

**11th International Topical Meeting
Research Reactor Fuel Management (RRFM)
and
Meeting of the International Group of Reserach Reactors
(IGORR)
Centre de Congrès, Lyon, France
11 - 15 March 2007**

**THE DALAT NUCLEAR RESEARCH REACTOR OPERATION AND
CONVERSION STATUS**

**PHAM VAN LAM, NGUYEN NHI DIEN, LUONG BA VIEN,
LE VINH VINH, HUYNH TON NGHIEM AND NGUYEN KIEN CUONG**

*Nuclear Research Institute
01 Nguyen Tu Luc Street, Dalat, Vietnam*

THE DALAT RESEARCH REACTOR



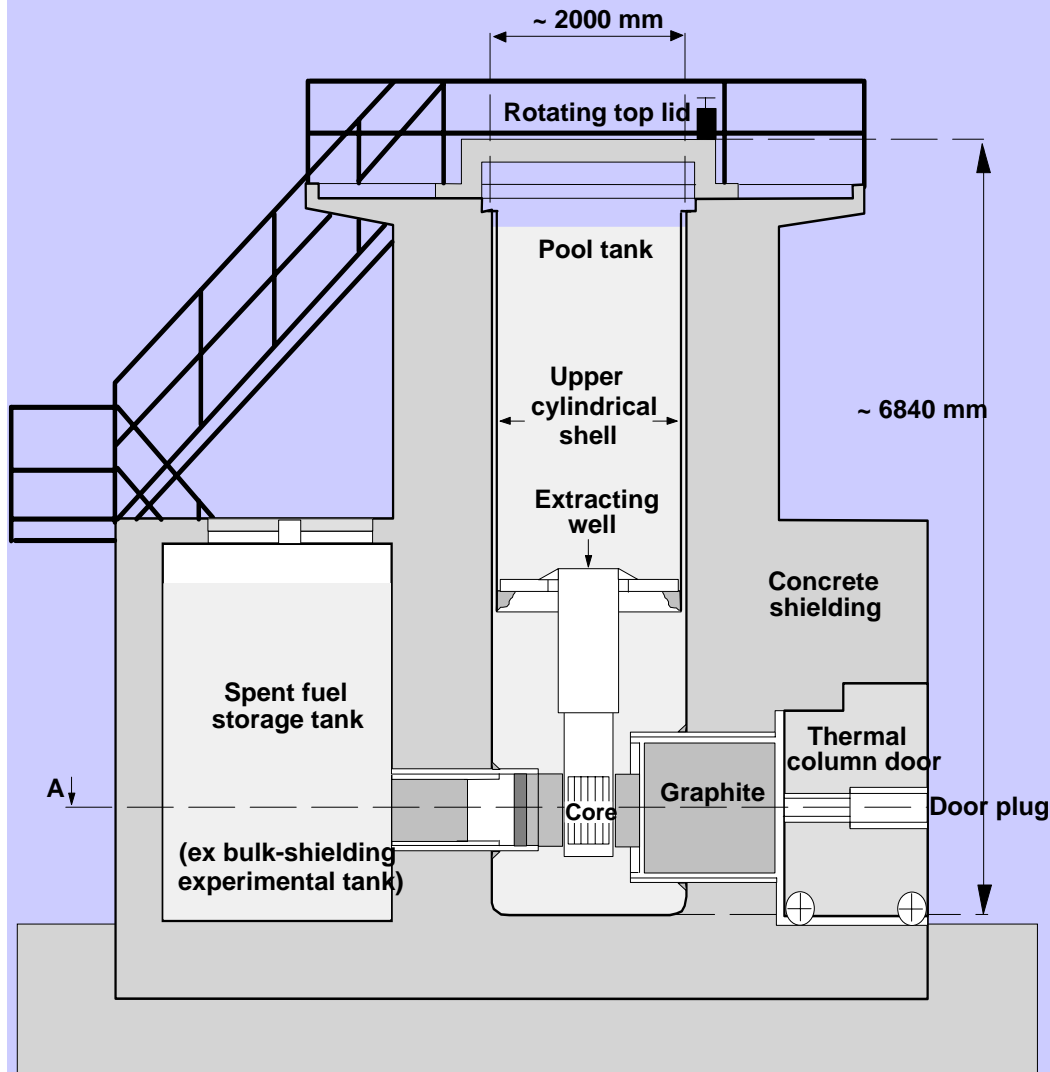
◆ The Dalat Nuclear Research Reactor (DNRR) is a pool type research reactor

◆ Reconstructed from the 250 kW TRIGA-MARK II reactor

◆ The reactor aluminium tank, the graphite reflector, the thermal column, the horizontal beam tubes and the radiation concrete shielding were retained

Outside view of the DNRR

THE DALAT RESEARCH REACTOR

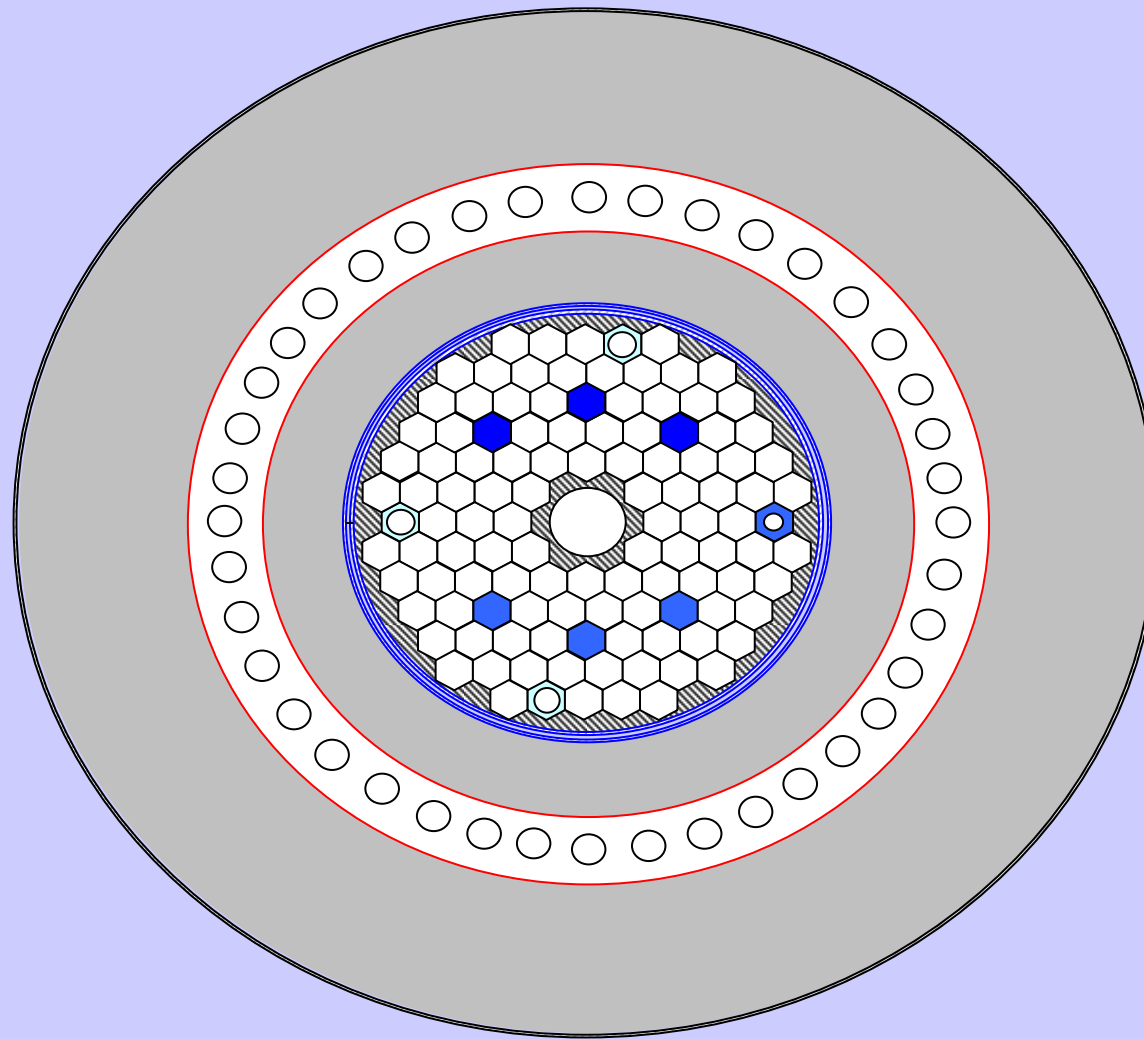




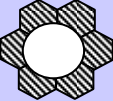





- ◆ The reactor core, the control and instrumentation system, the primary and secondary cooling systems as well as other associated systems were newly designed and installed
- ◆ The core is loaded with WWR-M2 fuel assemblies (FA) with 36% enrichment
- ◆ The reconstructed reactor reached its initial criticality in November 1983 and attained its nominal power of 500 kW in February 1984

THE DALAT RESEARCH REACTOR

◆ Reactor has operated for

- Radioisotopes production;
- Neutron activation analysis;
- Basic and applied research in nuclear physics;
- Research on reactor physics and thermo-hydraulics;
- Personnel training and education.

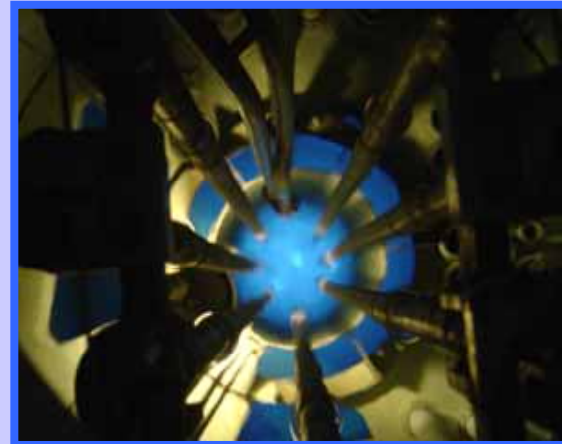
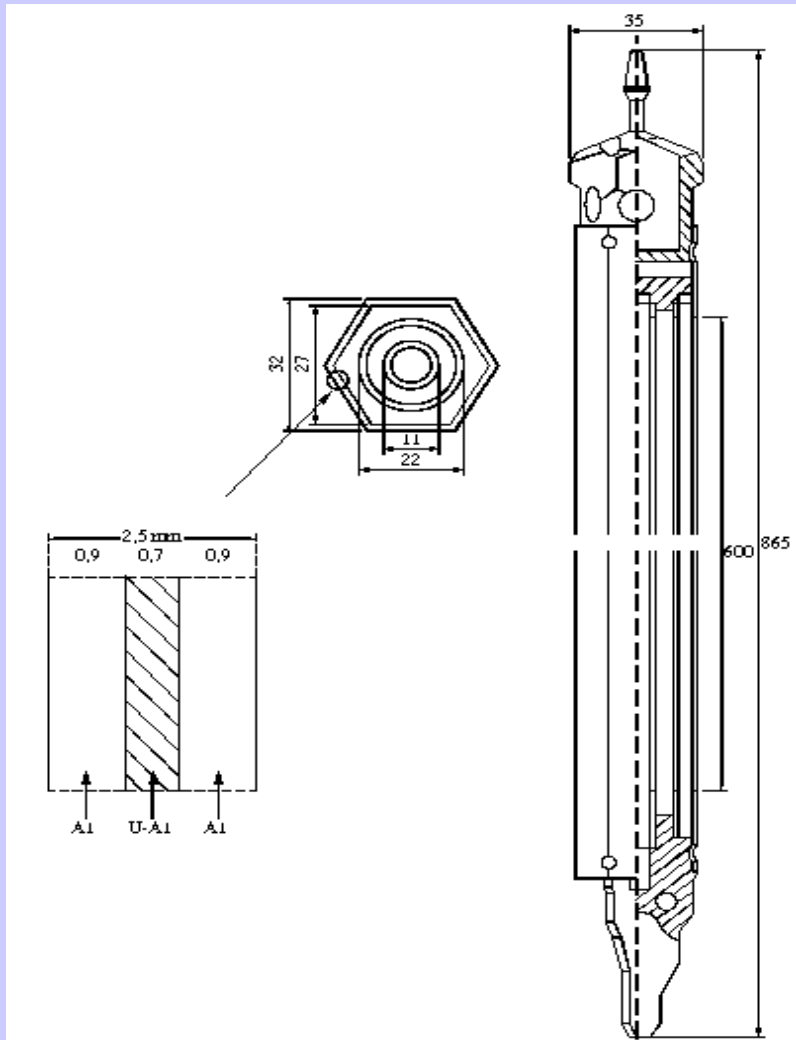


- | | | |
|--|---|--|
|  Fuel assembly |  Irradiation channel |  Neutron trap |
|  Regulating rod |  Beryllium block |  Irradiation hole |
|  Control rod |  Graphite reflector | |

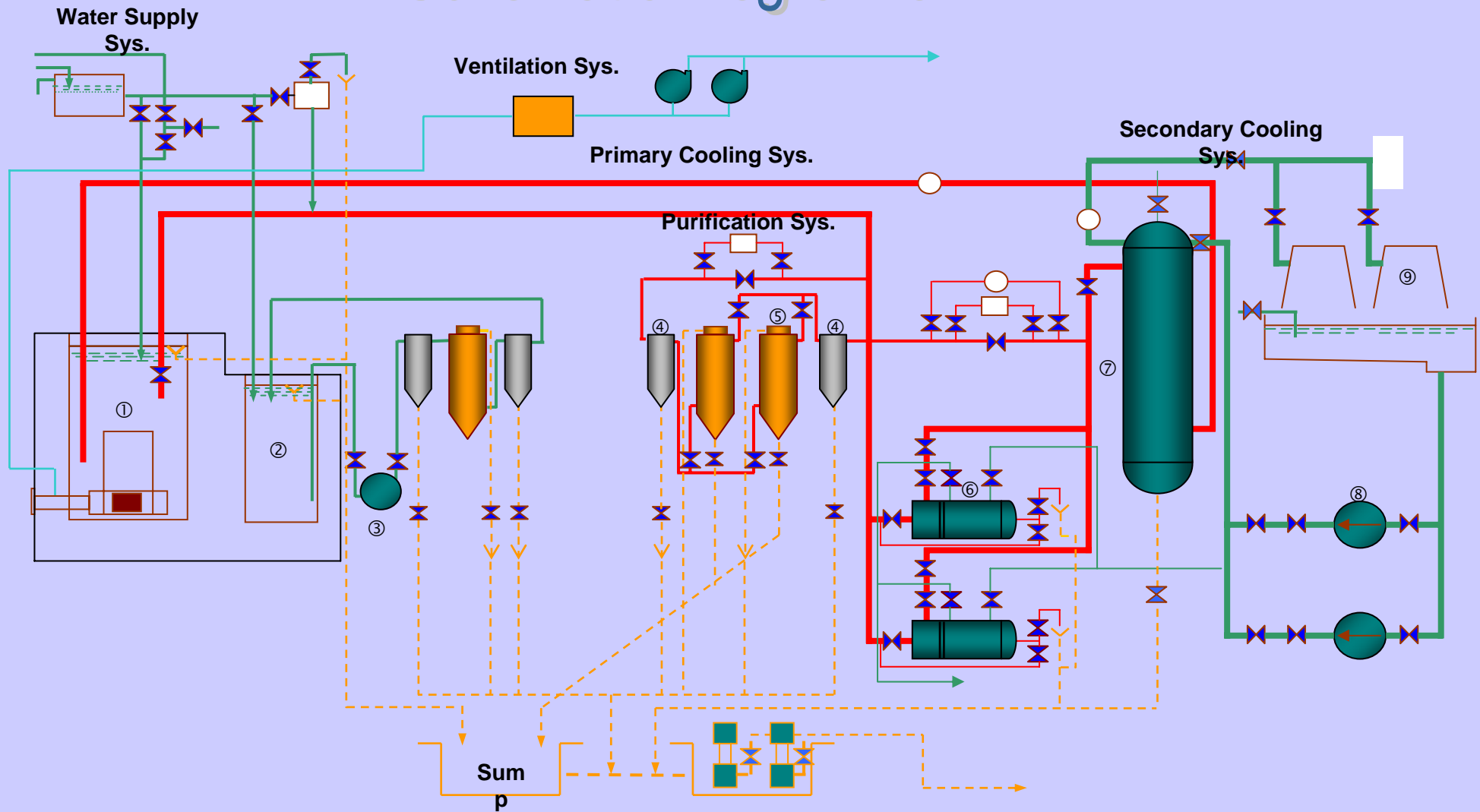
Core configuration with the 104 fuel assemblies

Fuel assembly

- ◆ Fuel assembly WWR-M2 type:
 - + Al-U alloy, 36% enriched U-235
 - + Total long: 865 mm
 - + Fuel meat part long: 600 mm
 - + 3 layers (2 round tubes inside, 1 hexagonal outside)
 - + Fuel meat thickness: 0.7 mm
 - + Cladding thickness: 0.9 mm



Schematic Diagram of DNRR



REACTOR OPERATION



- Operation regimes:

+ continuously at 500 kW:

108 hrs/cycle, 1 cycle/month,

→ 1250 hrs/year

+ short run for experiments and training

- Total operation time from March 1984 to December 2006:

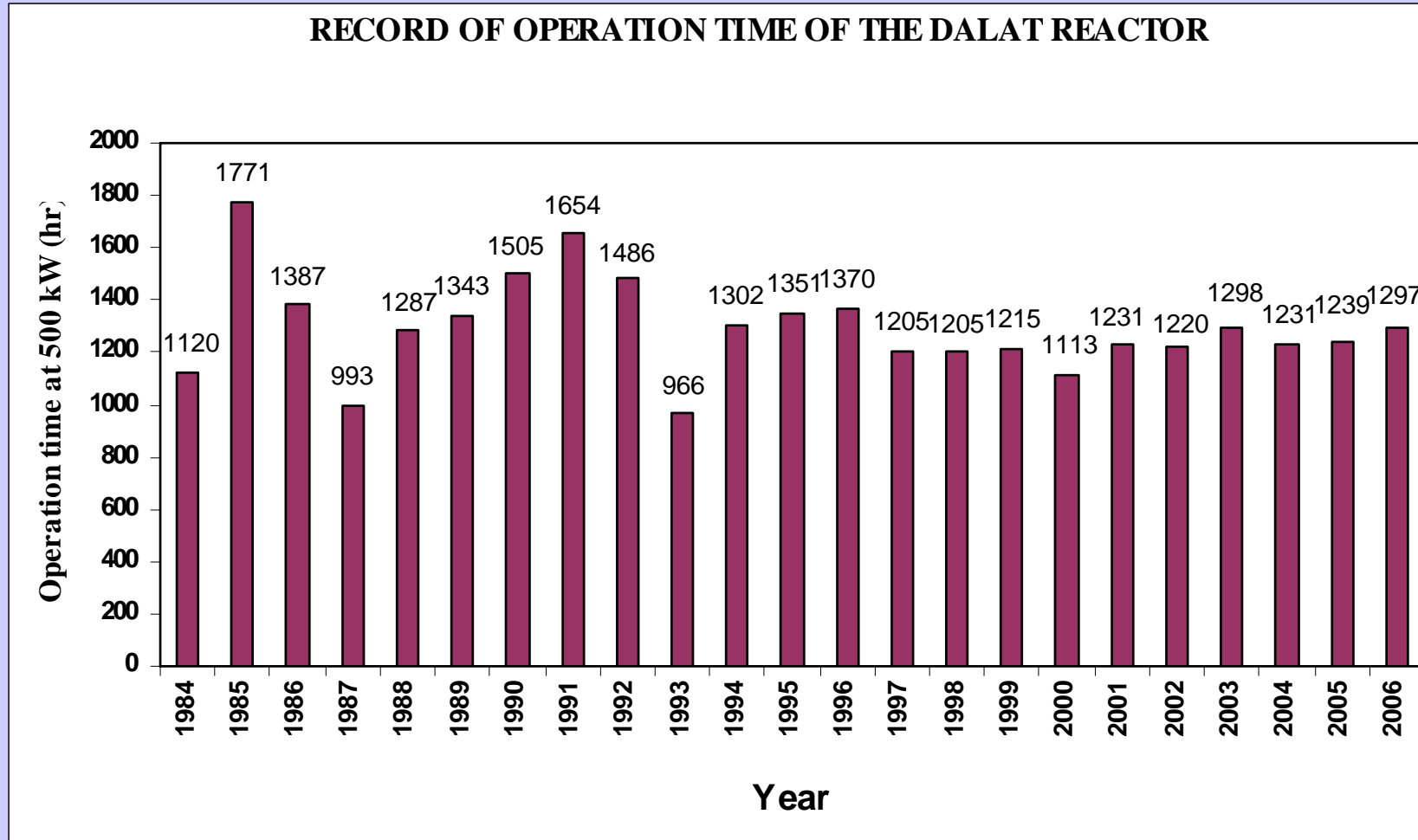
→ about 29,800 hrs

→ the total energy released was about 600 MWd.

- The number of unexpected scrams in the last 22 years:

256, mainly due to unstable working of the local electrical supply network (70%), due to equipment failures (20%), and human errors (10%).

REACTOR OPERATION



RADIOISOTOPE AND RADIOPHARMACEUTICAL PRODUCTION



I-131 production line



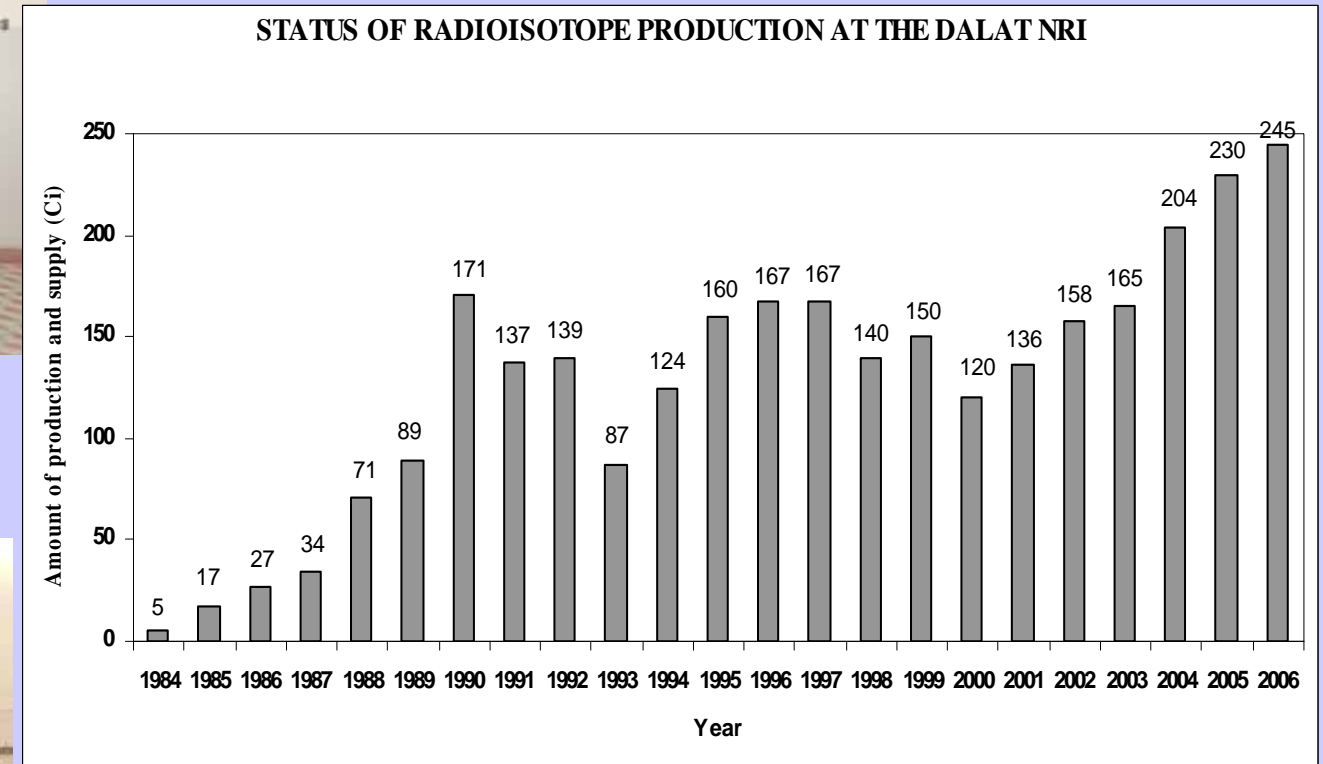
RI products of NRI

- **Main radioisotopes & radiopharmaceuticals regularly produced for medical purposes are:**
 - . ^{131}I solution and capsules
 - . $\text{Tc}^{99\text{m}}$ generators from Mo by (n,γ) reaction
 - . ^{32}P applicator,
 - . ^{32}P , ^{51}Cr , ^{153}Sm , etc. solution
 - . In-vivo labeled kits for $\text{Tc}^{99\text{m}}$
 - . In-vitro T_3 , T_4 kits
- **Other radioactive tracers for sedimentology study, oil field study, and industry application can also be produced:**
 - ^{46}Sc , ^{192}Ir , ^{198}Au , etc.
- **Small sources:**
 - ^{60}Co , ^{192}Ir , etc.

YEARLY RADIOISOTOPE PRODUCTION FOR MEDICAL USE (in Ci)

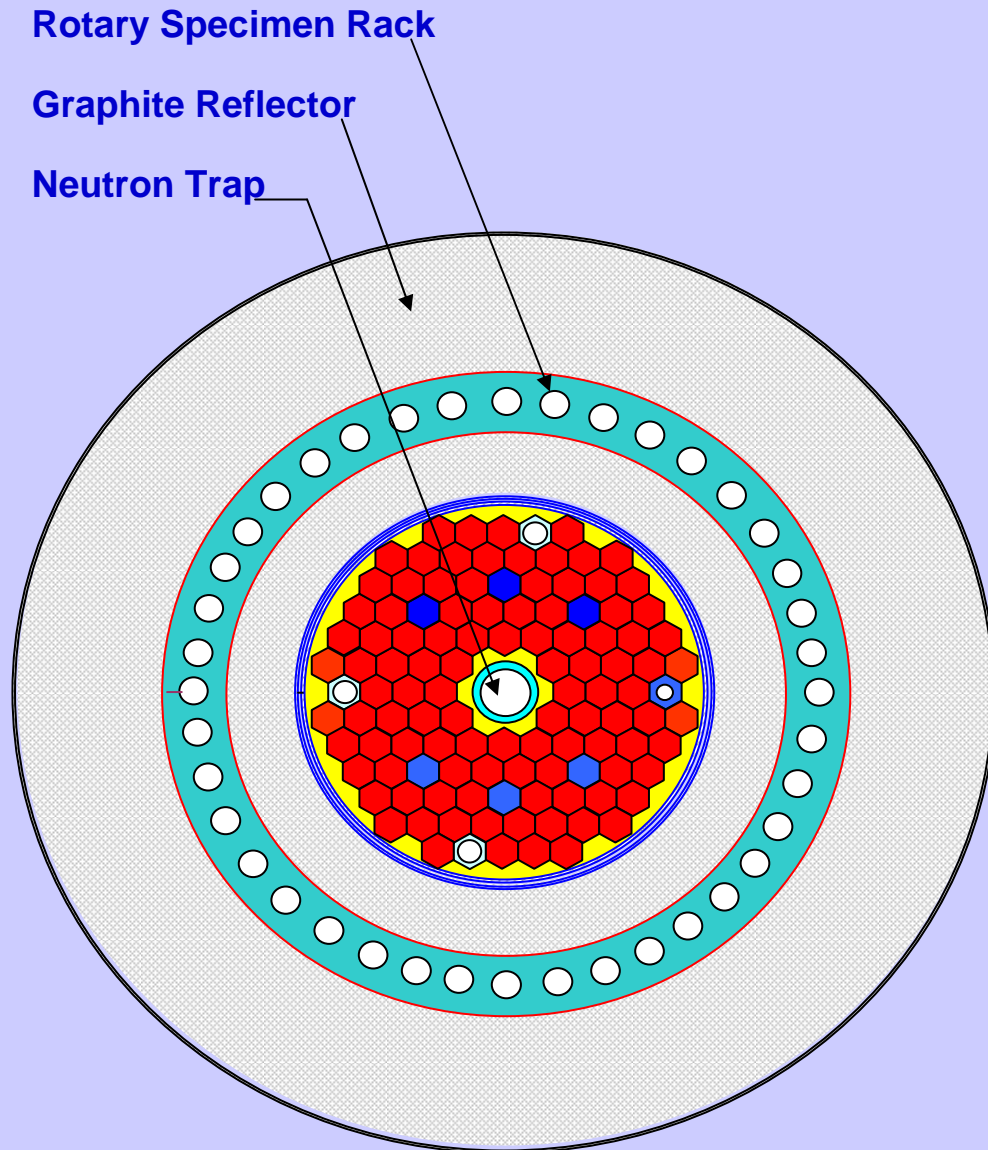


Diagnosis and Treatment by I-131



Diagnosis of brain by ^{99m}Tc -HMPAO

Reactor control and protection system



- ◆ 2 safety rods
- ◆ 4 shim rods
- ◆ automatic regulating rod
- ◆ The reactor control and instrumentation system was upgraded in 1994
- ◆ Now we are carrying out project to replace the reactor control system by new one except control rods

Reactor control and protection system

- ◆ This project is supported by International Atomic Energy Agency and Vietnam Government
- ◆ Equipments are supplied by company SNIIP-SYSTEMATOM, Russia
- ◆ New control system ensures the safety, control, check and monitoring of the reactor facility:
 - *channels for monitoring of reactor power and period by thermal neutrons flux density (NFME channels);*
 - *channel for monitoring of process parameters;*
 - *channels for logical processing of signals from NFME channels, from technological and supporting systems and for generation of control signals for protection safety system and for normal operation system;*
 - *channel for automatic power regulation; channels for reactivity monitoring;*
 - *channel for monitoring of control rods position;*
 - *information channels for displaying operative information at control panel;*
 - *buttons and keys of control panel;*
 - *equipment for archiving, diagnostic and recording*

Integrated channel of control safety system



Control panel and Data acquisition and processing unit



Monitor



New control system

- Replacement work on 9 December 2006
- The work will be fulfilled in March 2007
- And then the DNRR will be operated with new control system.

Reactor core conversion status

- The study on reactor core conversion has been done in the framework of joint study between RERTR program at Argonne National Laboratory (ANL) and Vietnam Atomic Energy Commission (VAEC)
- Ministerial research theme on DNRR core conversion
- Each LEU (enrichment of 19.75%) fuel assembly contains an average of 49.7 g ^{235}U with $\text{UO}_2\text{-Al}$ dispersion fuel meat. The fuel layer with a thickness of 0.94 mm is wrapped between two aluminium alloy cladding layers of 0.78 mm thickness.

Reactor core conversion status

- The neutronic calculations indicated that around April 2006 if 36 fresh HEU WWR-M2 fuel assemblies or 36 fresh LEU WWR-M2 fuel assemblies are inserted without fuel shuffling over the next four operating cycles, the core could operate for an additional 10.5 years or 14.1 years, respectively

**Summary of operating times for Incremental Insertion of 36 fresh HEU or
36 fresh LEU fuel assemblies beginning in April 2006**

Cycle	HEU or LEU FA Inserted per Cycle	Total HEU or LEU FA Inserted	FPD with HEU Fuel	Cum. Years Oper. Using HEU	FPD with LEU Fuel	Cum. Years Oper. With LEU
1	8	8	143	2.8	183	3.5
2	8	16	265	5.1	344	6.6
3	10	26	413	7.9	546	10.5
4	10	36	547	10.5	733	14.1

Reactor core conversion status

- Shutdown margins for four reloaded cores range from -4.1% to -4.41% which are much greater than the required value of -1%
- At the Neutron Trap, the fast and thermal flux of mixed fuel core (using HEU and LEU fuel) decrease only several thousandths compared to those of HEU core
- In all other comparison locations, the fast flux is essentially the same.

Reactor core conversion status

- In these same locations the thermal flux has been reduced 1 to 3.4% as more LEU fuel is reloaded
- The total power peaking factors for the mixed fuel cores are slightly smaller ($\sim 1\%$) than those in the corresponding HEU cores
- The calculated temperature feedback coefficients and kinetics parameters are not so different between the current core and mixed fuel core

Neutron flux performance comparisons for four reload cycles:

LEU/HEU ratio

	Cycle 1		Cycle 2		Cycle 3		Cycle 4	
	Thermal	Fast	Thermal	Fast	Thermal	Fast	Thermal	Fast
<u>Dry Irradiation Channels</u> Cell 13-2 Cell 7-1	0.999 0.994	0.995 0.993	0.992 0.997	0.995 0.995	0.974 0.994	0.998 0.994	0.972 0.966	1.002 0.989
<u>Wet Irradiation Channel</u> Cell 1-4	1.000	0.994	0.996	0.997	0.983	1.005	0.967	1.006
Neutron Trap	0.997	1.001	0.997	1.000	0.997	0.994	0.995	0.992

Reactor core conversion status

- The requirement of thermal-hydraulic safety margin for the mixed fuel core in normal operational condition is satisfied
- The Accident analyses for reactivity insertion, maximum positive reactivity insertion and fuel cladding failure were done
- The results of analysis for reactor power, fuel cladding temperature and coolant temperature in the investigated cases of positive reactivity insertion have no much the differences between the two cores.

Reactor core conversion status

- The results of analysis for the fuel cladding failure shown that the changing from HEU core to mixed fuel core will not affect significantly on the MHA consequences
- The insertion of fresh LEU WWR-M2 fuel assemblies instead of fresh HEU WWR-M2 fuel assemblies will keep the reactor operating as safe as current core

Reactor core conversion status

- Now we are working for contracts between Russia, Vietnam, USA and the International Atomic Energy Agency for Nuclear fuel manufacture and supply for DNRR and Return of Russian-origin non-irradiated highly enriched uranium fuel to the Russian Federation
- According to the plan we will received 36 new LEU fuel assemblies in the second half of 2007
- We will execute fuel reloading by using LEU fuel and create mixed core with 104 fuel assemblies

Conclusions

- The DNRR is operated mainly in continuous runs of 100 hrs, once every 4 weeks, for radioisotope production, neutron activation analyses, training and research purposes
- Total operation time at nominal power of the DNRR from March 1984 to December 2006 is 29790 h.
- The total energy released was 595 MWd.
- Now we are carrying out project to replace the reactor control system by new one
- The replacement will be fulfilled in end of March 2007. And then the DNRR will be operated with new control system

Conclusions

- The study on reactor core conversion has been done
- The results of study showed that operation time of mixed core by inserting 36 LEU FA last much longer than 36 HEU FA
- Neutron flux performances at irradiation positions are not significantly changed
- The insertion of fresh LEU WWR-M2 fuel assemblies instead of fresh HEU WWR-M2 fuel assemblies will keep the reactor operating as safe as current core
- Now we are realizing conversion project for DNRR

Thank you !

