INIS-XA-N--214

INVAP

MULTI-PURPOSE

REACTOR

INVAP S.E.- MORENO 1057-(8400) BARILOCHE-ARGENTINA
TEL.944·22121-FAX 944·23051-TELEX 80715 INVAP AR

INDEX

CONTENT

INTRODUCTION

REACTIVITY BALANCE

DESIGN CONCEPT

COMPUTERIZED SUPERVISION AND CONTROL SYSTEM

BACKGROUND

DATA SHEET

INTRODUCTION

The Multi-Purpose-Reactor (MPR), is a pool-type reactor with an open water surface and variable core arrangement. Its main feature is plant safety and reliability. Its power is 22 MW_{th}, cooled by light water and moderated by beryllium. It has plate-type fuel elements (MTR type, approx. 20% enriched uranium) clad in aluminium. Its cobalt (Co^{60}) production capacity is 50000 Ci/yr , 200 Ci/gr.

The distribution of the reactor core and associated control and safety systems is essentially based on the following design criteria:

- upwards cooling flow, to waive the need for cooling flow inversion in case the reactor is cooled by natural convection if confronted with a loss of pumping power, and in order to establish a superior heat transfer potential (a higher coolant saturation temperature).

- easy access to the reactor core from top of pool level with the reactor operating at full power, in order to facilitate actual implementation of experiments. Consequently, mechanisms associated to control and safety rods are located underneath the reactor tank.

- free access of reactor personnel to top of pool level with the reactor operating at full power. This aids in the training of personnel and the actual carrying out of experiments, hence:
    - a vast water column was placed over the core to act as radiation shielding;
    - the core's external area is cooled by a downwards flow which leads to a decay tank beyond the pool (for N^{16} to decay);
    - a small downwards flow was directed to stream downwards from above the reactor core in order to drag along any possibly active element; and
    - a stagnant hot layer system was placed at top of pool level so as to minimize the upwards coolant flow rising towards pool level.

REACTIVITY BALANCE

The reactivity balance of the reactor is controlled by **two separate, diverse and independent systems**:

- the reactor control and safety plates; and
- a fast gadolinium injection system.

Thus, the actuating mechanisms of the two systems enhance safety via diversity, while they also provide easy access to the reactor core for fuel changing, experiments, etc.

DESIGN CONCEPT

The design concept bases on the requirement of a versatile utilization reactor. It has been mainly designed for:

- *neutron radiography* for research and industrial purposes;
- *radioisotope production* for medical and industrial purposes;
- *basic and applied research* in reactor physics and nuclear engineering;
- beam hole experimentation for *neutron scattering experiments* and neutron radiography;
- *material testing*;
- *activation analysis*;
- *uranium-thorium determination*;
- irradiated fuel elements *gamma scanning*;
- *materials irradiation* ; and
- *training* of scientific and technical personnel.

Irradiation boxes are used for radioisotope production. Boxes are either inserted in the core or positioned within the external reflector. Manipulation and distribution of irradiated items is carried out within the hot cells located at the top of the reactor pool. Additional labs are also contemplated to study and manipulate irradiated materials.

Different rabbit systems, one central irradiation facility and several reflector irradiation positions are provided for irradiation experiments.

In order to facilitate research activities, the reactor has been provided with: a) neutron beam channels, b) high-pressure and high temperature loops for fuel rod irradiation or material samples irradiation , and c) a Neutron Radiography Facility.
Cold Neutron Source, Time of Flight Facility and Neutron Diffractometers could also be supplied.

There is an auxiliary pool for spent-fuel storage and for storing samples resulting from the test loops. A transference gate connects the reactor pool to the auxiliary pool.

Reactor safety is complemented with a network of radiation detectors located in contamination-risk areas, plus a fire-detection and, manual and automatic fire-extinguishing system.

Auxiliary services such as water supply, compressed air, electrical energy system, communications system, workshops, phusical security system and labs have also been considered.

COMPUTERIZED SUPERVISION AND CONTROL SYSTEM

A **"Multi-Parameter Distributed Processing Data-acquisition,Display, and on-line supervision and control system"** is provided. Its main objectives are:

- to supervise and monitor the various systems involved in the functioning of the installation in order to assist Control Room personnel to operate the plant;

- to provide overall visual plant control while maintaining a detailed record of all actions undertaken; and

- to provide a short and long term memorization of analog and digital data for post trip logs, post transient analysis, event analysis.

BACKGROUND

This reactor has been designed both on the basis of previous works and the know-how acquired by **INVAP S.E.** in the nuclear field, as well as on the scientific knowledge and expertise acquired by the **Argentine Atomic Energy Commission (CNEA)** for over thirty years in designing and building nuclear research reactors.

Research reactor activity began in Argentina in 1958, when the RA-1 reached criticality. This actually constituted the first nuclear fission in the Southern Hemisphere.

As from then, CNEA has built and put in operation the RA-2, RA-3 and RA-0 reactors.

The *RA-6 reactor, designed and built by INVAP* (based upon previous experiences of CNEA), for the Balseiro Institute - a center devoted to the formation of physicists and nuclear engineers in San Carlos de Bariloche, Argentina - was completed in 1982. The RA-6 is a 500 KW, open-pool type reactor with plate-type fuel elements, specifically designed for teaching and training of personnel.

The RP-10 reactor, designed and built by CNEA for Perú, reached criticality in 1988. This is a 10 MW, open-pool type reactor with MTR-fuel elements. *INVAP supplied the complete nuclear instrumentation, reactivity control drive mechanisms and various other mechanisms and components.* Earlier, in 1978, CNEA and INVAP had provided the IPEN (Perú), with the RP-0 critical facility which was a neutron model of the RP-10 reactor. **This reactor constituted the first concrete evidence of nuclear technology transference between two Third World countries.**

In April 1989, the *NUR reactor in Algeria was inaugurated as a result of the "Haut Commissariat a la Recherche" (HCR)/INVAP cooperation agreement.* The NUR is a 1 MW, pool-type, MTR-fuel element reactor. INVAP had the sole responsibility for the overall project. It included participation of Algerian personnel throughout all project stages. This was considered by both parties as an optimum mechanism for the transference of technology.

In addition to the above, INVAP has been responsible for the following projects in the nuclear area:

- RA-5, a natural uranium and heavy water critical facility. Revision of an earlier project.
- RA-7, a 100 MW natural uranium and heavy water reactor. The entire conceptual engineering and the basic engineering of the main systems.
- Proposal for a 2 MW, pool-type reactor with plate-type fuel elements for the Institute of Nuclear Affairs of Colombia.

INVAP S.E. is currently working on the CAREM project, a 15-30 MW_e nuclear-electric plant. As part of this project, INVAP is building the RA-8 reactor, a critical facility for testing the CAREM core (under an agreement with CNEA).

Furthermore, INVAP manufactures at its own labs and workshop facilities all the critical components for nuclear reactors such as nuclear and conventional instrumentation, radiation detectors, reactivity control mechanisms, equipment for radiological control, etc.

DATA SHEET

1. REACTOR

Type:	Open pool
Power output:	22 Mw_{th}
Average thermal flux:	1.5 E^{14} $n/cm^2.sec$
Use:	Radioisotope production Research Training

Cobalt Production (for medical purpose):
50000 Ci/yr of Co^{60}
specific activity 200 Ci/gr

2. CORE

Fuel:	approx. 20% enriched Uranium
Fuel element:	Plate-type Clad in Aluminium
Coolant:	Light water (forced upwards flow)
Moderator:	Light water
Reflector:	Beryllium oxide Light water
Control:	6 absorbing rods in Ag-In-Cd
Shut-down systems:	2 separate, diverse and independent systems.
Core configuration:	Variable

3. COOLING SYSTEM

Number of circuits: 2 (Core and pool circuits)

3.1 CORE COOLING

Type:	Centrifugal pump
Heat exchanger:	Plate-type
Number of circuits:	2
Number of pumps:	4
Flow:	1700 m^3/h
Nominal temperatures:	
	40 °C inlet
	52 °C outlet

3.2 POOL COOLING

Type:	Centrifugal pump
Heat exchanger:	Plate-type
Number of circuits:	1
Number of pumps:	2
Flow:	100 m^3/h
Nominal temperatures:	
	40 °C inlet
	45 °C outlet

3.3 COOLING-AUX. POOL

Type:	Centrifugal pump
Heat exchanger:	Plate-type
Functioning:	Intermittent

4. SECONDARY SYSTEM

Type:	Cooling tower
	Centrifugal pumps

5. WATER CLEAN-UP SYSTEM

Type:	Mixed bed ion exchange columns
	Filters
N°. of equipment:	
	2 columns
	2 filters
Conductivity at outlet:	less than 2 micro S

6. REACTOR TANK

Diameter:	4.5 m
Height:	12 m
Material:	Stainless steel

7. AUXILIARY POOL

Diameter:	3 m
Height:	8 m
Material:	Stainless steel

8. SHIELDING FOR REACTOR TANK AND AUXILIARY POOL

Axial: Light water

Radial:

Light water.

Reinforced heavy concrete.

9. IRRADIATION FACILITIES

9.1 HORIZONTAL CHANNELS FOR

Neutron-beam extraction

- Tangential: 1
- Radial: 2

9.2 PNEUMATIC TRANSFER SYSTEMS

Quantity: Variable

9.3 IRRADIATION BOXES

Type:

with Graphite.

without Graphite.

Placement: Core grid

Number: Variable

10. TRANSPORTATION OF IRRADIATED MATERIAL

10.1 MECHANICAL TRANSPORT

Use: Irradiated material being transferred from reactor tank to transference cell.

10.2 TRANSFERENCE HOT CELL

Use: Loading/unloading of irradiated capsules to irradiation boxes.

Main equipment:

Shielded window.

Remote-handling tongs.

Shielding: Reinforced concrete and lead.

10.3 HOT CELL FOR LOADING

Use: Loading of irradiated capsules in transfer shielding.

Main equipment:

Shielded window.

Remote-handling tongs.

Shielding: Reinforced concrete and lead.

11. SPECIAL EQUIPMENT

11.1 UNIVERSAL CELL

Use: Opening of irradiated capsules, handling and preparation of irradiated samples.

Main equipment:

Shielded window.

Mechanical master-slave manipulators.

Airtight box.

Capsule-opening device.

Shielding: Lead.

11.2 RADIOCHEMICAL HOODS

Use: Lodging of pneumatic loop terminals

Handling of irradiated material

Quantity: Variable

11.3 NEUTRON-ACTIVATION ANALYSIS LAB

Equipment:

- Irradiation head.
- Loading and receiver station.
- Drive system.
- Pneumatic system.
- Detector of hyper-pure Germanium (HPGe).
- Multichannel.
- Data-acquisition and processing system.

11.4 LAB FOR DETERMINING URANIUM-THORIUM

Equipment:

- Irradiation head.
- Measurement station.
- Container for the storage of samples.
- Drive system.
- Pneumatic transfer system.
- BF_3 detectors and auxiliary electronics.
- Personal Computer.
- Data-acquisition and processing system.

11.5 LAB FOR GAMMA SCANNING OF IRRADIATED FUEL ELEMENTS

Equipment:

- Mechanical system.
- Drive system.
- NaI and HpGe detector.
- Auxiliary electronics.
- Personal Computer.
- Data-acquisition and processing system.

11.6 TEST LOOPS

- Test Loop within the core.
- Test Loop on the external reflector.

12. MANAGEMENT OF FUEL ELEMENTS (FE)

Irradiated FE: Deposited at auxiliary pool.

Burn-up FE's Storage Capacity: through out the life-span of the reactor.

13. INSTRUMENTATION

13.1 NUCLEAR INSTRUMENTATION

Start-up Instrum.: three fission chambers.

Power Instrum.: four ionization chambers.

Appropriately redundant and diversified safety chains.

Control Room:

- Main Control Room facing the reactor pool:
    - **Main Control Desk.**
    - **Security Officer's Desk.**
    - **Shift Supervisor's Desk.**
- Emergency Control Room

Aid to Operation System:

- **Computerized reactor Aid to Operation System.**

13.2 RADIOLOGICAL PROTECTION INSTRUMENTATION

Equipment:

- Detection of Fuel Element failures.
- Detection of activity in the secondary.
- Detection of I^{131}, noble gases and aerosols in the stack.
- Movable monitor for I^{131}, noble gases and aerosols.
- Fixed monitors for area activity.
- Various types of portable monitors.
- Whole Body Contamination Monitors.

14. REACTOR BUILDING VENTILATION SYSTEM

Type: Confinement with dynamic depression.

Hermetic isolation valves for emergency conditions.

Depression: 10 mm of w.c.

Filters:

- Absolute extraction filters for normal conditions.
- Absolute and carbon-activated filters for emergency conditions.
- Absolute and carbon-activated for recirculation under emergency conditions.

15. GENERAL SERVICES AND FACILITIES

Services:

- Industrial compressed air.
- Clean and dry compressed air.
- Fire-detection.
- Manual and automatic fire extinguishing system.
- Electrical power system.
- Stand-by power system backed by batteries.
- Electrical power system for illumination and power supply.
- Emergency power illumination system.
- Closed TV circuit.
- Internal telephone network.
- Loudspeaker system.
- Internal gas network.
- Internal network for cold/hot water.
- Bridge crane, 5 Tn, w/auxiliary hook (1 Tn) in stainless steel.

INVAP F. P. Moreno 1089 - C.C. 961 - 8400 S. C. de Bariloche - RIO NEGRO - ARGENTINA
Tel.: 54 - (944) - 22121 - Telex: 80715 INVAP - AR - Fax: 54 - (944) - 23051