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JRC

THE JOINT RESEARCH CENTRE

SCIENCE AND TECHNOLOGY FOR EUROPE

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The Joint Research Centre (JRC) is the scientific laboratory of the Commission of the European Communities. It is located on four sites, in Belgium, Holland, the Federal Republic of Germany (FRG) and Italy, where scientists employed by the Commission perform basic and applied research needed by a modern Community of twelve nations.

The Joint Research Centre was set up in the 1960s to fulfill a perceived need for nuclear research on a European scale. It has since developed a broad range of scientific expertise, as Europe's needs have changed.

The scientific, regulatory and administrative bodies of the Community are the JRC's main users. They are charged with boosting the competitiveness of European industry within an open market, and for this they need normative and pre-competitive research. The Community is also charged with providing science that must be done on a European scale: provision of reference materials and measurement techniques, database services, environmental observations, research on safety, and the dissemination of scientific capabilities throughout Europe.

The JRC is now undergoing a change. It will make its expertise and facilities more readily available to European industries and agencies of national governments. It is planned that a significant share of the research done by the JRC will be funded by such customers in five years time.

The aim of this brochure is to inform potential customers of the services, facilities and expertise at their disposal at Europe's Joint Research Centre. All enquiries for more detailed information are welcome.

THE EUROPEAN CONNECTION

European nations are among the world's most advanced in terms of scientific research.

The Joint Research Centre by virtue of its status as a European body, adds a further dimension to Europe's national research programmes:

1 The JRC is on one hand independent of local concerns, and on the other closely allied with the aims of the Community. This makes it especially suited to regulatory and normative research, aimed at opening the internal European market. It also provides an independent source of scientific expertise capable of dealing impartially with situations in different countries.

2. The JRC has a natural vocation for research on cross-boundary problems, such as those related to the environment or to risk analysis. It is also in a position to perform research that must, by definition, be international: creating standardised reference materials and measurement techniques, studying norms for industrial safety, performing the basic research needed for industrial harmonisation in Europe.

3. The JRC provides some research facilities that are so expensive , or specialised, that it is not practical to duplicate them in all the member states of the Community. It ensures that all member states have equal access to these facilities, while guaranteeing a long-term commitment to research considered to be in the interests of all Europeans.

5. The JRC trains researchers from every Member States of the Community, and fosters collaborations between national programmes; this will promote the development of a more integrated scientific community throughout the whole of Europe.

The JRC will continue to devote much of its activity to research needed by the European Commission. But the JRC will no longer be limited to this role. Its activities in the next decades will be based on the assumption that private companies, universities and agencies of national governments have interests that are on a European scale as well, and can best be served by research done by a European laboratory.

FOUR SITES

GEEL, ISPRA, KARLSRUHE, PETTEN

HOUSING NINE INSTITUTES

Central Bureau for Nuclear Measurements .... (Geel)

Institute for Transuranium Elements ...... (Karlsruhe)

Institute for Advanced Materials .... (Petten, Ispra)

Institute for Systems Engineering .... (Ispra)

Institute for Environmental Sciences .... (Ispra)

Institute for Remote Sensing Applications .... (Ispra)

Institute for Safety Technology .... (Ispra)

Centre for Information Technologies and Electronics (Ispra)

Institute for Prospective Technological Studies .. (Ispra)

ISPRA

The Joint Research Centre's Site at Ispra, 60 kilometres away from Milan in northern Italy, is the largest of the four sites. It houses the Institutes for Systems Engineering, Environmental Sciences, Remote Sensing Applications, Safety Technology, Prospective Technologies, the Centre for Information Technologies and Electronics as well as part of the Institute for Advanced Materials.

A partial listing of the major facilities available at Ispra, many of them unique in Europe, includes advanced testing and calibrating equipment for photoelectric cells and other solar installations; a large facility for studying materials under static and dynamic stress; a tritium laboratory; a cyclotron for irradiating test materials; an advanced informatics laboratory; large experimental installations for studying safety and process dynamics in nuclear and chemical plants; a simulator to test techniques for managing fissile material and other highly controlled inventories; a mobile laboratory for environmental analyses; a chamber for studying indoor pollution; a non-destructive testing laboratory; and a group devoted to technological forecasting.

Ispra prides itself on the flexibility with which its researchers can address themselves to new problems. It has moved from its previous primary concentration on nuclear research into a broader range of concerns. This flexibility will be an advantage, as Ispra increases the research it does for outside customers.

Ispra's annual operating budget is 155 MioEcu.

More than 1.800 people are working at the Ispra Site; 1.600 are officials or temporary agents of the Commission, the others being visiting scientists, grant holders (Fellowships from one to three years) trainees or staff from public or private sectors under temporary secondment.

GEEL

The Central Bureau for Nuclear Measurements is located at the Joint Research Centre's Site at Geel, which is 60 kilometres away from Antwerp in Belgium. It engages in the exacting business of making reference measurements and materials for the nuclear industry, and also for non-nuclear materials. The laboratory possesses two Van de Graaff particle accelerators and one electron linear accelerator (Linac).

The Linac provides intense bursts of neutrons which make it one of the most advanced machines available in Europe for the study of neutron-nucleus interactions. The Van de Graaff accelerators produce beams of hydrogen, deuterium or helium, for nuclear measurements and the assay of trace elements in various samples. This analytical tool is backed up by some of Europe's most accurate mass spectroscopy.

The laboratory has special skills in the handling of very thin films, such as those used in the semiconductor industry. It also possesses a modern facility for producing large reference samples of biological material.

Geel has an annual operating budget of 20 MioEcu; it employs 200 officials or temporary agents; more than 30 visiting scientists, grant holders or trainees are also active at this Site.

PETTEN

The Joint Research Centre's Site at Petten houses the Institute for Advanced Materials; there are three operational groups. The High Flux Reactor is designed for studies of the effect of intense radiation on materials.One materials division is devoted to the characterisation of materials under complex conditions of temperature, stress and corrosion, while a newly established group is concentrating on materials processing technology based on the exploitation of the Petten materials data base The Site is 100 kilometres north of Amsterdam, among the dunes of Holland's North sea coast.

The High Flux Reactor is one of the most advanced reactors in Europe for testing the effect of fast and thermal neutrons on materials. Besides experiments in the reactor, twelve horizontal tubes can convey beams of neutrons to experimental samples, for neutron radiography, activation analysis, diffraction, scattering, and capture. The neutron beam can be used for enhanced carbon dating of samples and accurate measurement of trace elements. There is also a gamma radiation facility and a service for producing radioisotopes.

The materials division at Petten possesses the most advanced facilities in Europe for studying the effects of corrosive environments, temperature and complex patterns of stress simultaneously on materials and components, metal or ceramic. Static and dynamic stresses can be imposed A wide range of analysis facilities provide quantitative materials characterisation.

Petten has an annual operating budget of 35 MioEcu . At the time being, 160 officials or temporary agents are working at the Petten Site; this number will be increased to 200 in the near future. More than fifteen visiting scientists, grant holders or trainees are also active at this Site.

KARLSRUHE

The Joint Research Centre's Site at Karlsruhe, houses the Institute for Transuranium Element; this Institute is pre-eminent worldwide in the study of actinides. It is located outside Karlsruhe, about 100 kilometres from Frankfort. The laboratory is equipped to safely handle highly toxic and radioactive materials, and to study the behaviour of such materials under extreme conditions.

Investigators at Karlsruhe perform detailed studies of fuel behaviour and waste management for the nuclear industry, and handle "problem" isotopes for any user. It is one of very few laboratories in Europe licensed to handle plutonium. The demands of studying conditions in nuclear reactors have led to expertise in observing materials, including alloys and ceramics, under extreme conditions of heat and pressure, and also to novel ways of handling materials, such as the use of acoustic energy for managing aerosols. The laboratory can employ the chemical properties of actinides to examine mechanisms of catalysis, magnetism and superconductivity and to study the electronic structure of materials.

The JRC in Karlsruhe has an annual operating budget of 20 MioEcu.

200 officials or temporary agents are working at this Site,where 15 visiting scientists, grant holders and trainees are also active.

EXPERTISE AT THE JRC

- Nuclear Safety
- Reference measurements and materials
- Advanced materials
- Reliability of structrures
- Environment
- Earth observation by remote sensing
- Fluid dynamics, heat transfer and industrial safety
- Information technologies and technological forecasting

EXPERTISE : NUCLEAR SAFETY

Europe is at a crossroad in its commitment to nuclear power. It must base its decisions on a clear assessment of the safety of nuclear technologies. Europe must also store, dispose of or recycle tons of radioactive materials. The JRC, even as it diversifies from its initial emphasis on nuclear research, intends to maintain the scientific expertise Europe needs to manage a safe nuclear future.

The Institute for Transuranium Elements in Karlsruhe has specialised in the study of actinides, and is equipped to perform detailed analyses on whole, irradiated fuel rods from power reactors. It has 21 "hot cells", encased workrooms impervious to radiation, in which samples with up to a million Curies can be handled by remote control. The laboratory is licensed to deal with plutonium, and can perform experiments on the physical and chemical properties of extremely toxic, radioactive material in some 600 glove-boxes.

The laboratory is developing mathematical models for predicting the performance of fuel rods, and can measure the vapour pressure of fuels up to 6000 degrees Kelvin, the diffusion and conduction of heat in fuels, their thermal expansion and optical emissivity up to 3000 degrees. Samples can be levitated, laser-heated, then splat-cooled at over a million degrees per second to enable the detailed study of fuel properties at high temperature.

The laboratory's particular expertise in actinides permits it to study in detail the migration of fission products in fuel, and in waste for storage. Spent nuclear fuel, including novel fuel mixtures, can be reprocessed experimentally, and researchers at the laboratory are studying the option of "burning" spent fuel and other high-level radioactive waste in fast reactors.

Facilities at Karlsruhe permit study of highly radioactive or toxic materials by light, electron and scanning electron microscopy, by electron-probe micro-analysis, and by x-ray diffraction. Photoelectron spectroscopy can be used to investigate the surface properties of materials, while changes in structure and properties can be measured at pressures up to half a million bars.

The valence state of various materials, such as glasses for disposing of wastes, can be analysed by x-ray absorption. The laboratory is a world leader in preparing highly pure, single crystals of actinides and their compounds for physical investigations.

At Petten, the High Flux Reactor is used to irradiate structural materials and fuels intended for fission or fusion reactors. The high flux exposes materials in a short time to an industrial lifetime of radiation, whereupon any changes in their properties, in areas such as creep, fatigue or crack growth, can be analysed. The response to irradiation of components for new reactor types, such as graphite and coated particle fuel elements, or steels intended for fusion reactors, are evaluated at Petten, as are the responses of fuel to simulated disturbances. Staff at Petten are particularly good at designing irradiation devices that can control the load of radiation and the environment, under which components must be tested.

At Ispra several major facilities for studying nuclear safety are available :

LOBI, built in collaboration with the Ministry for Science and Technology of the FRG, is designed to simulate loss-of-coolant accidents and transients in light water reactors. It can be used to study detailed thermohydraulics, including heat transfer and two-phase flow events, in various kinds of plants. The team has developed expertise in simulating processes in complex systems.

FARO (fuel melting and release oven) is a large-scale facility for melting up to 100 kg of uranium dioxide to simulate a wide variety of possible accidents in reactors. Several high temperature and high pressure test sections have been designed built and instrumented. Particular skills had to be developed in high temperature technology and in the design, calibration and testing of measuring equipments in a hostile environment.

PERLA is a laboratory for research on safeguards and the management of fissile material, from fuel production to waste disposal. Its aim is to apply laboratory results to real industrial environments. Among its services are the comparative calibration of instruments such as detectors that are used for measuring the fissile component of materials throughout the nuclear cycle. The team running PERLA has learnt to integrate a wide range of techniques to achieve this goal: advanced procedures of accountancy; techniques of surveillance, from seals on containers to automated video monitoring that includes pattern recognition; the computing, verification, and the training of personnel required to keep detailed track of a complicated and highly controlled inventory.

PETRA, the Plant for Evaluating and Testing of Radwaste management alternatives, is an installation specifically designed to simulate the handling of high-level and medium-level wastes and to devise treatments for waste that are safer and cheaper. The installation consists of three "hot cells", or processing areas for highly radioactive material, areas for decontamination, a pool for storing waste , and a "hot" workshop. Batches of up to six kilogrammes of uranium, in the form of irradiated fuel rods, can be treated in variations of the Purex process, and the type and amounts of materials that result can be processed using various storage materials. The computerised control system can be adapted to the needs of a variety of users. A full range of analytical facilities equipped for radioactive materials, is available.

ETHEL, the European tritium-handling experimental laboratory, will be ready at Ispra in 1990. Intended primarily for Europe's research on nuclear fusion, Ethel is meant to help designers and licensing authorities assess the effects of tritium on equipment, and to aid in developing new techniques for monitoring and handling tritium.

Other facilities for research on nuclear fusion are aimed at developing the Next European Torus and Europe's part in the international programme, ITER. Research is focussed on reactor design, development of structural and tritium-breeding materials, tritium technology and safety. Techniques used range from computer simulation to structural studies of stainless and manganese-chromium steels. Scientists at the JRC study possible accidents and the environmental impact of fusion, and issue a status report on fusion safety studies performed worldwide.

The various accelerators available at the JRC, including the two Van de Graaffs, and one linear electron accelerator at Geel and the cyclotron laboratory at Ispra, are suited for studying the response to radiation of materials destined for nuclear installations. The facilities can also be used to study non-nuclear applications of various materials. On all the JRC sites there are complete facilities for ensuring radiation safety, from accurate monitoring of exposure to radiation to the presence on-site of medical teams specializing in radiobiology and health physics.

Due to its active participation in the PHEBUS fission product project at Cadarache, France, JRC is acquiring new expertise in advanced experimentation and computer modelling of fission product chemistry and physics, internationally debated key issues of nuclear reactor safety.

EXPERTISE : REFERENCE MEASUREMENTS AND MATERIALS

Common norms and standards are one of the keys to opening the European market by 1992. The JRC has a role to play in doing the research needed to set up norms and standards. The JRC Unit particularly devoted to this task is the Central Bureau for Nuclear Measurements. Scientists at Geel obtain reference data, with very high precision, on radionuclide decay, actinides, and other nuclear reference materials. This is used to calibrate measuring devices, particularly in the field of nuclear safeguards.

The Community Reference Bureau, based in Brussels, stores standardised reference samples of industrial material, from quartz to plastic, at Geel. There they are cataloged and distributed. Geel is developing its ability to establish reference samples of non-nuclear materials as well. It has just acquired facilities to process large amounts of biological materials, which can then be characterised with extreme accuracy and used as references, for example for measuring trace contaminants. Research aimed at developing extremely accurate mass spectroscopy is a particular preoccupation at Geel.

Other work on standardisation is done at the JRC by the European Solar Test Installation at Ispra. ESTI calibrates and issues certificates validating photovoltaic elements for sale in Europe, and has extensive experience in dealing with confidential commercial contracts. It has the most advanced equipment in Europe for measuring the electrical performance and durability of solar cells and modules, under laboratory and field conditions, and can expose photovoltaic cells to intense lighting cycles to simulate the effects of ageing.

Ispra also possesses a passive solar facility, in which various solar components and building components and techniques intended to conserve energy can be tested in a standardised way.

The facility allows components to be tested not only for their effect on the flow of energy, but also for their total impact on comfort, including warmth, noise level and illumination. Ispra has considerable expertise in performing "energy audits" of conventional and solar buildings, including computer-based analysis and the development of plans for energy conversion.

EXPERTISE : ADVANCED MATERIALS

A key technology for European industry in the next decades will be the development of new materials. Some of the experimental techniques needed to enter this field are extremely complex; in some cases it may not be clear whether investment in techniques for testing materials will be warranted by return on investment. The JRC intends to fill this gap by providing facilities for testing novel materials.

At Petten, the materials research concentrates on relationships between properties of materials, their microstructure and their environment. The laboratory is uniquely capable of applying a range of dynamic and static stresses to a material sample, while at the same time submitting it to corrosive environments and high temperatures, continuous or cyclic. This simulates the real industrial conditions under which many materials must perform, but under which few are tested.

Creep, fatigue, the development of scale and the initiation and propagation of cracks can be monitored continuously as the material is exposed. In another unique facility at Petten, multi-axial stress analysis can be performed, also under extreme environments and with continuous monitoring. For example, the effects of circumferential stress on a pipe carrying material under pressure, which is at the same time subject to external stress, heat and corrosion, can be observed. Models describing failure in such systems can be tested.

Ceramics have rarely been studied under conditions of dynamic stress. A programme to perform such tests on ceramics, and on composite materials, is beginning at Petten. The results of corrosion can be studied by gravimetry and thermogravimetry, and facilities for examining microstructure during corrosion include hot-stage microscopy.

Acoustic and extensometric techniques are available at Petten to study the effects of thermal shock and other stresses on materials with coatings or "sandwich" structures. Microstructure can be studied using optical metallography and ceramography; scanning, reflection and transmission microscopy; electron microprobe, x-ray and Auger spectroscopy;x-ray and electron diffraction and acoustic emission. An EMF micro-cell is available for studying the thermochemical properties of small quantities of high-temperature superconducting ceramics.

Investigators have studied coatings designed to resist the large heat transients produced by the plasma of fusion reactors. Various techniques for coating deposition have been studied and the films characterised.

At Ispra, a surface engineering laboratory using combinations of ion, laser and electron beams is being used to modify metal, ceramic and other surfaces. When finally completed it will be the first facility of its type in Europe.Changes in hardness, resistance to wear and corrosion induced by the treatments will be assessed using the full range of techniques available at Ispra and Petten.

A similar network of facilities exists for studying films and surface properties. X-ray glancing-angle spectrometry, extended x-ray absorption fine structure (EXAFS), Auger and XPS spectroscopy can be used to determine the physical properties of surfaces and subsurfaces.This array of techniques, plus related studies such as Rutherford back-scattering and nuclear modifications, is enhanced by extensive cooperation with several European laboratories.

Ispra's cyclotron provides beams with high intensity, yielding high resolution, which can be used as a source for positron-annihilation studies to detect structural defects and impurities in surfaces down to depths of one micron. Activation techniques, such as proton activation analysis, can also be used, for example, to study wear.

Radiation damage studies for low activation materials for fusion reactors are under way. Special radiation chambers have been developed for radiation simulation by light ions delivered by Ispra's cyclotron. Devices for in-beam measurements of electrical resistivity, radiation creep and fatigue growth have been constructed and are constantly working. Radiation chambers for helium and proton implantation in a wide range of temperatures are available.

Thermal cycling has been found to be a major lifetime limiting problem for the first walls of near term fusion reactors. At Ispra a facility for thermal cycling has been set-up, which allows to expose specimen of 0.3 m^2 to cyclic thermal powers as high as 150 KW.

At Karlsruhe, facilities exist to study detailed physical and chemical properties of materials under strict isolation for toxic or radioactive materials. To this end, equipment for extended x-ray absorption fine structure (EXAFS) can be used to determine chemical states in alloys, compounds and composites. Electron spectrometry can be used to investigate electronic structure in a surface layer several atoms thick in order to study corrosive, absorptive and chemical properties of materials. A particular speciality at Karlsruhe is the use of actinides which cannot be handled in most laboratories, to investigate basic mechanisms of catalysis, magnetism and superconductivity.

Equipment is available at Karlsruhe for the containerless heating of metallic and non-metallic samples to extreme temperatures, while their thermophysical properties are monitored. Phases that occur at high temperatures in some materials can be stabilised by rapid cooling; these sometimes exhibit unusual and technologically interesting properties.

EXPERTISE . RELIABILITY OF STRUCTURES

Ispra has a laboratory using ultrasonic and radiographic techniques for non-destructive testing of large components.

The advantage conferred by the JRC's scientific and technical independence is illustrated by the central role the laboratory plays in the Project for the Inspection of Steel Components (PISC) performed in collaboration with OECD/CSNI. For PISC Ispra developed test assemblies, ranging in size from a few to 16.000 kilograms, for calibrating equipment meant to detect defects in steel components. Ispra collated the data from PISC activities around the world, referring them to destructive tests on irradiated and cold materials to check the inspection procedures. As a result the laboratory possesses particular skills in data base management and the development of software for inspection of industrial components and evaluation of inspection procedures.

In Ispra is structural laboratory, large, hollow industrial components can be tested at various internal pressures, while strain is monitored by laser holography, acoustic and thermal emission, and image processing. The laboratory derives and tests models of cumulative damage and probabilistic safety assessments, as well as numerical codes for estimating the lifetime of components.

A large Dynamic Test Facility (L.D.T.F). is also available at Ispra. Using this machine, it is now possible to measure the mechanical response, up to failure of small structures and large specimens of steel and concrete, under dynamic and static loading conditions at controlled strain rates. This facility is essential for the development and validation of both dynamic material models and structural codes.

The L.D.T.F. utilizes the elastic energy stored in two 100 m cables, preloaded up to 5 Mega-Newton and can develop 85 Megawatts over 40 milli-seconds. Considerable effort has been put into developing a number of techniques to measure forces, strains, displacements etc... up to failure.

In parallel with experimentation, computer codes and nonlinear material behaviour models have been developed to predict the transient dynamic response of structures. These have many applications outside the restricted field of nuclear safety, including metal forming, impact damage, earthquakes, etc...

EXPERTISE : ENVIRONMENT

The environment will be one of Europe's most important concerns for the foreseeable future. The JRC is ideally placed to address those concerns, because it is, like many environmental problems themselves, transnational.

The measurement of trace contaminants is one example of the way in which the JRC's nuclear expertise can be used to serve broader interests. At Ispra cyclotron e.g. is used regularly for the production of radioactive tracers for studies of the propagation of pollutants in the biosphere. At Petten, neutron activation analysis performed with the High Flux Reactor can be used to determine very small concentrations of heavy metals in samples ranging from biological material to residues from coal-burning plants.

At Ispra, a wide range of environmental phenomena are studied, including air and water pollutants, toxicology of trace substances and the impact of chemicals and toxic wastes on human health and the natural environment. The chemistry and photochemistry of air pollutants, their transformation and transport, are studied, both by simulating complex atmospheric reactions in test chambers and in sunlit teflon bags, and by systematic measurement of real pollution levels.

Ispra has developed a mobile laboratory, a van equipped to measure sulphur dioxide and nitrogen oxides (NOx) at ground level and at altitude, as well as carbon monoxide, ozone and aerosols. The measurements are backed by three-dimensional acoustic radar to provide wind profiles and a mobile micrometeorological station. Another van carries some of Europe's most advanced equipment for releasing and tracking tracers to determine where airborne pollutants go in complex terrain. Ispra organises international pollution tracing exercises, providing the reference measurements and calibrating instruments for measuring sulphur dioxide, soot and other particulates, ozone, nitrogen oxides and hydrocarbons.

Ispra also works on tackling the pollution at its source. It has developed a process for desulphurising flue gases which produces useful chemicals, sulphuric acid and hydrogen, instead of gypsum like most industrial processes. A pilot plant using the process is under construction in Sardinia. Research is now aimed at extending the process by using the hydrogen produced during desulphurisation to rid the flue gases of nitrogen oxides as well.

Information as well as industrial technology is needed to handle Europe's pollution problems. Ispra specialises in data bases directed at environmental concerns, and has developed ECDIN, the Environmental Data Information Network, documenting the environmental, legal, toxic and chemical properties of thousands of chemicals. ECDIN includes also the European Inventory of Commercial Chemical Substances (EINECS), information on all chemical substances put on the European market before October 1981.This is needed for the application of the EEC Directive on dangerous substances, and can be used to compare new chemicals which may require more stringent controls. This data bank, loaded on the Ispra main computer, is available on-line to concerned authorities; it contains data related concerning more than 100.000 chemical substances. Further work will be be focused on the detection and analysis of chemicals which present the highest potential risk to human health.

Ispra has also developed REM (Radioactivity Environmental Monitoring), a data base containing the various measurements of environmental radiation made after the nuclear accident at Chernobyl, which can be accessed by users throughout Europe.

A unique experimental environment facility will become available at Ispra in 1989: the great indoor laboratory. A walk-in chamber of 30 cubic metres, the "Indoortron", is designed to simulate conditions in the enclosed environments where people spend most of its time. The air in the chamber can be varied from extremely clean, to realistically polluted.

Emissions from various sources of indoor pollution, such as household chemicals, paints, resins or burning furniture, can be analysed and monitored in the Indoortron. Equipment designed to sample and analyse air in other indoor areas can be standardised, and models of the indoor atmosphere can be constructed and tested. It can also be used for controlled exposures of animals or humans to acute and chronic indoor pollution.

Ispra also does toxicological research, concentrating on long-term, low-level exposure to trace metals. Here Ispra's capabilities in measuring trace quantities by neutron activation and in the production of radioactive tracers with very high specific activity, can be put to good account. Cell culture and animal systems are available, and ultraclean rooms can be used for analyses. The loop is closed by the study of trace metal migration in real environments.

Ecotoxicological effects of trace metals on the development,vitality and composition of freshwater communities (microorganisms) are studied in controlled micro-ecosystems at some prealpine lakes around Ispra. As a more versatile method a laser flow cytometer has been developed which uses single-celled algae as a sensitive indicator of theecotoxicological status of fresh- or seawater. Models desscribing the movements of pollutants in freshwater ecosystems have been devised, andtested experimentally. If supplied with sufficient experimental data these models allow to predict the recovery of polluted or eutrophized lakes and to give advise on appropriate abatement measures.

The environmental impact of toxic chemical wastes is considered on one hand by laboratory and in field (mobile analytical unit) characterization with sophisticated analytical techniques and on the other by the development of a decision support system ChEM for the management of post-chemical accident situations. This will give information on emergency measures to prevent further contamination, suggest strategies for decontamination and rehabilitation of affected areas and for long term surveillance of the population.

A new activity at Ispra will be oriented towards food and drug analysis and to the operation of data banks related to these fields. Typical examples of already ongoing activities are the identification of wine chaptalisation and the analysis of starch in food-stuffs.

EXPERTISE : EARTH OBSERVATION BY REMOTE SENSING

Several satellites are now orbiting the globe, taking pictures of the earth from space. The pictures are capable of revealing much useful information: the state of crops, the extent of ocean pollution, changes in climate and land use. These pictures are useless, and can even be misleading, without expert processing and interpretation. Remotely sensed information also, by definition, transcends national boundaries. For all these reasons, Europe needs an independent,continent-wide capability in interpreting remotely sensed images.

Investigators at Ispra have specialised in several aspects of interpreting satellite information. One is images of the sea. This is especially difficult because water absorbs 95% of the light that reaches its surface. Only few per cent of the light is reflected, and can be sensed from space. Nonetheless marine remote sensing is one of the few ways to monitor events over such a huge, relatively unobserved area. It is only with improvements in observations of temperature and wind fields at sea, for example, that really reliable weather forecasting will be possible.

Investigators have developed a new airborne device which fires laser beams of various wavelengths at the sea, then measures the time decay of the fluorescence induced in oil slicks on the surface. This reliably identifies the chemical composition of oil slicks, and can be applied to other chemicals at sea. These have been extremely difficult to derive from images available until now.

Remote sensing of sea surface temperature and colour, a measure of chlorophyll and sediment in sea water, has been combined into methods for following the transport of pollutants in coastal waters. The information is also being used to construct more broadly applicable models of marine circulation. In another application the team has devised and tested methods of using low-resolution imagery to follow the upwelling of nutrients, and consequently to monitor fisheries, along the coast of West-Africa.

Optimal use of the remotely-sensed images that are now available, and of those to come from the next generation of remote sensing satellites, requires long experience with data collected over time, plus wide experience in comparing images with each other and with other types of measurements made on the ground. Ispra has built up this experience across the range of satellite imagery, from low-resolution images produced by weather satellites, to pictures from airplanes, to state-of-the-art data from high-resolution satellites.

The team has also developed methods to test and interpret satellite and airborne images. One is an optical radiometer placed under the sea surface to measure the light that is scattered in the water column, so images taken remotely of the sea can be properly calibrated. Another is a rotating shadow-band spectrophotometer. This instrument measures how sunlight is scattered by suspended particles in the atmosphere. The measurements can be used to correct pictures taken from above, and also to observe the aerosol itself, including the amount of precipitable water in the air.

The land has been the focus of most remote sensing to date, and Ispra has expertise in that area as well. Projects have included the mapping of agricultural land use in Europe, a difficult task because of Europe's topography and style of farming. Investigators have also worked on the integration of geographical information systems from different national data bases; monitoring rainfed agriculture and deforestation in Africa; and the analysis of tropical catchment areas to permit conservation and land use planning.

Ispra is also taking part, with other European laboratories, in developing the interpretation of microwave images, especially those produced by synthetic aperture radar. They will become available on the European Space Agency's ERS-1 satellite, to be flown in the 1990's. Ispra has set up a data base for radar cross-sections to act as a reference and calibration for future measurements. It has collaborated with the space agency in testing and calibrating the kind of data that will come from ERS-1.

Ispra also has a laboratory for image-processing. It includes five work stations for processing colour video images and a high resolution laser-beam film writer. The team in the laboratory is developing methods for compressing data in images using matrix theory, geometric transformation of images and image enhancement including linear and non-linear mapping.

The laboratory is also working on automated image recognition. The work can be applied to industrial image recognition, in security and robotics for example, as well as to the processing of remote sensed images. It includes classifying picture elements using statistical decision theory; use of spatial frequency to classify textures; development of context-dependent methods aimed at recognising objects from their spatial and temporal relationships with other objects.

EXPERTISE . FLUID DYNAMICS, HEAT TRANSFER, AND INDUSTRIAL SAFETY

The JRC's long experience with various industrial systems, and especially nuclear plants has led to the development of expertise in heat transfer and fluid dynamics. The complexities of these two types of phenomena are of relevance to a wide range of industrial design problems.

Heat transfer has been investigated over a wide range of geometries, flow conditions and operating parameters, including high temperatures, pressures and heat fluxes, two-phase flow, and capillary structures. This expertise has been applied to the design of temperature heat pipes for passive heat transfer in space. The team has also produced among the most advanced furnaces available that are capable of heating very homogeneously with a high degree of control and reproducibility.

Safety of process technology is another extension of the team's expertise in heat transfer. Accidental mixing of water with hot melts and the related vapour explosions is one area of study. Complex flow regimes are of increasing concern to chemical plant managers, especially from the point of view of venting in case of accidents. Expertise acquired at Ispra in the course of studying abnormal behaviour in nuclear plants is now being applied to the design of chemical processes. Experimental equipment is available for analysing the flow of materials and energy in the complex systems that can occur in chemical plants.

The team at Ispra has collaborated with several international groups to study multi-phase flow in chemical processes. Fires (facility for investigating runaway events safety), a chemical reactor housed with appropriate instrumentation in a bunker, is under construction. Codes aimed at predicting flow in venting systems, as well as the influence of system geometry and various physical events, can be analysed in a multiphase-multicomponent flow facility.

Modelling is another area where investigators at Ispra have specialised . They participate in international programmes to develop and test computer codes for studying large thermohydraulic systems, as well as developing multidimensional computer codes of their own. Beside the models themselves, the team has specialised in developing the necessary informatics including interactive graphics and expert systems.

The team also develops techniques for analysing systems. One group specialises in the thermal analysis of building, including the effects of solar water heating and combined active and passive solar heating systems, seasonal storage and heat pumps. A solar house at Ispra permits the testing and comparison of heating systems under a wide range of conditions.

Making industrial systems safe is of concern to engineers, and increasingly to regulators and other people responsible for industrial activities. "Safeness" is an elusive quality, however; it requires the broadest possible analysis of systems, both as a whole and in terms of their components.

For this reason a special, multidisciplinary unit for risk analysis and hazard management has been set up at Ispra. It has focussed on the analysis of systems in the chemical and nuclear industries, on energy transformation and supply, and on transport of dangerous substances.

The team has made a special point of trying to include the human-machine interface as accurately as possible in models of system reliability, both as a means of predicting the effects of errors, and as a means of adapting systems to avoid them. It has, for example, built a model of a plant operator. Such models can be applied to numerous other situations, such as air traffic control, and can also be used to help design simulators for training purposes.

The overall aim of the unit is to combine different kinds of analysis and information into analytical tools that enable managers to make decisions. One result has been the development of software for "fault-tree" analysis, among the most powerful available since it is based on heuristic techniques developed for artificial intelligence rather than on fixed algorithms. The system employs complex, non-additive means of deriving total risk from the probabilities of different events. It can be adapted to the analysis of risk in a wide variety of situations.

The team has developed a decision support system which treats the risks arising from the complete cycle of hazardous substance production, transportation, use and disposal. IRIMS, the Ispra Risk Management Support system, contains data bases, simulation models and an optimisation module which are integrated through an easy to use interface. IRIMS is a modular system, which can be easily modified for specific applications, and is implemented on a high-resolution colour workstation. The system HELP has been derived from IRIMS for use on a personal computer and is specific to the problem of optimal route selection for hazardous substance transportation, considering transportation costs and risks.

Integration of data is one thing; acquiring the data needed to assess risk is another. Investigators at Ispra have studied the extreme conditions that can afflict particular components of a system, such as rapid depressurisation in cooling plants, high-temperature reactions, the behaviour of materials under extreme loads and "runaway" chemical reactions. All these types of events are central to the kinds of accidents for which designers and managers need to plan.

The team has developed both experimental, and modelling techniques to simulate such accidents. The techniques used for these simulations can be more widely applied than the cases for which they were developed. Scientists at Ispra have helped investigate the accidents at Seveso and Bhopal. Others work on the interactions of refrigerants and fuel in nuclear and chemical reactors. One team models complex, chaotic events using mathematical approaches such as fractals to describe deterministically events that used to be thought of as stochastic.

In the image processing laboratory research is aimed at using automated pattern recognition to enforce security and emit early warnings of abnormal behaviour in a wide range of industrial systems. It includes laser interferometry to reveal deep faults in components, and the integration of other, novel techniques for measuring strain in materials into overall system monitoring and the diagnosis of possible failures (see "Expertise: Reliability of structures"). Models and knowledge-based systems are being adapted to model the effects of sequences of changes in the properties of components, with the aim of predicting and improving reliability over the lifetime of an industrial plant.

EXPERTISE : INFORMATION PROCESSING AND TECHNOLOGICAL FORECASTING

Information will be the wealth of the next century. Handling information is already increasingly the key to generating wealth. Recognising this, a special team has been set up at Ispra to deal specifically with information processing.

It is equipped with a large mainframe and several other large computers, backed by extensive auxiliary equipment and access to public data transmission networks. One arrangement links the centre with supercomputers in Europe.

Two systems for managing data bases are available on the Amdahl. ADABAS is useful for searching and updating large data bases, and permits the creation of individual applications. IMS is available for managing administrative and procedural data. Both are used at Ispra. Many of the data bases have their own user-friendly interrogation systems and graphic output.

The data bases are available on the international public network. ECDIN lists chemicals that could effect human health or the environment. EINECS is the official inventory of chemicals on the European market since October, 1981, in accord with the EEC directive on dangerous substances. REM contains all types of radioactivity measurements performed throughout Europe after the nuclear accident at Chernobyl.

ERDS is a tool for safety analysis in nuclear power plants, and relates continuously updated experience in operating plants to models for assessing risk. It includes AORS, Abnormal Occurrences Reporting System, which merges and analyses national reports;CEDB, Component Event Data Bank with date on component failures; and OUSR, Operating Units Status Report, with data on productivity and outage in nuclear plants.

The HTM data base on high temperature materials contains mechanical properties of materials used at high temperatures in industry, including tensile strength, creep, fatigue, hot work, toughness and crack growth. EDSES, the European Data System for Energy Savings hosts data from the EEC's "Energy Bus" programme listing possible energy savings assessed for medium and small-sized industries. Finally HELP is an interactive decision-making tool for routing the transport of hazardous materials, and IRIMS is a similar tool for making decisions about hazardous materials, using a broader spectrum of industrial risks.

The science of developing software, as well as the software itself, is studied in the informatics centre, with the main emphasis placed on engineering scientific software. The centre participates in the Toolpack project, an international collaboration to develop a portable programming support package for the Fortran language. It is involved in the development of an international standard for Fortran, and investigates ways of using vector, parallel and connectionist architectures in existing large scientific software systems.

The artificial intelligence laboratory concentrates on a number of areas at the forefront of this rapidly changing field. They include graphics for expert systems; pictorial data bases for navigational systems; advanced, interactive computer interfaces; artificial reality; qualitative physics; diagnostic tools for nuclear reactors; chemical hazards; and software for three-dimensional image processing.

The centre is served by DUAL, a backbone network developed to provide high-speed access through fibre optics to the mainframe and to networks inside and outside the JRC. The network is highly modular, can take all current types of interface, and provides state-of-the-art methods of data communication and handling, computer conferencing, distributed and parallel processing. The system has been patented and is marketed under a joint arrangement with a private company; work continues on updated models.

Besides dealing with the present, the JRC is well placed to consider Europe's future in science and technology. Its own history has been a reflection of Europe's changing concerns, in providing for its energy needs, its productivity, its industrial and environmental safety. A special team has been set up at Ispra to predict the effects of the technological choices facing Europe, to enable policy makers and industrialists to assess the impact of decisions they make now.

This expertise has developped in part out of the JRC's involvement with nuclear power. One facility available at Ispra is a set of computer models for projecting how energy systems, from regional to multinational, are likely to evolve under various conditions. The models can be used to find the optimum economic conditions for undertaking the development of a technology, or for predicting the impact of environmental regulations.

Studies related to the forecast of technology growth are increasingly in demand throughout the industrial sector, as investment in new technology becomes more and more expensive, with increasing risk factors both from the long lead times involved in development, and increasing concern about impact at many levels, from environment to employment. Ispra's experience in the energy sector can be applied to such studies. Areas that have already been treated include the management of resources, the development of new materials, and the environmental impact of industrial processes. New proposals for research and development can be analysed at Ispra, and impacts assessed, well before any significant investment is needed.

A. Summary of major facilities at the JRC

ISPRA

Installation for Testing Solar Energy Converters (ESTI)

The facility is used to develop acceptable test procedures for photovoltaic devices, for the calibration of reference standards and the direct testing of industrial prototypes and series products.

Large Dynamic Test Facility (LDTF)

This installation has been developed to submit large specimens of materials (steel - concrete) and small structures to dynamic Loads of up to 5 MN at cross-head velocities up to 25 m/s.

Materials Testing Cyclotron MC40

This machine is used for the study of the effects of neutrons, protons and electrons on samples of materials. The cyclotron features strongly in studies on materials intended for application in fusion machines, where intense bombardment of the walls by ions and 14 Me V neutrons takes place.

Radioactive Waste Management Chemical Treatment Facility (PETRA)

This installation is used to test chemical operations at pilot level on representative reprocessing plant waste streams.

Laboratory for calibrating and testing of equipment and training of staff (PERLA)

This laboratory is used in connection with the Safeguards and Fissile Materials Management activity. Work involves the calibration and reliability testing of equipment and the training of Commission and other Safeguards inspectors.

Installations for Nuclear Safety Research

- LOBI is a large test loop for the study of off-normal behaviour in light water reactor primary cooling circuits.
- FARO is a multipurpose facility to investigate post accident heat removal and interactions between fuel and coolant in nuclear reactors.

Tritium Handling Laboratory

This installation, which is under construction, is a laboratory for the development of safe methods for handling Tritium in the quantities required for later thermonuclear fusion experiments and demonstration machines.

Ispra Informatics Centre

The Centre is equipped with a large main frame computer backed up by extensive auxilliary equipment and highly developed networks with access to public data transmission networks.
A special arrangement with centres in Europe provides access to super-computer facilities via data transmission links.

Nuclear laboratories

Apart from the specialized laboratories mentioned above there are other hot-cell facilities where more general work such as the examination of irradiated fuel from nuclear power stations is performed.

GEEL

Accelerators

Several accelerators are located on this site. These comprise a linear accelerator which has been developed to a point where it is considered to be a technical leader in this specialized area as well as two Van de Graaff accelerators. They are devoted to obtaining nuclear data in connection with its role as the Community's "Central Bureau of Nuclear Measurements".

Laboratories for the preparation of Reference Materials

These laboratories are equipped for the production and accurate assay of reference materials and special targets for all parts of the nuclear fuel cycle,and for some non-nuclear applications. The reference materials are issued with a certificate and sold throughout the world.

KARLSRUHE

Nuclear Laboratories

These installations consist of glove boxes and shielded cells together with all relevant services for research on the alpha particle emitters and highly beta/gamma active materials such as irradiated nuclear fuels. Equipment ranges from fabrication lines for experimental plutonium-containing fuels to precision apparatus for the measurement of physical parameters on metallic and ceramic materials. The institute enjoys a unique place in world actinide research and this is reflected in its facilities.

PETTEN

Materials Environmental Testing Laboratory (ETL)

This laboratory carries out mechanical and corrosion tests on metals and ceramics at high temperatures under atmospheric conditions encountered in service. Simulated serviceenvironments provided include combinations of oxidizing,carburising and sulphidising atmospheres with inert and vacuum conditions. A special line of explosion-proof enclosures house tests on simple tubular components.

The High Flux Reactor (HFR)

This is a materials testing reactor operated by the Commission for JRC programmes. A major part of the reactor is occupied by irradiations for Dutch and German national nuclear programmes and special financial arrangements exist by which these two Member States finance the greatest part of the operation. The plant was extensively modernized in 1984.

B. - Other Installations (Ispra)

Lidar Fluorosensor

A tool for the analysis of remote targets in environmental investigations.
The fluorosensor systems is based on a frequency tripled Nd-YAG laser for excitation, on a scanning telescope for fluorescence light collection, on a streak-camera equipped with two-dimensional CCD system for readout of the multispectral time decay data and a computer for data acquisition and reduction

Laboratory for Image Processing

A comprehensive equipment for processing digital data obtained from remote sensing is available; it includes a central computer (DEC VAX 785) linked by DECNET to peripheral computers, 4 tape units, 1 G byte disk unit, 20 video terminals, line printers. In addition : 4 colour video image processing working stations, graphic terminals and digitizing table, a colour laser beam film writer (VIZIR).

Hot Cells Laboratory

It includes an entrance cell and 20 alpha-tight lead cells. It can treat

- 60 Ci of fission products in small-scale prototype radiochemical studies
- 250 (exceptionally,1000) Ci of fission products total storage in irradiated fuel
- 10 to 20 Ci per sample for mechanical and metallographic testing of irradiated samples of various steels and other structural materials.

In addition 3 laboratories are installed in the controlled area : the thermodynamic lab., the microstructural Lab, the metallographic lab

Waste Treatment Installation

It includes reception tanks with total capacity of 500 m^3, a 250 m^3 process tank where a flocculation-precipitation-centrifugation process takes place. The resulting sludge is transferred to the low level waste solidification plant which includes alpha-tight working box and cementation equipment, an alpha-beta-gamma processing cell, and volume reduction facilities (furnace, shredder, cutting tools, several presses).

Non-Destructive Testing and Instrumentation

The laboratory uses ultrasonic and X-ray techniques for the inspection of metal components. The main equipment of the laboratory includes :
- ultrasonic equipment
- 50, 150, 300 and 400 Kv X-ray radiography instruments
- 1 and 2 MeV linear accelerator
- equipments for magneto-forming and welding by electrical pulses
- equipment for microelectro erosion

IRIMS - The Ispra Risk Management Support System

The IRIMS systems is an attempt to integrate a number of Databases containing information relevant to risk management with several existing Simulation Models which can be used to address problems of environmental assessment, risk analysis and system optimization.
The present version of the IRIMS system is a demonstration prototype. The available Databases include : the Chemical Substances Database, the Industrial Accidents Database, the Regional and Geographic Database, etc.. The Simulation Models include chemical process simulation, long range atmospheric transport, transportation risk, groundwater pollution etc..

Mobile Unit for Mapping Atmospheric Pollution

The Mobile Unit for mapping atmospheric pollution can offer a wide range of services :

- location and parametrisation of a plume
- stack emission evaluation
- mapping of ground-concentration and pollution burden
- mass-flow and transport evaluation
- validation of dispersion models

The Mobile Unit has been specifically assembled to facilitate a wide range of chemical monitoring instruments to analyze various pollutants in a large area and a computer to analyze the incoming data.

INDOORTRON

A walk-in exposure chamber of 30 m^3 volume featuring inert internal surfaces and controlled temperature and humidity will be available begin of 1989. The atmosphere can be controlled from extremely clean (zero) air to realistic concentrations of organic or inorganic air pollutants.
The chamber will serve the following purposes:

- test of indoor (and ambient) air sampling and measuring equipment:
  evaluation and standardization of instruments and methods;
- study of emissions from indoor pollution sources (e.g. building materials, furniture, household products);
  emission inventory; emission factors for model calculations;

Clean Laboratory for Preparation of Environmental Samples

The laboratory provides the preparation of environmental samples (e.g. vegetation, soil, human blood) for further isotopic mass spectroscopy analysis of trace metals under extremely clean conditions to avoid contamination by normal laboratory practice. The laboratory is equipped with furnaces, microbalances, atomic absorption spectrometers, wet chemistry.

Multiphase-Multicomponent fluid flow test Facility

The small scale "Multiphase-multicomponent fluid flow test facility" is used for the study of 2-phase-2-component flow phenomena dealing with runaway reactions in venting ducts for parameter acquisition and code verification. The facility consists mainly of a 40 l test vessel operating at a max. pressure of 15 bar and a max.temperature of 250°C, and a flashing and quenching vessel of 1 m^3, equipped with special instrumentation like densitometer.

Facility for Investigating Runaway Events Safety

The "Facility for investigating runaway events safety" enables to validate mathematically simulating models and to characterize instrumentation for runaway prediction experimentally by performing batchwise selected chemical runaway reactions.
The facility consists mainly of a 100 l standard batch reactor operating at a max. pressure of 15 bar and a max. temperature of 200°C, equipped with special runaway control instrumentation, housed in a bunker

How to interact with the JRC

1. The most convenient way is the contractual agreement. The work is performed according to the specifications of the customer, in the frame of a contractual agreement agreed upon by the JRC and the partner (governmental agencies, industry...). The customer pays for the work executed by the JRC

   Such work can be :

   - industrial research, at the request of a single customer or within a multiple customer scheme (cooperative research)

   - operation of specialized facilities, at the request of a single/multiple customer

   - supply of technical services (e.g. specialized chemical analysis)

   - supply of scientific and technical consultancy

2. If the theme interesting the third party has a direct link with the work performed under the specific research programmes of the JRC, the formula of a collaboration contract can be envisaged where costs are shared by the third party and by the programme.

3. Other forms of collaboration are also introduced : industrial clubs and associated laboratories.

   - Members of an industrial club are paying an entrance fee and annual dues to belong to the club; they are associated with a research activity which is generic by nature and they influence its orientation; they are receiving first hand information along the execution of the programme which is geared according to their common needs. Such kinds of club are in formation in the following areas : advanced materials, industrial risks ...

   - Associated laboratories with the JRC are laboratories who are working together within a formalized framework, along similar lines of research; exchange of personnel is, in general, a vital component of the association as well as joint marketing, common formulation of work. The goal of the association is to team competences, to increase scientific excellence, to increase Community cohesion, to facilitate scientific consensus or to increase technology transfer.

<u>Enquiries for further information are welcome and should be adressed to the</u>

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