BACKFITTING OF RESEARCH REACTORS*

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1. INTRODUCTION

Numerous nuclear centres operate research reactors with nominal thermal powers ranging from several hundred kW to the range of 5 to 10 MW. Many of these reactors, of various origins, are from 10 to 20 years old and may require adapting or modernizing to raise their power level or to repair worn parts, or simply to replace parts that have become obsolete following the development of new technologies.

Two of Belgonucleaire's recent achievements in the field of backfitting are the Turkish TR1 and TR2 reactors and the Iraqi IRT 5000 reactor. The main aspects of these projects are described below.

2. THE TURKISH TR 1 AND TR 2 REACTORS

In 1977, the Turkish Atomic Energy Commission (TAEK) decided to enlarge the existing AMF type 1 MWt TR1 reactor facilities at the Cekmece Centre for Nuclear Studies and Training (CNAEM) located 40 km away from Istanbul. The plant has been modified to include a second reactor of 5 MWt power in the same pool.

Three specific fields were covered :

a) core structure for the TR2 reactor with the exception of the already existing fuel and control rods.

The scope pertained mainly to the design and construction of
- . the support unit for the core, control rods and neutron chambers
- . the support unit for the control rod drives
- . a set of tools for handling the various core components
- . a mobile platform above the pool to permit handling.

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b) cooling and purification circuits for both the TR1 and TR2 reactors

The scope covered specifically the design and construction of
- . a new stainless steel lining for the pool to replace the old ceramic lining
- . new primary and secondary loops for the existing TR1 and the new TR2 reactors, including the atmospheric cooling towers
- . circuits to measure the N16 level and for the detection of cladding rupture (DRG)

c) instrumentation and control for the TR2 reactor

The scope pertained mainly to the supply of the nuclear and thermodynamic instrumentation channels i.e.

- neutron channels with their detectors
  - . 3 safety channels working in a 2 out of 3 logic
  - . 1 control channel allowing manual and automatic operation. The automatic operation mode is equipped with a fast and a slow correction loop. The fast correction loop takes the neutron flux into account. The slow correction loop is based on thermal power correction or on N16 correction.
- temperature, pressure, flow and level instrumentation adapted to the new reactor, mainly
  - . core inlet and outlet temperature
  - . warm layer temperature
  - . pool temperature
  - . heat exchanger temperatures
  - . core differential pressure
  - . primary and secondary flowrates
  - . pool level
- health physics equipment, mainly
  - . 11 gamma channels in the reactor rooms
  - . 3 gas activity monitoring channels
  - . 3 dust monitoring channels
  - . 2 DRG channels
  - . 3 fast neutron channels
- 4 control rod drives
- all systems pertaining to interlocks, displays, alarms and emergency shut-down of the reactor.
- a new control room equipped with 13 panels and a control desk for the new TR2 instrumentation and control equipment ; spare room has been provided for the existing TR1 control equipment intended to be transferred there at a later stage.

Fuel was loaded into TR2 at the very beginning of December 1981, the reactor reached criticality for the first time on December 10, 1981 and reached its nominal 5 MWt power level on October 5, 1982.

3. THE IRAQI IRT 5000 REACTOR

In February 1982, BELGONUCLEAIRE, through its subsidiary, Belgatom, was entrusted with the task of replacing and modernizing the instrumentation equipment of the IRT 5000 reactor at the Tuwaitha Nuclear Energy Centre located 30 km away from Baghdad, in Irak.

The contract covered :

- dismantling of the existing instrumentation system
- design, construction, installation and start-up of the new system dimensioned so as to allow the reactor to operate at an 8 MWt power level.

The entire new system uses the existing measuring chambers and control rod drives, some existing cables and in line instruments. In addition, the new equipment is designed to meet the various operating criteria of the original plant.

Specifically, the following equipment has been supplied :

- start-up, safety and operating neutron channels compatible with the existing cables and detectors. A total of 9 channels were concerned.
  . 2 channels (log power + period) for the period measurement and protection
  . 1 channel for the linear flux recording
  . 1 channel for the period controller.

  These four channels are connected to four existing mobile ionization chambers automatically lifted as function of the flux.

  . Another linear channel uses a fixed ionization chamber and performs flux control. Combined with a demand signal from the "power demand potentiometer" it generates the error signal used to drive automatically the control rod.

  . Two other linear flux channels, connected to a fixed ionization chamber, are used as safety channels inducing a reactor shutdown by overpower.

  . A third log power + period safety channel using also an existing fixed ionization chamber provides safety actions for neutron flux level and period.

  . Finally the last fixed ionization chamber is connected to a linear amplifier the output of which is sent to a frequency converter providing a sound at a frequency directly tied to the neutron flux level, thus warning the operator of any change of power.

- Temperature, pressure, flow and level instrumentation necessary to meet the conditions imposed by the existing equipment.
- Health physics equipment to survey the reactor hall and the existing ventilation system, mainly 5 gas and aerosol monitoring systems connected to the existing ventilation ducts or stack.
- All systems pertaining to interlocks, displays, alarms and emergency shut-down of the reactor.
- Numerous panels and a control desk for the existing control room, a public address system and an insulation test circuit to survey the existing low voltage circuits.

The contract has been signed in February 1982 and the provisional acceptance has been signed by the customer in November 1983. As the old system dismantling started only in May 1983, the reactor has been shut down for less than 6 months.

That very short time is mainly due to

- very good collaboration with the customer who gave us all the required detailed information concerning the old system and the interfaces with parts of the system which were not replaced
- good preparation of the paper work before the dismantling of the old system
- use of connectors instead of classical terminals, allowing connections and complete tests in the workshop
- easy start up of the new system with a staff of personnel using the new system exactly the way it used the old one, the "man-reactor" relation being as close as possible to the old one.

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The backfitting of research reactors covers a variety of activities :

- Instrumentation and control.
  Control systems have developed rapidly and many reactor operators wish to replace obsolete equipment by new systems.

- Pool liners.
  Some pools are lined internally with ceramic tiles. These may become pervious with time necessitating replacement, e.g. by a new stainless steel liner.

- Heat removal system.
  Deficiencies can occur in one or more of the cooling system components. Upgrading may require modifications of the system such as addition of primary loops, introduction of deactivation tanks, pump replacement.

Recent experience in such work has shown that renewal, backfitting and upgrading of an existing reactor is economically attractive since the related costs and delivery times are substantially lower than those required to install a new research reactor.