Spent Fuel Management in Slovakia

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Outline

- Introduction
- Spent fuel management
- Research and Development
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Nuclear facilities in the Slovak Republic

Introduction

- The skills in handling spent fuel have been collected in Slovakia for more than 35 years. During this time period a well established spent fuel management system was created.
- In Slovakia there are four nuclear power units in operation. These units produce about 300 spent fuel assemblies (approximately 36 ton of heavy metal) a year.
- For temporary storage of the spent fuel after its terminate reloading from the reactor core the at-reactor spent fuel storage pools are used. The spent fuel is stored in a grate and cooled by water with presence of the boric acid. After at least 2.5 years of storage in the at-reactor pools, the spent fuel is removed to the Interim Spent Fuel Storage Facility (ISFSF).
- The capacity of the ISFSF is 14112 spent fuel assemblies. The spent fuel will be stored there for at least 50 years.

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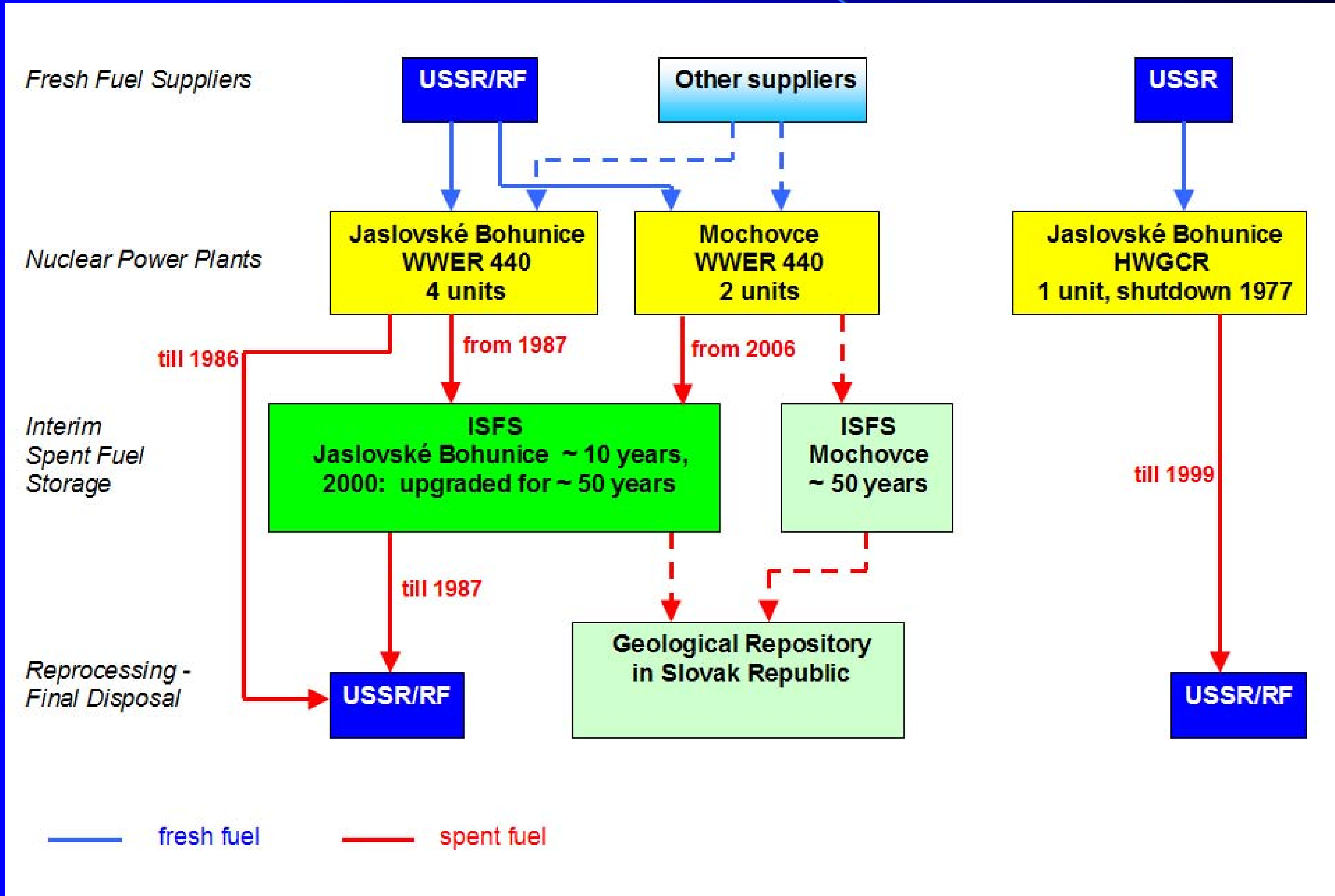

Introduction
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- The Slovak Government established the basic policy of spent fuel management in several resolutions.
- In 2000 the Slovak Government adopted the power policy of the Slovak Republic that is also related to the concept of fuel cycle back-end.
- In 2008, the Slovak Government accepted in its Decision Nr. 328/2008 “The proposal on the strategy of the back-end of the nuclear power engineering”. The material contains the philosophy of the spent fuel management including the deep geological repository development.

Introduction
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- The state supervision on nuclear safety of spent fuel management is performed by Nuclear Regulatory Authority of the Slovak Republic (UJD).
- The legislative framework in the Slovak Republic is based on acts and regulations.
- Acts are at the highest legislative level.
- Based on general requirements described in the acts, the regulations describe more detailed requirements.
- Several guides were issued by UJD. Unlike the acts and regulations, are guides for operators not binding.

Introduction

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- Act No. 541/2004 Coll. on Peaceful Use of Nuclear Energy regulates
  - the conditions for use of nuclear energy for peaceful purposes,
  - the obligations and rights of legal persons and natural persons in the use of nuclear energy,
  - the classification of nuclear materials,
  - the conditions for their production, processing, procurement, storage, transportation, use, accounting and control,
  - conditions for management of radioactive waste from nuclear installations and of spent nuclear fuel,
  - state supervision of nuclear safety at nuclear installations,
  - procurement and use of nuclear materials,
  - management of radioactive waste and management of spent nuclear fuel.

Introduction
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- Regulation No. 53/2006 Coll. on Radwaste and Spent Nuclear Fuel Management by which details of radioactive waste management and spent fuel management are regulated. This regulation describes general requirements placed upon radioactive waste management and spent fuel management. Spent fuel shall be managed to minimize the effect of ionizing radiation exerted upon operators, population and environment; to maintain subcriticality; remove residual heat and minimize generation of radioactive waste.
- Regulation No. 57/2006 Coll. on the Details of Transport of Radioactive Materials and Radioactive Waste regulates the process and methods of road, rail, water and air transport of radioactive material, radioactive waste from nuclear facilities and spent nuclear fuel and the scope and content of the documentation required for issuance of approval for transport of radioactive material.

Introduction
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- Guide of UJD on Construction and Operation of Spent Nuclear Fuel Storages describes requirements for design and operation of spent nuclear fuel storage, especially fulfillment of safety functions. Guide provides detailed information on realization and control of these functions during the whole operating life. Guide was developed according to the IAEA requirements for spent fuel handling and in accordance with Act No. 541/2004 and Regulation No. 53/2006.

Spent Fuel Management

- In 2009 the UJD approved the spent fuel transportation container C-30 for next utilization.
- The license was issued for the transport of spent nuclear fuel from four units in operation as well as from two shut-downed units.
- In order to be able to start the decommissioning of shut-downed units earlier, the licensee requested specific conditions for the transport.
- The residual heat was increased and the cooling time was decreased.

Spent Fuel Management
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Spent Fuel Management
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- The original conditions for C-30 transport container:

	Wet transport	Dry transport
Max. amount of assemblies	30	30
Basket type	T-12	T-12
Max. residual heat	15 kW	8 kW
Avg. burnup	40 $MWd.kgU^{-1}$	14 $MWd.kgU^{-1}$
Max. burnup	44 $MWd.kgU^{-1}$	15 $MWd.kgU^{-1}$
Max. residual heat of one assem.	630 W	-
Max. enrichment	3.6 % U235	2.5 % U235
Min. cooling time	2.5 years	2.5 years

Spent Fuel Management
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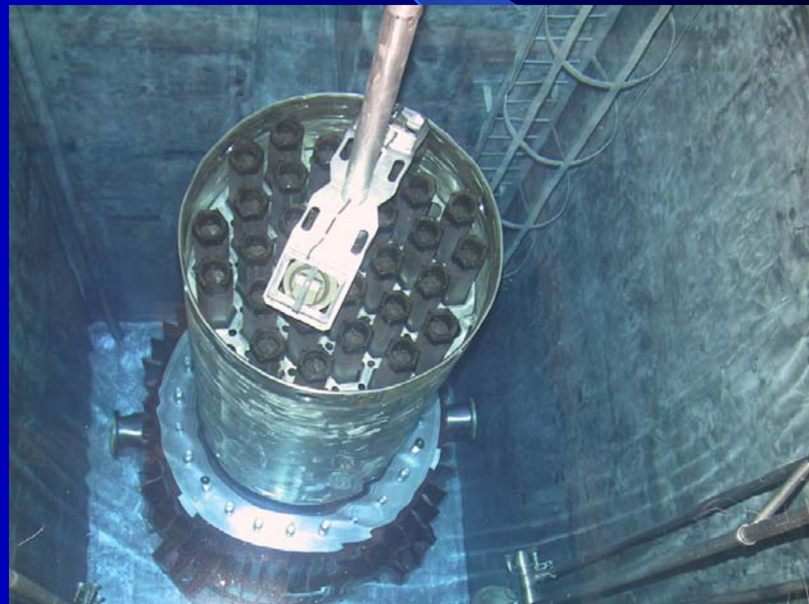

Spent Fuel Management
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- The conditions approved by the new license:

Basket type	KZ-48	T-12	T-13
Max. amount of assemblies	48	30	18
Max. residual heat	24 kW	24 kW	24 kW
Avg. burnup	50 $MWd.kgU^{-1}$	46 $MWd.kgU^{-1}$	50 $MWd.kgU^{-1}$
Max. Burnup	55 $MWd.kgU^{-1}$	50 $MWd.kgU^{-1}$	55 $MWd.kgU^{-1}$
Max. residual heat of one assem.	605 W	605 W	605 W
Max. enrichment	4.4 % U235	3.82 % U235	4.4 % U235

- Minimum cooling time depends on initial enrichment and basket type and varies from 2.8 to 3.6 years.

Spent Fuel Management
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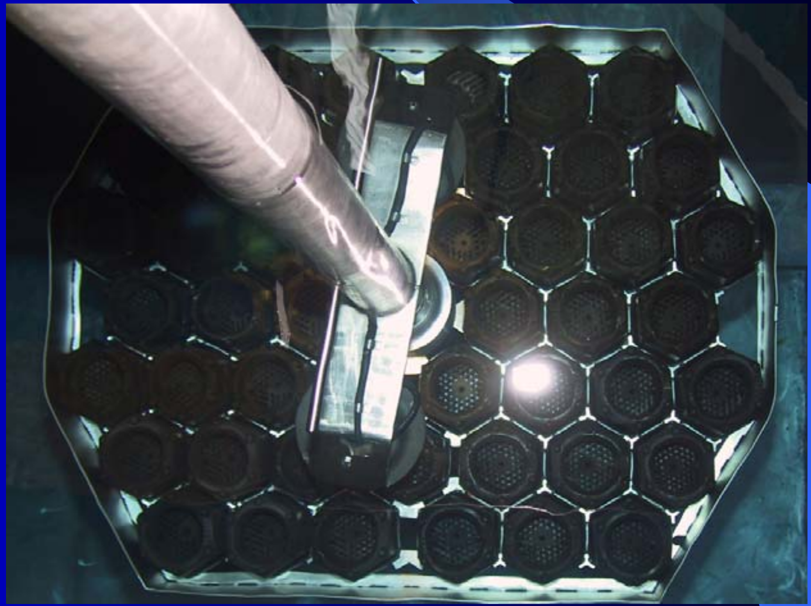

Spent Fuel Management
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- After shut down of first unit of V-1 NPP by the end of 2006 the operator, in order to shorten the transition period from operation to decommissioning, applied for a new license for transport of spent fuel form V-1 NPP to ISFSF.
- The residual heat production for one assembly was increased to 800 W, which is also limit for ISFSF.
- Also required cooling time was shortened for some assemblies.

Spent Fuel Management
continued

- The conditions approved by the new license:

Basket type	KZ-48	T-12	T-13
Max. amount of assemblies	48	30	5
Max. residual heat	22.4 kW	22.4 kW	4 kW
Avg. burnup	44 $MWd.kgU^{-1}$	44 $MWd.kgU^{-1}$	44 $MWd.kgU^{-1}$
Max. Burnup	44 $MWd.kgU^{-1}$	44 $MWd.kgU^{-1}$	44 $MWd.kgU^{-1}$
Max. residual heat of one assem.	800 W	800 W	800 W
Max. enrichment	3.82 % U235	3.82 % U235	3.82 % U235

- Minimum cooling time has been determined to 1.8 year.

Research and Development

- UJD steers various research tasks under the Research & Development program (R&D).
- The Division of Nuclear Materials has executed a task of the burnup credit (BUC) application in the criticality calculation of the VVER-440 fuel assemblies in cooperation with Nuclear Power Plants Research Institute (VUJE).
- The task was divided into two parts - first is already finished (years 2005 - 2007), second is in progress (years 2008 - 2010).

Research and Development
(continued)

- The aim was to examine possibilities of the VVER-440 spent fuel storage and transport with higher original enrichment in the existing storage and transport facilities. It consists of the analysis of the possibility to transport and store the VVER-440 spent fuel with original enrichment up to 5% U235 in the existing C-30 transport container with T-12 or KZ-48 casks and in the at-reactor spent fuel storage pools.
- Under those subtasks we have developed methodology for BUC utilization, taking into account actinides only, and we have validated the SCALE 5.0 system as a tool for VVER-440 fuel.
- The second part of the project will also include fissile products. This subtask started in 2008 and will be finished in 2010.

Research and Development
(continued)

- In order to have validated results three Slovak organizations (VUJE, JAVYS, UJD) have joined an international consortium focused on further investigation of nuclide composition of VVER-440 spent fuel within the framework of project ISTC #3958. Having these results we will continue the verification of the SCALE 5.1 and 6 systems for nuclide composition calculations. The UJD will prepare a guide on BUC application in Slovakia.
- The BUC will be necessary for the licensing of the new fuel with enrichment of 4.87% U235 in at reactor pool and in basket KZ-48.
- Last item is the preparation of the safety reports (for transport and storage) for the new fuel with average enrichment 4.87% in basket KZ-48 with burnup credit application.

Research and Development
(continued)

- Another R&D project is focused on determination of the relation between the spent fuel residual heat generation and surface temperature of the transport container C-30. The residual heat generation is calculated by a special software.
- During the transportation of the spent fuel the surface temperature of the transport container is limited.
- The results of this project will enable better anticipation of the surface temperature and residual heat release.

Research and Development
(continued)

- The project simulates real condition during the transport of spent fuel in transport container C-30 with basket KZ-48 inside.
- In each position in the basket KZ-48 we placed a dummy assembly in order to have the same volume of water inside the transport container C-30.
- Every second dummy assembly has an electrically heated coil.
- Temperature is measured inside of the transport container as well as on selected spots on surface.
- The results will be processed and a mathematical dependency between known heat and surface temperatures will be calculated.

Research and Development
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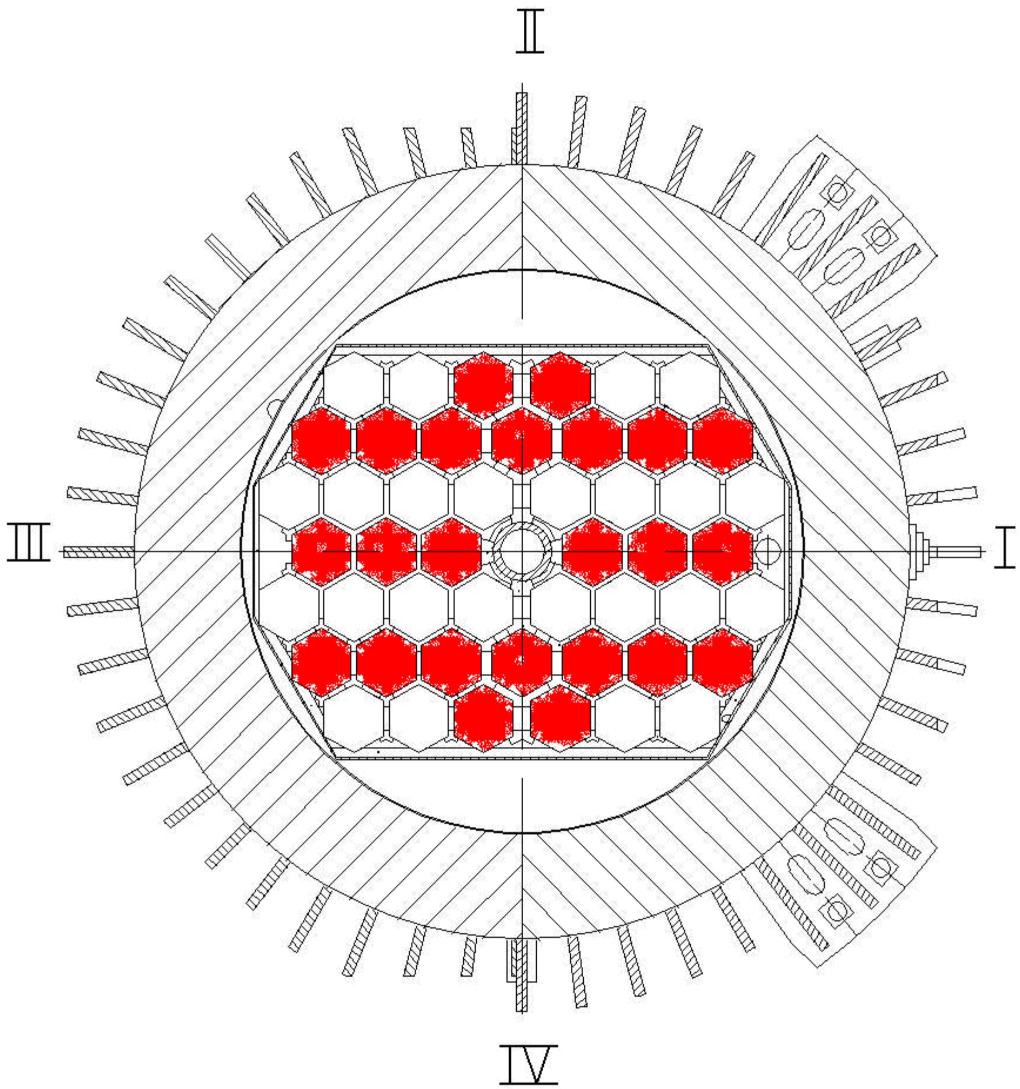
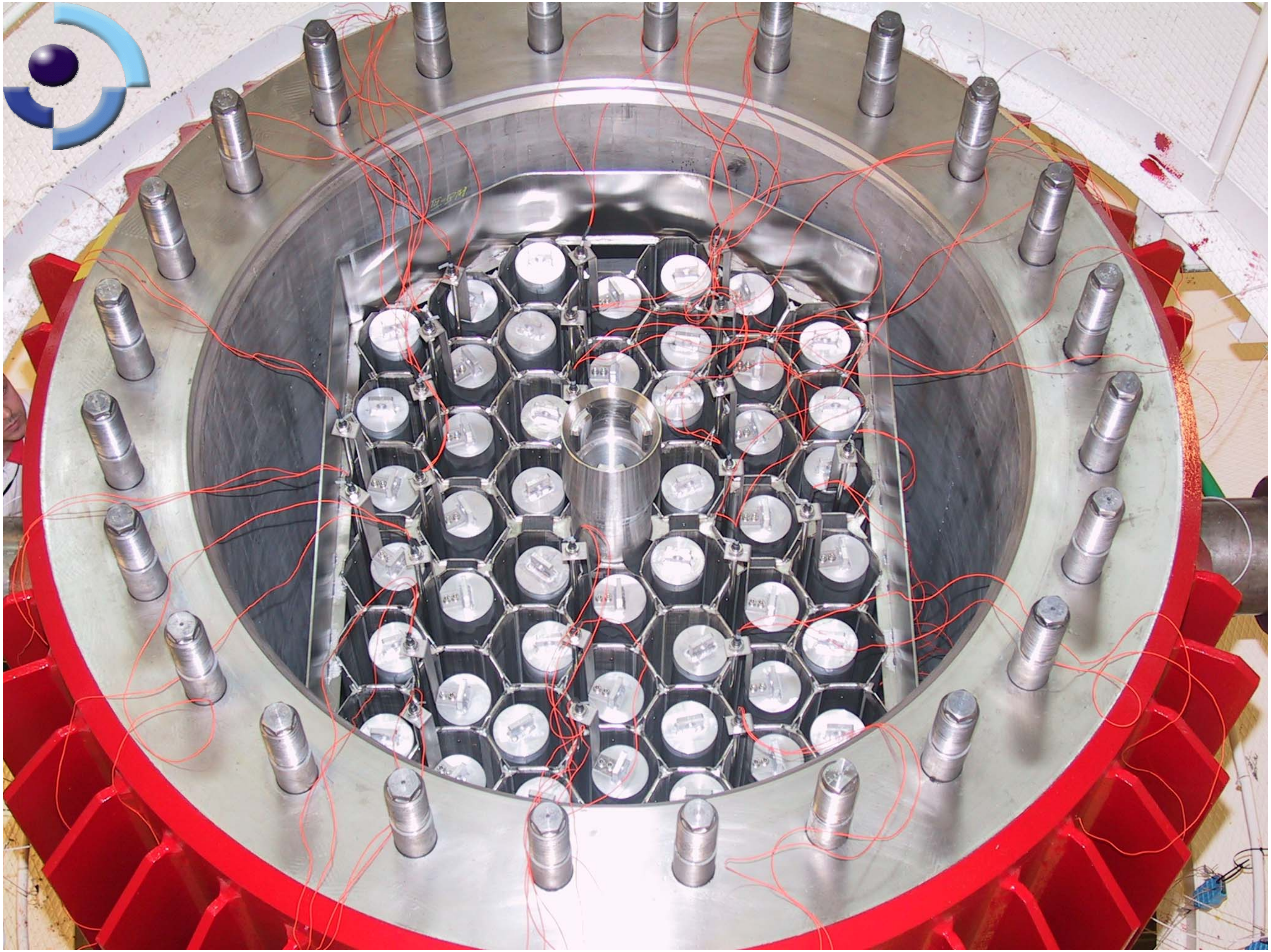
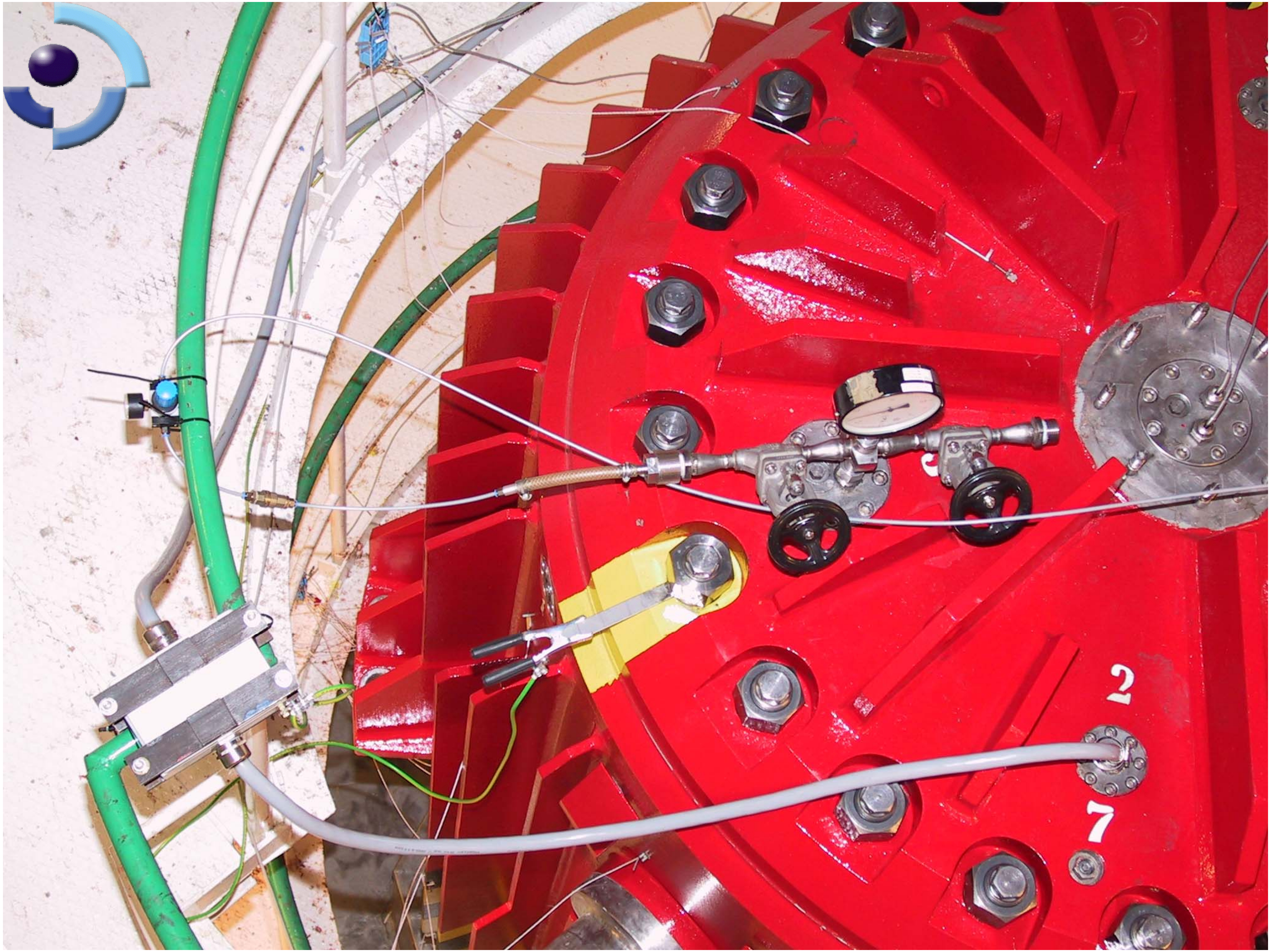
- Picture shows the conditions during the experiment (red means heated).



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Spent Fuel Monitoring

- In 2005 the operator of the ISFSF started installation of an inspection stand. The stand is intended to be used for dismantling of leaky assemblies.
- Besides, the stand will be used for various measurements and monitoring of the condition of spent fuel. The inspection stand SVYP-440 will have following modules:
  - Remote visual inspection of the selected surfaces of fuel assemblies and their components,
  - Ultrasonic inspection of the cluster fuel elements,
  - Eddy-current inspection of clad integrity of the individual fuel elements,
  - Gamma-spectrometry of the individual fuel elements,
  - Measurement of length of the fuel column in cluster of the fuel elements,

Spent Fuel Monitoring
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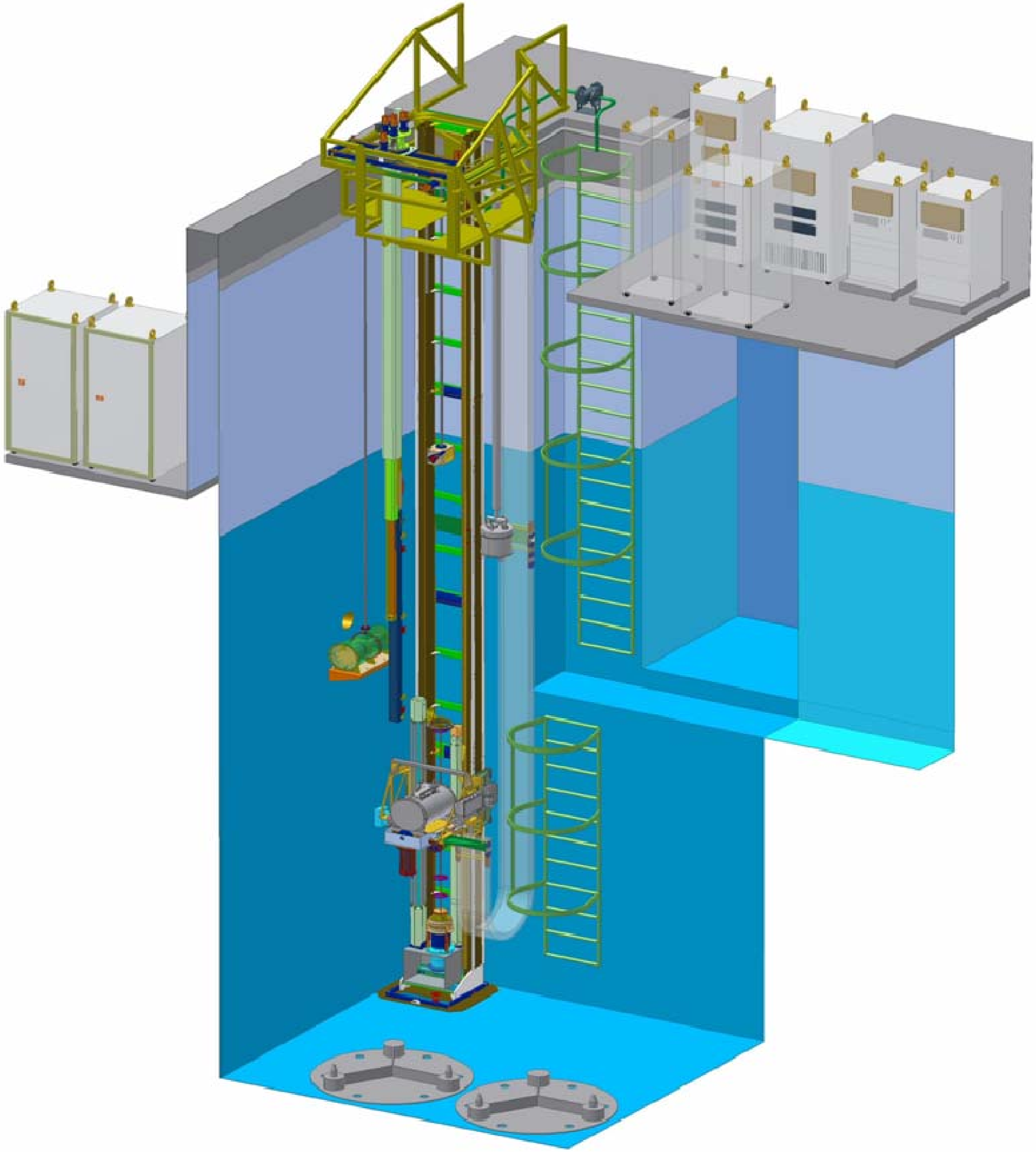
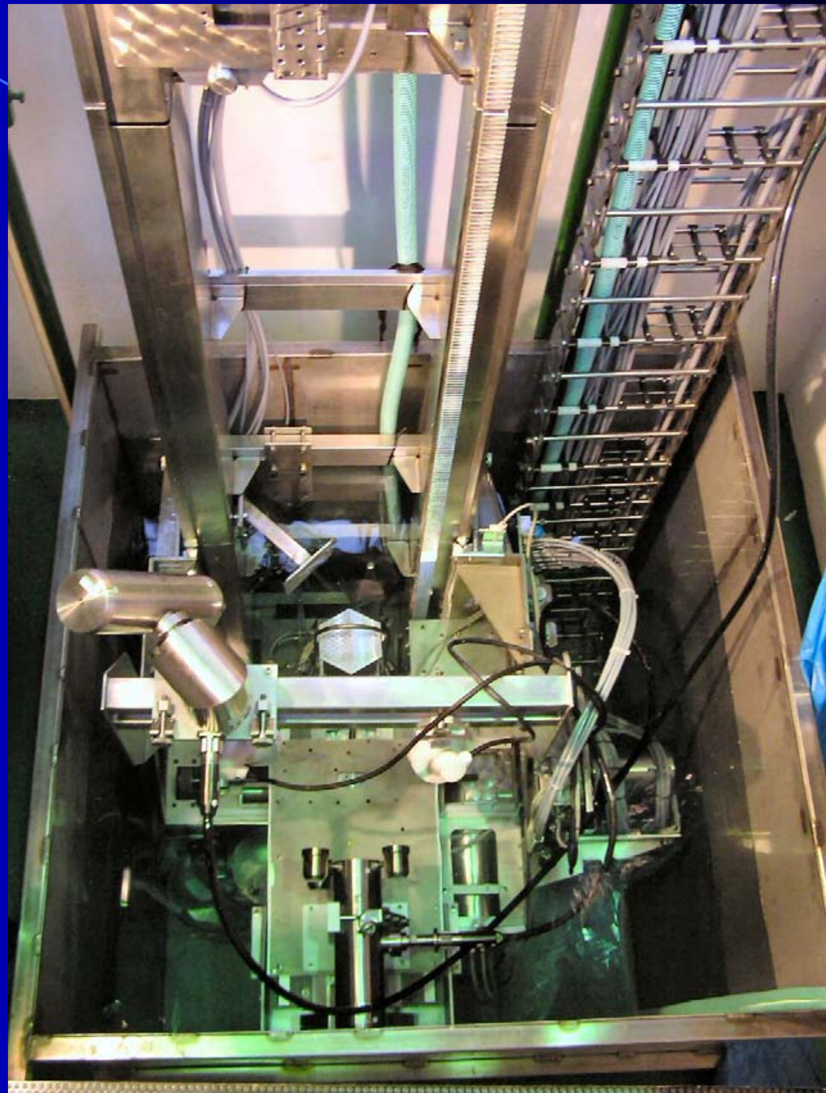
- Spectroscopy measurement of length of fuel column of the individual fuel elements,
- Optical measurement of length of the individual fuel element,
- Diameter and ovalness measurement of the individual fuel element by induction method,
- Optical measurement of deflection, torsion and length of the fuel assembly,
- Mechanical measurement of clearance between fuel and clad of the individual fuel elements,
- Eddy current measurement of oxide depositions on clad of the individual fuel elements,
- Oxide deposition sample intake from clad of the individual fuel elements and their consequent analysis,
- Pressure measurement of the fission products inside the individual fuel elements.





Conclusion

- New requirements on spent fuel management (higher enrichment, higher burnup, residual heat generation, shorter cooling time, new licenses, and others) have required a new approach from UJD.
- UJD have started several projects, which results will be used for a better understanding of spent fuel behavior during its storage, transportation and deposition.