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COMMISSION OF THE EUROPEAN COMMUNITIES

Multiannual Programme of the Joint Research Centre 1980 - 1983

1980 Annual Status Report

Operation of the High Flux Reactor

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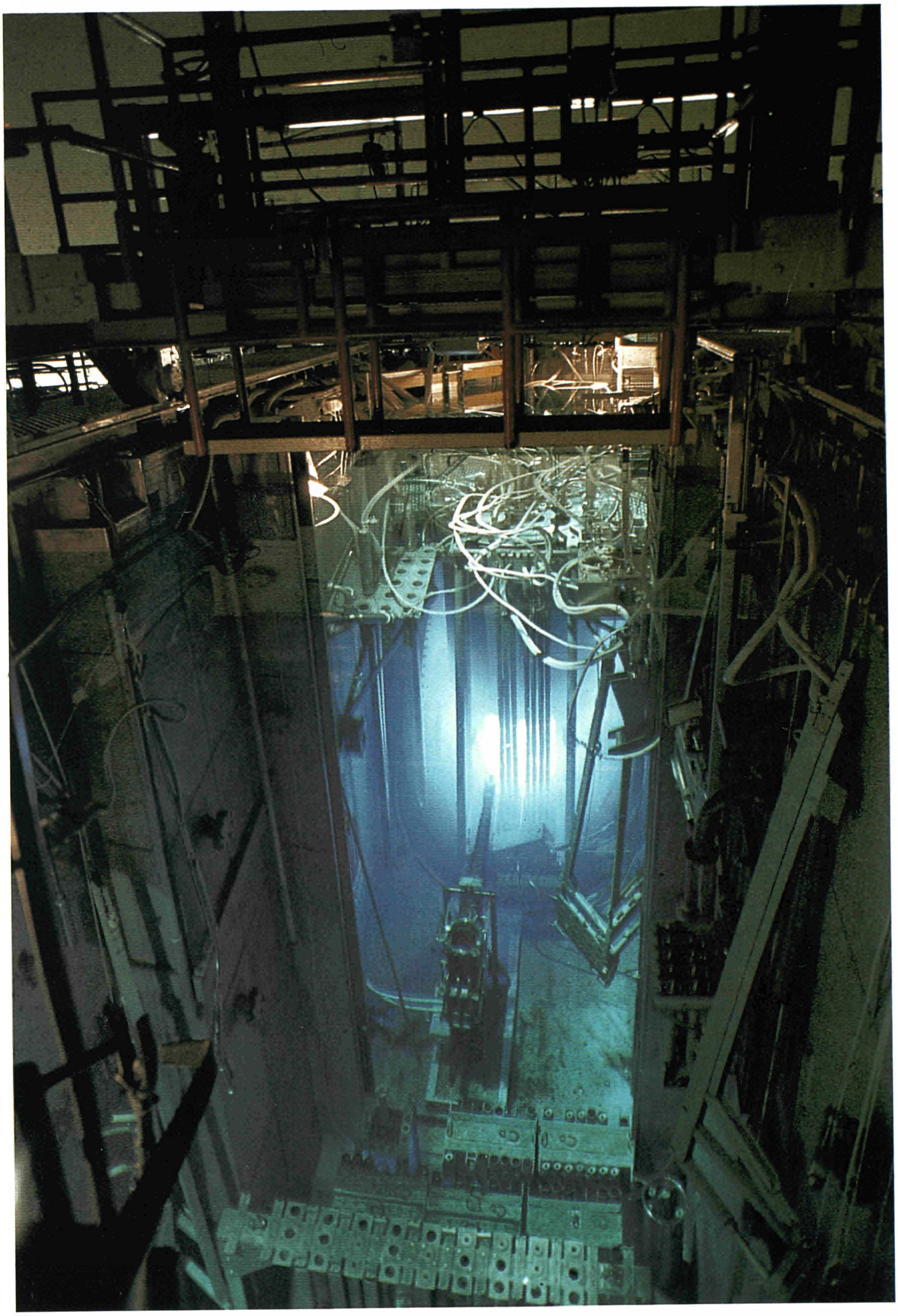


HFR PETTEN

PROGRAMME MANAGEMENT

- OPERATION AND UTILIZATION WITHIN JRC PLURIANNUAL RESEARCH PROGRAMME
- OPERATION BY EXTERNAL ORGANIZATION UNDER CONTRACT
- PREDETERMINED FOUR YEARS' FUNDING, DETAILED ANNUAL BUDGETS
- LONG - TERM SUPPLY AND SERVICE CONTRACTS
- CENTRAL DECISION MAKING, VARIOUS ADVISORY COMMITTEES
- DETAILED PERMANENT PROJECT AND RESOURCE PLANNING
- INTEGRATED PROJECT WORKING GROUPS
- SEMI-ANNUAL PROGRAMME PROGRESS REPORTS AND FINANCIAL SURVEYS.

- TYPICAL HFR BUDGET :

REACTOR OPERATION AND MAINTENANCE STAFF (75)	20 %
REACTOR MODIFICATIONS AND DEVELOPMENT	8
GENERAL SITE SERVICES	17
JRC TECHNICAL AND ADMINISTRATIVE STAFF (88)	29
TOTAL FUEL CYCLE (IN EQUILIBRIUM)	15
MAJOR INVESTMENTS	2
ELECTRICITY, WATER, INSURANCES	4
EXPERIMENTAL EQUIPMENT	5
	100 %

OPERATION OF THE HFR REACTOR 1980

Research staff	**41 persons**
Budget "Operation of the HFR"	**12.048 Mio ECU**
Use of HFR by other JRC Programmes	**0.717**
Use by commercial clients	**0.175**
Total	**12.940**

Projects

Unlike most of the other JRC research programmes, "HFR Operation" is not formally subdivided into individual projects. For the sake of the Programme Progress Reports, however, three projects are defined:

1. **HFR Operation and Maintenance**
2. **Reactor Utilization**
3. **General Activities**

On a lower level of subdivision, the term "project" appears again when referring to irradiation projects and individual supporting activities.

1. INTRODUCTION

The Council Decision of March 13, 1980, concerning the 1980/83 JRC research plan, defines for HFR Petten:

F. OPERATION OF LARGE-SCALE INSTALLATIONS
Supplementary programme

F.1. Operation of the HFR reactor
(nuclear activity)

It also allocates a four years' budget of 52,22 Mio ECU and a staff of 88, of which 41 are research staff.

The proposed Technical Annex to the Council Decision reads as follows:

OPERATION OF THE HFR PETTEN

The operation of the reactor will continue to the benefit of the research programmes of the participating Member States and for the JRC's own requirements. Outside clients will also be able to use the irradiation facilities on payment.
During the next programme the teams will continue the maintenance and upgrading of the reactor and the development and improvement of the irradiation equipment and apparatus to enable this installation to hold its place among the most important means of irradiation of the Community.

2. RESULTS

2.1 Facilities and Services

2.1.1 Reactor *)

As one of the four most powerful research and test reactors in the European Community, HFR Petten is characterised by its simplicity in design and operation, resulting in both high reliability and great flexibility in use.

In 1980, the regular operation at 45 MW continued, according to a predetermined calendar, and without major problems from the plant and its components. Four shipments of fresh fuel elements to the reactor site, and two transports of irradiated elements to reprocessing kept the local inventory on the previous level.

Regular inspection and maintenance of all plant components has been carried out during the extended scheduled outages in January and July. Except some wear on primary pumps and heat exchangers, no particular observations are to be made. The reactor containment building has been subject to its large pressure and leak test, to be carried out every four years, with very satisfactory results.

In line with a traditional policy of permanent upgrading and modernisation, a large number of minor components have been replaced during the year.

*) High flux materials testing reactor HFR Petten. Characteristics of facilities and standard irradiation devices. EUR 5700. (Revised edition 1981-1982 will be issued soon).

HFR Petten

MAIN CHARACTERISTICS

TANK-TYPE MATERIALS TESTING REACTOR

45 (50) MW

H_2O COOLED/MODERATED — Be MODERATED/REFLECTED

MTR (PLATE) TYPE FUEL ELEMENTS,

93 % ENRICHED, 1 g ^{10}B PER ELEMENT

29 IRRADIATION POSITIONS, — 11 HORIZONTAL BEAM TUBES

COOLANT PRESSURE 0,24 MPa, — COOLANT TEMPERATURE 313 K

ANNUAL AVAILABILITY 76 % — AVERAGE UTILIZATION 73 %

MAIN UTILIZATION

- NUCLEAR SAFETY
- ENERGY
- FUNDAMENTAL RESEARCH
- LIFE SCIENCES
- PROTECTION OF THE ENVIRONMENT

UPGRADING AND DEVELOPMENT

1966 - 1980

- POWER INCREASES 20 TO 30, 30 TO 45 MW
- INTRODUCTION OF BURNABLE POISON FUEL (1973/74)
- SEVERAL CORE CONFIGURATION CHANGES
- COMPLETE REPLACEMENT OF REACTOR AND GENERAL PURPOSE EXPERIMENTAL INSTRUMENTATION
- NEW IN-TANK EXPERIMENT PENETRATIONS (1976)
- SEVERAL IMPROVEMENTS ON MAJOR PLANT SYSTEMS
- IN-HOUSE COMPUTER CODE DEVELOPMENTS
- NEW REACTOR AND EXPERIMENT DATA LOGGERS (1980/81)
- NEW DISMANTLING CELL TRANSFER SYSTEM (1980/81)
- BEAM TUBE NEUTRON RADIOGRAPHY FACILITY (1979/81)

FUTURE DEVELOPMENTS

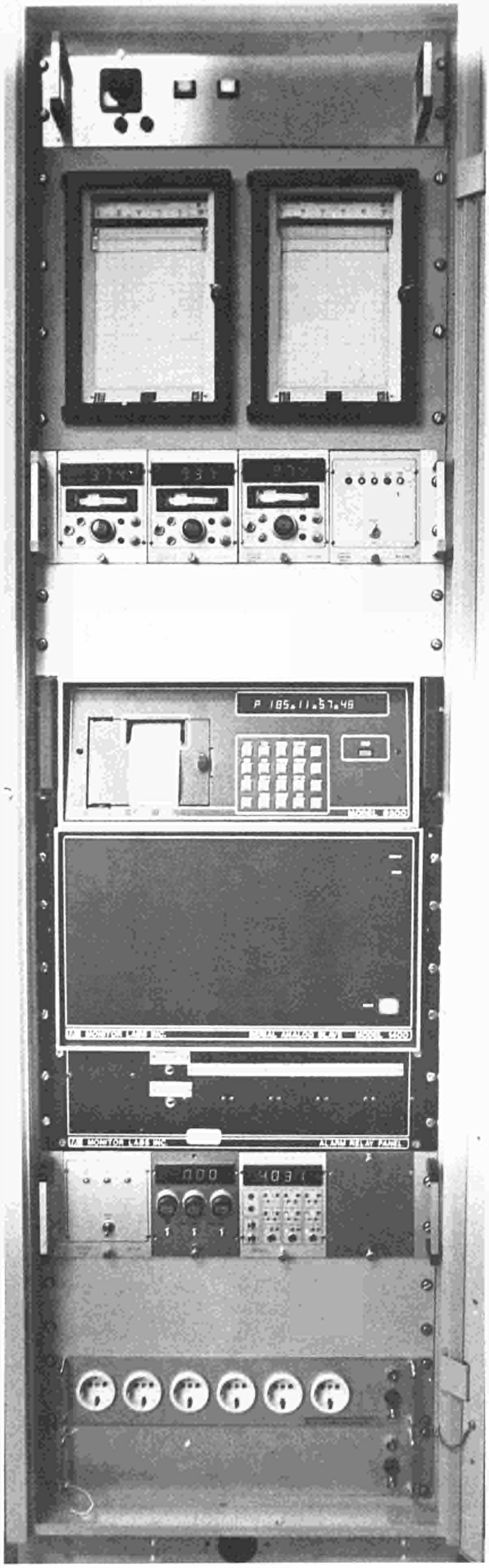
- STUDIES ON COMPLETE REACTOR INSTRUMENTATION AND CONTROL ROOM REPLACEMENT
- REPLACEMENT OF THE REACTOR VESSEL (1982/83)
- DEVELOPMENT OF REDUNDANT SHUT-DOWN SYSTEMS
- STUDIES FOR APOWER INCREASE TO 60 MW
- REPLACEMENT OF PRIMARY HEAT EXCHANGERS (1982/84)
- MEDIUM ACTIVITY LABORATORY (1984/85)
- MODIFICATION OF THE REACTOR BUILDING ENTRANCE/EXIT AREA (1981/82)
- ENLARGED COMPUTING FACILITIES
- NEUTRON BEAM QUALITY IMPROVEMENTS (COLD SOURCE, FILTERS)
- NEW POOL NEUTRON RADIOGRAPHY CAMERA, IMAGE ANALYSER (1982)

2.1.2 Irradiation Facilities

Users of the reactor find a number of basic services and facilities which are made available to them on a routine basis and which help to cut down on development time and cost.

Major developments in 1980 have been :

- complete replacement of the pool side facility support table with its drive mechanisms, bringing about a large improvement for the operation of safety-related experiments (see paragr. 2.2.2),
- final pre-start commissioning of the fission product analysis installation Sweep Loops (see paragr. 2.2.3),
- replacement of obsolete data loggers by modern micro-processor controlled units,
- introduction of a series of new irradiation devices for fast reactor fuel transient testing,
- improvement of neutron activation analysis equipment (see paragr. 2.2.4),
- development of several new radioisotope production facilities.



GENERAL PURPOSE FACILITIES

FRONT VIEW OF A NEW CONTROL CABINET WITH MICRO-PROCESSOR BASED 140-CHANNEL DATA LOGGER

STANDARD IRRADIATION FACILITIES

1. NON-FISSILE MATERIALS TESTING

Graphite, stressed or unstressed, metal or graphite / He environment ø 6.....20 mm; 300........1200°C
Specimen recycling.

Steel, unstressed, Na environment, tensile specimens, ø 6.....12 mm, 550......650°C
also: non-cylindrical (Charpy, CT, etc.)

Low temperature Al specimen capsules (various sizes)

Graphite and steel creep facilities with on-line measurement

In-core instrumentation test rigs

Under development: In-pile fatigue and crack growth capsules

2. FISSILE MATERIALS TESTING, IN-TANK FACILITIES

Single or triple, double-walled Na (NaK)- filled, 500.......1000°C clad temperature, 400.......1200 Wcm^{-1}
Optional: Neutron screen, central thermocouple, fission gas pressure transducer, ...

Single or double-walled HTGR fuel rigs, graphite / He environment, 100......1000 Wcm^{-1},
800.....1500°C fuel temperature. Continuous fission gas sweeping and analysis.

Under development: BF_3 operated power transient facility.

3. FISSILE MATERIALS TESTING, POOL SIDE FACILITY (PSF)

Single-walled Boiling Water Fuel Capsule (BWFC), variable power, 70...150 bar water pressure,
200....800 Wcm^{-1}, 250.....350°C clad temperature. Continuous fission product monitoring
Pre-irradiated fuel pins
Optional: Different types of fuel pin instrumentation

Double-walled, Na (NaK)-filled, single or double carrier capsule. Variable power, 500....1200 Wcm^{-1},
400.....800°C clad temperature. Fuel pin length up to 500 or 1600 mm.
Optional: Different types of fuel pin instrumentation.

Under development: Encapsulation facility for pre-irradiated fuel pins

4. MISCELLANEOUS

Different radioisotope production rigs, mostly reloadable during reactor operation.

Gamma irradiation facility.

Borosilicate glass pellet capsule

Two neutron radiography installations

Beam tube nuclear and solid state physics equipment: Several diffractometers and spectrometers, mirror and filter systems, with ancillary cryogenic equipment and process computers

5. STANDARD OUT-OF-PILE CONTROL FACILITIES

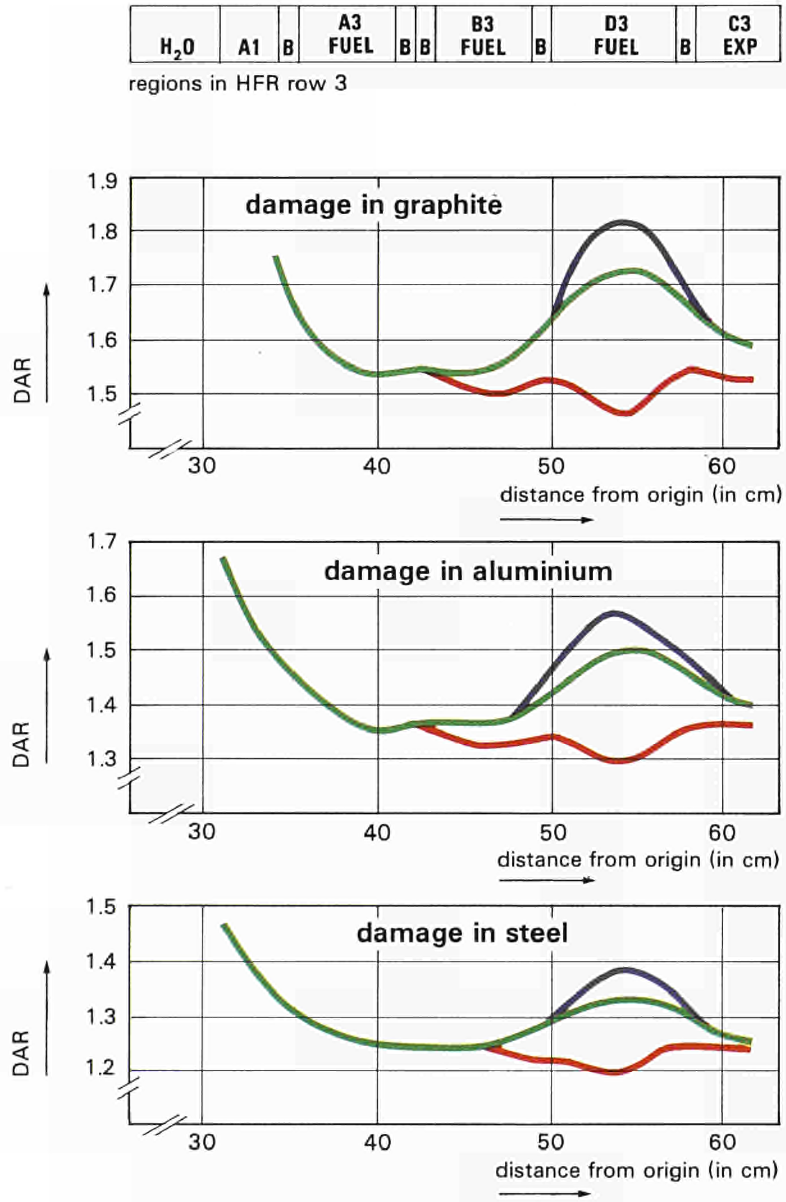
Gas mixing and control panels
Cooling water control circuits
Micro-processor based data loggers
Computerized data acquisition and processing

2.1.3 Ancillary Services

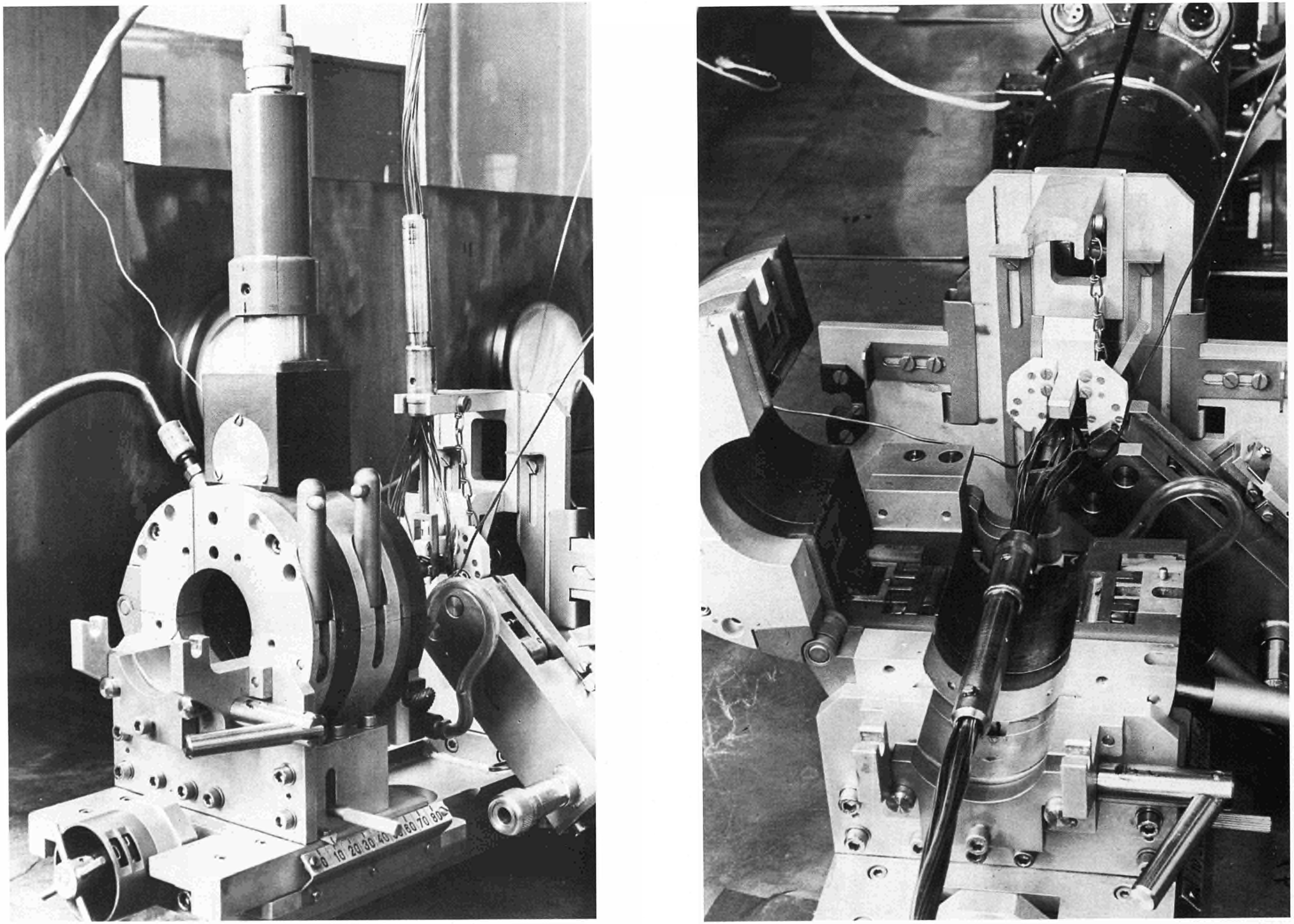
Users of the reactor find access to the necessary ancillary services, ranging from several computer installations and their software to a full spectrum of post-irradiation facilities.

More specifically, work on general-purpose support to HFR irradiations comprised :

- efforts to accurately determine the reactor's nuclear characteristics by a combination of detector dosimetry, self-powered neutron detector and gamma calorimeter measurements, and computations.
  Novel results have been obtained for the so-called Damage-to-Activation Ratio (DAR), an essential parameter for the interpretation of radiation damage experiments. Its variation has been studied in several regions. The results (see figure below) underline the influence of the sample "micro-environment" on the local radiation damage.
- gradual introduction of a central twin-computer-based data acquisition and processing system for reactor and experimental data,
- installation of a new "dry" neutron radiography camera, using beam hole HB8,
- continued construction and cold testing of the remote encapsulation facility EUROS,
- new shielded transport containers, together with their lifting and manipulation gear.



DAR VALUES ALONG THE CENTRE LINE OF HFR ROW 3.
Loading of position C3: green = S-assembly; blue = steel mock-up; red = graphite mock-up



ANCILLARY SERVICES. REMOTE ENCAPSULATION FACILITY EUROS.
FIRST ASSEMBLY AND WELDING TESTS USING A DUMMY IRRADIATION CAPSULE.

2.2 Utilization

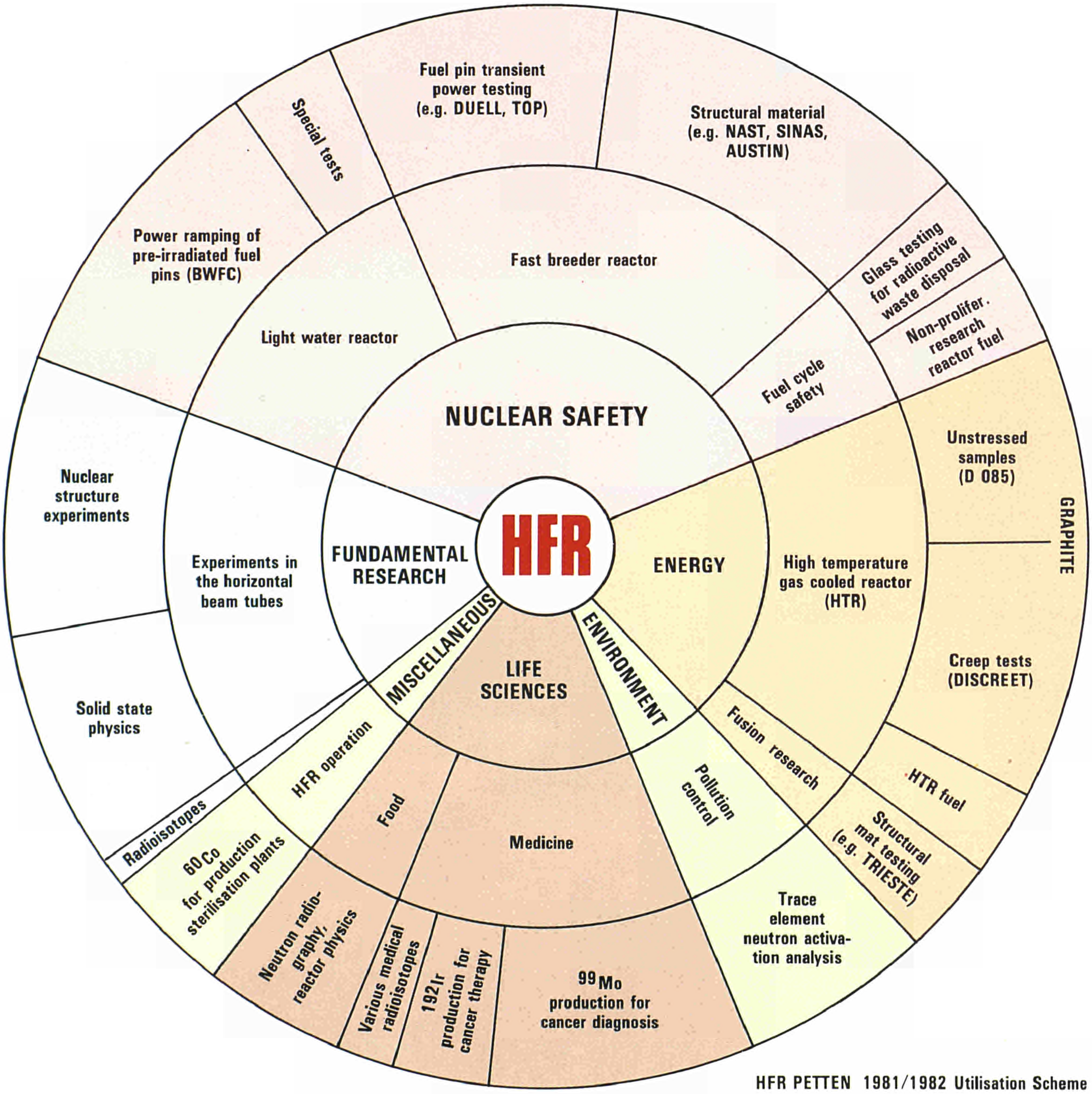
2.2.1 Scope

The experimental work carried out in HFR Petten originates from the following research fields :

1. nuclear safety
2. energy
3. environment
4. fundamental research
5. life sciences (medicine and food)
6. miscellaneous

Their relative importance in reactor utilization is shown in the circular diagram below.

Typical topics are treated in the following paragraphs.



HFR PETTEN 1981/1982 Utilisation Scheme

2.2.2 Nuclear Safety

A large part of the experiments carried out in HFR Petten concerns the behaviour of nuclear reactor core materials under transient and abnormal conditions.
Fuel pins which have already operated for two or three years in light water power reactors are submitted to transients in specially developed irradiation capsules in order to test their resistance against abnormal conditions (overpower).
The accurate knowledge of this behaviour allows large power reactors to be operated with a maximum of assurance against the release of radioactivity (fission products). The HFR BWFC (Boiling Water Fuel Capsule) experimental programme features 25 to 30 experiments per year, including their non-destructive tests before and after irradiation.

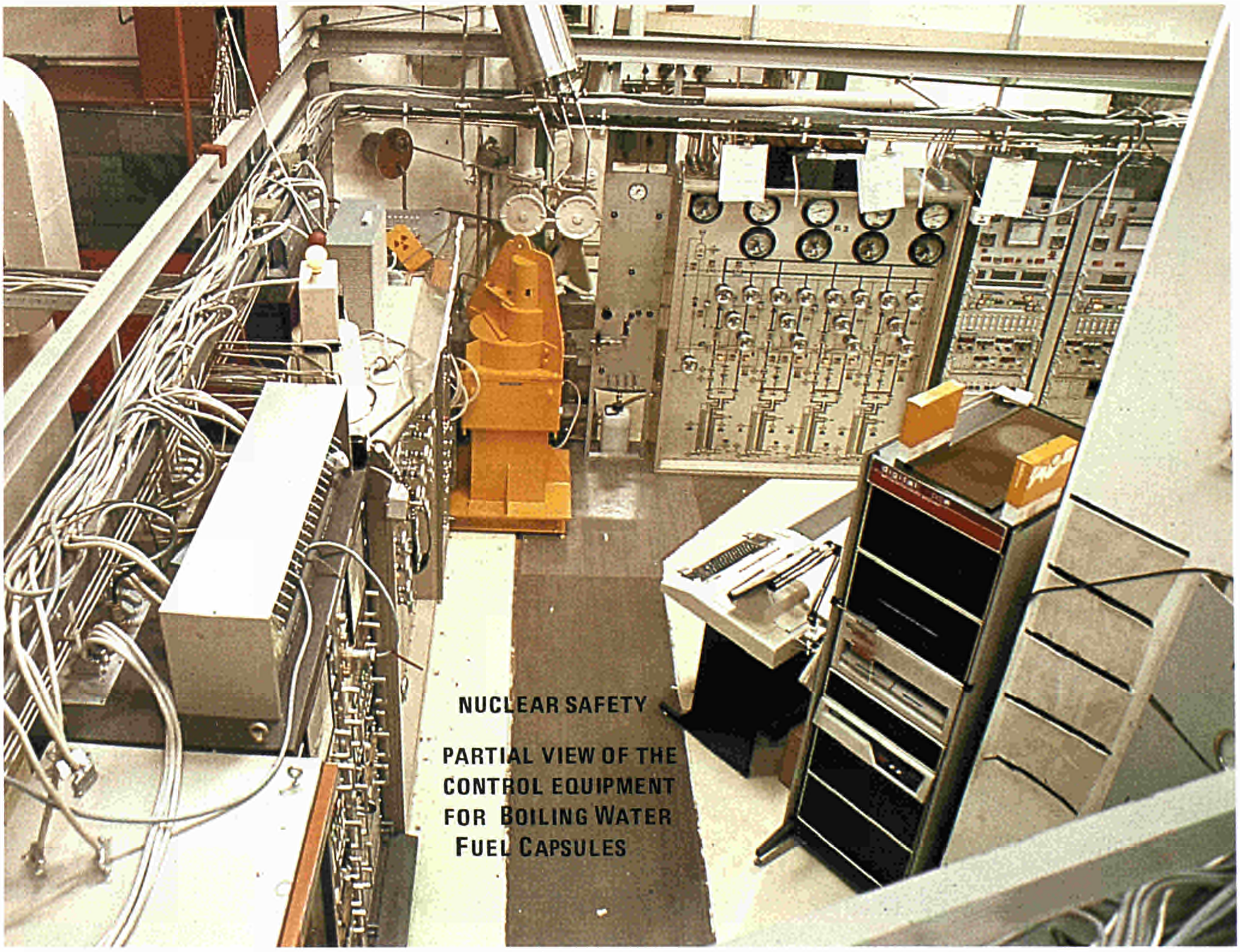
Similar experiments have been developed since 1977 for fast breeder reactor fuel pins of which 8 to twelve are submitted to transient power irradiations every year in specially designed capsules. The translation of the HFR environment into real fast reactor conditions is achieved by a combination of particular neutron flux measurements and computer calculations. Certain irradiation devices use cadmium filters to simulate the fast reactor neutron spectrum.

Another safety problem in breeder reactors concerns the response of neutron-irradiated structures to mechanical stresses including vibration and shock. Nearly 1000 stainless steel specimens have been irradiated in HFR over the past five years, and transferred to post-irradiation mechanical testing in shielded laboratories ("hot cells").

In another field, boron-silicate glass pellets containing small amounts of uranium have been irradiated in cadmium-screened capsules. These experiments simulate the long-time radiation damage by radioactive waste to its glass matrix, and should supply answers to the question how long waste can safely be excluded from the environment.

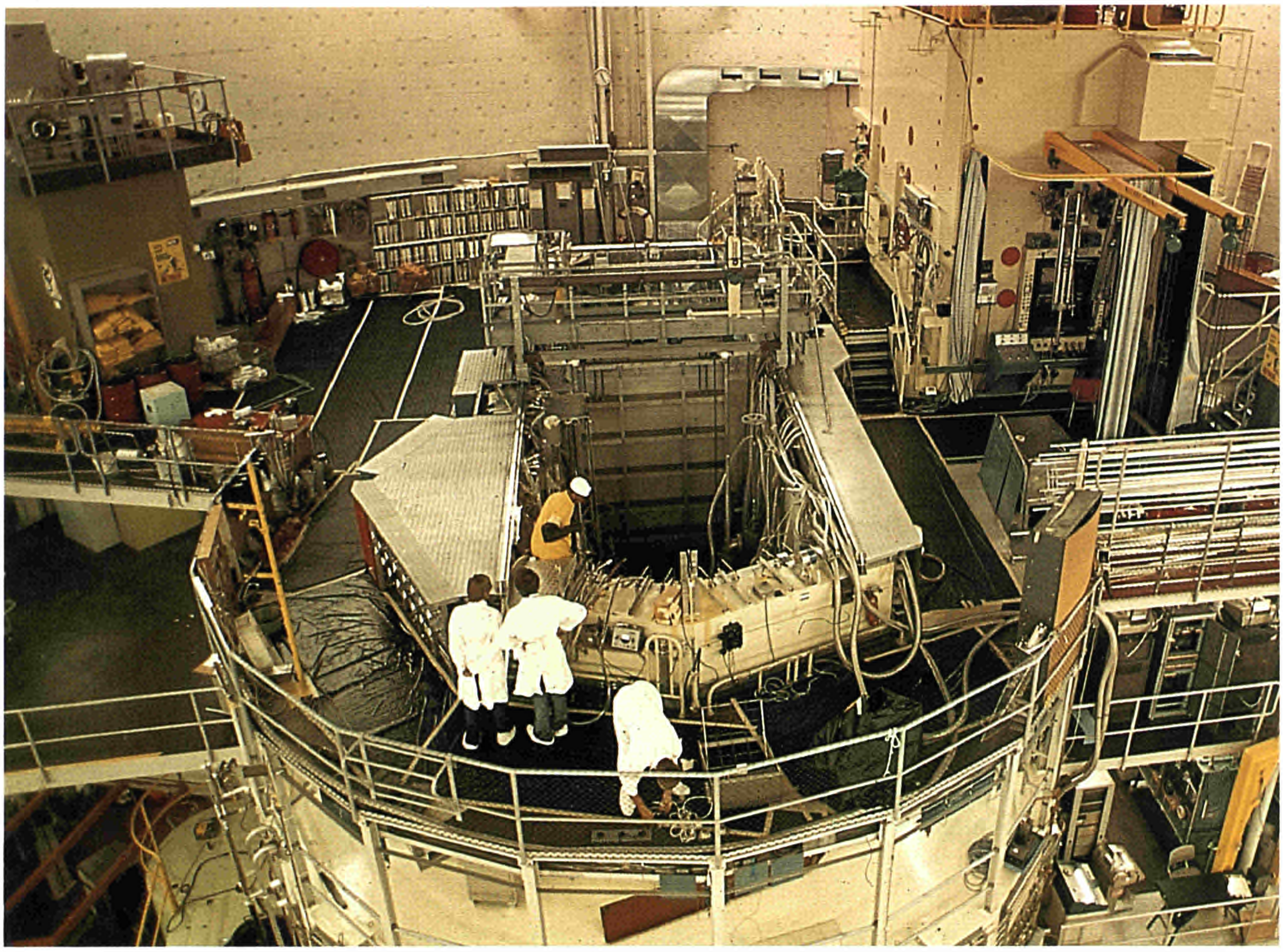
The 1980 achievements can be summarized as follows :

- transient condition testing of 27 pre-irradiated light water reactor fuel pins,
- six operational power transient tests on fast breeder fuel pins, five fast breeder fuel pin loss-of-cooling tests,
- irradiation of about 150 stainless steel samples for investigations into safety aspects of the mechanical behaviour of irradiated structures,
- one simulation test on glass pellets for radioactive waste fixation.

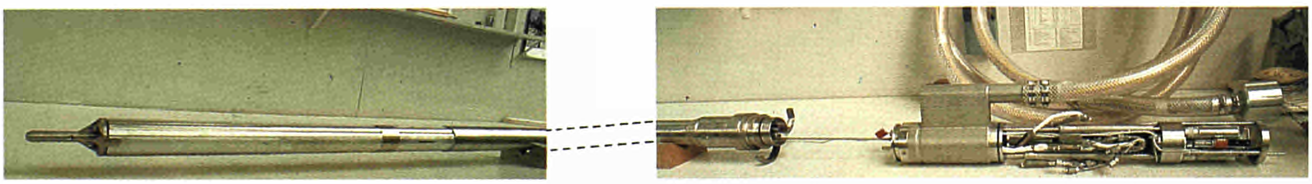


NUCLEAR SAFETY

PARTIAL VIEW OF THE CONTROL EQUIPMENT FOR BOILING WATER FUEL CAPSULES



PREPARING A REACTOR CORE LOADING CHECK DURING SHUT-DOWN

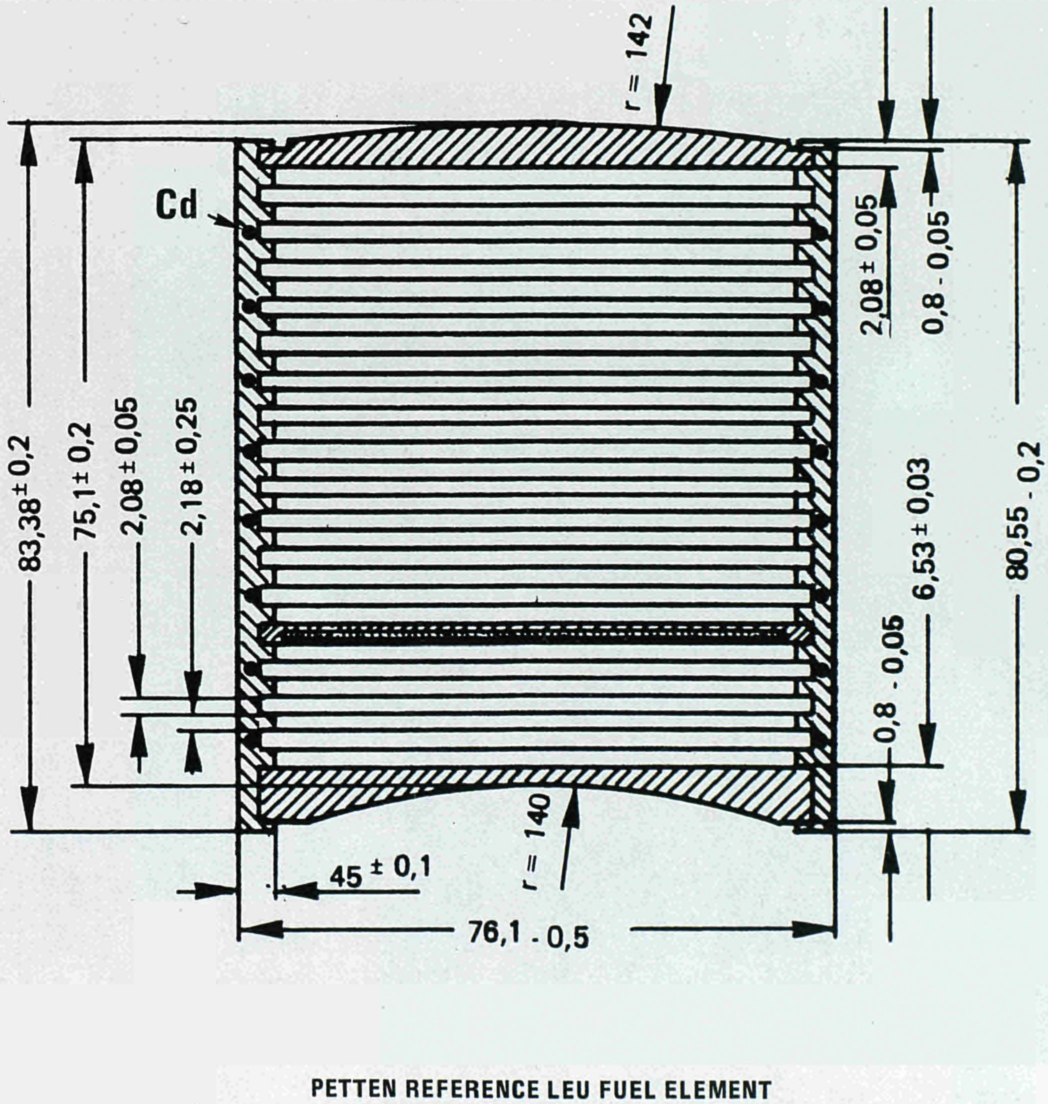


STANDARD IRRADIATION FACILITIES

LOWER PORTION AND HEAD OF A RELOADABLE IN-CORE IRRADIATION CAPSULE

Development of Proliferation-Proof Research and Test Reactor Fuel (Project "LOUISE")

One of the recommendations of Working Group 8C of the International Nuclear Fuel Cycle Evaluation (INFCE) concerned the fuel of research and test reactors: wherever technically and economically feasible these reactors should be converted from the presently used highly enriched uranium to proliferation-proof reduced enrichment material.
Studies on such novel fuel elements have been carried out at HFR Petten since 1977. As a contribution to the technological development, an element has been developed and designed for irradiation testing of research reactor fuel with 20 °/o enrichment. This project, managed by ECN, is covered by a large international collaboration involving the Argonne National Laboratory, USA; CERCA, Romans, France; NUKEM, Hanau, Germany; and the International Atomic Energy Agency, Vienna.
The first test irradiations are now planned for 1981. Together with non-destructive and destructive post-irradiation analyses, they will provide the necessary technological basis for the future conversion of low and medium power research reactors (up to 5 . . . 10 MW) to proliferation-resistant fuel.



PETTEN REFERENCE LEU FUEL ELEMENT
SECTION OF AN IRRADIATION TESTING ELEMENT

2.2.3 Energy

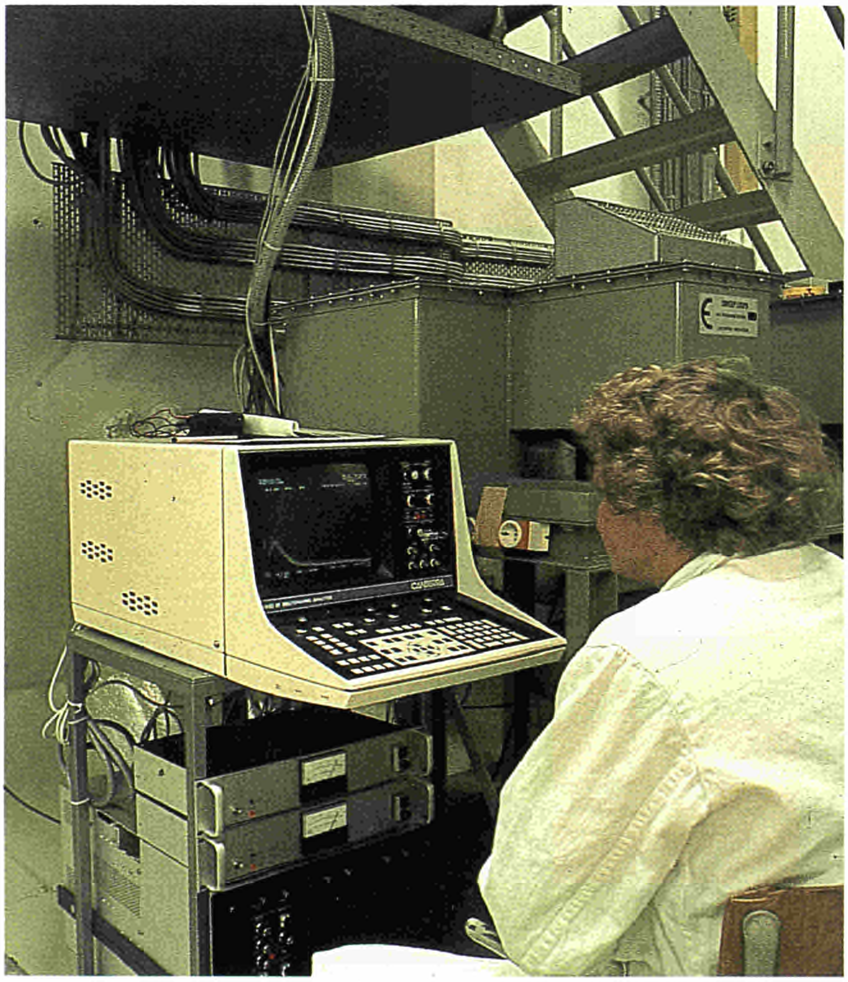
Sweep Loops for the Development of the High Temperature Reactor

The High Temperature Gas Cooled Reactor (HTR or HTGR) offers a number of advantages as compared to the current light water reactors :

1. higher thermal efficiency, i.e. improved utilization of resources and reduced waste heat release,
2. large flexibility of its fuel cycle, including proliferation-resistant solutions,
3. better inherent safety,
4. possible utilization for high temperature chemical processes, including coal gasification and liquefaction (replacement for natural gas and oil).

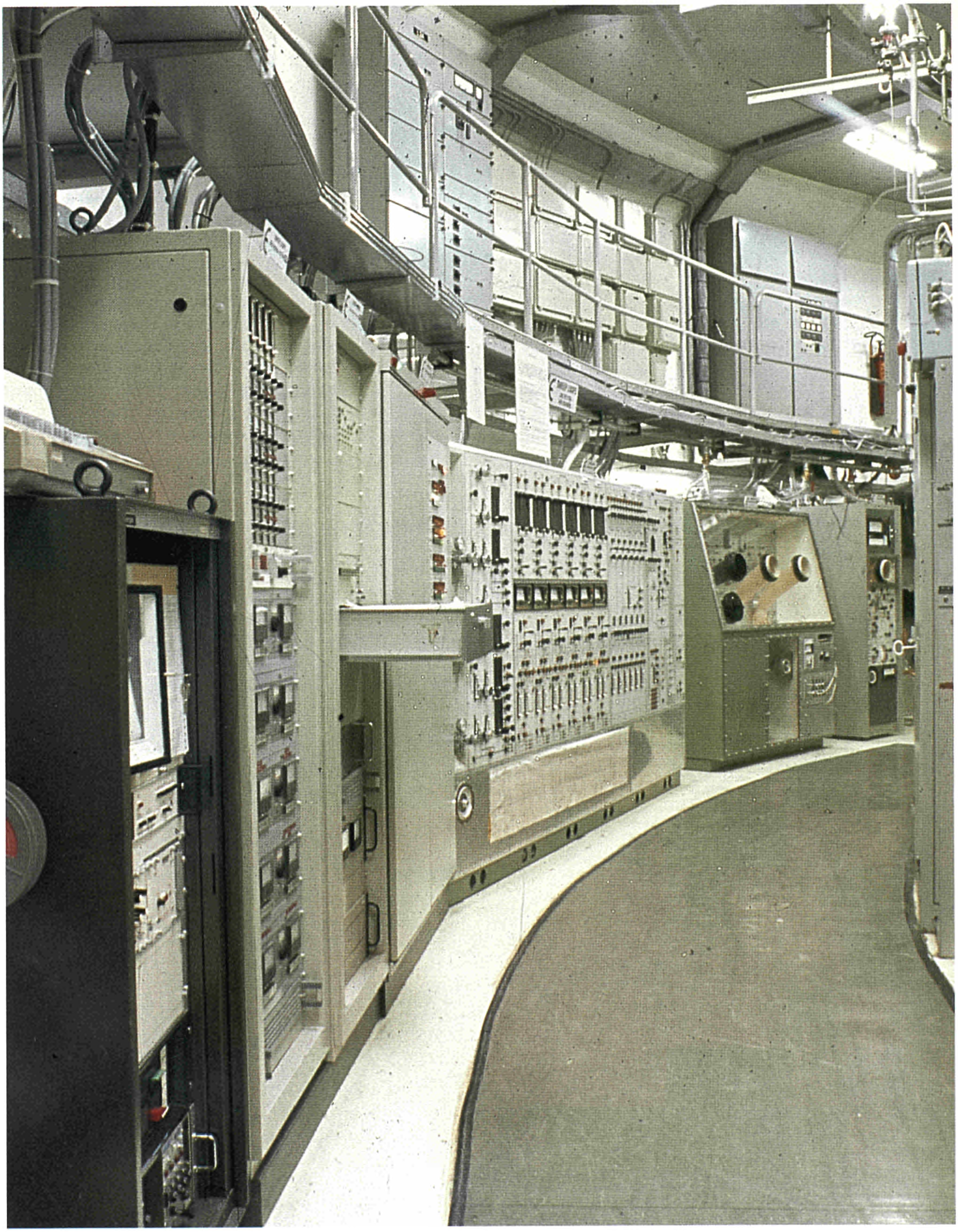
The development of this reactor type is actively pursued in the Federal Republic of Germany and in Japan with contributions from a number of other countries.
HFR Petten has been in charge of test irradiations for two materials which are typical for the HTR :
- graphite as a predominant core structural material
- coated particle fuel elements.

As a contribution to HTR fuel element irradiation testing, a large new facility has been installed and taken into operation by the end of 1980: the so-called "sweep loops" control the radioactivity (i.e. fission product) release from HTR fuel specimens irradiated under representative conditions in HFR Petten.
The installation which can operate and control independently six fuel samples is equipped with a central programmable microprocessor controller and with a computer-controlled gamma spectrometer, and is the most advanced of its kind in the world.
Intense experimental utilization is planned during the coming five years.



ENERGY

FUEL TESTING FOR THE GAS-COOLED HIGH TEMPERATURE REACTOR.
MULTI-CHANNEL ANALYSER FOR ON-LINE MEASUREMENT OF RADIOACTIVE RELEASE.



ENERGY

FUEL TESTING FOR THE GAS-COOLED HIGH TEMPERATURE REACTOR.
PARTIAL VIEW OF THE NEW CONTROL EQUIPMENT OF THE "SWEEP LOOPS"

2.2.4 Protection of the Environment

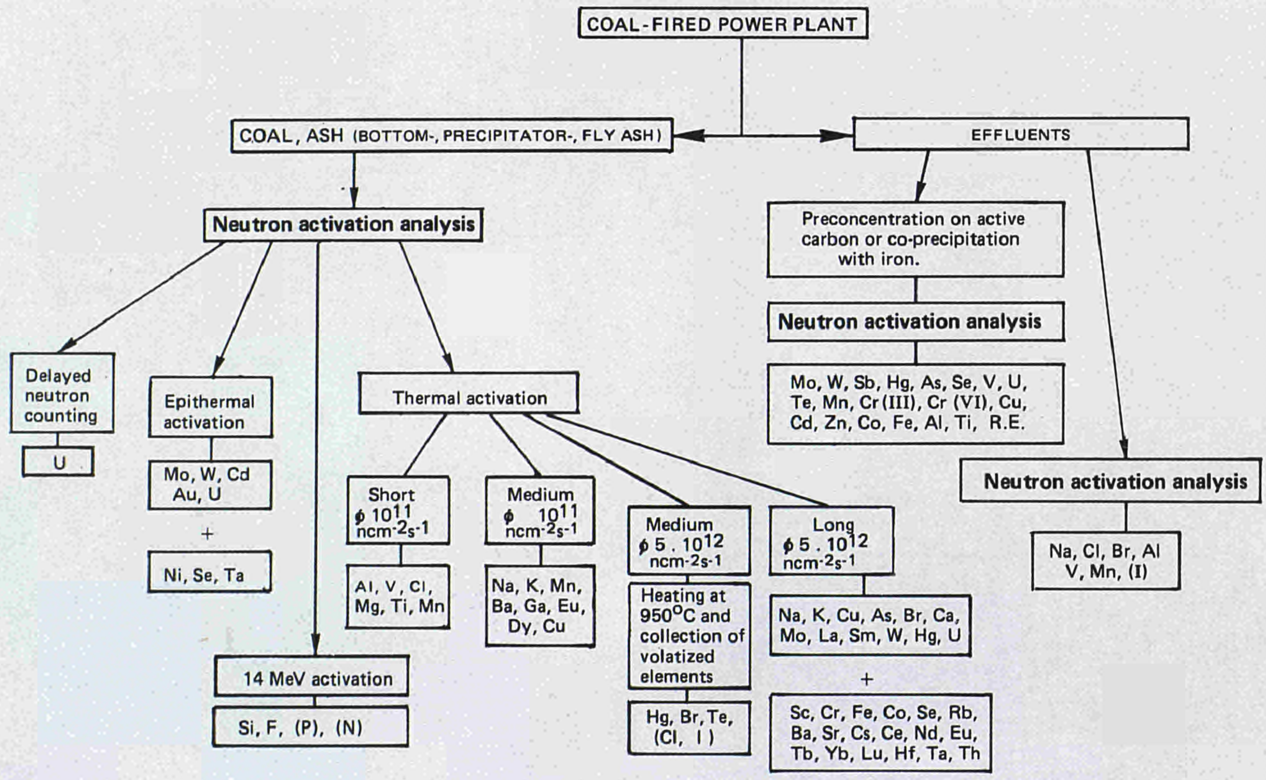
The increased utilization of coal as a replacement of oil has been considered since several years. For an assessment of its environmental impact, however, the detailed knowledge of the impurities contained in coal is required.

Neutron activation analysis is a very efficient and accurate method for the determination of a large number of trace impurities and contaminants, like arsenic, mercury, cadmium, uranium, etc. HFR Petten offers several facilities for activation analysis over a wide range of irradiation times and sample volumes, using both conventional and prompt gamma ray techniques. About 20 elements are routinely determined in coal and ashes by instrumental methods. Recognition of country of origin of coal samples has been shown by the concentration determination of 17 trace elements. Also relations for trace element concentrations were found between coal and coal ashes (fly ash) for pulverized coal burners. Trace element concentrations in leach solutions of fly ash have been determined for environmental studies. In general the trace elements are concentrated on activated charcoal before determination by neutron activation analysis.

For prompt gamma ray measurements the neutron beam at HB 4 was modified in such a way that the beam is split into two beams, one of which can be used for activation analysis. The installation has been completed and approved for operation during 1980.

The irradiation facility PROF, one of the most useful for instrumental neutron activation analysis, has been replaced.

A large number of trace element determinations have been carried out on rock samples for geologic studies. Typical uranium determinations in rocks and sediments have been made, using the delayed neutron counting method after activation in the fast pneumatic systems FASY. This experimental fast pneumatic system has to be revised and a part of the instrumentation has been renewed, completion is expected in the next year.



ENVIRONMENT POLLUTION CONTROL OF COAL-FIRED POWER PLANTS
FLOW SHEET OF NEUTRON ACTIVATION ANALYTICAL PROCEDURES

2.2.5 Fundamental Research

Certain interactions of neutrons with matter, like prompt gamma emission after neutron capture, scattering, diffraction, etc., can be used for studies of fine structures of nuclei or crystal structures of solids. The installation around the reactor use "beams" of neutrons extracted from the core through horizontal tubes. Spectrometers arranged around the target area measure intensity, energy, orientation and polarization of the emitted radiation, which are then analysed by means of computer codes.

Solid State Physics

In 1980, all experimental facilities for neutron scattering research have continuously been in operation. A major fraction of the experiments that were carried out stemmed from joint programmes of ECN and the Dutch Universities.

Instrumental

- In the course of recent years, the loading scheme of the HFR core had been gradually changed in such a way that the flux values for the horizontal beam tubes had decreased appreciably. During the year, the problem has been quantified and reactor loading modes for future improvement have been designed.
- For the neutron diffractometer at HB5 a new set of "Soller" slits for reaching a high resolving power were almost completed.
- New electronics instrumentation and a mini-computer became ready for installing. The development of the required software was nearly finished.
- Sample positioning and temperature control in the helium cryostat for the four circle diffractometers were improved. The instruments can be continuously operational during a period of several months.
- On the triple-axis spectrometer a position sensitive line detector and its instrumentation have been installed. This is of particular significance for diffuse neutron scattering research.

Research

The research programmes carried out by means of the HFR neutron scattering facilities covered several topics in crystallography, chemistry, solid state physics and metal physics.
This comprised the following subjects :

- determination of crystal and magnetic structures. (neutron diffraction). For this purpose over one hundred diffraction patterns of powder samples were collected.
- Spin densities and form factors of alloys of transition metals (polarized neutron scattering). The theoretical formalism for the analysis could be improved significantly.
- Clustering and relaxation effects in binary and ternary alloys of copper, nickel and iron. The experimental phenomena could now be interpreted by means of a theoretical model (diffuse neutron scattering).
- Short-range ordening in a spinglass system, its temperature dependence and the effect on the magnetic properties (diffuse neutron scattering).
- Structure of liquid alloys of alkali metals and in particular the details in the partial structure factors of Na-K and K-Cs systems (neutron diffraction).
- Phase transitions in antiferromagnetic systems. New structural phase transitions were established in a linear chain system (neutron diffraction). The character of the boundaries of phases in a spinflop system were studied in great detail by means of critical neutron scattering.

Based on this work there have been 25 external publications in 1980, among which two Ph.D theses.

Nuclear Physics

- *General*

Four horizontal beam tubes have been used by the FOM-ECN Nuclear Structure Group during 1980. Cooperation and close contacts with university laboratories and nuclear research centers on national and international level were continued.
The excellent link between the Petten nuclear physics research and the Dutch university research is demonstrated by the number of Ph.D theses from the Petten Nuclear Structure Group, which this year reached a total of 15.

- *Scientific programme*

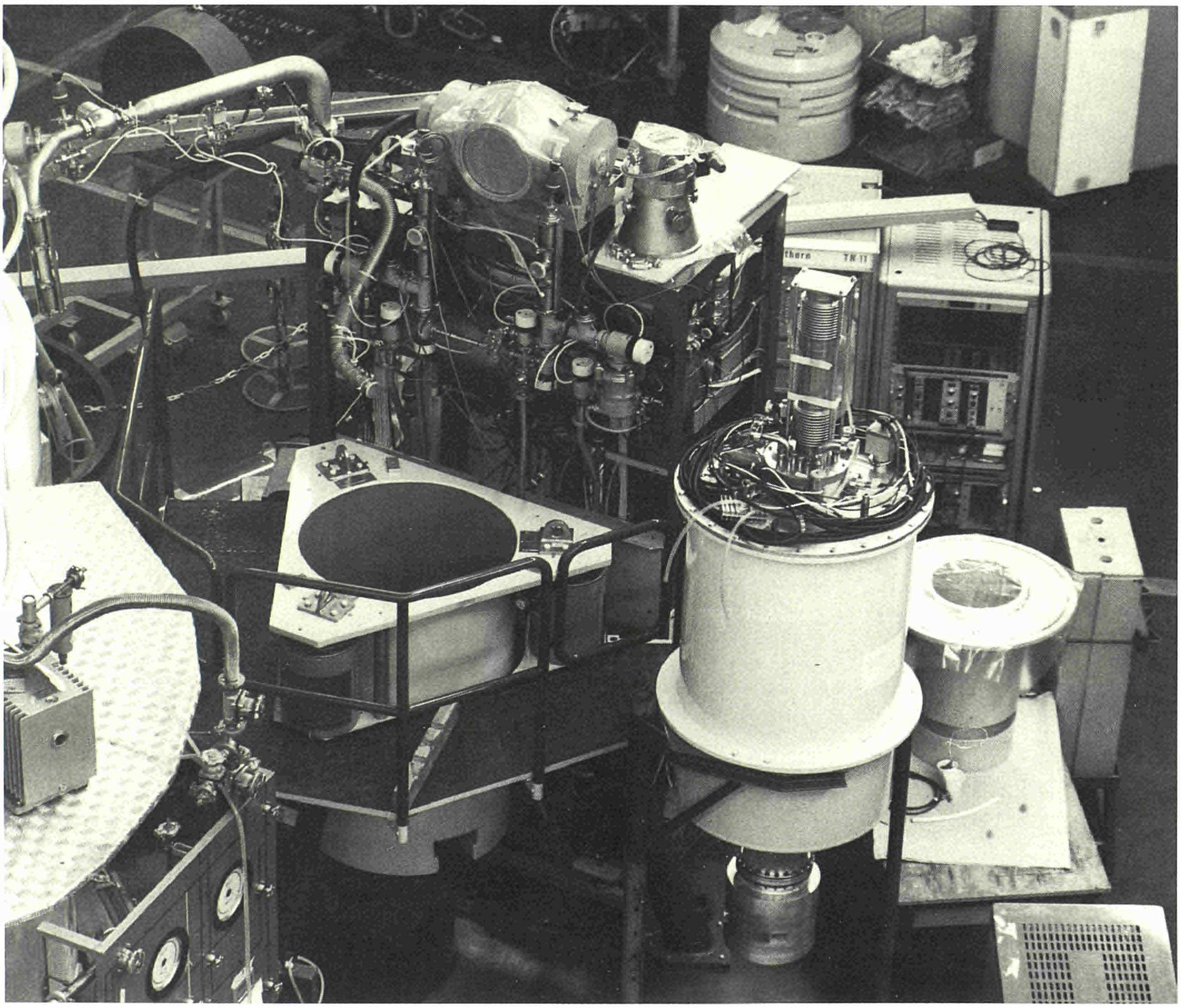
Nuclear spectroscopy (mostly in the energy range $E_\gamma > 2{,}5$ MeV) has been carried out on the nuclei ^{24}Na, ^{46}Sc, ^{48,50}Ti and ^{64,66}Cu.
Measurements on circular polarization of γ-rays following capture of polarized thermal neutrons were performed on the ^{23}Na(n,γ) and the ^{47,49}Ti(n,γ) reaction. Shell model calculations using the CYBER computer have been prepared in collaboration with the Van de Graaff laboratory in Utrecht.

- *Experimental*

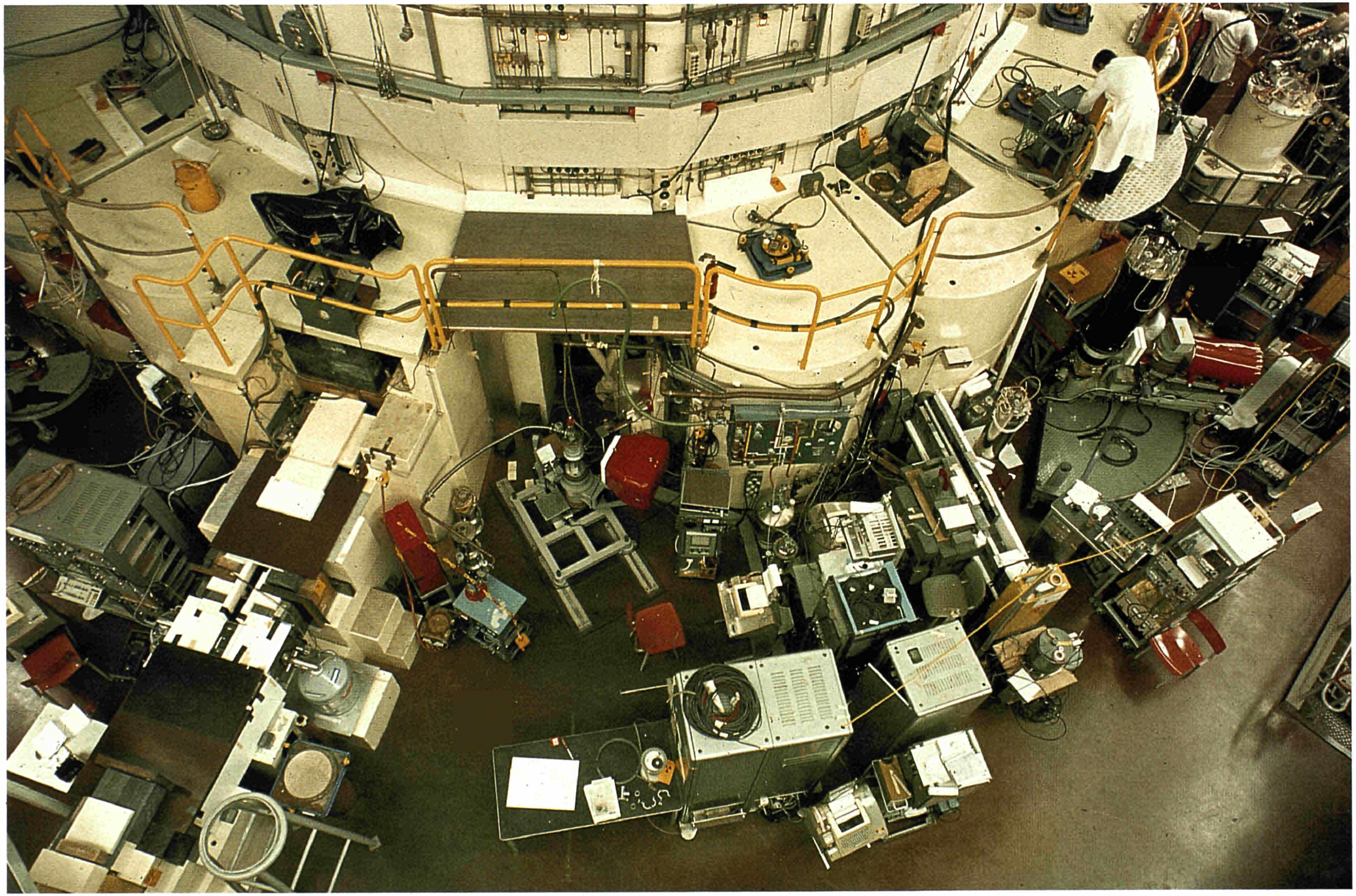
1. The magnet of the nuclear orientation set-up at HB2 has been operating at 7,7 T *). A future uprating to 10 T is in study.
2. The pair-spectrometer at HB0 has provided a vast amount of precisely determined γ-lines resulting in a better insight in the level schemes of the nuclei formed by neutron capture.

   Excitation energies and branching ratios have been determined for 132 bound levels, among which 27 new levels have been proposed.
3. By means of a pyrolytic graphite crystal a Bragg-reflected thermal neutron beam has been extracted at HB4. This facility is being used by the ECN Neutron Activation Group (see paragr. 2.2.4).
4. In the frame of a tripartite agreement preparations have been made for a parity-interference experiment in Petten: a fast neutron spin-rotator has been installed at HB7. This device, which allows a 180^{o} spin flip within 25 ms, is now in operation for the circular polarization experiment.

*) 1 T (Tesla) = unit for the strength of a magnetic field.



NUCLEAR PHYSICS.
MAJOR COMPONENTS OF THE NUCLEAR ORIENTATION SET-UP AT HB2.



FUNDAMENTAL RESEARCH

VIEW ONTO THE EXPERIMENTAL EQUIPMENT FOR NUCLEAR AND SOLID STATE PHYSICS USING THE HORIZONTAL BEAM TUBES

2.2.6 Life Sciences

Radioisotopes for Medical Applications

Diagnosis and therapy of cancer have made increasingly use of a short-lived radioisotope called "Technetium 99m" (^{99m}Tc) which can be produced in high purity by radioactive decay of another short-lived radioisotope, viz. "Molybdenum 99" (^{99}Mo).

^{99}Mo is produced in HFR Petten by two different techniques :

1. irradiation of molybdenum (activation route)
2. irradiation of highly enriched uranium (fission product route).

Several facilities have been developed to satisfy the increasing demand for ^{99}Mo, including new in-core capsules from which the irradiated targets can be unloaded during reactor operation. Presently, transports with ^{99}Mo leave Petten every week, according to an exact time table.

Most of the other isotopes produced in HFR in 1980 have been for medical applications. In total, 1700 individual samples have been irradiated.

Studies for the production of ^{60}Co have been started, in order to satisfy the future large demand for this isotope in food-stuff sterilisation plants.

Activation analysis is in use for trace element studies in human serum and the albumen fractions therein. This study is undertaken in co-operation with the university hospital of the Free University of Amsterdam and will result in a Ph.D. thesis.

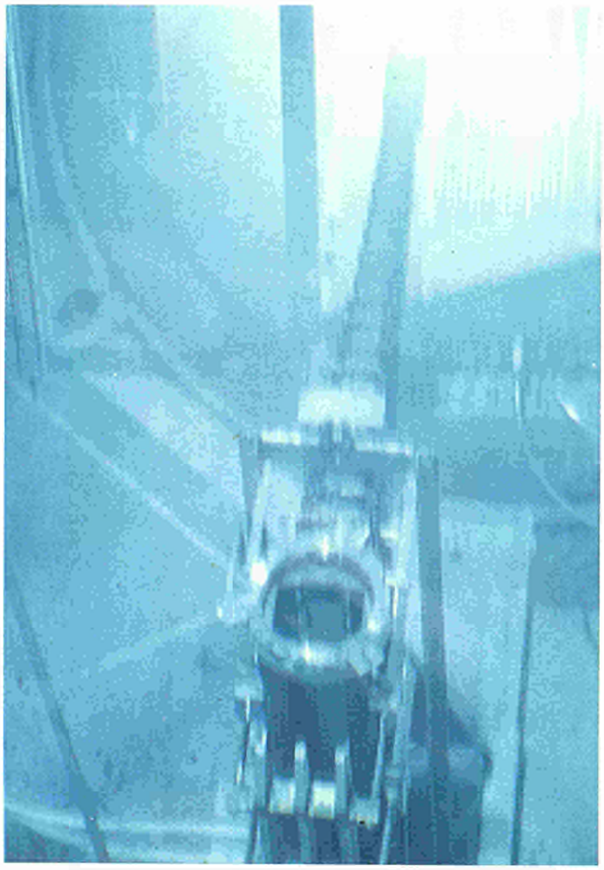
2.2.7 Miscellaneous

Neutron radiography is used at HFR Petten on a routine basis for the control of irradiated experimental equipment and for the examen of neutron-induced structural changes in fissile material. 240 neutron radiographs have been taken and evaluated in 1980.

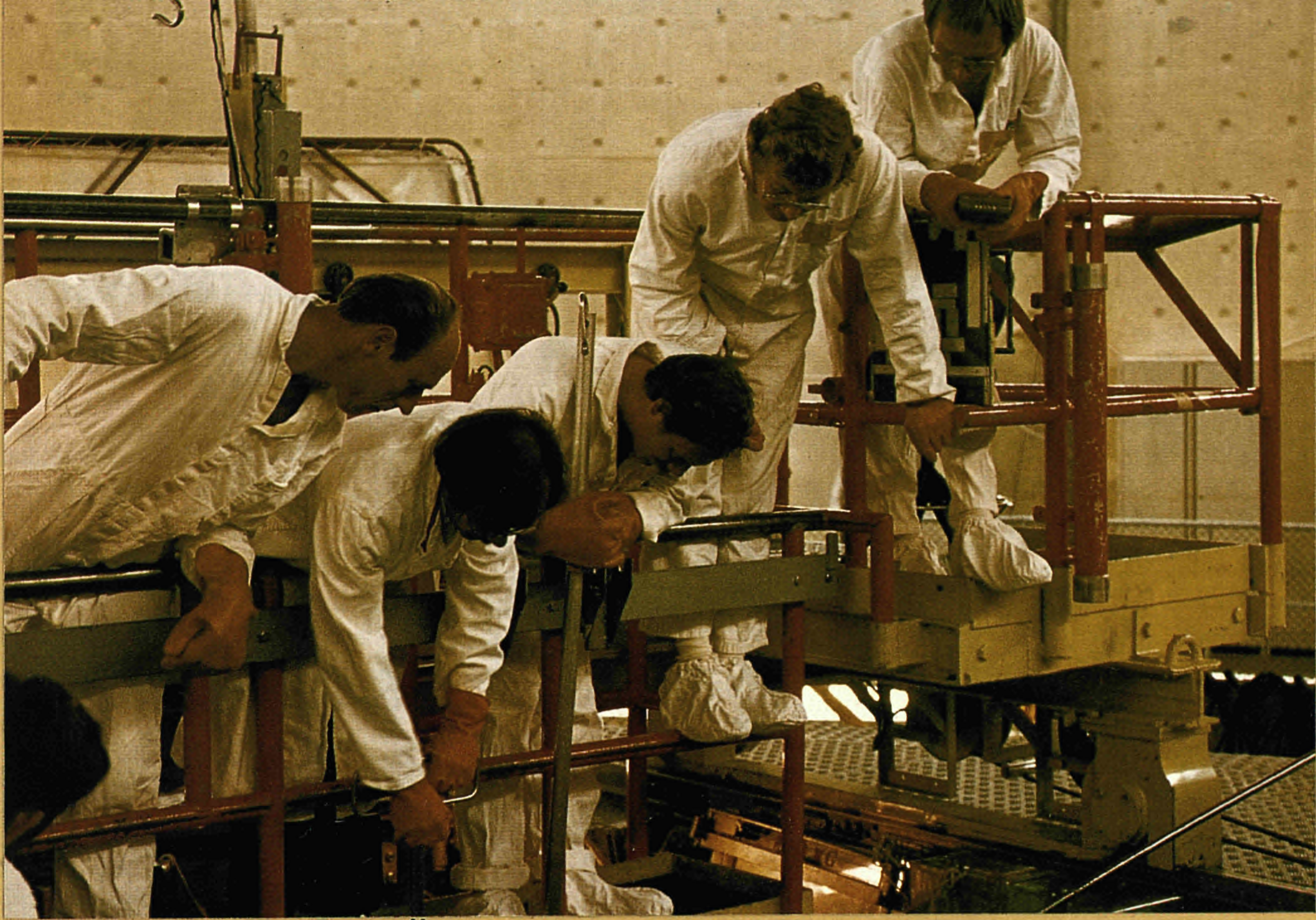
As a novel development, filtered beams have been used for investigations into fast breeder reactor fuel structures which had been "invisible" with the more conventional methods of neutron radiography.

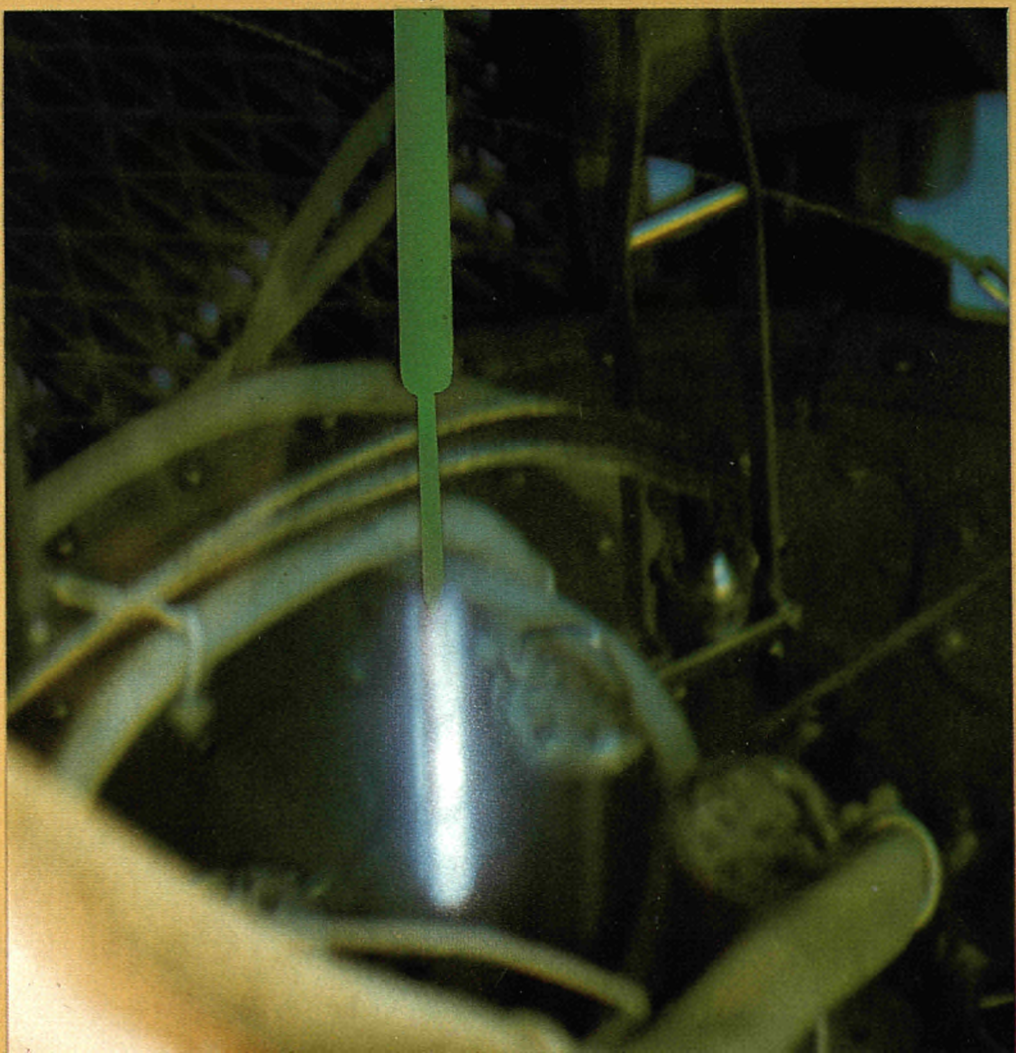
Several special test devices have been loaded in various reactor positions throughout the year, including

- a nuclear heating calorimeter,
- a capsule with aluminium specimens for reactor vessel material surveillance,
- instrumentation and power measurement test rigs, in preparation of a future large safety experiment ("TOP") for the fast breeder reactor.



NEUTRON RADIOGRAPHY CAMERA IN THE HFR POOL





LIFE SCIENCES

MOLYBDENUM-99 PRODUCTION FOR CANCER DIAGNOSES. UNLOADING OF THE IRRADIATED SAMPLES FROM A NEW HFR IN-CORE FACILITY.

3. CONCLUSIONS

HFR Petten has been operated in 1980 in fulfilment of the 1980/83 JRC Programme Decision.
Both reactor operation and utilization data have been met within a few percent of the goals set out in the annual working schedule, in support of a large variety of research programmes.
Major improvements to experimental facilities have been introduced during the year and future modernization has been prepared.

HFR Petten

UTILIZATION

WHY ARE THESE EXPERIMENTS CARRIED OUT IN THE HFR ?

- **FAST BREEDER REACTOR STRUCTURAL MATERIALS IRRADIATIONS :**
  SEVERAL HIGHLY RELIABLE IRRADIATION CAPSULES AND SPECIAL HOT CELL EQUIPMENT AVAILABLE
- **FAST BREEDER REACTOR FUEL PIN TESTING UNDER ABNORMAL CONDITIONS AND UNDER OPERATIONAL TRANSIENTS :**
  LONG-STANDING EXPERTISE, AVAILABILITY OF THE PSF, AND OF SPECIAL IN-PILE INSTRUMENTATION, ADVANCED CONTROL EQUIPMENT
- **LIGHT WATER REACTOR FUEL PIN POWER RAMPING :**
  AVAILABILITY OF THE PSF AND LARGE CONTROL EQUIPMENT
- **HIGH TEMPERATURE GAS COOLED REACTOR GRAPHITE AND FUEL ELEMENT IRRADIATION :**
  MODERN SWEEP LOOP FACILITIES; WELL-KNOWN FLUX SPECTRA, SEVERAL PROVEN CAPSULE TYPES, HOT CELL RE-ENCAPSULATION FACILITY FOR ACTIVE SAMPLES
- **NUCLEAR STRUCTURE AND SOLID STATE PHYSICS EXPERIMENTS :**
  NUMEROUS EXPERIMENTAL INSTALLATIONS, LONG-STANDING EXPERTISE
- **RADIOISOTOPE PRODUCTION, ACTIVATION ANALYSIS :**
  REGULAR REACTOR OPERATIONS, MANY SPECIAL FACILITIES, HIGH NEUTRON FLUXES
- **NEUTRON RADIOGRAPHY, NEUTRON DOSIMETRY DEVELOPMENT :**
  MODERN, PURPOSEFUL EQUIPMENT, WELL-KNOWN FLUX SPECTRA

UTILIZATION

1980 ACHIEVEMENTS

- FAST BREEDER REACTOR STRUCTURAL MATERIALS IRRADIATIONS :
  IRRADIATION AND HOT CELL TESTING OF 150 VESSEL STEEL SPECIMENS
- FAST BREEDER REACTOR FUEL PIN TESTING UNDER ABNORMAL CONDITIONS AND UNDER OPERATIONAL TRANSIENTS :
  11 FUEL PINS TESTED UNDER TRANSIENT CONDITIONS
- LIGHT WATER REACTOR FUEL PIN POWER RAMPING FOR IMPROVED OPERATING ECONOMY AND SAFETY :
  POWER RAMP TESTS ON 27 PRE-IRRADIATED FUEL PINS
- HIGH TEMPERATURE GAS-COOLED REACTOR GRAPHITE AND FUEL ELEMENT IRRADIATIONS :
  CONTRIBUTION TO THE DATA BASE OF THE HTGR : 900 GRAPHITE SAMPLES UNDER IRRADIATION, SOME UNDER STRESS (CREEP SAMPLES)
- RADIOISOTOPE PRODUCTION, ACTIVATION ANALYSIS :
  1700 SAMPLES AND CAPSULES IRRADIATED FOR MEDICAL AND INDUSTRIAL APPLICATIONS, ENVIRONMENTAL POLLUTION CONTROL, RESEARCH PURPOSES
- NUCLEAR STRUCTURE AND SOLID STATE PHYSICS EXPERIMENTS :
  CONTINUOUS UTILIZATION OF EIGHT HORIZONTAL BEAM TUBES.
  IMPROVEMENTS ON SEVERAL EXPERIMENTAL SET-UPS
- NEUTRON RADIOGRAPHY, NEUTRON DOSIMETRY DEVELOPMENT :
  240 NEUTRON RADIOGRAPHS TAKEN
  CONTRIBUTIONS TO HFR FLUX LEVEL AND SPECTRA KNOWLEDGE, AND TO INTERNATIONAL DOSIMETRY WORK.
- NON-PROLIFERATION :
  CONTRIBUTIONS TO THE DEVELOPMENT OF REDUCED ENRICHMENT FUEL FOR RESEARCH REACTORS.

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