

## RIC system-Background, Description and Requirements:

### 0. System Background

The Koeberg In-core instrumentation system systems, also known as the RIC system consists of two separate operating systems, namely:

1. **The In-Core Movable Detector Flux Mapping system.**
2. **The Reactor Coolant Core Exit Temperature Measurement system**

Both subsystems have exceeded their qualified life and have obsolete equipment, which resulted in declining reliability of the RIC system.

#### High-level Requirements:

1. System must be fully functional during and after a seismic event (SSE).
2. System shall be verified and validated.
3. Proven and reliable modern solution (Operating Experience (OE) can be referenced).
4. Long-Term support from OEM (in line with Koeberg's extended 20-year operation).

#### Information Required:

1. Description of the operation of the proposed system.
2. Outline of the system (for both subsystems) implementation considerations.
3. Time frame for implementation.
4. Estimated cost projections and work breakdown structure.
5. Requirements for commissioning.
6. Maintenance requirements.

The sections below (along with Attachment A) provide an overview of the current system:

### 1. The In-Core Movable Detector Flux Mapping system

The In-Core Movable Detector Flux Mapping system measures the flux distribution inside the core. The flux measurements, once processed, provide a three-dimensional, measured power distribution in the core. This provides a means of detection and confirmation of any deviation from normal in-core operation and confirmation that certain values used for design and accident studies are being adhered to. That is,

- Verify that the fission power distribution at any time during the core's life, and the power distribution versus fuel burn-up match reactor core nuclear and thermal design parameters. • Monitor fuel burn-up in each assembly.
- Calculate enthalpy distribution and verify that the hot spot factors used in the accident design studies are conservative ones.
- Detect a possible error in the reactor core loading. • Together with a secondary heat balance, calibrate the ex-core instrumentation (RPN).

The key components comprising the in-core flux measurement system are:

- **Flux Detector:** The flux detectors are 5 miniature fission chamber detectors, uranium-235 coated central electrode operating in an argon atmosphere. They are positioned in retractable stainless-steel conduits known as guide thimbles.
- **Drive unit:** The drive unit is designated to drive a helical chamber detectors, uranium-235 coated central electrode operating in an argon atmosphere. They are positioned in retractable stainless-steel conduits known as guide thimbles
- **Position encoders:** They are attached to the drive wheels and provide the detector position readouts.
- **Group Selectors:** The group selectors, with three or four output directions, allow the flux detectors to be routed from the drive unit to their normal paths (10 off), backup paths (10 off), storage path or common calibration path.
- **Convergent selector:** The convergent selectors, with two or five input directions, allow the flux detectors to be routed from their respective path selector from their normal group selector, backup group selector, respective group selectors in the case of the common group used for calibration.
- **Path selector:** The path selectors enable the flux detectors to be routed from their convergent selector towards each of the ten grouped paths which lead into the reactor core.
- **Leak detection device:** Any reactor coolant leakage occurring in the retractable thimble is detected by a leak box equipped with an electrode. The defective thimble is then closed off by actuation of an isolation valve. This alarm and protection system is located upstream of the drive system and operates automatically.
- **Isolation valves:** Automatic isolation valves are mounted on each line downstream of the path selector. These electrically operated valves, normally closed, prevent leakage of the primary circuit coolant in case of thimble failure. The valves are opened during path selection and are closed again once the flux detector returns to the path selector. The leak detection device is fitted upstream of the valves and prevents the valve opening once a leak is detected. Manual isolation valves are also provided, but these can only be accessed when the reactor is shut down.
- **RIC 002 AR Cabinet:** Five control cabinets for flux mapping system. Cabinet 1 controls its detectors movement into paths 1-10, cabinet 2 controls its detector into paths 11- 20 etc.

## Flux Mapping system operation

(Attachment B shows the layout for flux detector routing) The operator selects the path on the control desk, which aligns the group, convergent and path selectors to the selected path (1 of 51), and opens the corresponding guide thimble valve (provided the leak detector has not closed it). The operator then starts the drive unit at high speed, pushing the detector and its drive cable in its selected guide thimble towards the core. When the encoder determines that the detector has reached the bottom of the core, it switches the drive unit to slow speed and starts the flux recorder. When the encoder determines that the detector has reached the top of the core, it puts the drive unit into low-speed reverse. The recorder continues recording. An analogue voltage proportional to the neutron flux measured is transmitted to the plant computer (KIT). When the encoder determines that the bottom of the core has been reached, it again changes the drive unit to high speed. Once the detector has been returned to its original start position, the drive unit stops

## **RIC 002 AR (Control Cabinets)**

The scope mainly includes RIC 002 AR obsolete equipment, namely:

- Keyboard, indicator lights, switches, push buttons on consoles.
- Synchro-coding system.
- Electronic boards - logic and analogue drawers.
- Switches and Pushbuttons.
- Alarm and annunciator panel.
- Distribution cabinet - Electromechanical relays and contactors.

While the scope is focused on RIC 002 AR, proposals for upgrading and modernization of the entire flux mapping system will be considered.

## **2. The Reactor Coolant Core Exit Temperature Measurement system**

The Reactor Coolant Core Exit Temperature Measurement system measures the reactor coolant exit temperatures. The key components of the Reactor Coolant Core Exit Temperature Measurement system are:

- **Thermocouples (51 in number):** Measure the exit reactor coolant fluid temperature. Stainless steel clad, aluminium insulated, chromel aluminel (chrome-Al) thermocouples.
- **Thermocouple cold junction cabinets:** Provide correction voltages for the thermocouple reference leg.
- **Thermocouple cable routing:** The thermocouple leads pass out of the reactor vessel head through four columns via a vessel head adapter (conex seals). The upper part of the thermocouple conduit then leads to a connector and connector plate via the vessel head lifting device structure. The extension wires are then routed along the cable runs through the penetrations up to the two cold junction boxes, KBS, (located in the periphery outside containment at the 15,5 m level of the electrical building). The wires then go from the penetration cold junction boxes into the input terminals of the core cooling monitor cabinets.
- **Core cooling monitoring cabinets and displays (KIT computer room):** Obtains inputs from the in-core thermocouples, RCP (primary system) hot leg RTDs and the reactor coolant system pressure instruments. Data on the temperatures inside the cold junction boxes, are also available on the core cooling monitor.
- **Core cooling monitoring recorders (KIT computer room):** Display and graph the RIC thermocouple temperatures, one recorder per core cooling monitor train.
- **Core cooling monitoring remote display (Unit control room console P6):** Display reactor coolant saturation margin signal and highest thermocouple temperature.

## System operation (CCM)

The core exit temperature signals are processed digitally by the Core-Cooling Monitor (CCM). The system is used to calculate the saturation temperature from the actual reactor coolant system pressure and to determine the margin to saturation based on the actual temperature inputs. The in-core temperatures are permanently graphically recorded up to 1 200°C .

In the case of an accident, the system will continuously measure the temperatures, allowing the operator to follow the evolution of the in-core temperatures during and after the accident. The lowest saturation margin temperature and the highest thermocouple temperature is sent to remote digital displays located in the control room, which are used when the accident procedures are in use.

The RIC thermocouple temperatures are recorded on specially modified Chessel 4001 18 pen recorders (RIC 001 EN - Train A and RIC 002 EN - Train B), located in the RIC cabinets.

The data acquisition and processing are performed in the Plant Computer rooms inside cabinets RIC 011 AR for Train A and RIC 012 AR for Train B (CCM).

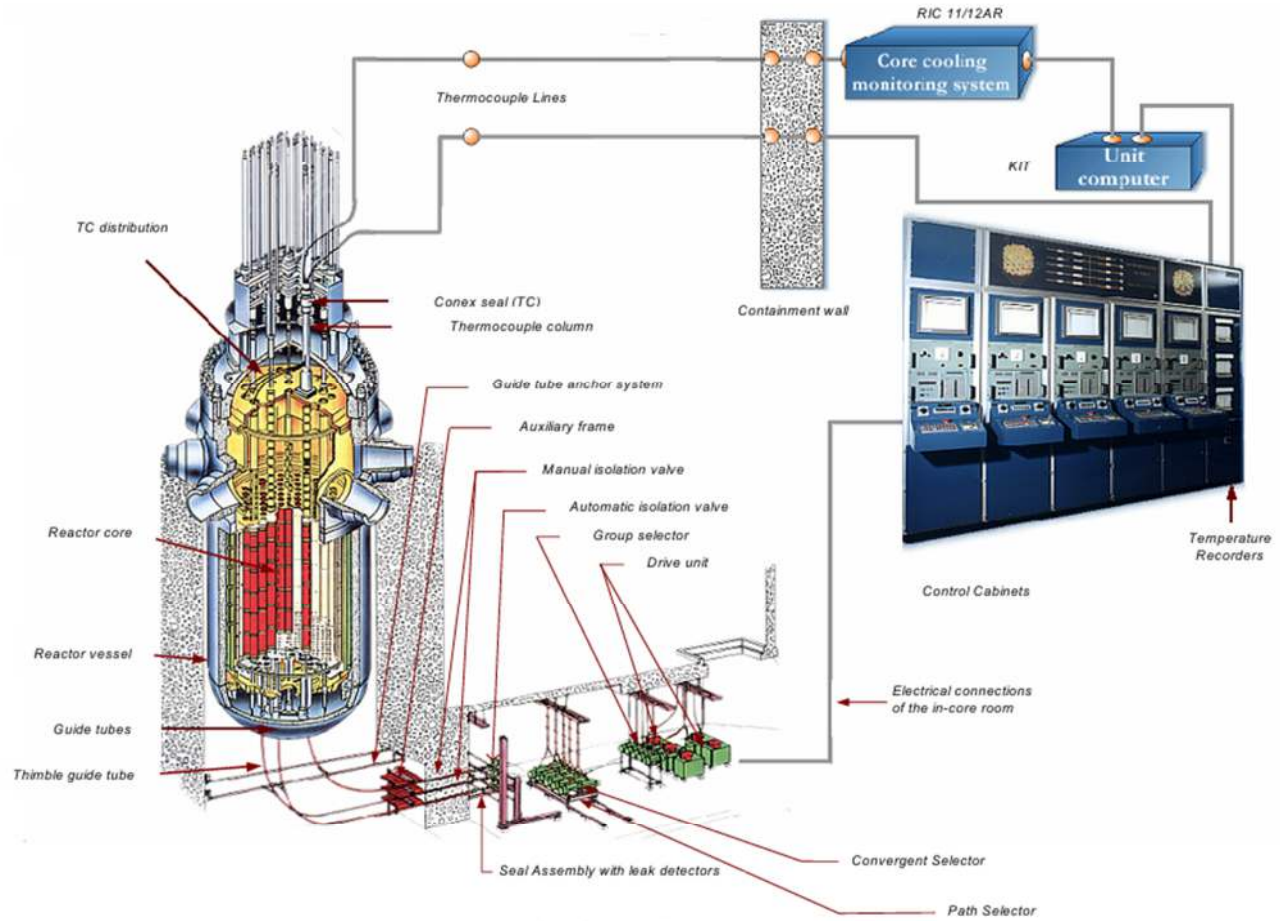
The CCM remote displays RIC 001 PP and 002 PP (inside unit control room desk P9) displays reactor coolant sub-cooling margin and highest thermocouple temperature. The temperatures signals are also sent to KIT (the plant computer) in digital form via serial links (Train A and Train B). The following supplies, currently supplying the existing CCM, and shall supply the replacement CCM:

<i>Equipment</i>	<i>Power Supply Requirements</i>	
RIC 011 AR (CCM Train A)	LNA 102 JA	220 Vac
	LCA 242 - 008 JA	48 Vdc
RIC 012 AR (CCM Train B)	LND 102 JA	220 Vac
	LCB 232 – 011 JA	48 Vdc
RIC 001 AR (Recorders)	LNE 333 – 051 JA	220 Vac

The current core cooling monitoring system (RIC 011 AR and RIC 012 AR) is obsolete, and electronics spares are no longer available.

**NB:** The Reactor Coolant Core Exit Temperature Measurement system project concerns the core cooling monitoring subsystem. The thermocouples and wiring inside the containment are excluded from the scope of this project.

# ATTACHMENT A: RIC System Overview



RIC - System Overview

# ATTACHMENT B: RIC Flux Detector Routing

