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Management of Operation & Utilization of China Advanced Research Reactor

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1. Introduction

China Advanced Research Reactor (CARR) is a tank in pool, inverse neutron trap type, light water cooled, heavy water reflected, multi-purposes research reactor. The maximum thermal neutron flux of the reactor is $1.0\times10^{15}n/cm^2\cdot s$, and the reactor power is 60MW.

It is designed and constructed by China Institute of Atomic Energy (CIAE). The construction project began on Aug. 26, 2002, and the reactor achieved criticality on May 13, 2010. It is scheduled to complete power increasing commissioning by the end of 2011.

CARR will provide an important platform for further development of the nuclear science research and applications.

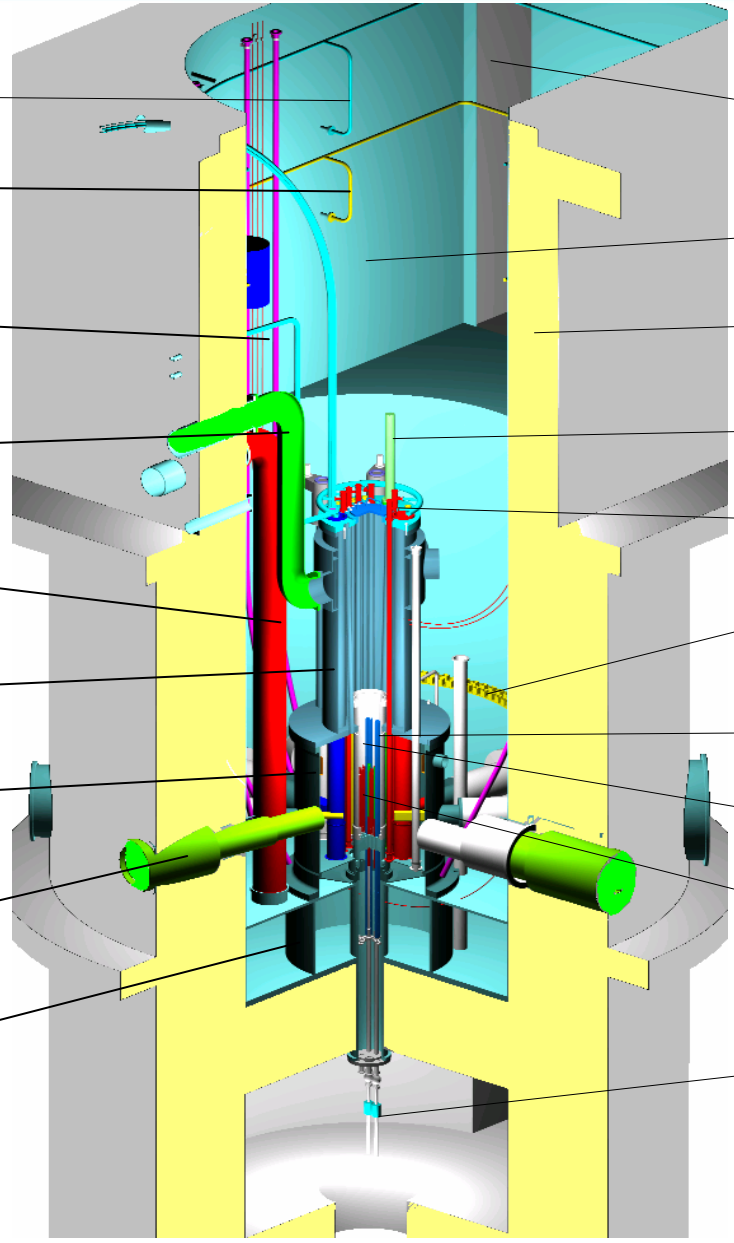
CARR is located in CIAE site, Fangshan district of Beijing. The direct distance from CIAE to the center of Beijing city is about 37km.

2. Reactor descriptions

Main parameters of reactor

1) Reactor power	60MW
2) Reactor type	tank-in-pool
3) Coolant	H_2O
4) Reflector	D_2O
5) Max. thermal neutron flux	
in core region	1.0×10^{15} n/cm^2·s
in reflector region	8.0×10^{14} n/cm^2·s
6) Fuel element	
type	plate
number	21
	(17 standard,4 CR follower fuel)
fuel meat	U_3Si_2-Al
^{235}U enrichment	19.75wt%
cladding	Aluminum alloy
7) Primary coolant	
temperature	35/56.2℃
flow rate	2400 m^3/hr
pressure	0.85 MPa

Cut view of reactor body



Inlet of warm water layer(14)

outlet of warm water layer(13)

Tube for ion. chamber

inlet of primary coolant(11)

outlet of primary coolant(12)

Flow guiding tank(9)

Heavy water tank(8)

Horizontal beam tube(7)

Decayed tank(10)

Pool gate(17)

Reactor Pool(16)

Concrete shielding(15)

Safety rod drive(5) mechanism

Vertical tube(6)

Storage racks for irradiated fuel

Guide tube of control rod(3)

Core vessel(1)

Fuel element(2)

Control rod drive(4) mechanism

View of Control Console of CARR

3. Application & Utilization Facilities

- **Application fields**

1) Neutron Scattering Experiments

With 9 horizontal beam tubes and experimental equipments installed at the beam ports, CARR will provide powerful capability for conducting a great deal of studies covering material science, life science, environment science, researches in physic-chemistry fields and in other relevant areas in the future.

2) Medical/industrial Radioisotope production (RI)

Vertical tubes with different diameters and different neutron flux levels, will be used for production of various medical/industrial radioisotopes, especially the products with high specific activity in industrial scale, such as ^{125}I, ^{131}I, ^{32}P, ^{35}S, ^{14}C, ^{153}Sm, ^{60}Co, ^{90}Sr, ^{99}Mo, ^{113}Sn, ^{192}Ir, ^{198}Au, ^{210}Po and ^{188}W, etc.

3. Application & Utilization Facilities

- **Application fields(cont.)**

3) Nuclear fuel/material irradiation test

A high temperature and high pressure test loop is planning to be installed according to a separate program.

4) Neutron activation analysis (NAA)

A rabbit system and HPGe spectrum system can be used for NAA.

5) Neutron transmutation doping (NTD)

Neutron transmutation doping for large diameter silicon ingots can be carried out for production of Si semiconductors.

6) others

Neutron radiography, technical training, etc.

- **Utilization facilities**

The utilization facilities of CARR consist of several irradiation facilities and beam experimental facilities, including as followings.

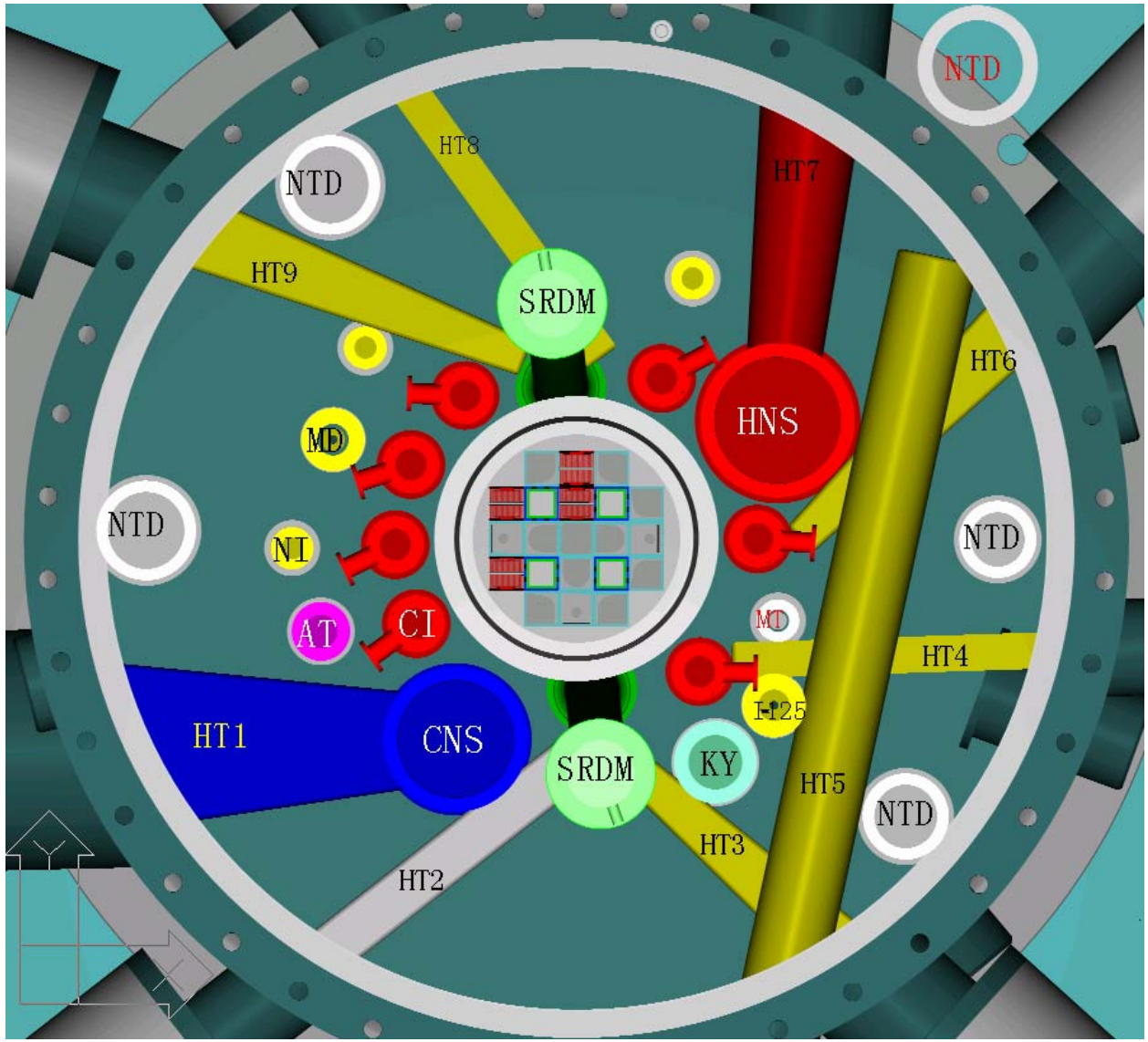
1) Nine beam tubes and associated device will be used for neutron radiography and neutron scattering ,include cold source.

2) 21 vertical irradiation tubes and associated device will be used for RI production, silicon NTD, fuel and material neutron activation analysis (NAA) and so on.

3) one hot cell for post-irradiation examinations of fuel and material.

5) Handling and transportation facilities.

Arrangement of exp. tubes

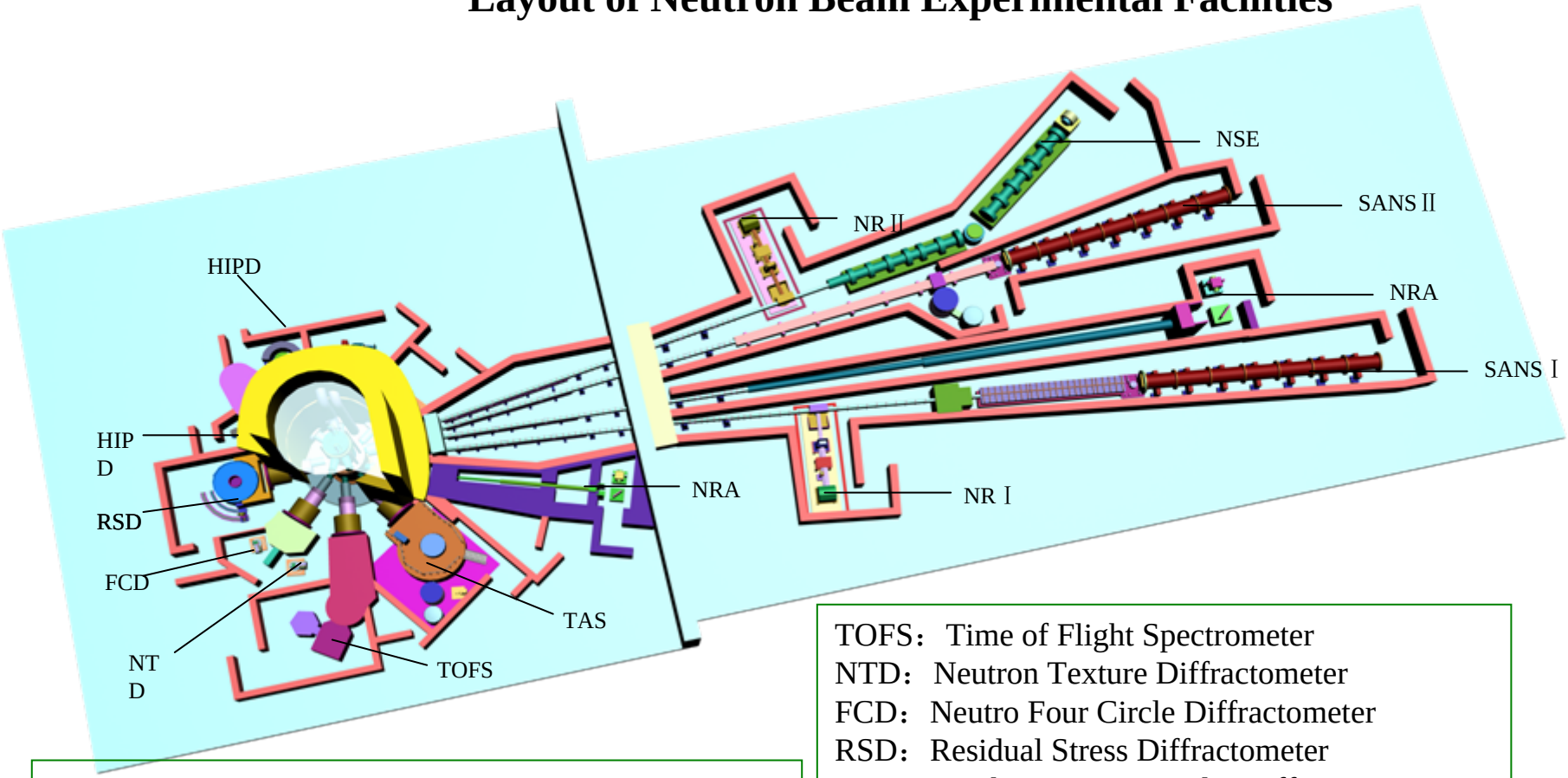


Vertical irradiation tubes

Tube name	Number	Inner dia. (cm)	Purposes	Associated facilities
CNS	1	26.0	Installation of Cold neutron source	CNS device and system, experimental equipments
HNS	1	28.0	Installation of Hot neutron source	HNS device, experimental equipments
CI	7	7.0	RI production	Water cooling system
MT	1	5.0	Material irradiation	Water cooling loop
KY	1	12.0	Fuel irradiation test	High temp. and high pressure test loop
I-125	1	7.0	^{125}I production	Transfer loop and equipments
NTD	4	12.0/20.0	NTD for Silicon	Hydraulic drive rotating devices
MD	1	7.0	^{99}Mo Irradiation	Water cooling system
AT	1	7.5	NAA	Pneumatic transfer system
NI	3	5.0	RI production	

Beam experiment equipments

Layout of Neutron Beam Experimental Facilities



NRA：Neutron Radiography Equipment
SANS：Small Angle Scattering Diffractometer
NSE：Neutron Spin Echo Spectrometer
CTAS：Cold Neutron Triple Axis Spectrometer
NR：Neutron Reflectmeter
TAS: Triple Axis Spectrometer

TOFS：Time of Flight Spectrometer
NTD：Neutron Texture Diffractometer
FCD：Neutro Four Circle Diffractometer
RSD：Residual Stress Diffractometer
HIPD：High Intensity Powder Diffractometer
HRPD：High Resolution Powder Diffractometer

Horizontal beam tubes

No.	Name	No. of beams	Experimental equipments	Purposes
HT1	CNS beam tube	4	1) small angle neutron scattering spectrometer, 2) Vertical surface polarization neutron reflection spectrometer,	Cold neutron source, Neutron scattering
HT2	Multi-filtration neutron tube	1	Planning	Thermal neutron and KeV neutron radiography studies
HT3 HT4 HT6 HT8 HT9	Thermal neutron beam tubes	2 1 2 1 2	1) high resolution powder neutron diffractmeter, 2) Triple axis spectrometer, 3) Time of flight spectrometer, 4) Powder diffraction texture measurement meter, 5) Neutron four circle diffraction meter, etc.	Neutron scattering, Nuclear data measurement, Prompt gamma neutron activation analysis (PGNAA)
HT5	Long tangential beam tube	1	Planning	Nuclear pumped laser (NPL) studies
HT7	HNS beam tube	2	multi-purpose neutron scattering spectrometer	Neutron scattering

Laws and Regulatory

- Laws

  - Environment protection Law of the People's Republic of China.
  - Civil Nuclear facility Safety Inspection Decree of the People's Republic of China.

- Regulatory requirements

  - Operational Safety Requirements for Research Reactors.
  - Safety Guideline for Research Reactors and Criticality Assemblies.
  - Others.

- IAEA Documents such as NS-R-4

4. Reactor management

Organization and responsibilities

- Regulatory body

  - Bureau of National Nuclear Safety

- Operation management

  - Operation organization: CIAE.
  - Operation management: Dept. of Reactor Engineering Research and Design.
  - Waste management: Dept. of Radiochemistry.
  - Health physics and radiation protection: Dept. of Radiological Safety.
  - Reactor operation: Division of CARR operation and utilization.

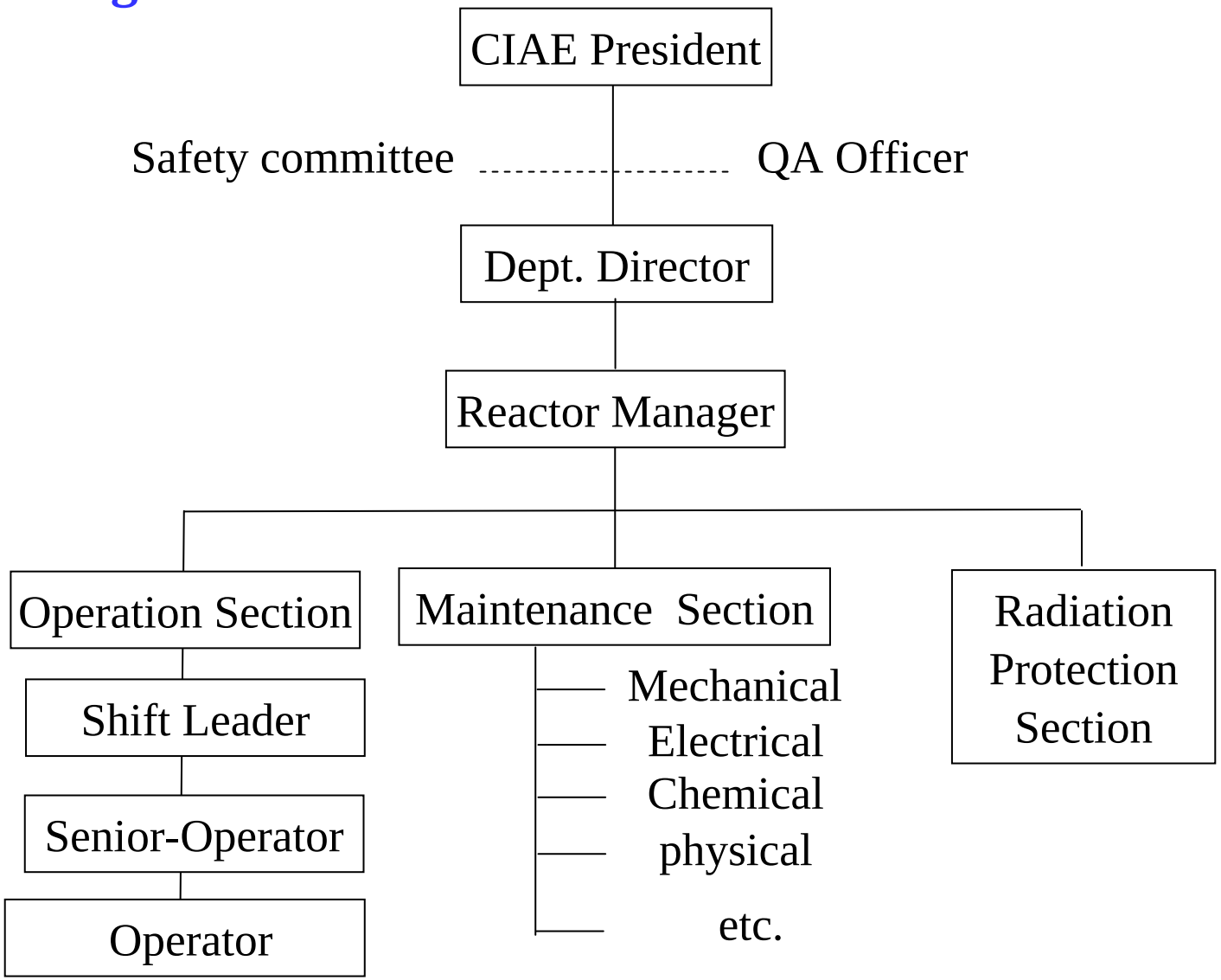
- Management systems at CIAE

  CIAE has accumulated adequate experience of operation and safety management, and well established QA system, such as:

  - Safety management
  - Quality assurance
  - Health & Environmental protection
  - Security
  - Emergency
  - etc.

4. Reactor management

Operation Organization



4. Reactor management

Regulations for Reactor Operation:

- ✓Organization and responsibilities
- ✓ personnel training and qualification
- ✓ Operation limits and conditions
- ✓ Operating procedures, including startup, power operating, shutdown, refueling, etc.
- ✓ Experiment and Irradiation management
- ✓ Maintenance, Periodic testing and inspection
- ✓ reactor core management
- ✓ Technical procedures and administrative controls
- ✓ Operation planning and control
- ✓ Review and verification
- ✓ Documentation
- ✓ Report, including periodic report, incident and accident report
- ✓ Radiation protection
- ✓ Emergency preparing
- ✓ etc.

4. Reactor management

➢Regulations for maintenance:

- ✓ Organization and responsibilities
- ✓ training and qualification
- ✓ Preventive maintenance & Corrective maintenance
- ✓ Periodic testing & inspection
- ✓ Additional non-routine maintenance, testing and inspection
- ✓ Technical procedures and administrative controls
- ✓ Planning
- ✓ Review and verification of the regulations
- ✓ Documentation
- ✓ Review of results
- ✓ Maintenance facilities
- ✓ Procurement and storage of spare parts
- ✓ Coordination and interfaces, interface control
- ✓ etc.

4. Reactor management

➢ Maintenance Facilities

- ✓Decontamination device
- ✓ handling tools
- ✓Mock-ups and models
- ✓Examination device
- ✓Etc.

- **Operation Program**

According to national safety regulations, operation safety evaluation shall be executed after one year's initial operation at power level ,and the revised "Final Safety Analysis Report" (FSAR) shall be submit to the regulatory body for applying operation license .

Initial operation will commenced in Jan.~ Dec. 2012.

after operation license is issued, CARR will operating in the mode of 10~20days/cycle, 12 cycles/year.

5. Future program

1) complete the installation of utilization facilities
2) To be a "*Nation al laboratory of neutron scattering research*" as initially intended (in progress)

3) To be a "*R & D center of nuclear technology application*" as expected.

4) open to users from domestic and abroad.

6. Remarks

CARR is a representative of multi-purposes and outstanding performance research reactor. It is believed that the completion of CARR project and its future operation will greatly enhance the capability of basic research and comprehensive application in the area of nuclear science and technology, pushing forward the peaceful use of nuclear technology.

The CIAE will sincerely welcome the domestic and the international users from universities and colleges, institutes, business enterprises, and other academic organizations to CARR to carry out researches, development and applications in various areas of nuclear science and technology, to share the sources of the platform of CARR

THANK YOU !