**RA10 - Utilization-driven Layout**

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**ABSTRACT**

The RA10 has been conceived, from the very beginning of the project, as a multipurpose reactor and, hence, major efforts were made during the Conceptual, Preliminary and Detailed Engineering stages to ensure an efficient and safe working environment for the staff and potential users.

The strategy implemented to manage this issue involved the establishment of a specific area within the design team dedicated to integrate the general guidelines defined by the project direction with regard to specific aspects such as:

* Customer/user requirements (commercial, technical, scientific)
* Regulatory requirements on nuclear and radiological safety
* Annual operating program (taking into account reactor scheduling)
* Availability, reliability and maintainability design objectives
* Radioisotope production logistics: handling, storage, transport mechanisms and supply routes (on-site and off-site)
* Safeguards and security

The implementation of this integral approach required a continuous interaction between the different engineering groups in order to:

* Establish a clear separation between the beam users and the activities involving radioisotope production.
* Locate the reactor process structures, systems and components apart from experimental and production areas.
* Separate pipelines and equipment containing active fluids from working areas, by adequate shielding bodies.
* Implement redundant radioisotope production routes minimizing staff exposures by introducing remote handling or process automation features.
* Identify the routes required for managing the radioisotope production, spent fuel and active waste.

# The RA10 Utilization Program

The demanding utilization program to be developed in the RA10 involves five main groups of activities divided into different practices:

1. Beam utilization
	* 1. Thermal beam lines
		2. Cold beam lines
		3. Underwater neutron-radiography
2. Radioisotope production
	* 1. Bulk irradiation positions
		2. Pneumatic irradiation positions
3. Irradiation loop and In-Core irradiation positions
4. Neutron activation analysis
5. Silicon ingots irradiation

Having these practices identified from the Conceptual Design Stage, the engineering process was developed focused on the requirements derived from them, thus addressing efficiently issues such as interfaces and compatibility with layout.

For each practice, alternative routes for the products generated were implemented at the maximum possible extent, thus ensuring a high availability of the experimental and production activities.

# Specific Requirements of Utilization Practices

## Beam Utilization

### Thermal and Cold Beams

The thermal and cold beams will be used by researchers focused on the operation of their experimental devices rather than the reactor operation.

Therefore, this group should be separated from the reactor operative areas as much as possible in order to minimize the requirements normally imposed by the reactor operation.

The experimental areas allocated to these activities are:

* The Neutron Guides Building
* The Reactor Beam Hall

Both areas are accessed by an independent entry and provide a safe and comfortable workplace as well as adequate environmental conditions for the sensitive instruments routinely employed in this field.

Primary and Secondary beam shutters provide a fast and secure method to isolate the experimental areas from the reactor active components (the core). These shutters may be operated independently, thus ensuring availability of some experiments while maintenance or assembly activities are performed in others.

No direct connections with the other reactor areas are provided, thus addressing safety and security issues.

### Neutron Radiography Beam

The neutron-radiography beam is operated from the Pools Top Area by remotely operated tools. The beam features an underwater irradiation device (sample holder, collimator, diaphragm, etc) enabling the remote loading and unloading of the samples.

Active samples are moved underwater after the neutron-radiography process and are stored in one of the several storage racks available at the Service Pool. Once the sample is rendered useless, it is handled as a solid waste and managed by the waste handling system encompassing volume reduction and conditioning tools.

## Radioisotope Production

### Bulk Irradiation Positions

The radioisotopes produced in these positions are handled underwater from the Pools Top Area using an Operation Bridge that travels along rails reaching the Service Pool. At the Service Pool, the rigs containing the production may be transferred to shielded elevators connecting the pool with the Hot Cells located at Level +13.

From these Hot Cells located at Level +13, shielded ducts allow the transfer of the radioisotopes to a dispatching Hot Cell at Level +0 where they are introduced into transport flasks and loaded in trucks in the nearby bay; or they are transferred to adjacent facilities by a connecting corridor.

The Truck Bay features adequate equipment to package, measure and label the radioisotopes and to release the containers.

Alternative routes are available to transport the radioisotopes towards the delivery area by means of transport flasks loaded underwater in the Service Pool or through the loading bays in the external faces and roof of the hot cells.

### Pneumatic Irradiation Positions

A pneumatically driven irradiation system using nitrogen as carrier and cooling gas transfers the targets remotely between a dedicated hot cell and the irradiation positions through shielded premises.

Once the radioisotopes are delivered into the hot cell, the transfer and final dispatch is made in the same way as the ones produced in the bulk irradiation positions.

## Irradiation Loop and In-Core Irradiation Positions

### Irradiation Loop

The RA10 is provided with a pressurized loop to irradiate fuel pins under different conditions. The system consists of a close loop developed inside the Reactor Pool and a dedicated room of special characteristics.

This room, located at Level +8, has a shielded area adjacent to the reactor concrete block to host the active components such as the circulation pump and heat exchanger plus a service area for the ancillary equipment.

All the connections between the in-pile section and the equipment located in this room are channeled through water-tight conduits embedded in the concrete reactor block piercing the Reactor Pool skin with water-tight flanges.

The room is prepared to handle a sudden depressurization of the loop and is served by a dedicated ventilation circuit thus ensuring adequate isolation from the surrounding working areas.

### In-Core Irradiation Positions

Adjacent to the room holding the Irradiation Loop components, another separate premise is located at Level +8 to receive the supporting equipment associated with the In-Core experiments foreseen for the RA10.

A water-tight channel connects this room with the Reactor Pool providing a suitable passage for instrumentation and process signals and services.

## Neutron Activation Analysis

A Neutron Activation Laboratory (NAL) and its associated Office are located at Level +8. Samples are transferred from the irradiation position to the NAL by pneumatically driven systems ensuring that only activities below the maximum admissible value are received in the radiochemical hot cells available in the lab.

The access to the NAL is made only from the Office and through a short corridor with doors in both ends to provide a suitable separation of the areas minimizing the chances of a potential spread of contamination.

A decontamination zone is located nearby servicing this and other premises in the area.

## Silicon ingots irradiation

The silicon ingots are irradiated in special positions available in the Reflector Vessel. After irradiation, the ingot within its irradiation canister is transported underwater up to storage positions located in the racks available at the Service Pool.

After being detached from the active irradiation canister, the ingots are removed from the water and cleaned at the top of the Service Pool. From this area, the ingots are transported using small trolleys up to a packaging and storage room located also at Level +13. During this transport, the ingots radiation dose and surface contamination are measured and cleared before abandoning the Reactor Hall. Further decontamination processes may be implemented in the Service Pool area if needed.

From the storage room at Level +13 the silicon already prepared for delivery and cleared from the radiological viewpoint are transferred up to the truck access at Level +0 using the Service Lift located in the South-West corner of the building or the embedded transfer hatch connecting both levels.

# RA10 areas impacted by utilization practices

## Levels and areas in the Reactor Building

The Reactor Building includes 7 levels namely: Level -8.8, Level -6, Level +0, Level +4, Level +8, Level +13 and Level +17. Each of these levels includes premises classified in 3 categories:

* Supervised Area (SA)
* Controlled Area (CA)
* Controlled Area within Reactor Containment (CARC)

The SA constitutes the interface between the free areas and the CA. The access to this area is granted after an adequate security screening and is limited to authorized persons or escorted visitors.

The CA is accessed from the SA through dressing rooms where adequate outfit may be obtained. These accesses also provide suitable measuring equipment to prevent uncontrolled spread of contamination.

The CARC is accessed through a “SAS” door system configured by a couple of doors enclosing a dressing area to pick up the required attire while maintaining the pressure difference established by the Confinement Ventilation System. The SAS doors also feature measuring equipment to prevent uncontrolled spread of contamination.

## Areas defined for reactor process

All the premises housing the major reactor process systems are located in areas away from the sectors allotted to utilization purposes.

In particular, the Levels -6 and -8.8 are primarily dedicated to install all the Cooling Systems (Core, Pools and Heavy Water), the Water Purification Systems (Reactor and Heavy Water), and facilities for waste handling (eg. storage pools).

Other process equipment distributed in levels above ground floor, such as air handling units or water supply tanks, are isolated from the utilization areas as much as feasible.

## Areas defined for utilization purposes

The following drawings sketch the distribution of areas in the RA10 for the main levels of the Reactor Building.



**Thermal and Cold Beams**

**Radioisotope production**

**Dispatching Area**

Figure 1: Ground Level (+0)



**Loop and In-Core devices**

**Neutron activation analysis**

Figure 2: Level +8



**Pools top area**

**Silicon storage & packaging**

**Radioisotope production**

Figure 3: Level +13

# Conclusions

The current layout of the RA10 balances in a very efficient manner the operational and utilization requirements.

The circulation of products and personnel considered in the layout minimizes the crossroads and mixed zones.

A continuous consultation process with the future users´ representatives demonstrated to be very useful to understand their requirements and to implement early actions over the layout of the facilities.