中国原子能科学研究院
CHINA INSTITUTE OF ATOMIC ENERGY

HOTLAB 2009 Conference

Development of Hot Cell Facility at CIAE

Zhengqiang LIANG

Director of PIE hot laboratory

China Institute of Atomic Energy

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Outline

- Background of hot cell facilities in China
- Introduction to the RFMEF
- CARR NDE Hot Cell
- CEFR Initial Examination Hot Cell
- Future need for Advanced Hot Cell Facility

Background of hot cell facilities in China

☐ Two organizations possess PIE hot cell facilities.

- China Institute of Atomic Energy (CIAE) :

  Three hot cell facilities: RFMEF

  CARR NDE Hot Cell

  CEFR Initial Examination Hot Cell

- Nuclear Power Institute of China (NPIC)
- Comparison:

  Relatively old

  Small in scale

  Shortage in advanced PIE techniques and instruments

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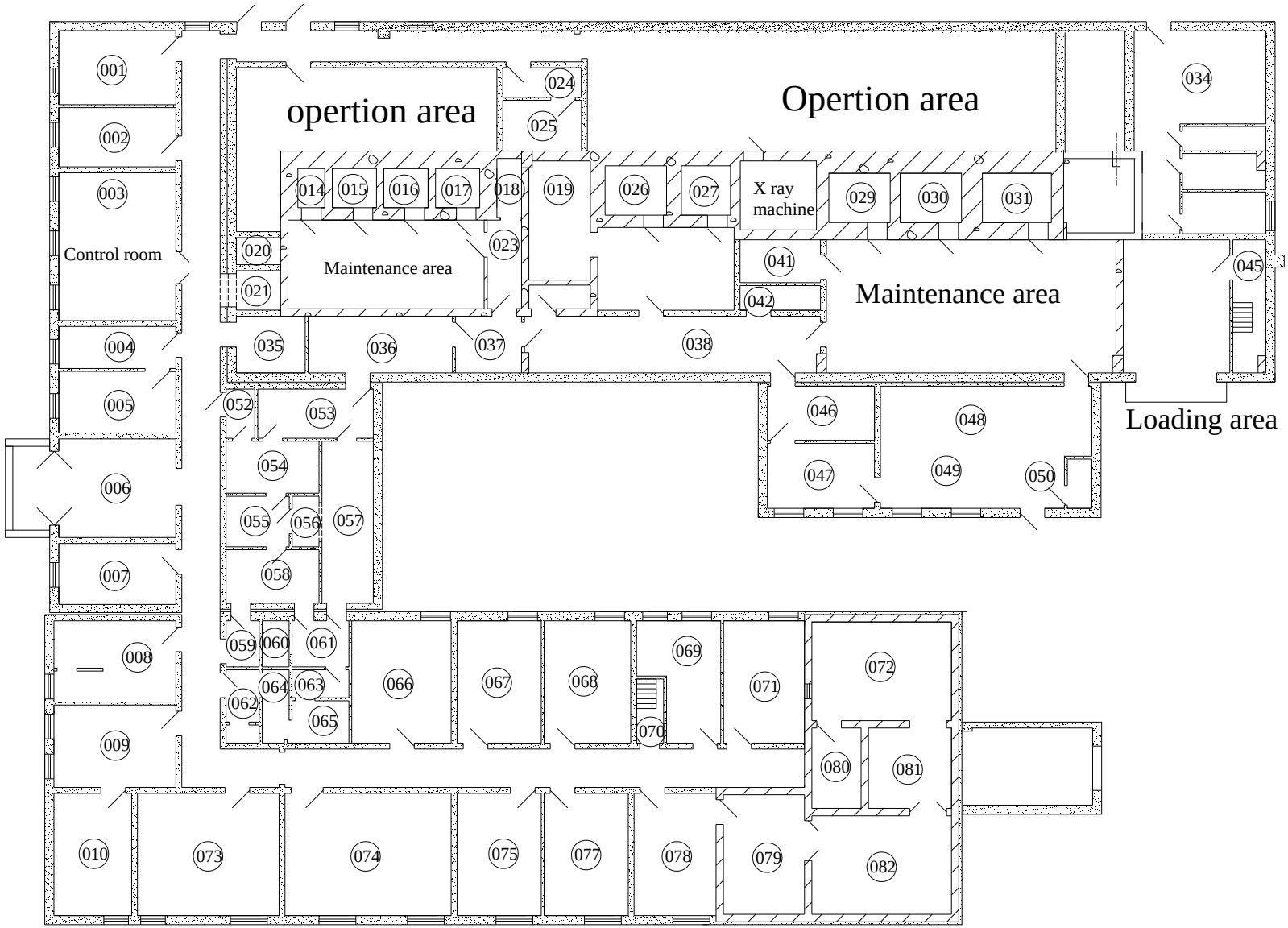
Introduction to the RFMEF

☐Reactor Fuel Material Examination Facility :

Facility consists of 3 groups:

- The first group : 3 cells for storage, cutting and NDE of fuel elements;
- The second group : 2 cells for mechanical property test
- The third group : 4 cells for metallographic and structural material analysis.

Plan arrangement RFMEF



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Technical Parameters

No. of hot cell	Inside dimension W×D×H(m)	Shielding capacity （Ci）	Wall thickness （mm）	No. of windows	Functions
1	2.8×2×3.3	10^4	900	1	Storage of spent fuel, visual inspection, dismantling of fuel assembly
2	2.5×2×2.2	10^4	900	1	Rod cutting
3	2.5×2×2.2	10^4	900	1	NDT of fuel rods
4	2×2×2.2	10^2	600	1	Puncture of fuel rods, fission gas release measurement
5	2.5×2×2.2	10^2	600	1	Tensile test
6	1.8×1.6×2.2	10^3	700	1	Vacuum resin mounting
7	1.8×1.6×2.2	10^3	700	1	Grinding and polishing
8	1.8×1.6×2.2	10^3	700	1	X ray diffraction
9	1.1×1.6×2.2	10^3	700	1	Metallographic analysis

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RFMEF

Operation area of RFMEF

PIE techniques

-Visual inspection and photograph
-Dimension measurement
-Dismantling of assembly
-NDE: Eddy current, gamma scanning for relative burn-up measurement, X radiography
- DE: Rod puncture and fission gas release measurement, fuel rod cutting, vacuum resin mounting, polishing, etching and metallography
-Mechanical testing: tensile, micro hardness, creep, fatigue and burst test.
-Electron probe micro analysis

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RFMEF

PIE apparatus

-Lead casks
-Periscopes
-Dimension measurement bench
-Eddy current and Gamma scanning bench
-Slit scanning X radiography device
-Rod puncture and fission gas release measurement device
-Gas chromatograph for fission gas analysis
-Tensile, creep, burst test machines
-Vacuum resin mounting device
-Grinding and polishing machine
-X ray diffraction machine
-Remote control optical microscope

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PIE equipments

Remote Control Optical Microscope

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PIE equipments

Multi-function tensile test machine

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PIE equipments

SEM CXA-733 EPMA

RFMEF

Refurbishment of the RFMEF

- RFMEF built in CIAE in 1970th
- Operated for 30 years
- Technological system and especially the auxiliary system were got aged
- Could not conform with the current laws and regulations.
- To eliminate the potential hazards and improve the examination process， some equipments and systems have been renovated.

Refurbishment of RFMEF

Contents of modification

-Power supply system： electric boards and cables renewed, A spared power supply system was established.
-Master-Slave manipulators: changed from M22 to ZC 109
-Renovation of gamma monitor system
-Gaseous effluent monitor system: A PING real time monitor system installed
-Ventilation system: Motors and filters are changed, pipes replaced by stainless steel.
-PLC system was equipped for the adjustment of air supply and exhaustion.
-Security and protection system is established.

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Refurbishment of RFMEF

Original pipe

New pipe

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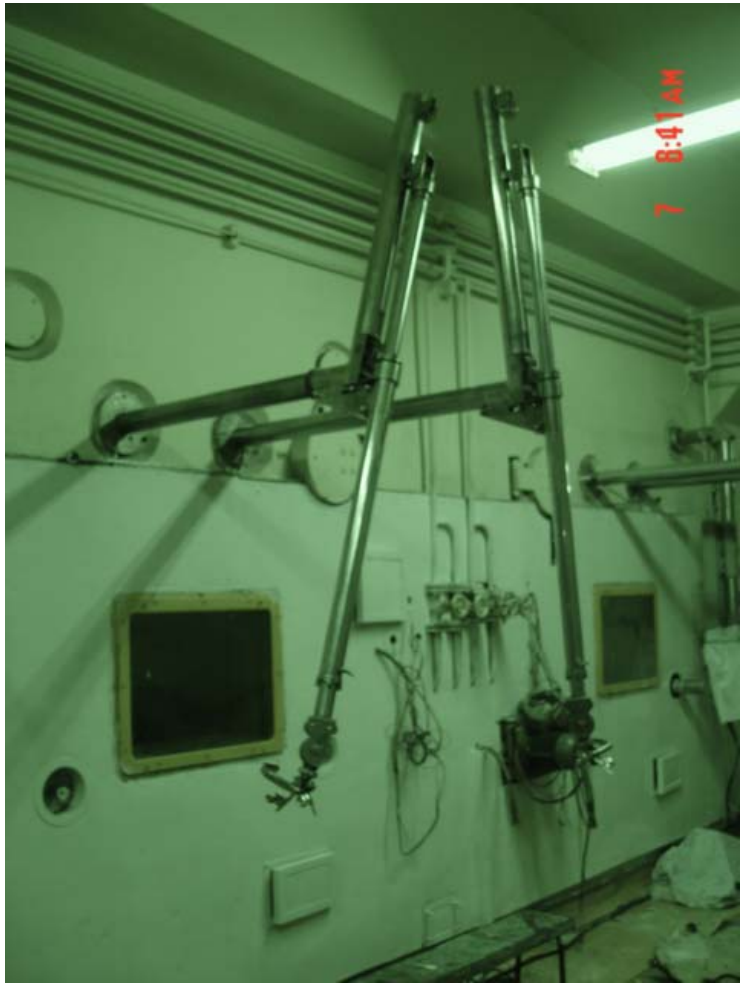
Refurbishment of RFMEF



M22 manipulator

ZC 109 manipulator

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Refurbishment of RFMEF

Dose rate meter

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Refurbishment of RFMEF

PING monitor system for gaseous effluent

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RFMEF

Research activities conducted

- PIE of fuel elements tested in the research reactor in CIAE.
- PIE of fuel assembly simulating Qinshan NPP.

  The assembly was tested in the HTHP loop of HWRR, with burn-up of 30GWd/tU.
- PIE of spent fuel rods (40GWd/tU) from Qinshan NPP.
- Surveillance test of RPV specimen for Qinshan NPP.
- Structure modification to surveillance capsules for Qinshan and C-1 nuclear power plants.
- Failure mechanism study to in-core components of NPP.

CARR NDE Hot Cell

Functions

-Transfer of CARR fuel assembly
-Non-destructive examination of CARR fuel assembly
-NDE of full size fuel rods from PWR
-Dismantling and NDE of irradiation capsules for material test
-Dismantling of radioisotope targets
-Transfer of fuel rods, radioisotope targets and irradiated materials

CARR: China Advanced Research Reactor

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China Advanced Research Reactor

CARR NDE Hot Cell

Technical specifications

- Dimension : 7×2.2×4.1m（L×W×H）.
- Walls Thickness: 1.3m;
- Density: 4.2 g/cm^3
- Shielding capacity: 3700TBq (10^5 Ci)
- No. of manipulators: 3 pairs of MT 200
- No. of view windows: 3

CARR NDE Hot Cell

Hot cell equipments:

- 2kN stainless steel crane
- One slope transfer tunnel for access of CARR fuel assembly
- One horizontal transfer tunnel for access of PWR fuel assembly
- Five storage wells: Φ150×2500mm
- An electric & hand driven trolley for transferring 250kN lead cask from outside to the hot cell.
- Extended chamber for full size examination of PWR fuel rods and real time X radiography.

CARR NDE Hot Cell

NDE techniques and Examination equipments

- Multifunctional NDE bench used for:
  -Dimension measurement
  -Eddy current testing
  -Gamma scanning
  -Real time X radiography
- A numerical controlled miller: for dismantling of fuel assembly, irradiation capsules and targets.
- A Periscope and two video cameras: for hot cell observation

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CARR NDE Hot Cell

Operation area of CARR hot cell

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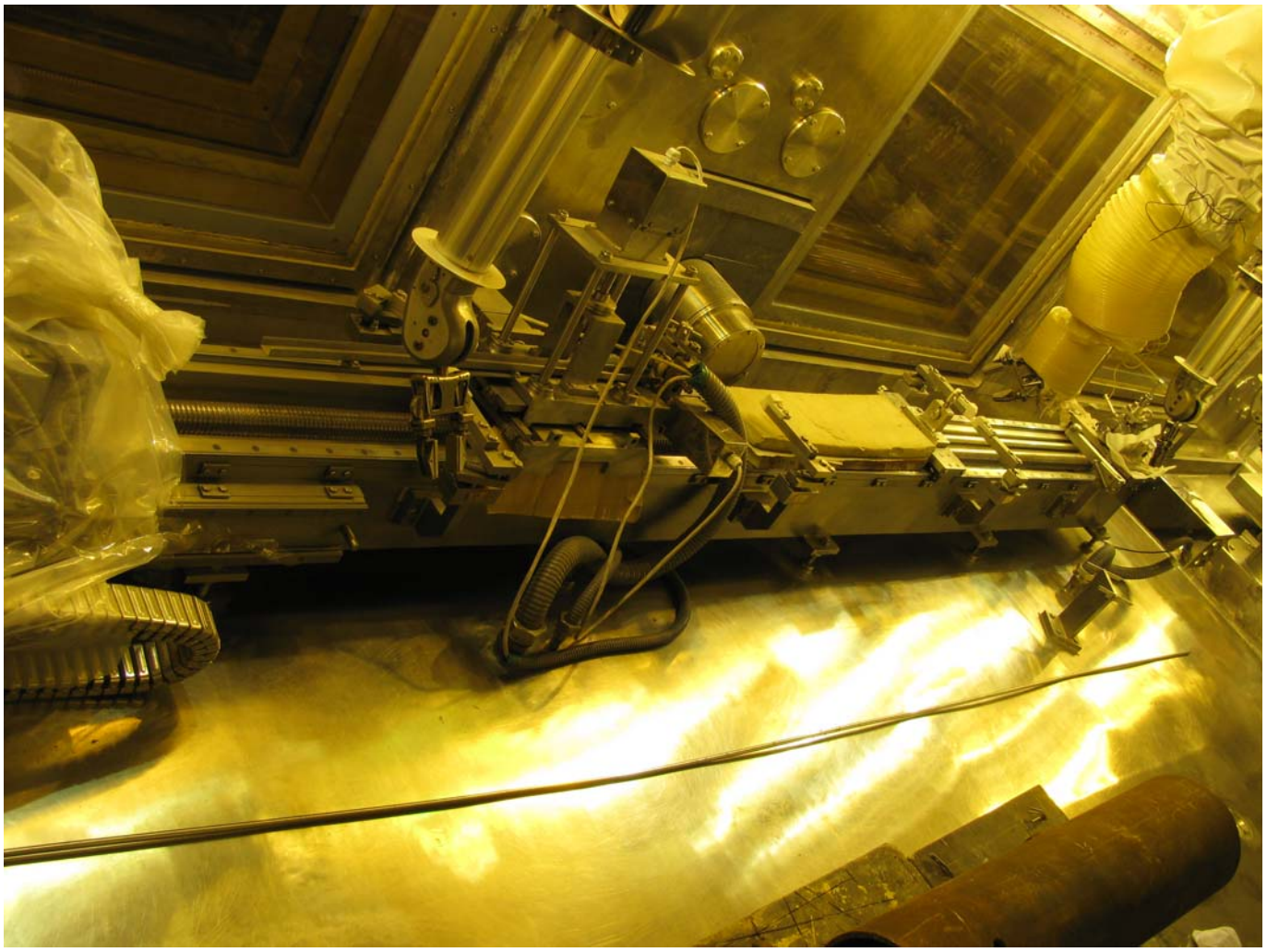
CARR NDE Hot Cell



The multifunctional NDE bench

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CARR NDE Hot Cell

R52 cask :for fuel rods transportation

CEFR Initial Examination Hot Cell

Introduction to the hot cell:

- For the initial examination of fuel assembly and materials tested in CEFR.
- Dimension of the cell: 6.6×2.2×4.3m
- Shielding wall thickness:1.2m
- Density: 3.6g/cm^3

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Irradiation Facilities for Material Research

China Experimental Fast Reactor

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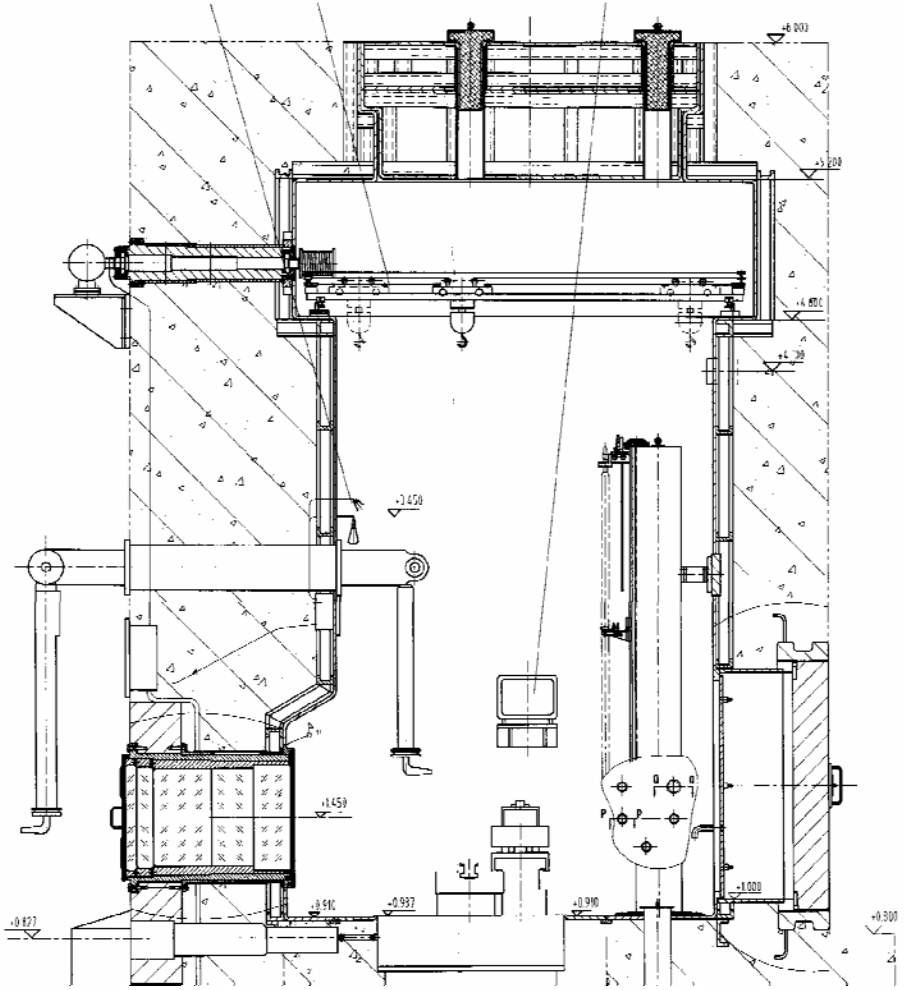
CEFR Initial Examination Hot Cell

Cell equipments:

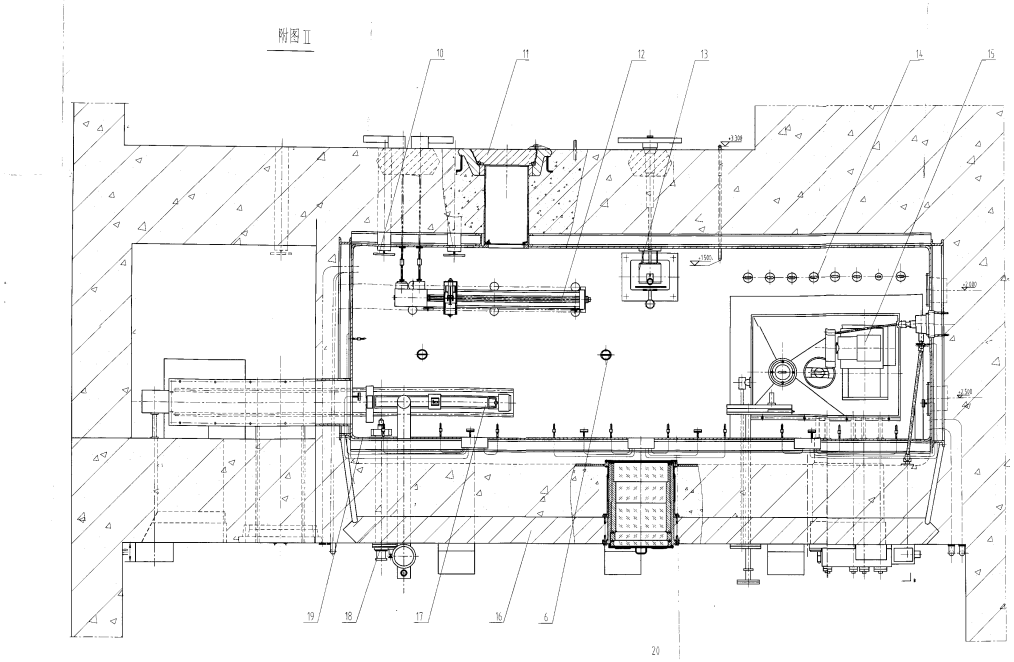
- Manipulators: 3 pairs of MT 200
- View windows:3
- Vertical transport hole: Φ150mm, for fuel assembly to get into the cell
- Stainless steel crane: 2kN



CEFR Initial Examination Hot Cell

Testing equipments

- Disassembly miller:
- Assembly test device:
- Fuel rod dimension measurement and EC test bench
- Slit scanning X radiography device
- Periscope
- Gamma scanning device



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Future need for the Advanced Hot Cell Facility

☐Backgrounds:

- China has a great need for nuclear energy and is developing nuclear power plant with rapid speed.
- The nuclear power plants in operation and under construction have different type of reactors, including PWR, PHWR and FBR in the future.

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Nuclear Energy in China

Name of NPP	Reactor Type	Rated Power（MWe）	Construction Started	Commercial Operation
Qinshan 1	PWR (China)	310	1985/3/20	1991/12/15
Daya Bay	PWR (French)	2× 984	1987/8/1	1994/2/1
Qinshan 2	PWR(China)	2× 650	1996/6/2	2002/2/6
LingAo	PWR (French)	2× 990	1997/5/15	2002/5/28
Qinshan 3	PHWR(Canada)	2× 700	1998/6/8	2002/12/31
TianWan	PWR (Russia)	2× 1060	1999/10/20	2006/5/12

NPPs in Operation. 11 units, 9.1GW, 1.2%

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Nuclear Energy in China up to June 2009

Name of NPP	Reactor Type	Rated Power（MWe）	Construction Started	Commercial Operation
LingAo 2	PWR (CPR1000)	2× 1080	2005/12/15	2010/8/31
Qinshan 2 Extension	PWR	2× 650	2006/4/2	2010/12/28
Hong yanhe	PWR(CPR1000)	2×1080	2007/8/18	2012/8/31
Ningde	PWR(CPR1000)	2× 1080	2008/2/18	2012/8/12
Fuqing	PWR	2× 1000	2008/11/18	2013/11/12
Fangjiashan	PWR	2× 1000	2008/12/18	2013/12/30
Sanmen	PWR(AP1000)	2× 1250	2009/4/19	2013/12/30
Haiyang	PWR(AP1000)	2× 1250	2009/12	2014

8 NPPs under construction

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Future need for the Advanced Hot Cell Facility

Role of the new facility:

- To match with the development of NPP
- To evaluate the integrity and behavior of structural materials
- Contribute to the interpretation of the material behavior
- Develop strategies for optimum life management of NPP
- Select materials for future generations of reactors

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Future need for the Advanced Hot Cell Facility

☐Conceptual design of the new hot cell facility

➢Consists of a storage pool and 4 hot cell lines.

➢Advanced PIE techniques and equipment will be installed at the hot cells.

➢This facility will be used to carry out comprehensive and detailed PIE, including the handling and examination of fuel assembly and structure materials of such power reactors as PWR, FBR, PHWR, and fusion reactor in the future.

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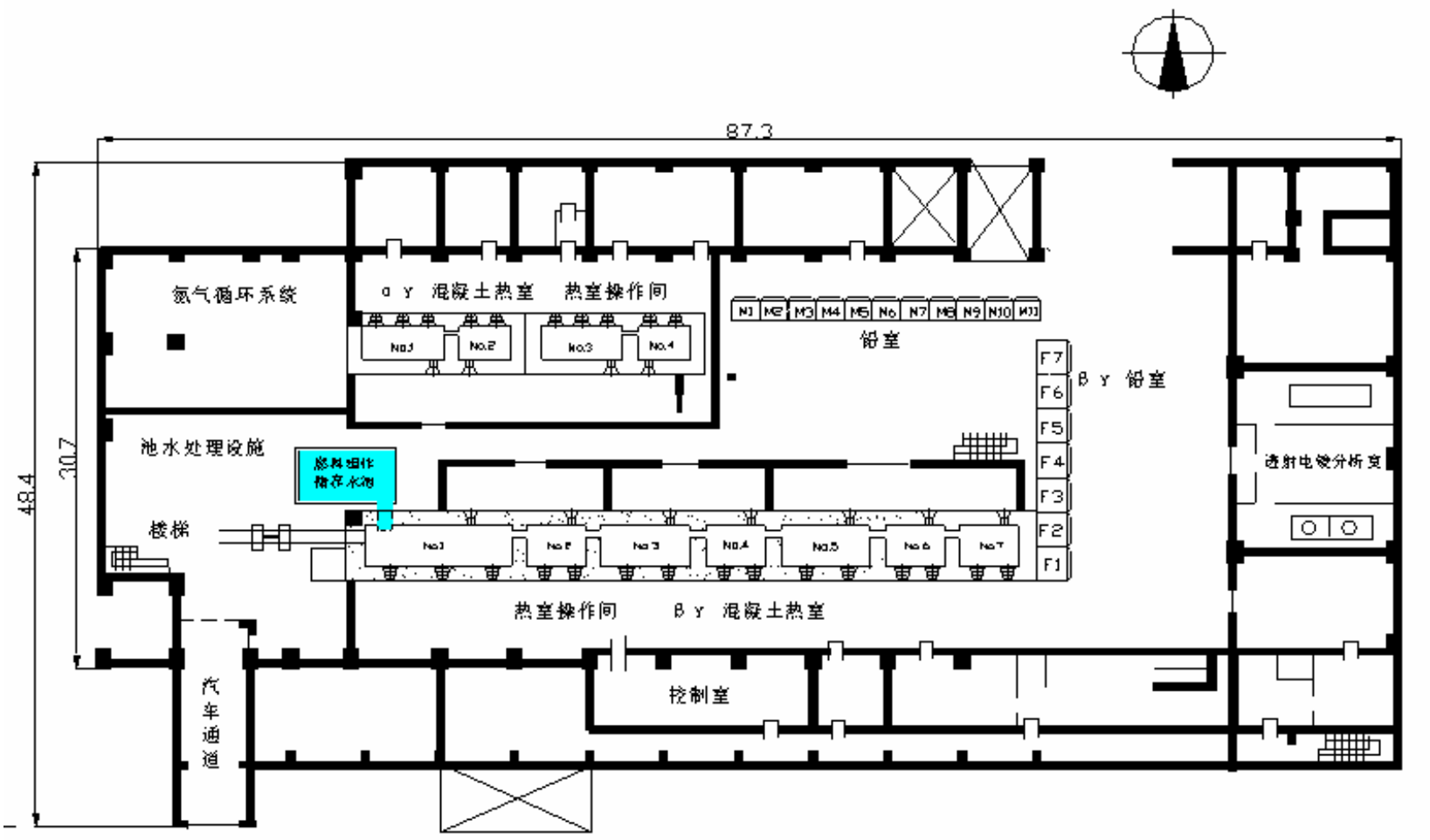
Future need for the Advanced Hot Cell Facility



Arrangement of the new hot cell facility

Future need for the Advanced Hot Cell Facility

☐Conceptual design of the new hot cell facility

➢4 hot cell lines.

•The first cell line: 7 β - γ concrete cells for examination of fuel assembly and fuel rod of PWR and PHWR,

•The second cell line has 7 β - γ lead cells for microstructure analysis of fuels and materials,

•The third cell line: 4 α - γ concrete cells for examination of fuel assembly and fuel rod of FBR,

•The fourth cell line: 11 β - γ lead cells for mechanical testing of materials.

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Future designs for the Advanced Hot Cell Facility

☐Advanced PIE techniques and instruments

➢Transport containers will be designed and manufactured for the transportation of spent fuel assemblies from nearly all NPP reactors.

➢A large storage pool will be built for the storage of fuel assemblies.

➢Re-fabrication techniques will be equipped in the facility for ramp and high burn-up irradiation test.

➢Advanced micro-analysis instruments such as SEM, TEM, EPMA, SIMS, X ray diffraction machine will be equipped.

➢Mechanical testing machine will be enlarged to instruments such as creep test, burst test, fatigue test, stress corrosion crack and other mechanical test.

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Thank you for your attention!