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The Current Status of TRR-II Project

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Introduction

Dr. Shih-Kuei Chen has been assigned as the manager of TRR-II project (Taiwan Research Reactor System Improvement and Utilization Promotion Project) since June 2000. The TRR-II organization has been reorganized to enhance the project management and to minimize the interfaces among decommissioning, reactor reconstruction, and experimental facilities design.

Several modifications suggested by the reviewing committee members to upgrade our reactor had been actualized in the present design. An extension of one year of the schedule due to the delay of old TRR removal engineering bid process was proposed by the project and approved by the authorities. The duration of the project will then be July 1998 – Dec. 2006. In the mean time, the project is able to spend more time exploring the design and construction techniques of reactor system, and training of personnel for neutron application research.

The progresses of the project in the past 18 months and the current technical status of the project are described in the order of Integral planning and Management, TRR dismantling, TRR-II reconstruction, and TRR-II experimental facility. The progress of TRR-II neutron application utilization will be presented in a separated paper.

1. Integral Planning and Project Management

1.1 Project Revision

Considering the suggestion of our Technical Reviewing Committee and Neutron Application Reviewing Committee, we have upgraded and modified our design for the past one year. The modifications include: Increasing the maximum thermal neutron flux from $1x10^{14}$ to $2.7x10^{14}$ n/cm^2sec, adding one more cold neutron guide (total of two), upgrading our four neutron instruments (small angle neutron spectrometer, triple-axis spectrometer, high resolution power diffractometer, and vertical reflectometer), implementing a separation between the working area of reactor operators and beam experimenters, enlarging the size of pool-side hot cell, increasing the secondary heat removal capacity by 25%, etc. Moreover, due to the imbroglio process of government procurement, the bid of TRR removal engineering has been delayed by 10 months. To compensate for the delaying and to acquire more time for exploring design optimization, we decide to propose project revision to our authority. The project revision of TRR-II is under processing in the past half year. The new schedule is extended for one year, and the project will be completed in the end of 2006 (the new project schedule is shown in Fig. 1.1-1). According to this new planning, almost all the TRR-II working items are proceeding on schedule at this moment. The previously allocated budget will be focused on removing the TRR vessel and constructing the new reactor. A new long-term project will be proposed to National Science Council to request extra budget to construct the experimental facilities.

1.2 Project Control

The software Primavera Project Planner (P3) was acquired for the control of progress, budget and resources of the project. The information of resource, schedule, cost, procurement and issue control are all integrated and manipulated by one software. We have implemented all control data into the program. There are reports and graphics presented to the management monthly. Work progress and actual cost are tracked and compared to baseline. Trends forecasting enables the management to take immediate and proper action. The configuration management software has been established and tested. All the design information of TRR-II structures, systems, and components, including design parameters, safety class, quality, applicable cod, functions and specifications, etc., will be collected in this system. All the project staffs can access this database to obtain the required information.

1.3 Nuclear Design

TRR-II is an open pool, water-cooled, heavy water reflected reactor. The entire core is submerged in a huge water pool of which the distance from the surface to the top of active fuel is 9 meters. The simplified core configuration is shown in Figures 1.3-1 and 1.3-2. As illustrated, the core is arranged

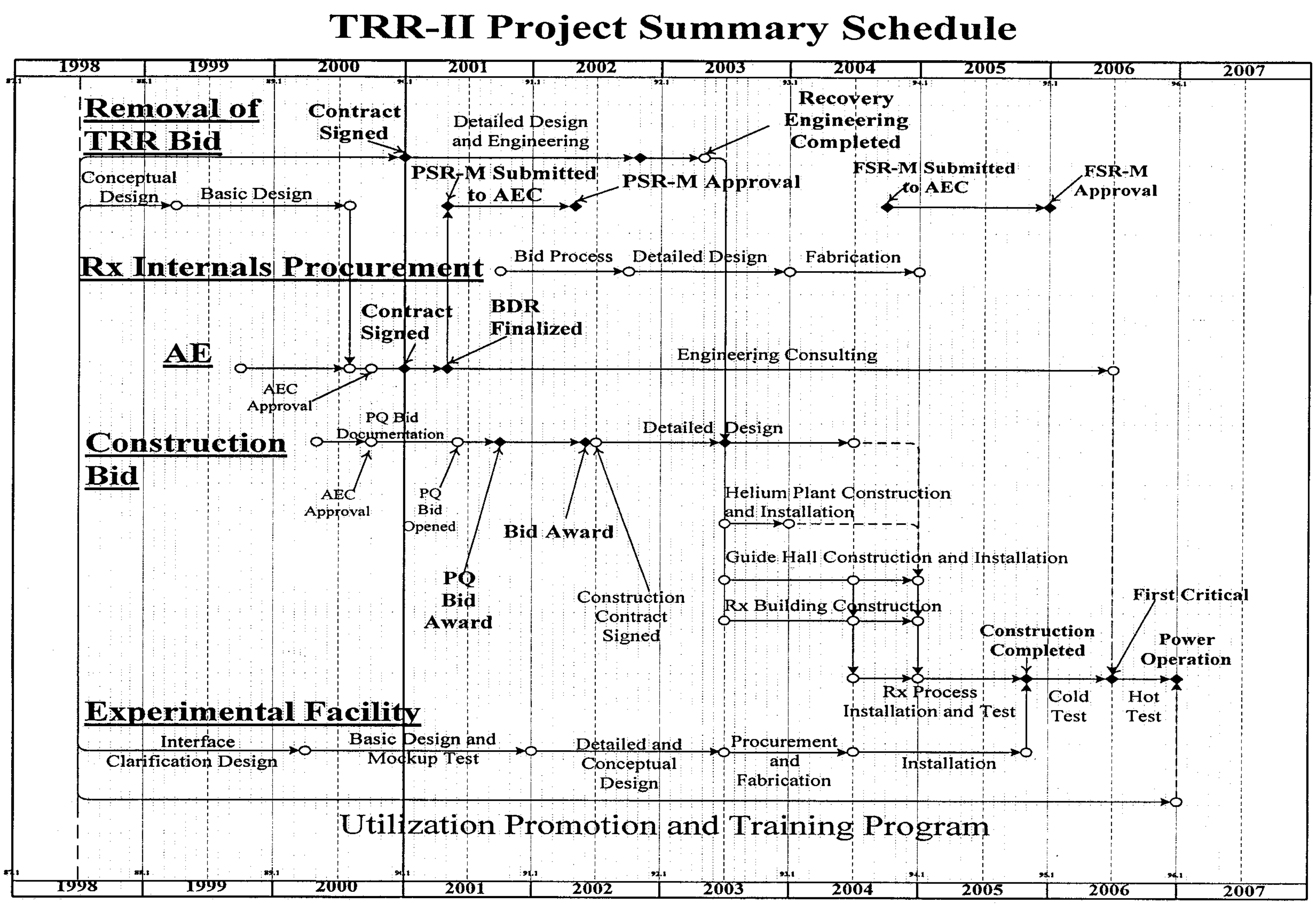


Figure 1.1-1 TRR-II Project Summary Schedule

as a 6 × 5 array that includes 21 standard fuel elements, 4 control elements, and 5 irradiation elements. The wall of core channel is made by 1.6-cm thick aluminum alloy (Al-6061). The core is surrounded by the radial D_2O reflector, and cooled by light water flowing downward axially. The cross section area and active length of the core are 49.00× 40.85 cm^2 and 60.0 cm respectively, and the grid pitch is 8.15 cm. The D_2O reflector has an outside diameter of 200 cm and a height of 130 cm. Basic design features are listed in Table 1.3-1.

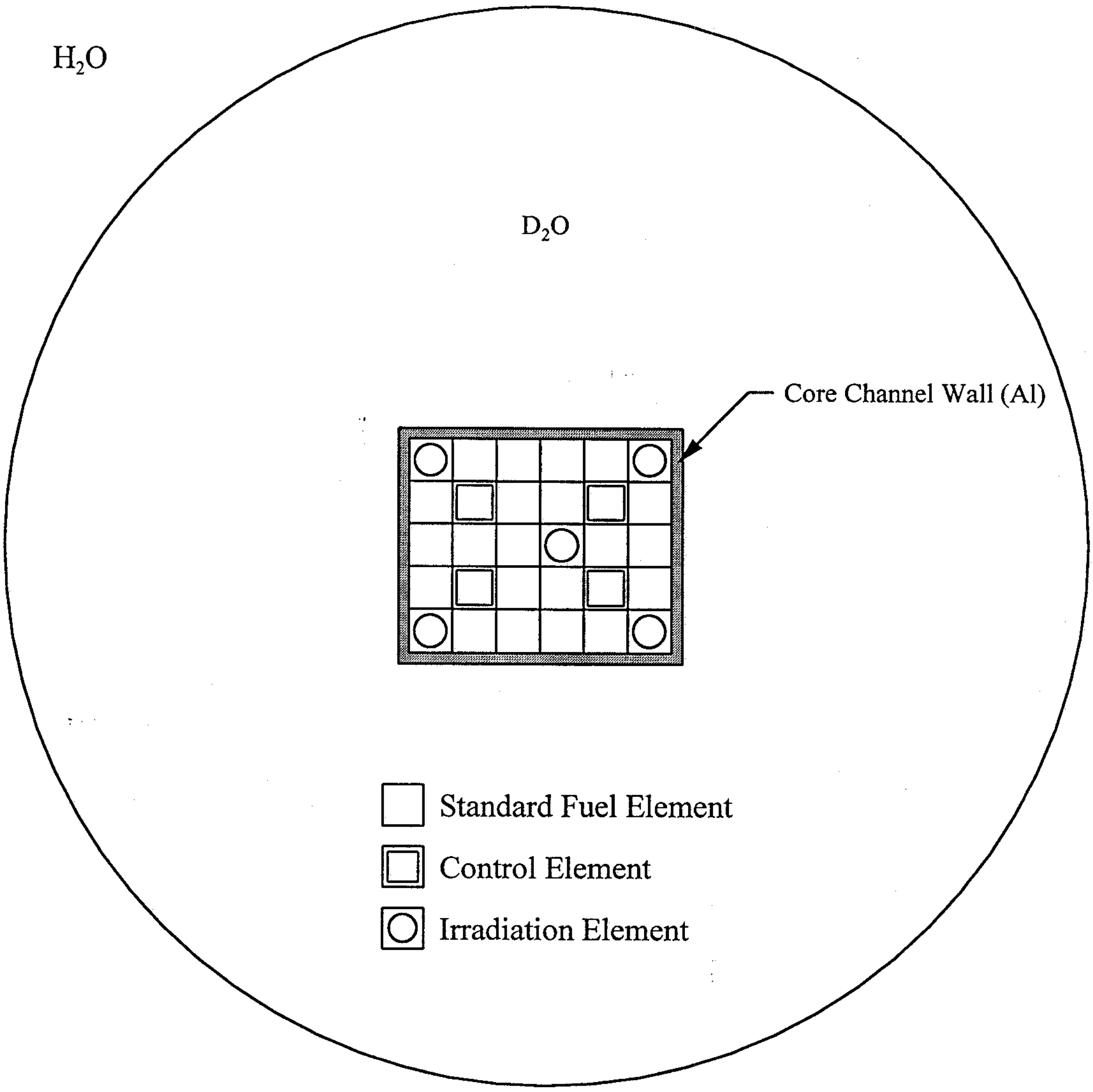


Figure 1.3-1 The Horizontal Configuration of TRR-II

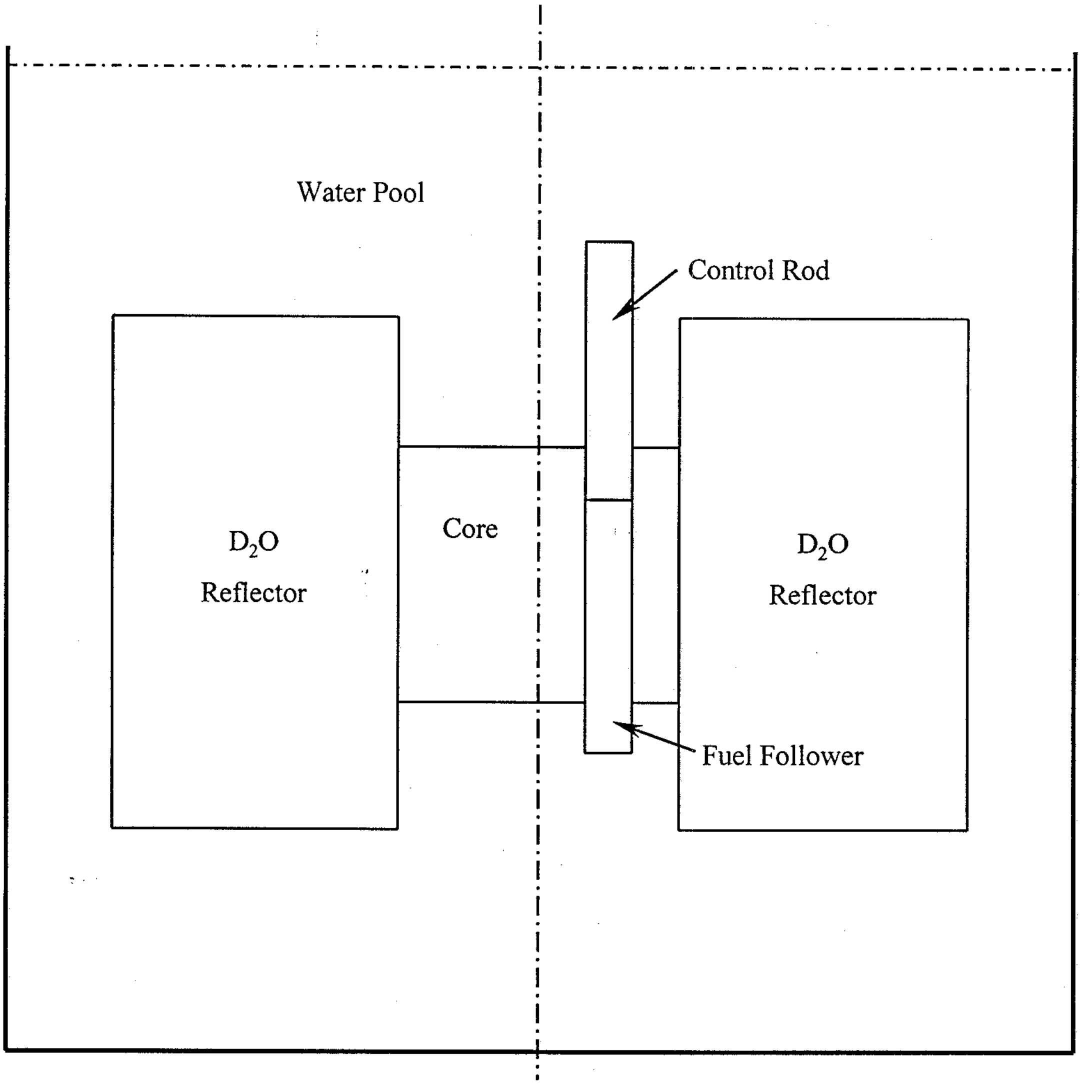


Figure 1.3-2 The Vertical Configuration of TRR-II

Table 1.3-1 TRR-II Core Design Features

Parameter	Value
Power Level (MW, Fission)	20
Fuel Meat Material	U_3Si_2-Al
U^{235} Enrichment (w-%)	19.75
Uranium Density (g/cm^3)	4.80
No. of Fuel Element	21
No. of Control Element	4
No. of Irradiation Element	5
Core Cross Section Area (cm^2)	49.0x40.85
Core Active Height (cm)	60.0
Core Loading of U^{235} (kg)	10.07
Cycle Length (Full Power Day, FPD)	32

1.4 Preliminary Safety Report

The preliminary safety report (PSR) was ready at August 15 and is being reviewed by Nuclear Safety Committee of INER. There are fifteen chapters in this safety analysis reports. The English version of PSR is also ready and will be delivered to an experienced research reactor vendor as supplemental information. This vendor is responsible for reviewing the basic design of TRR-II. All of the comments found in the basic design review will be feedback to PSR. Then PSR will be delivered to AEC to request the permission of TRR-II reconstruction in the mid of 2001. The reconstruction permit is expected to be approved in the mid of 2002.

1.5 Operation Management Planning

The operation guideline of TRR-II has been compiled and under discussion. The future TRR-II organization is proposed. There will be four Divisions under the TRR-II Director. Planning Division is responsible for scheduling the experiments, promoting the utilization, communicating with the TRR-II users, and also supporting administrative work. Ten persons will be needed in Planning Division. Technical Division is responsible for analyzing the fuel reload pattern, evaluating the reactor safety, designing the new experimental facilities, evaluating the modification of existing systems, and providing technical supports to all reactor users. Twenty engineers will be needed in Technical Division. Operation Division is responsible for operating the reactor, experimental facilities, irradiation facilities, and other supplemental facilities. The operators also have to support and monitor all the works carrying out in the reactor, such as radioactive waste handling & decontamination. Five operators with two licensed operators will be in one shift. Total will be five shifts. To maintain the license, the operator has to start and shutdown the reactor twice per two years at least.

2. **TRR Dismantling**

2.1 Transfer and Dismantle of TRR Reactor Vessel

After a time consuming screening process of second PQ on March 15th, 4 out of 9 bidders were selected by TRR-II as qualified teams to the final stage of campaign on April 17th. Basic design and preparation of the technical proposals took 3 more months. Three of the proposals were further qualified on 22nd Nov., and finally, the contract was granted to ATOMTECH Co., who offers the lowest price among the three qualified bidders. A supervision team has been formed and organized in the division for future implementation of the contract, detail design of the TRR Transfer will be carried out by the said contractors starting from Jan. 2001 officially. According to the approved ATOMTECH's proposal, methodology of TRR reactor separation, lifting, transfer, secure, and mock-ups are determined. Preparing of the preliminary safety analysis report is underway.

2.2 Dismantle of the Useless Systems and Components

A total of 87% phase 1 and phase 2 systems/components (by area) has been dismantled and removed from the TRR. Most of the phase 1 useless systems had been removed except the refueling flask. The flask is on the top of wet storage block and reactor, and is still operable for clean-up jobs of WSB; it is planned being removed before next July. Most of the phase 2 useless systems had been removed, systems/components such as primary coolant, secondary coolant, heavy water, etc. were dismantled, categorized, decontaminated, packed, and letdown in the TRR main hall for further transferring to INER's interim LLW storage site. The only components left being removed are the ion exchangers of the TRR spent fuel pool purification system, it will be the first priority activity among those dismantling works in the next 6 months. Removal scope of phase 3 systems/components are determined, and those systems/components to be removed further are: cooling tower, the MCC rooms, the liquid waste storage tank, and the machine shop, etc. so far. In order to evacuate workshop for TRR-II construction purposes, modification of an old building to provide working rooms for personnel of the dismantling division.

2.3 Construction of Waste Storage Facilities

With the capacity to store 420-ton reactor wastes with a total radioactivity of 6.48x109 million Bq, construction of the 93 silo type storage vaults was completed on 9th. December. The building as well as the storage vaults are designed to withstand seismic load of 0.225g, and are fabricated to comply with the requirements of RG 1.143 and ANSI 55.1 for storage of high activated LLW. Design of the dismantling building will be performed by ATOMTECH starting from next January, and it shall be completed before June. Since TRR segmentation is postponed, fabrication of the related supporting system inside the building will also be postponed. Those equipment are cutting station, HEPA and liquid treatment systems, wastes transfer vehicle, and other miscellaneous facilities. Modification of the HVAC system to maintain a minimum negative pressure during future TRR separating/transferring process is under way.

2.4 Simulation and Mockup

Limited underwater plasma cutting practice has been carried out in the mock-up facility equipped with a water tank, an underwater manipulator, sufficient power supply, air conditioning system, and miscellaneous service facilities. Performance of the related mock-up tests has been reduced to the amount of one time a month to assure the function of cutting machine is maintained. Test results are documented. Fabrication and installation of the real size mock-up plant consisting of a trio-column supports, a Y shape platform, and a 4 DOF manipulator, a water tank, and miscellaneous service facilities is under way.

2.5 Survey and Control

Performance of the dismantling division had been evaluated by the QA team of the project and proved to be acceptable to the TRR-II project. A vision system had been installed inside the TRR building and the area of silo-type interim storage facility. Monitoring capabilities are now available for the TRR main hall, temporary waste storage areas, inside/outside of the silo-type interim storage facility, etc. Security fence and guard has been installed to monitor the condition and activities in the territory of TRR. Two regular safety guards have been installed for hourly check of the dismantling activities and construction activities of the silo-type facility. Under the control of INER's Health Physics Guide, all radiological related activities of the dismantling tasks has been documented.

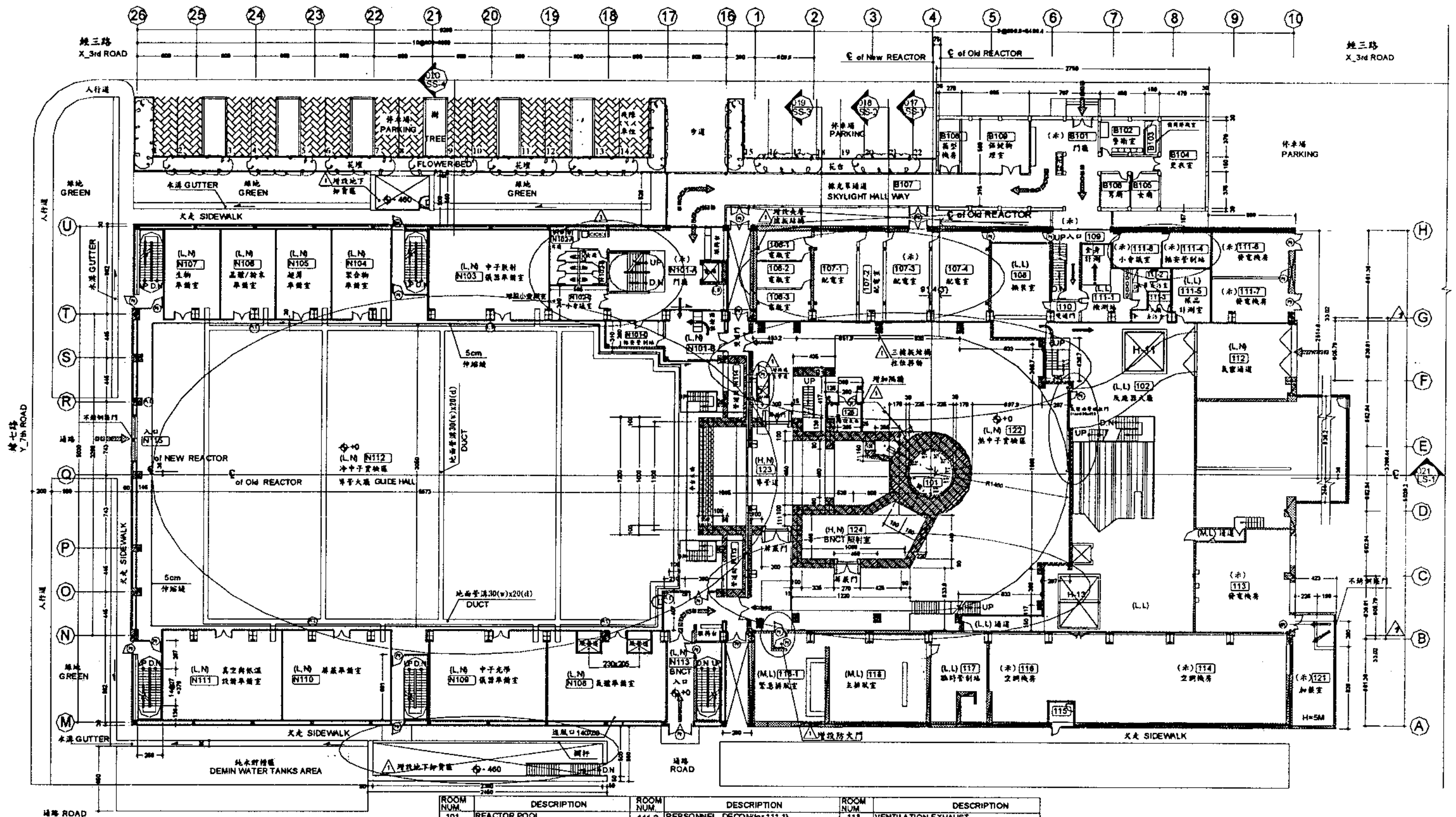
3. TRR-II Reconstruction

3.1 Reactor building and Plant System

The reactor building, as shown in Figures 3.1-1 contains the reactor itself, facilities for handling and storing the fuel, reactor fluid system as well as other supporting systems, and the thermal neutron experiment instruments. The design of reactor assembly is shown in Figure 3.1-2, The arrangement of tubes on D_2O tank is shown in Figure 3.1-3. The plant system consists of primary coolant system, heavy water system, spent fuel pool cooling & clean-up system, plant water system which includes secondary coolant system and water purification system, HVAC system, electric system, and supporting system. The overall system flow sheet is shown as Fig 3.1-4. The plant system is designed to the reactor thermal power of 25 MW instead of 20 MW to accommodate the future advancement. The reactor instrumentation and control systems include reactor protection system (RPS), nuclear instrumentation system (NIS), reactor power control system (RPCS) and engineered safety feature actuation system (ESFAS). The plant instrumentation and control systems include monitoring, alarm and data acquisition system (MADAS), main control room (MCR), alternate shutdown panel (ASP), multiplexing system (MUX), plant security system (PSS), process control system (PICS), radiation protection system (RMS), and experimental facility I&C Interface (EXPICS). In developing the control rod and driving mechanism (CRDM) system, a test rig for evaluating the mechanical performance of CRDM has been established in the laboratory. This configuration features a set of new water-cooled magnetic moving coils (MMC), a recently developed position indicator --- linear variable differential transformer (LVDT), and a PC-controlled data acquisition system.

3.2 Reconstruction Bid

There are three bids related to the reconstruction: Basic Design Review (BDR) bid, Reactor Internals Equipment Procurement bid and Civil Structure bid. INER will act as the prime contractor. The basic design documents are being reviewed by INER Nuclear Safety Committee, the draft review report will be issued by Nov. 30. In the mean time, TRR-II is negotiating with the some very experienced company on the BDR agreement. The contract has been signed at the end of year 2000. The engineering design and drawings of reactor internals have been completed. They are being reviewed by INER Nuclear Safety Committee and the BDR contractor. Base on the BDR results, the design and associated drawings will be modified for Reactor Internals Equipment Procurement Bid . The vendor will conduct design for machine shop drawing and manufacturing process, and the fabrication work. Currently this bid is planned be opened to domestic and international vendors. For domestic vendors, an experienced foreign partner might be a mandatory requirement. For civil structure bid, the scope of process system includes: isometric drawing of piping, cable tray and HVAC, and associated work of detailed calculation of piping size, elevation and support, construction ability evaluation, I&C, electrical and mechanical equipment and component procurement specifications, balance of material, request for quote, etc. In civil structure, the engineering work includes: ordinary and heavy concrete formula design and construction procedure development, detailed civil structure design and analysis, and associated work of construction ability evaluation, procurement specifications, balance of material, architecture design and notary by domestic register professional architecture engineer. Construction planning, sequence of construction engineering, scheduling, field manpower allocation and construction facility requirements are also included. And the construction work includes: system integration, equipment procurement and installation, civil structure, restoration engineering, Construction Management. The interface with TRR-II developing items, including experimental facilities, control rod drive mechanism, I&C, and Reactor Internals bid and overall engineering are managed by TRR-II. TRR-II engineers have surveyed and visited several (more than six) domestic engineering/construction companies, through wide and detailed discussion. Considering the engineering efforts needed, schedule and cost, we concluded that this bid should be a domestic bid. Of this bid, the budget limit will be announced, the potential vendors will be pre-qualified (PQ) and the first choice bid method will be used to evaluate the technical specification and price proposed by



ROOM NUM.	DESCRIPTION	ROOM NUM.	DESCRIPTION
B101	MAIN ENTRANCE HALL	N102-C	CONFERENCE
B102	GUARD	N103	NEUTRON SCATTERING INSTRUMENTS LABORATORY
B103	ALTERNATIVE SHUTDOWN PANEL	N104	SAMPLE PREPARATION LABORATORY
B104	LOCKER ROOM	N105	SAMPLE PREPARATION LABORATORY
B105	WOMENS TOILET	N106	SAMPLE PREPARATION LABORATORY
B106	MENS TOILET	N107	SAMPLE PREPARATION LABORATORY
B107	SKYLIGHT HALL WAY	N108	EXPERIMENTAL GASES ROOM
B108	AIR CONDITION ROOM	N109	NEUTRON OPTICS INSTRUMENTS LABORATORY
B109	HEALTH PHYSICS ROOM	N110	SHIELDING BLOCKS PREPARATION ROOM
N101-A	ENTRANCE HALL	N111	VACUUM AND CRYOGENIC EQUIPMENTS LABORATORY
N101-B	PERSONNEL CONTROL	N112	COLD NEUTRON FACILITIES AREA
N101-C	H.P. CONTROL(for N101-B)	N113	PIPING TUNNEL
N102-A	MENS TOILET	N114	PIPING TUNNEL
N102-B	WOMENS TOILET	N115	ENTRANCE(for EQUIMENT)

ROOM NUM.	DESCRIPTION	ROOM NUM.	DESCRIPTION	ROOM NUM.	DESCRIPTION
101	REACTOR POOL	111-2	PERSONNEL DECON(for 111-1)	118	VENTILATION EXHAUST
102	REACTOR HALL	111-3	PERSONNEL DECON(for 102)	118-1	EMERGENCY VENTILATION EXHAUST
106-1	BATTERIES-1	111-4	H.P. CONTROL	121	CHEMICAL ADJUSTING
106-2	BATTERIES-2	111-5	SAMPLE COUNTING	122	THERMAL NEUTRON FACILITIES AREA
106-3	BATTERIES-3	111-6	SAFETY DIESEL GENERATOR	123	GUIDE TUNNEL
107-1	SAFETY ELECTRICAL PANNEL-1	111-7	SAFETY DIESEL GENERATOR	124	BNCT
107-2	SAFETY ELECTRICAL PANNEL-2	111-8	CONFERENCE ROOM	125	CO2 BANKS
107-3	SAFETY ELECTRICAL PANNEL-3	112	AIR LOCK(for EQUIPMENT)		
107-4	MCC ROOM	113	NONE SAFETY DIESEL GENERATOR		
108	CHANGE ROOM	114	H.V.A.C. ROOM		
109	ENTRANCE	115	AIR LOCK(for EMERGENCY)		
110	AIR LOCK(for PERSONNEL)	116	H.V.A.C. ROOM		
111-1	PERSONNEL CONTROL	117	H.P. CONTROL(for 116)		

TRRⅡ 一樓平面圖(E.L.+0) 單位:公分

TRRⅡ 1st FLOOR PLAN (E.L.+0) UNIT:cm

Figure 3.1-1 TRR-II Second Floor Plan

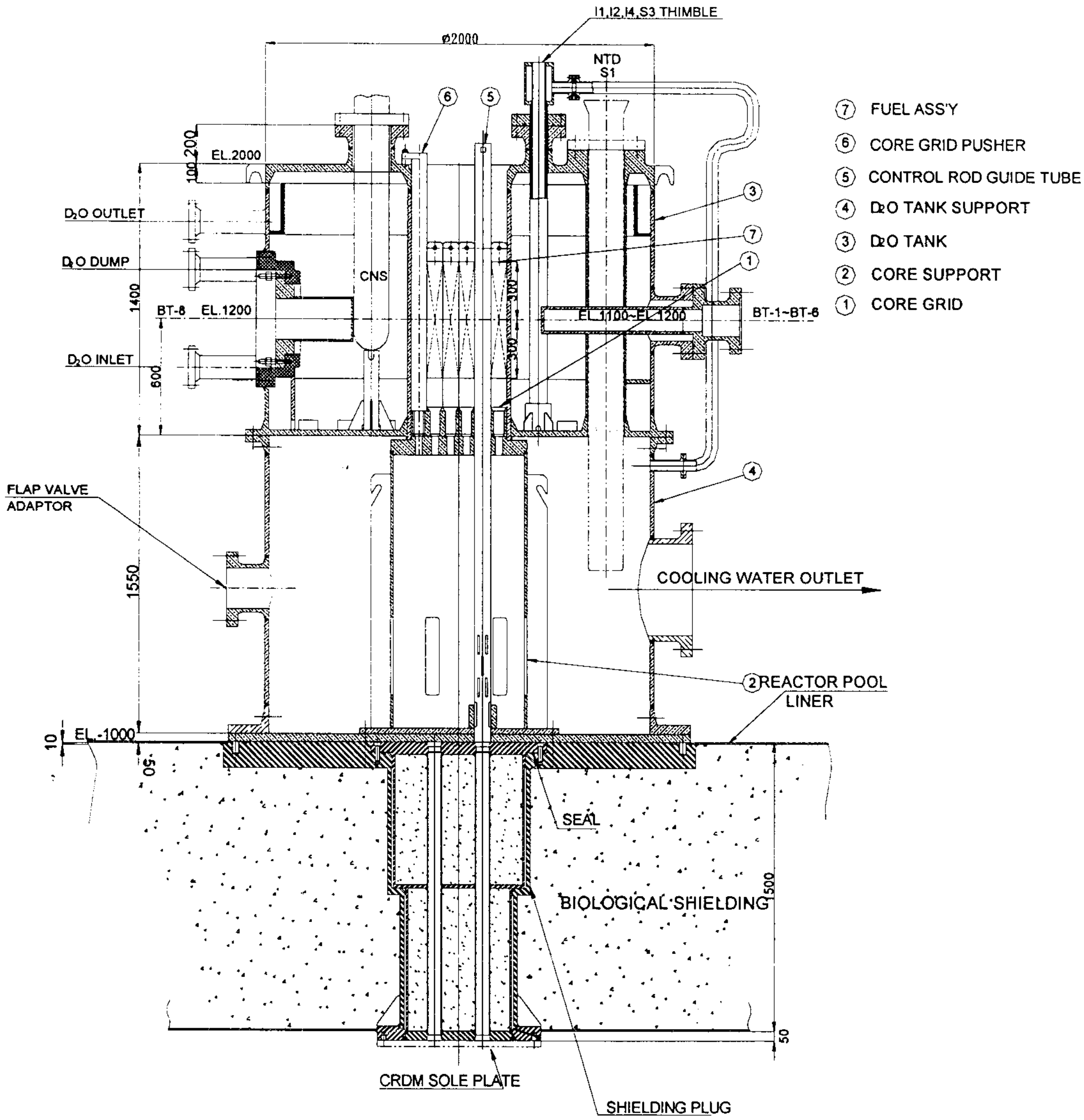
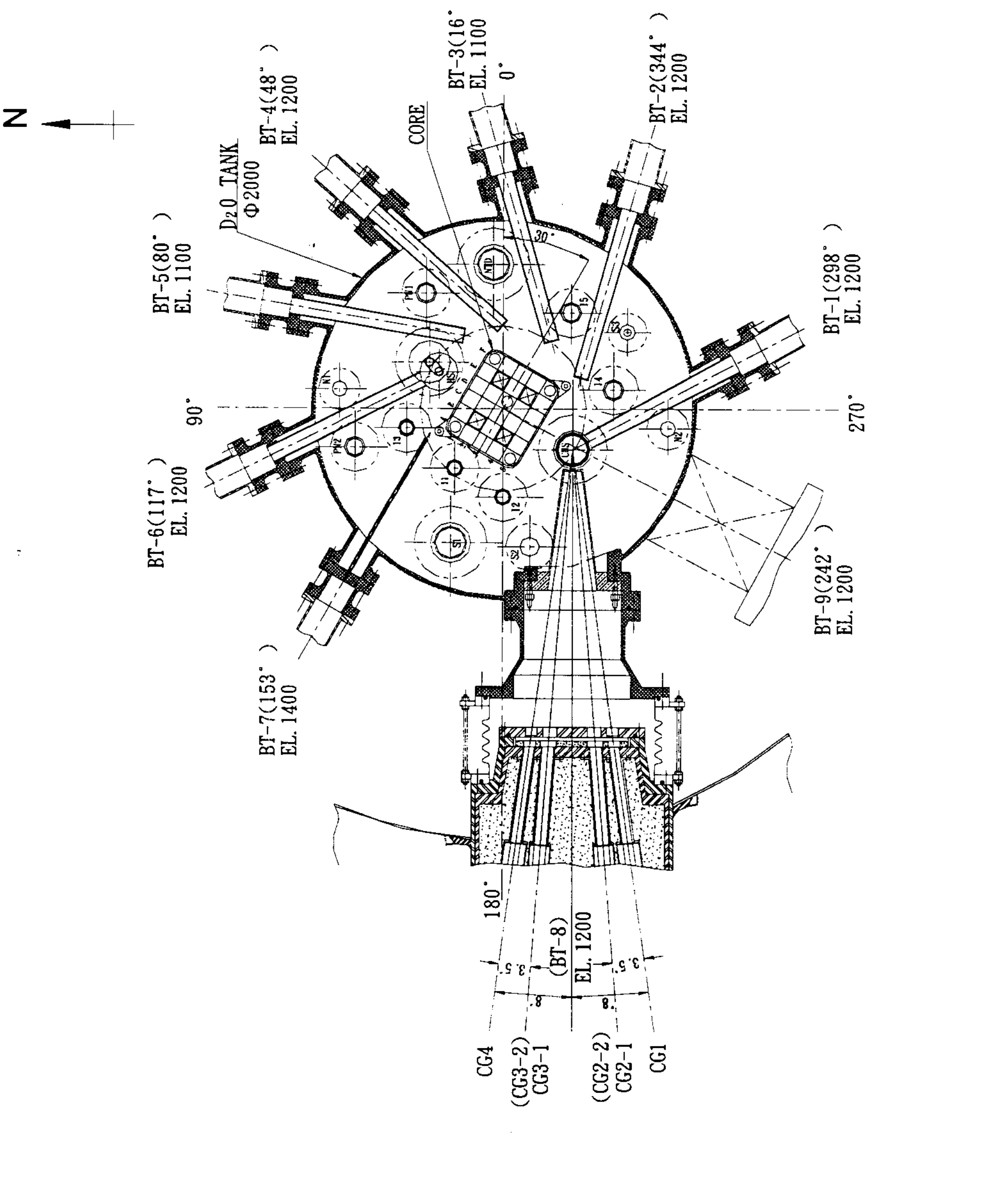


FIG 3.1-2 REACTOR ASSEMBLY



IN-CORE IRRADIATION	
A1	ISOTOPE
A5	PCTL
D3	BMIF
F1	BCTL
F5	PMIF

NEUTRON BEAM TUBE		
BT-1	TAS3.	TRIPLE AXIS SPECTROMETER NO3.
BT-2	HRPD	HIGH RESOLUTION POWDER DIFFRACTOMETER
BT-3	TAS1.	TRIPLE AXIS SPECTROMETER NO1.
BT-4	RSA	RESIDUAL STRESS ANALYSIS
BT-5	TAS2.	TRIPLE AXIS SPECTROMETER NO2.
BT-6	HS (DF)	HOT-NEUTRON SOURCE (DIFFRACTOMETER)
BT-7	NR	NEUTRON RADIOGRAPHY
BT-8	CN	COLD NEUTRON
BT-9	BNCT	BORON NEUTRON CAPTURE THERAPY

IRRADIATION TUBE THIMBLES		
I1	RTF	GRAYLOC
I2	Ir-192	BY TONGS
I3	Re-186, Ho-166	BY HYDRAULIC
I4	RPV	GRAYLOC
I5	Lu177, Br82	BY PNEUMATIC
PN1	INAA/RNAA	BY PNEUMATIC
PN2	CNAA	BY PNEUMATIC

NTD	Si IRRADIATION	BY MOTOR
	(D_2O TANK PENETRATION)	

CNS	CNS OUTER TUBE	
	CNS INSTALL NOZZLE	
HS	HS INSTALL NOZZLE	
	(SOURCE OD.)	

N1	COVER GAS	
N2	COVER GAS	
S1	PENETRATION FOR NTD	BY MOTOR
S2	SPARE NOZZLE	
S3	Pt 195	BY TONGS

□ FUEL ROD

☒ CONTROL ROD

Figure 3.1-3 Arrangement of Tubes on D_2O Tank

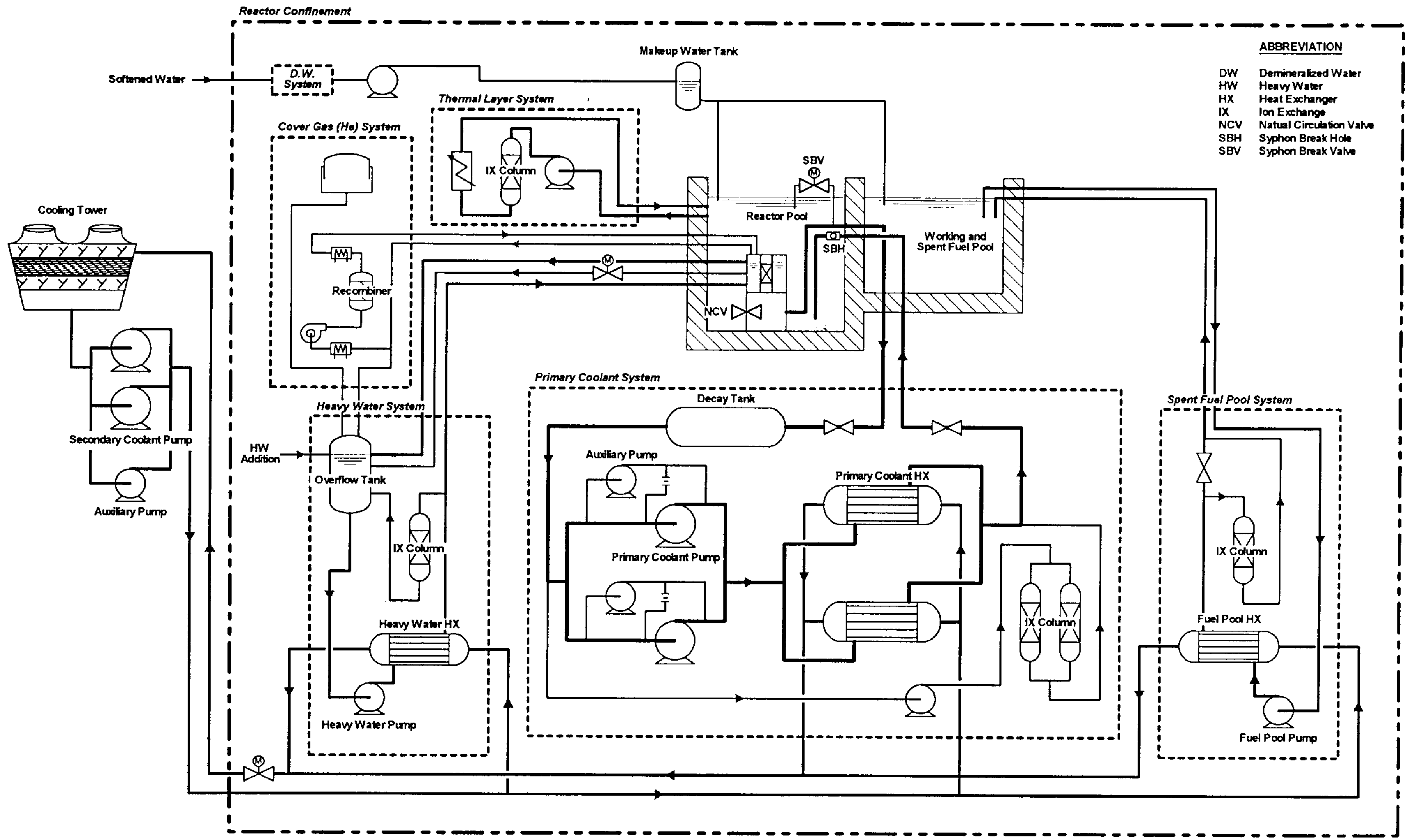


Figure 3.1-4 The overall system flow sheet

Vendors, i.e., to determine the bid winner. According to the Government Procurement Law, the authority - ROCAEC, has approved the above-proposed bidding approach. The PQ documents are being prepared and expected to be issued in the first quarter of 2001.

4. Experimental Facilities

4.1 Cold Neutron Source

The concept of CNS facility and the mock-up tests of full-scale hydrogen loop have been designed. The TRR-II CNS system consists of a hydrogen loop, a helium refrigerator loop, and the auxiliary systems. The mockup test facility of the hydrogen loop has been built at INER in November 2000. Another mockup test facility to observe the flow pattern in moderator cell with liquid nitrogen has been designed and fabricated in December 2000. A glass vessel and electrical heaters will be used for simulating the geometry and heat load of moderator cell. Several moderator cells were fabricated. Their mechanical properties were tested and microstructures were analyzed, especially around the welding zone. Details of the present status will be presented in a separated paper.

4.2 Nuclear Fuel, Material and Water Chemistry Irradiation Facilities

Seven facilities have been proposed in the future planning, including five irradiation facilities, namely, BMIF (BWR material irradiation facility), PCTL (PWR corrosion test loop), RTF (ramp test facility), BCTL (BWR corrosion test loop) and PMIR (PWR material irradiation facility), and two service facilities, PSHC (pool-side hot cell) and UWNR (underwater neutron radiography). Due to the budget limitation, only BMIF, PSHC and UWNR will be constructed in the program. Yet the conceptual design of the others will be completed also, mainly the PCTL and RTF to represents all the rest four facilities, just for the purpose of the definition and reservation of necessary interfaces. For the present, all the design aspects of all facilities have been documented and clarify their interfaces with all the reactor systems have been clarified. Operation procedures were then discussed to improve the system design, and the mockup or facility design was made.

4.3 Radioisotope Production

Five vertical irradiation tubes are provided for radioisotope production. These irradiation positions are located within the core (A1) and inside the heavy water tank (I2, I3, I5 and S3), respectively (refer to Figure 3.1-3). Three target transferring approaches: crane hanging, hydraulic transferring, and pneumatic transferring, are used in these irradiation facilities. About twenty different types of radioisotopes used in the field of nuclear medicine, agriculture and industry are produced. Recently, The full size mock-up of pneumatic and hydraulic tubing is setup. The input/output and rotary system for pneumatic transferring targets is completed. Programming of process control system is finished at the first stage. The mock-up of hydraulic transferring system is designed and setup.

4.4 Neutron Activation Analysis

Neutron activation analysis (NAA) facilities permit measurements of trace elements in materials following neutron irradiation. These facilities provide pneumatic tubes for transferring samples contained in capsules (rabbits) to the heavy water tank for neutron irradiation and then back to laboratories for counting induced radioisotopes (delayed radiation). The mock-up of neutron activation analysis system is setup, and programming of process control system is finished at the first stage.

4.5 Neutron Transmutation Doping

The neutron transmutation doping (NTD) method uses a thermal neutron flux to transform a tiny fraction (3.1%) of a silicon isotope, Si-30, into phosphorus, P-31, and thus achieving n-type doping within the bulk single crystal silicon. The mechanical design of NTD components is undergoing, and the NTD operation procedure design is finished at the first stage.