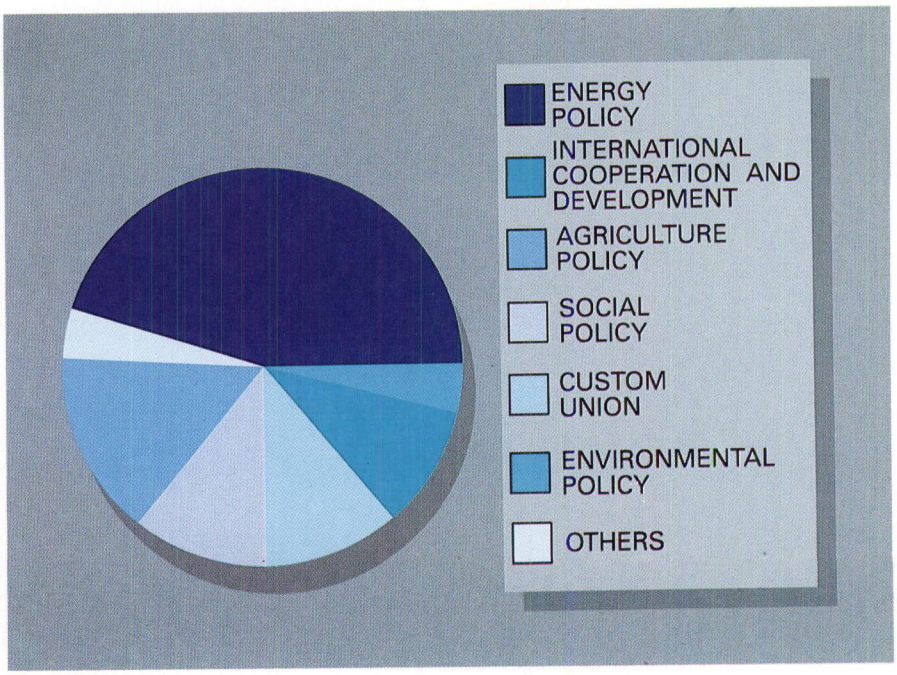

Figure 104: A percentage breakdown of the total JRC support to the Community policies

munity with the IAEA, an increasing effort has been dedicated to technical assistance to the IAEA Safeguards Department, in the harmonization of techniques and procedures of potential use in safeguarding the nuclear fuel cycle.
Training courses for IAEA inspectors have been organised in the PREPERLA facility.

Upwelling off the coast of northwest Africa

The JRC has improved the understanding of the upwelling phenomenon off the NW African coast by the analysis of satellite data. The sea surface temperature has been processed from bi-monthly satellite images together with daily meteorological data. Spreading plumes and eddies that were practically unknown until now in this area were demonstrated. The methods developed are very promising in improving monitoring and understanding of the interactions between oceanography and biological activities, necessary for the management of the living resources.

Remote sensing and desertification in Sahelian countries

The JRC Surveillance Project (Surveillance des Ressources Naturelles Renouvelables en Afrique) has continued in the frame of the project "Monitoring dynamics of desertification at the boundaries of Sahara using remote sensing techniques".

Satellite Data Archives

Current research on the vegetation dynamics of West Africa makes intensive use of time series of satellite data; low resolution data are used. Limited series of "AVHRR" data from the weather satellites NOAA-7 and NOAA-9 currently available at the JRC will be completed through the acquisition of the longest existing archive covering West Africa. The temporal sequence of vegetation index measurements over selected sites will be used for monitoring the seasonal evolution of vegetation during the 1981-86 period in order to establish relationships between such dynamics and weather conditions during the corresponding periods.

Three vegetation dynamics are under investigation.

- assessment of rainfed crop production in Sud-Sahelian Africa
- assessment of environmental degradation in the headwaters of the Niger Basin
- evaluation of transformations taking place at the interface between forest and savanna in the southern part of West Africa.

JRC Support for Social Policy

Biological Monitoring and Occupational Exposure to Chemicals

In the series, Industrial Health and Safety, a fourth volume was issued (EUR Report No. 11135 EN). It contains five monographs: ENDRIN, ALDRIN &DIELDRIN, ARSENIC, VANADIUM, COBALT.

Renal insufficiencies and trace metals

Recent studies suggest that trace metals (TM) could be responsible for symptoms of uremia. Moreover, neurological disorder can be caused by aluminum in uremic patients on hemodialysis. A recent EC resolution is aimed at limiting the risks of aluminum exposure to patients. The objective of the work is to study possible imbalances of other trace metals in body tissues of uremic patients and their effect on health impact, in collaboration with renal units of European hospitals.

JRC Support for the Common Agriculture Policy

Sugar addition to wine

Two types of activity can be mentioned:

- Scientific expertise: evaluation of the technical and research work performed under contract by some European laboratories on the detection of sugar addition to wine (chaptalization).
- Laboratory work: detection and determination of natural contents of glycerol, fructose and glucose or added methanol and diethylene glycol.

Scientific support to the management of integrated plant protection

The objective of the work is the improvement of integrated plant protection activities through the implementation of the DG VI research programme for the period 1984-1988.

The activities included the management of common actions under contract and the organization of several meetings.

Application of remote sensing in agriculture

At the end of 1986 the Directorate General for Agriculture and the Statistical Office approved the conclusions of an expert group which strongly recommended to study further the applications of remote sensing to agricultural statistics. The JRC is responsible for the project, which is described on table 6.

Table 6: Outline of the Agriculture Project

Action	Method	Geographic Localization	Input	Accuracy Statements
1. Regional inventories (acreage)	Regression estimate	5 selected administrative regions	High resolution satellite data	Precision of the regression estimate
2. Vegetation conditions and yield indicators	Spatial or temporal comparison of V.I. and TS (integrated indexes)	Selected regions and sampling of sites for the first two years then all of Europe	Low resolutions satellite data (mainly AVHRR)	Comparison with conventional methods
3. Models of yield prediction	• Improvement of actual agromet models - better repres. of stations - improving the data • Integration of satellite. data in agromet models • Deriving agronomic parameters (ETR) • Direct relationship		Low resolution satellite data High resolution satellite data. Meteorological data	Comparison with conventional methods. Control on the 50 sites for annual crops and complementary one for permanent crops
4. European rapid estimates of acreages and potential yield	Computer-assisted photo-interpretation	Sampling of some 50 sites through Europe	High resolution satellite data	Assessment by specific sampling surveys on the 50 sites
5. Advanced agriculture information system	Integration of all available results	Sampling of some 50 sites through Europe and selected regions	All data available	Economic comparison between methods
6. Area frame sampling and associated surveys	Stratification-segmentation-sample-surveys with farmers	Whenever it is needed, mainly on 5 regions and 50 sites	Satellite imagery to build area frame	Accuracy statements of inventories
7. Long-term studies	• Using new sensors with the preceding methods • GIS-expert systems		New satellite data (microwave, etc.) New analysis methods (expert systems, GIS, etc.)	Comparison of results or timeliness.

JRC Support for Environmental Policy

The JRC has set up the European Inventory of Commercial Chemical Substances (EINECS), which lists all chemical substances put on the European market before October 1981. This inventory is essential for the application of the sixth amendment to the EEC Directive on dangerous substances (EEC/67/548). A major milestone was reached with the publication of the final English version of the inventory. In 1987, the major achievement was the opening of the on-line version of that inventory. This version, loaded on the Ispra main computer, is available by telephone line to the competent Commission services and the Member States contact points. Through EINECS on-line it is possible to retrieve many kinds of data on the reported chemicals.

The Central Laboratory for Air Pollution, set up for the implementation of the EC 80/779 directive on limits and guidelines for SO_2 and suspended particulates, continued its mission with the check of station instruments in Italy and Greece.

JRC Support for Energy Policy

Energy Bus Programme

JRC Ispra collects and disseminates technical information and provides technical advice to the Community Energy Bus Programme.

Demonstration projects concerning photovoltaic (PV) energy

The activities planned for 1987 in support to the management of the PV demonstration programme have been carried out as scheduled, these activities include.

1. The monitoring of systems: Operational data of several projects were analyzed:
2. The stimulation of the activities of the European Working Group on PV-Plant Monitoring.
3. The issuing of the PV Monitoring Newsletter. This Newsletter is an important tool for the release of information concerning demonstration projects in the PV Community.

4. The prototype of a portable monitoring was assembled and successfully tested.
   In addition to these activities, progress reports on the ongoing projects were reviewed and assistance was provided in the selection of new projects.

Safeguards

This includes two types of activities, in 35 specific tasks performed by three JRC establishments:

1. One category of "continuous" activities for the Euratom Safeguard Directorate concerns assistance in radioprotection, the chemical analysis of samples taken by inspectors and the maintenance of JRC developed instruments.

   During 1987 the JRC laboratories performed nearly 2000 analyses of the chemical and isotopic composition of nuclear materials. JRC Geel continued to work on the quality control of safeguards analysis performed in analytical laboratories.

2. A second category of specific activities, generally limited in time, concerns the field testing and calibration of instruments supplied to the inspectorate. The following results were obtained:

   - Optical Surveillance and Monitoring techniques.

     An instrument was delivered to the Safeguards Directorate for archiving images of metal seals on laser disc and for computerised image recognition.

     An automatic system for monitoring liquid level in twenty-four plutonium nitrate storage tanks was cold tested at Ispra and in a nuclear facility.

   - Destructive Analysis Techniques

     Support was provided to inspectors in four fuel fabrication plants for performing destructive analysis of uranium samples, using mass spectrometry and potentiometry.

   - Non Destructive Analysis Techniques

     The following instruments were developed and made available to the inspectors

     an assay system for small samples of low-enriched uranium powder and pellets, based on the delayed neutron technique.

     an instrument for the determination of plutonium in bulk quantities, based on neutron colleration technique.

   - Data Management and Evaluation.

     For each measuring instrument developed for the Inspectorate, interactive microprocessors or personal computers were developed with the appropriate software for in-field data evaluation and possible headquarters validation.

     Extensive theoretical support was given to the interpretation of data obtained from neutron detection instruments on a variety of uranium and plutonium samples.

     The transmission of encrypted accountancy data via telephone line is being tested between Ispra and Luxembourg headquarters.

Furthermore twelve training courses for inspectors were organized, mostly for application of gamma spectroscopy and neutron measurements of uranium and plutonium samples.

JRC Support to the Customs Union

Analysis of imported goods

Two types of support are furnished to the Customs Union

1. Technical assistance for the implementation of EEC Regulation 2340/86 concerning chemical and biological substances.
2. Identification of the chemical and structural composition of products for which this is unknown or not well defined, and for which it is difficult to apply a correct customs tariff.

Import of scientific instruments

Scientific support is given to help determine whether imported scientific and technical instruments should be duty-free.

Technical assistance has been given to the preparation of cases under review in the Court of Justice.

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ANNEXES

ANNEX A

PUBLICATIONS, ISPRA COURSES, APPLICATION OF RESULTS AND FAIRS

Publications

In 1987 the JRC published 796 papers. Table 7 gives the distribution of these publications among research programmes

Table 7: Distribution of JRC publications among research programmes

	EUR Reports	Conference papers	Public. in scientific journals	Special publications	Total
Nuclear Measurements, and Reference Materials	3	33	31	/	67
High Temperature Materials	3	32	5	/	40
Fusion technology and Safety	10	43	18	5	76
Reactor Safety	19	92	18	9	138
Radioactive Waste Management	4	19	13	5	41
Safeguards and Fissile Materials Management	3	24	2	6	35
Nuclear Fuels and Actinide Research	4	49	26	/	79
Testing of Solar Energy Systems	5	23	3	9	40
Energy Management in Buildings	/	3	1	/	4
Environmental Protection	8	69	27	2	106
Application of Remote Sensing Techniques	3	28	4	3	38
Industrial Hazards	6	19	14	6	45
Exploitation of the HFR reactor	2	9	2	/	13
Miscellaneous	8	35	8	23	74
TOTAL	**78**	**478**	**172**	**68**	**796**

An evolution of these publications during the 1984-1987 programme is illustrated in Fig. 4.

Ispra Courses

During 1987, 12 Ispra Courses were held, with a total duration of 59 days, in the following fields:

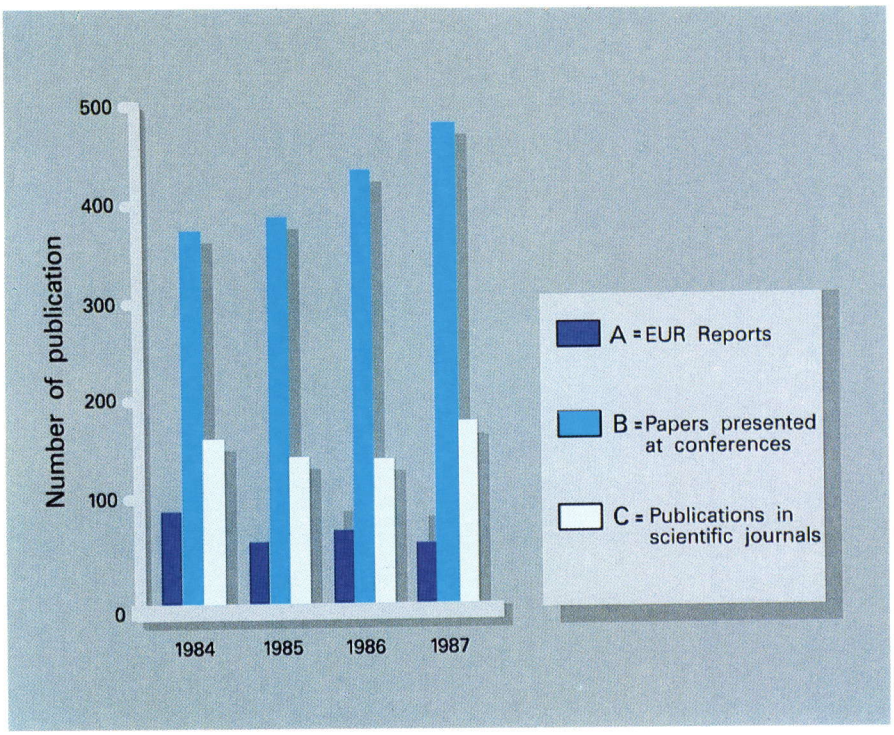
- Engineering and materials — 1 course
- Risk and Reliability Analysis — 3 courses
- Environment — 2 courses
- Health Physics and Radioprotection — 3 courses
- Remote Sensing — 2 courses
- Information Science — 1 course

Courses are commonly given in English with the exception of one course in Health Physics and Radioprotection which was in Italian.

Courses are generally organized at the Ispra site with the exception of

- one of the courses in Health Physics and Radioprotection held in Madrid in collaboration with the Universidad Tecnica de Madrid;
- The course in Information Science, held in Patras (GR) in collaboration with the Technological and Educational Institute of Patras.

Figure A1: A categorised evolution of the JRC publications (1984-1987)



The courses were attended by a total of 340 participants from Member States of the European Community, 26 from other States and 63 from the JRC or other services of the Commission.

The lectures were given by 135 lecturers from various organizations and universities, research institutes, and industry of the Member States of the European Community, and by 34 staff members of the Ispra Establishment or other services of the Commission.

Utilization of results

A programme to transfer scientific results achieved by the JRC to industry is being run in collaboration with DG XIII. This is summarised in Table 8.

Exhibitions and Fairs

In 1987 the JRC participated in various exhibitions in different countries, including the United States. As 1987 was proclamed the Year of the Environment, the main theme covered by the JRC exhibits was environmental protection and safety. Innovations in the field of informatics, marketable results from the development of new sensors (Lidar fluorosensor, new oxygen sensors) together with know-how in the application of remote sensing techniques, data bases and artificial intelligence were among the exhibits. A list of the events in which the JRC was represented with its own stand or as part of the EC stand is given in Table 9.

A particularly large number of visitors attended the JRC stand in Spain, where the EC presented its R&D programmes for the first time.

Table 8: Applications of JRC research Results, 1987

Project	Item	Achievement
MARK 13 A Process for Flue Gas desulphurisation	Testing of electrolytic cell elements for pilot plant	Improvement of the oil fired burner system and possibility of introduction of various cell types
GAS controlled Heat Pipe Furnace	Construction of a prototype	Production and testing of a computerized control system
Integrated Flange Sealing System	Testing of the System	Verification of tightness under different conditions
Identification by measuring surface texture	Improvement of the identification system	Tests on various kinds of surface marks after mechanical and electrical modification
Informatics (Dual Network)	Demonstration of the Dual Network	Exhibition in USA, Switzerland, Berlin, France
Electro-erosion to produce complex shapes	Improvement of commercial machine	Testing of a series of improved commercial type machines
Passive downward heat transport	Production of an Industrial Prototype	Improved thermal insulation. Construction of a prototype for mountain regions
Oxygen sensors	Improvement and testing of a new nonstichiometric oxygen sensor	Evaluation of the precision and rapidity of the measuring electrode in poor oxygen atmosphere
Superplastic Stainless Steel	Development of superplastic stainless steels	Improvement of the experimental systems for the evaluation of deformation of superplastic Stainless Steel
Absorption of Gases in Zeolites	Purification of gases	Testing the procedure by using test gases
Remote Handling	Testing of sealing components	Verification of tightness up to 10-9 Torr.
Antioxydants for plastics	Preparation of the material	Purchase of starting materials and solvents
Microinjection valve	Performance evaluation of the piezo-electric valve	Contract with outside firm not yet expired

Table 9: JRC Participation in fairs and exhibitions during 1987

Exhibition	Theme	Date
1. Hannover Fair	Environmental Protection (Atmospheric Pollution, Ispra, Mark 13A)	4-12 April
2. IPAF (Int. Pollution Abatement Fair)-Birmingham	Environmental Protection	7-10 April
3. First World Supercomputer Exhibition-Santa Clara (California, USA)	Informatics (Dual Network)	3-8 May
4. Grande Fiera d'Aprile - Milano	Safety and Environmental Protection	1-8 April
5. IFAT-Int. Trade Fair for Waste Disposal Munich	Environmental Protection (Air Chemistry)	19-23 May
6. Flanders Technology - Ghent	Environmental Protection (Indoor Air Pollution, ECDIN)	11-17 May
7. 5th Annual European Fiber Optic Communications And Local Area Network Exhibitions - Basel	Informatics (Dual Network)	1-5 June
8. TECNOVA - Madrid	Technologies for Safety and Protection of the Environment	14-20 September
9. A.I.T. - Parma	Remote Sensing	29 September - 2 October
10. AFVALTECH '87 - Ultrecht	Environmental Protection (Air Chemistry, ECDIN)	10-13 November

ANNEX B

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ANNEX C

GLOSSARY OF ACRONYMS AND ABBREVIATIONS

AVHRR	Advanced Very High Resolution Radiometer
BCR	Bureau Communautaire de Référence - Community Bureau of Reference
BIPM	Bureau International des Poids et Mesures
BRITE	Basic Research in Industrial Technologies in Europe
CATHARE	French Large System Thermohydraulic code
CBNM	Central Bureau for Nuclear Measurement
COST	Scientific and Technical Cooperation
DRUFAN	German Large System Thermohydraulic code
EAC	European Accident Code
ECDIN	Environmental Chemical Data Information Network
ECU	European Currency Unit
ESARDA	European Safeguards Research and Development Association
ESSOR	Experimental reactor (Ispra) - no longer in operation
ESTI	European Solar Test Installation
EURATOM	European Atomic Energy Community
EUROTRAC	European Experiment on Transport and Transformation of Environmentally Relevant Trace Constituents in the Troposphere (EUREKA project)
FARO	Experimental Facility for Fuel Melting
HFR	High Flux Reactor (Petten Establishment)
HTM	High Temperature Materials
IAEA	International Atomic Energy Agency
IRIMS	Ispra Risk Management Support
ISPRA MARK 13 A	Flue Gas Desulphurisation Process developed at the JRC Ispra
KFK	Kernforschungsanlage Karlsruhe (FRG)
LANDSAT	Earth Observation Satellite (US)
LMFBR	Liquid Metal Fast Breeder Reactor
LOBI	LWR off Normal Behaviour Investigation (installation)
LWR	Light Water Reactor
MIRAGE	Migration of Radioisotopes in the Geosphere
MOX	Mixed Oxide Fuels
NDA	Non Destructive Analysis
NEA	Nuclear Energy Agency (of the OECD)
NOAA	National Oceanic and Atmospheric Administration (US)
NET	Next European Torus
PAGIS	Performance Assessment of Geological Isolation
PAHR	Post Accident Heat Removal
PERLA	Performance and Training Laboratory (Nuclear Safeguards)
PETRA	Facility for Treatment of Radioactive Waste
PREPERLA	First phase of Perla Laboratory
PISC	Programme for Inspection of Steel Components
PSA	Probabilistic Safety Analysis
REIMEP	Regular European Interlaboratory Measurement Evolution Programme
SCK/CEN	Studiecentrum Kernenergie/Centre d'études nucléaires
UKAEA	United Kingdom Atomic Energy Authority
WHO	World Health Organization

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