THE ROLE OF REGULATORY AUTHORITY IN SAFE OPERATION OF RESEARCH REACTOR

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Andrzej T. MIKULSKI
National Atomic Energy Agency
ul. Krucza 36, 00-522 Warszawa (Poland)

Contents:

Introduction

Regulatory authorities in industry (not new)

Two Independent organizations for:

- promoting nuclear energy
- safety and radiological protection

Role of regulatory authority

Transposition of international documents (e.g. Code of Conduct, Safety Guides and other regulations to everyday practice

Atomic Energy Law in Poland

(new version in force since January 1, 2002 and modified in 2006)

defines:

- structure of National Atomic Energy Agency (NAEA)
- duties and responsibility of the president of NAEA
- relation to other governmental bodies
- act as a basis for several governmental decrees and regulations
- provides regulatory infrastructure
- defines licensing procedures for nuclear installations

Regulatory practice (in reference to research reactor)

<u>Regular activities</u>

(1) review of quarterly reports of reactor operation

(2) perform regular inspection

(3) granting permission for

- change of reactor configuration
- granting permission for any experiments
- granting permission for non typical irradiation

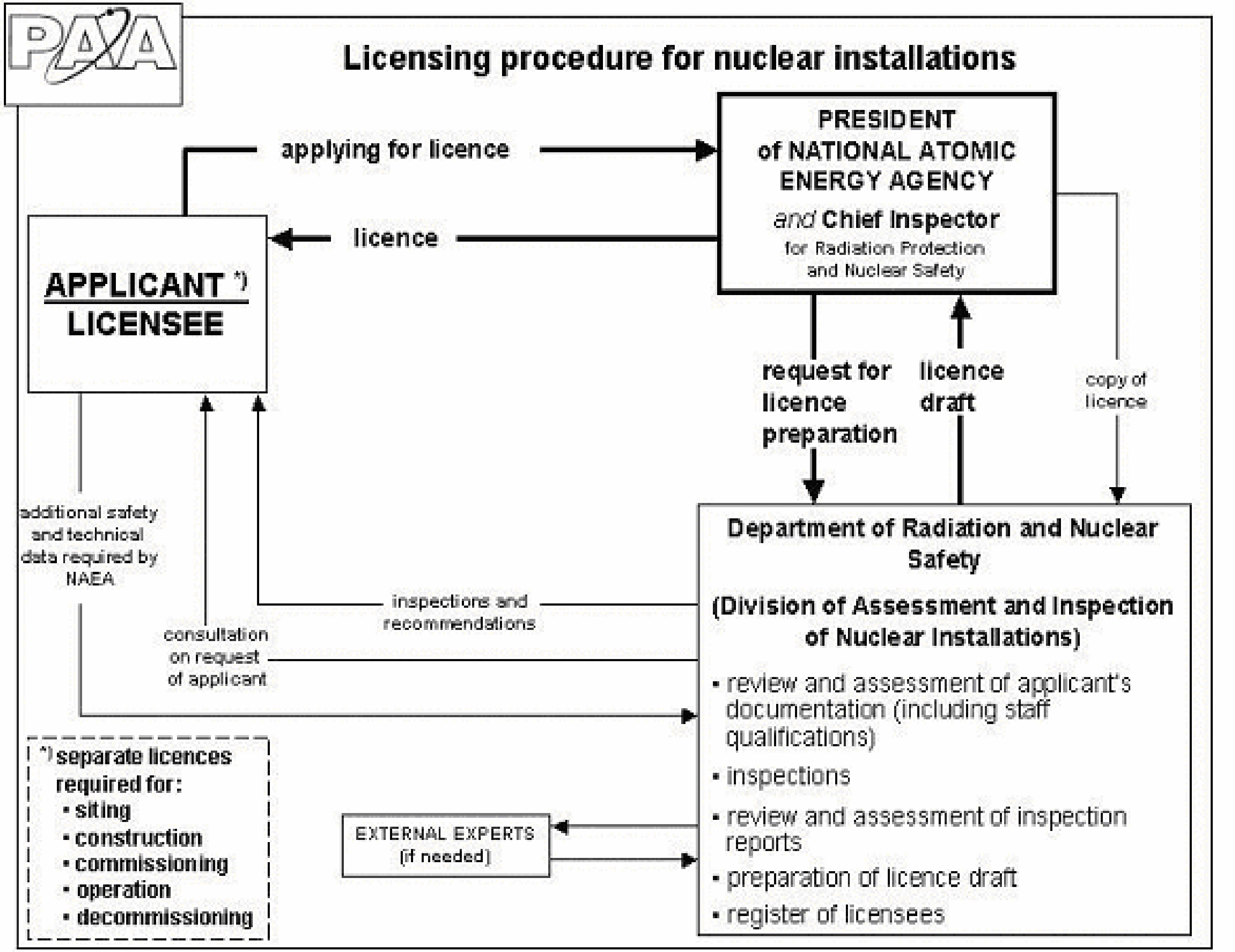
<u>Other actions</u>

(1) granting licence for reactor operation (5 years)

(2) permission for conversion from 80% to 36% enriched fuel

(3) non typical irradiation

(4) refurbishment of equipment



Inspection procedure for nuclear installations and radiation applications

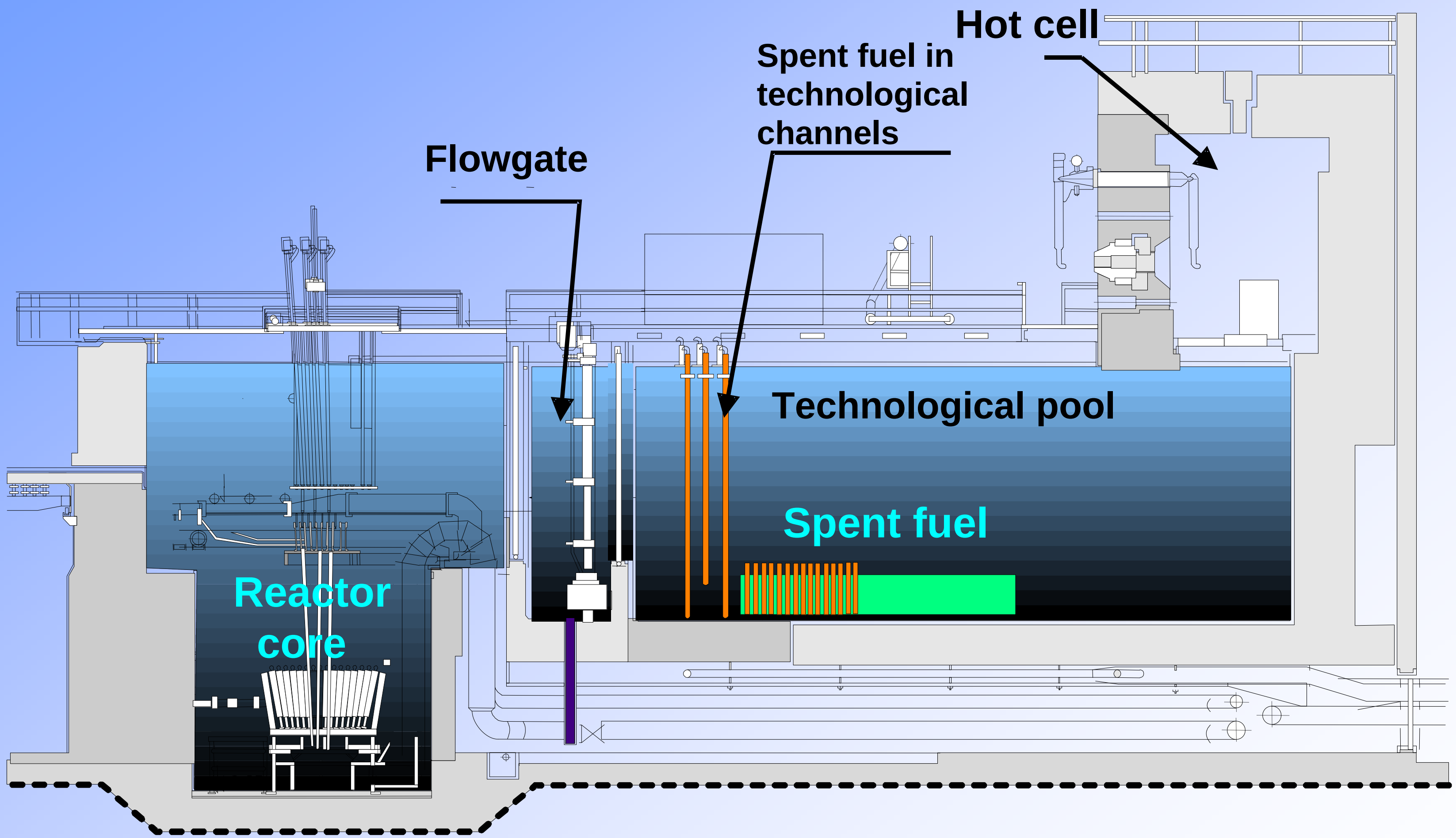
General view of MARIA reactor

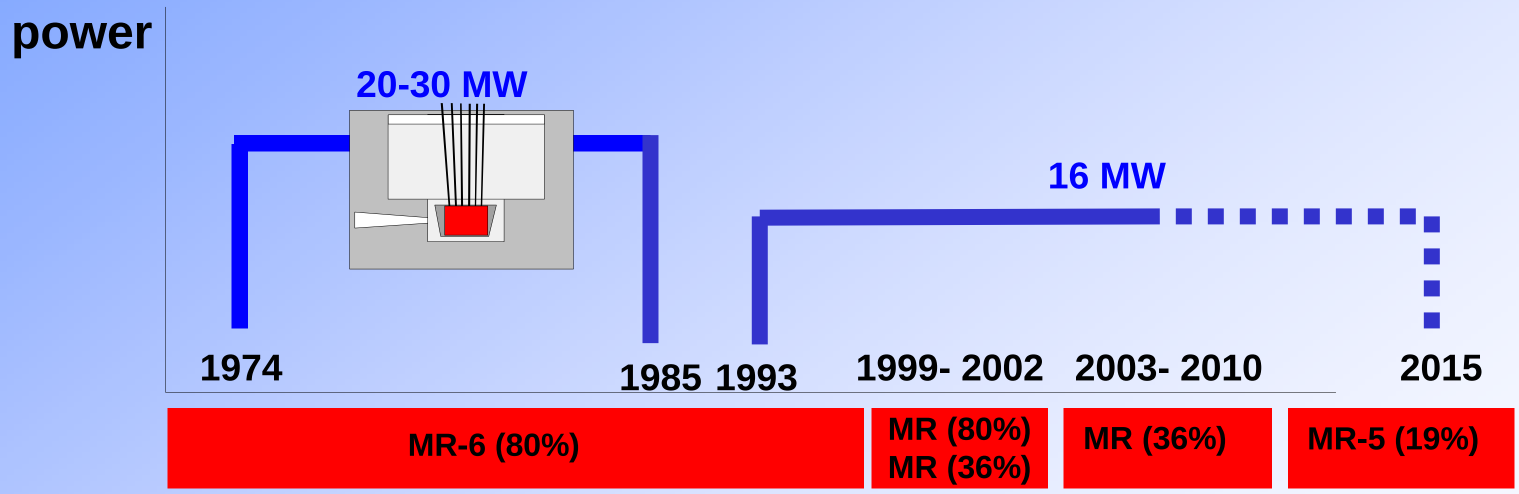
Control room of MARIA reactor

Andrzej T. MIKULSKI
Conference on Research Reactors, Sydney, November 2007

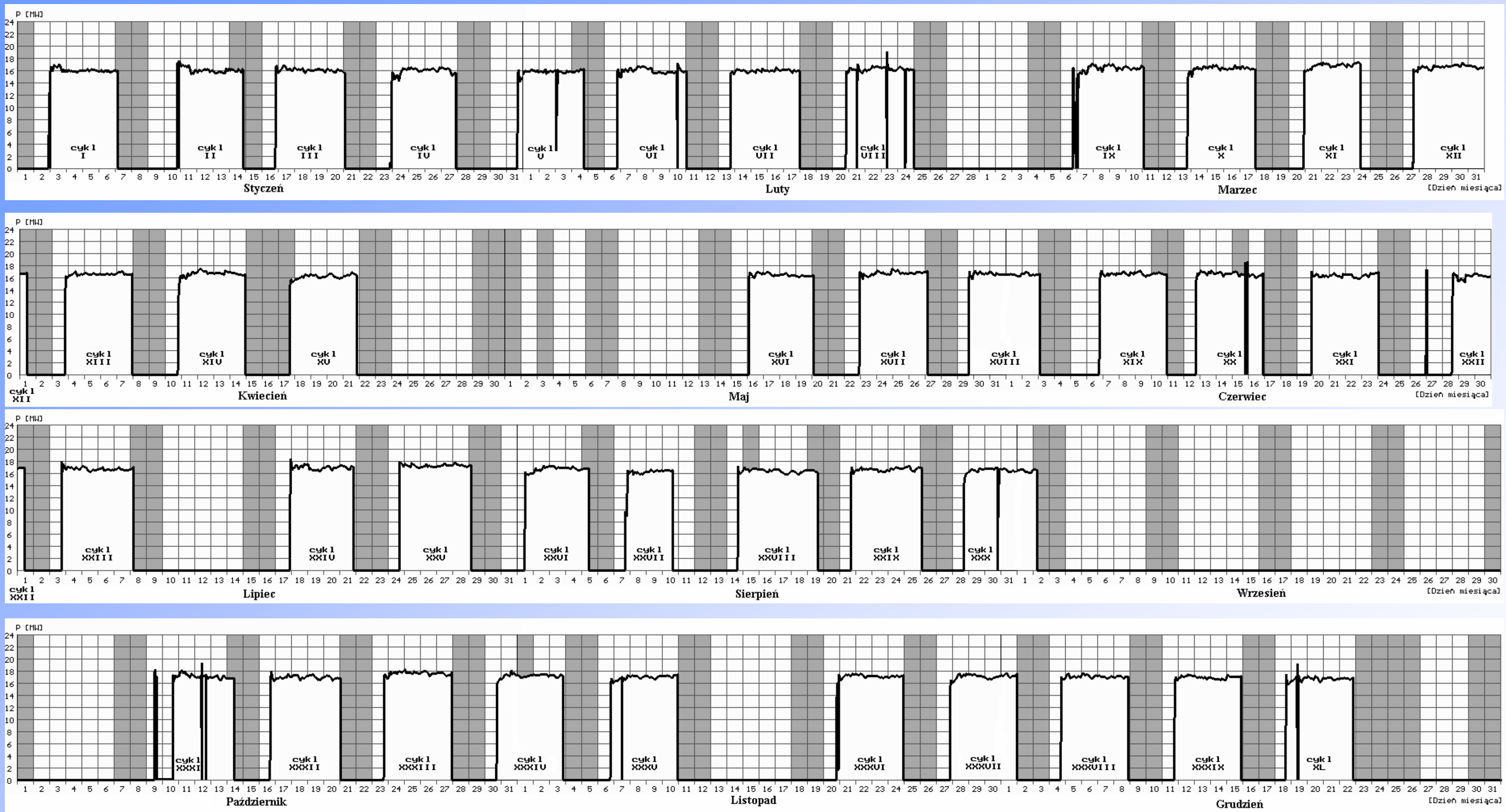
National Atomic Energy Agency
ul. Krucza 36, 00-522 Warszawa (Poland)

VERTICAL CROSS SECTION OF MARIA REACTOR



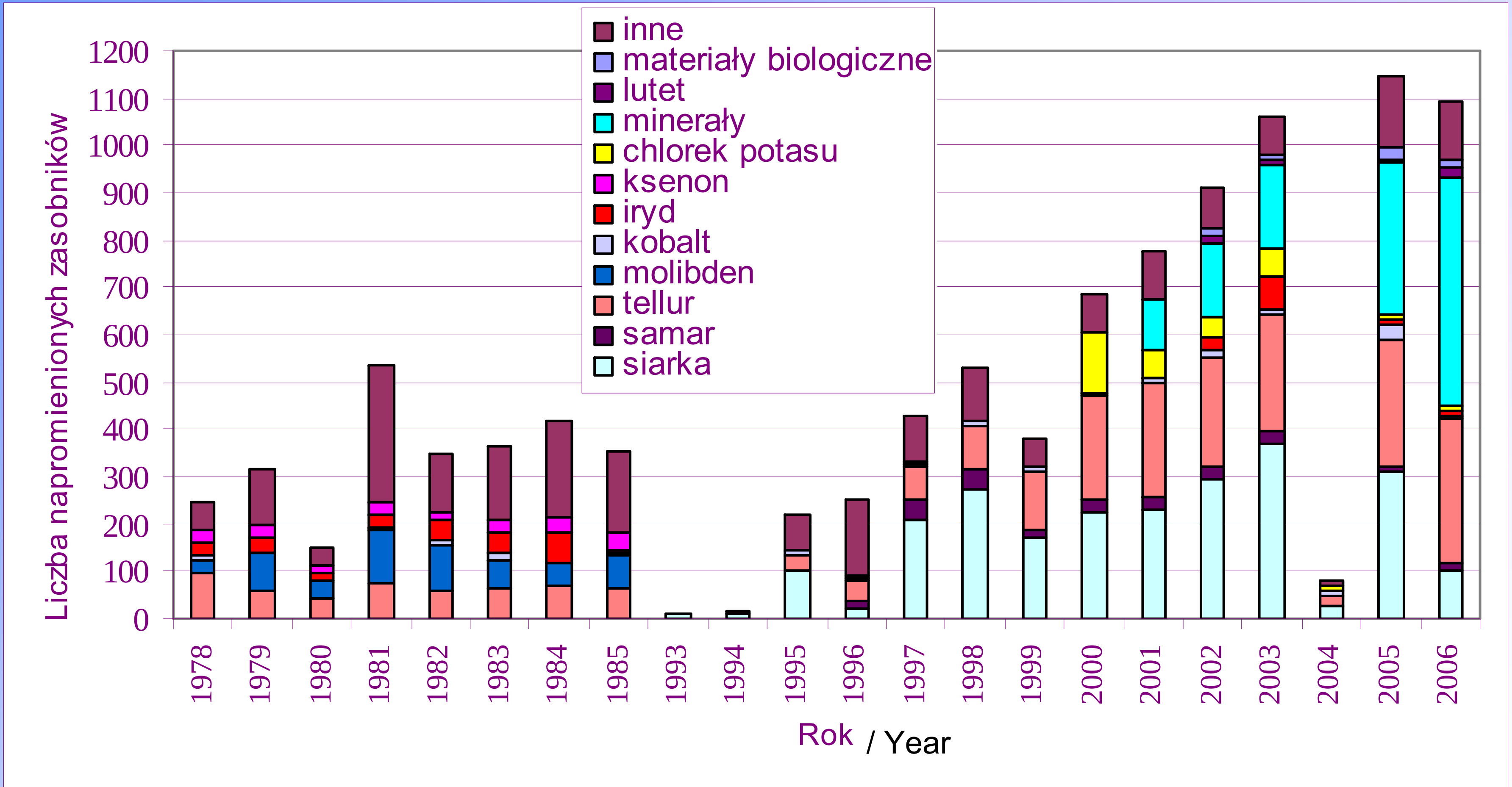


History (1974 - 2007) and perspective of the MARIA reactor operation



October November December

The schedule of the reactor MARIA operation in 2006 year



inne
materiały biologiczne
lutet
minerały
chlorek potasu
ksenon
iryd
kobalt
molibden
tellur
samar
siarka
Liczba napromienionych zasobników
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1100
1000
900
800
700
600
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400
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200
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1978
1979
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1981
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2004
2005
2006
Rok / Year

General information about operation of the MARIA reactor in for 2006

	quarter of year	I	II	III	IV	Total
Number operation cycles		12	10	8	10	40
Time of work at nominal power [hours]		1201	995	808	1002	4006
Mean thermal power [MW(th)]		16.3	16.7	15.6	17.2	16.5
Total produced thermal power [MWh(th)]		19 599	16 608	12 630	17 256	66 093
No of fuel elements in core		22	23	23	23	---
No of unplanned automatic scrams		6	5	3	5	19
Causes of scrams	equipment failure	5	3	0	2	10
	loss of external power	0	2	1	1	4
	operator's error	1	0	0	1	2
	fault in equipment operation	0	0	0	0	0
	water activity in secondary loop	0	0	1	0	2
	crossing of operational limits	0	0	1	1	2
	unknown	0	0	1	0	1
Consequences	restart of reactor	5	5	1	5	16
	shortening of operation cycle	1	0	2	0	3
No of discovered equipment unit failures		5	1	3	0	9
No of repairs and maintenance works		10	17	25	15	67
No of tests and overhauls		8	29	42	7	86

Information required by regulatory authority

concerning operation of the MARIA reactor

1. Quarterly reports (important in the past)

2. Data after end of an operational cycle (more actual information required):

- vibration of fuel channel cooling system equipment (pumps and engines)
  System VMS (Vibration Monitoring System)
  (regular data transfer since 2001)
- measured technological parameters
  (flow and temperature in fuel channels etc.)
  System GTREMA (old) and SAREMA (new)
  (regular data transfer since 2003)

Typical contents of a quarterly report (example of 2nd quarter 2007)

1. Introduction
2. Reactor operation
3. Core configuration
4. Irradiation of isotopes
5. Unplanned scrams
6. Service of technological systems
   - 6.1. Maintenance works
   - 6.2. Testing, inspections and overhauls
   - 6.3. Other technical activity (e.g. connecting of SAREMA system)
7. Measurements and research
   - 7.1. Usage of horizontal channels
   - 7.2. Chemical analysis
   - 7.3. Vibration diagnostic
8. Status and training of operating personnel
9. Dosimetric status
   - 9.1. Dosimetric service
   - 9.2. Radiological protection of personnel
   - 9.3. Emission to environment
   - 9.4. Low active and solid state waste
   - 9.5. Technical state of dosimetric equipment
10. Conclusions

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Performance indicators for the MARIA reactor

Year	Work	Availability factors		No of unscheduled	No of	Collective dose
	time [h]	total	per year	shutdowns	employees	[man-Sv]
2000	3748	99.0	43.0	5	52	0.085
2001	3580	98.0	40.0	10	56	0.094
2002	3814	99.5	44.5	6	58	0.170
2003	4010	96.0	46.0	11	57	0.190
2004	300	100.0	3.4	1	58	0.226
2005	3830	99.0	43.7	15	58	0.124
2006	4006	99.1	45.7	19	58	0.100

Remarks: - increase of collective dose in years 2002-204 was due to fuel cladding
- number of unscheduled shutdowns in 2006 was rather high but most of them was due to equipment failure (some relays was in operation since 1974 and they were replaced

Inspections

- regular inspections (normally one or two per year)
- special inspections in order to clarify information presented in quarterly reports

Typical inspection for:

1) procedure of fuel conversion,
2) fulfilment of requirements in irradiation process,
3) evaluation of documentation concerning design of new equipment
4) evaluation of operational documentation (keeping log books),
5) radiological protection (dosimetric system) and requirement for its upgrading,
6) operation of computer systems GTREMA and VMS

List of inspection in the MARIA reactor in last 4 years

Date	Number	Type	Scope of inspection
22.04.2004	1/2004	special	inspection of fuel encapsulation
08.11.2004	2/2004	regular	inspection of operational documentation
09.12.2004	3/2004	regular	inspection of dosimetric department
02-07.02.2005	1/2005	special	loading of new fuel elements
21.04.2005	2/2005	regular	inspection of operating departments
11.07.2005	3/2005	regular	inspection of operating documentation
22.09.2005	4/2005	regular	review of physical protection
11.05.2006	1/2006	regular	review of 1st quarter operation
29.08.2006	2/2006	special	inspection of technical modifications
22.11.2006	3/2006	regular	review of 2nd quarter report
04.04.2007	1/2007	regular	inspection of operational documentation
29.05.2007	2/2007	regular	inspection of dosimetric department

Examples of regulatory authority activity

(based on transferred parameters by GTREMA)

Verification of limits specified in operational licence:

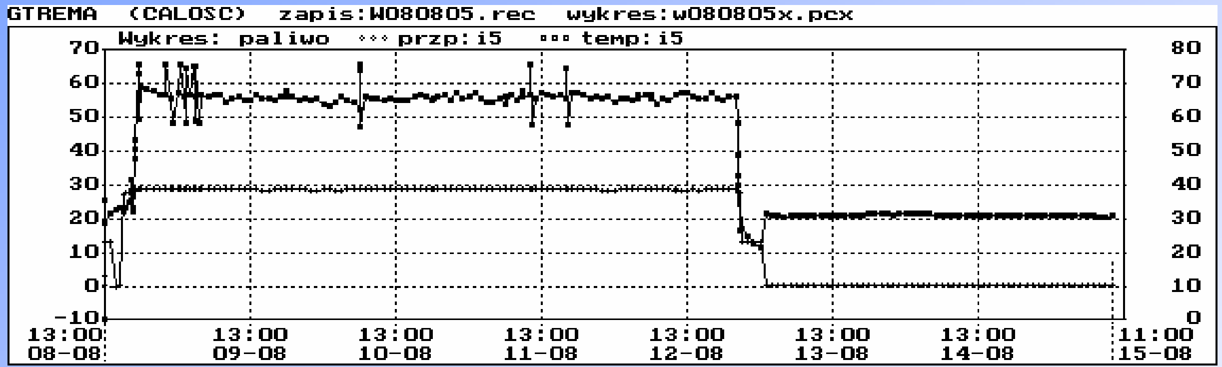
1) minimal coolant flow through fuel channels,
2) maximal outlet temperature from fuel channels,
3) thermal power generated in an individual fuel channel,
4) estimated power generated at a position of the most effective control rod.
5) minimal pressure drop over reactor core (this parameter is responsible for cooling of control rods and inadequate cooling in the past caused serious problems)

Examples of regulatory authority activity

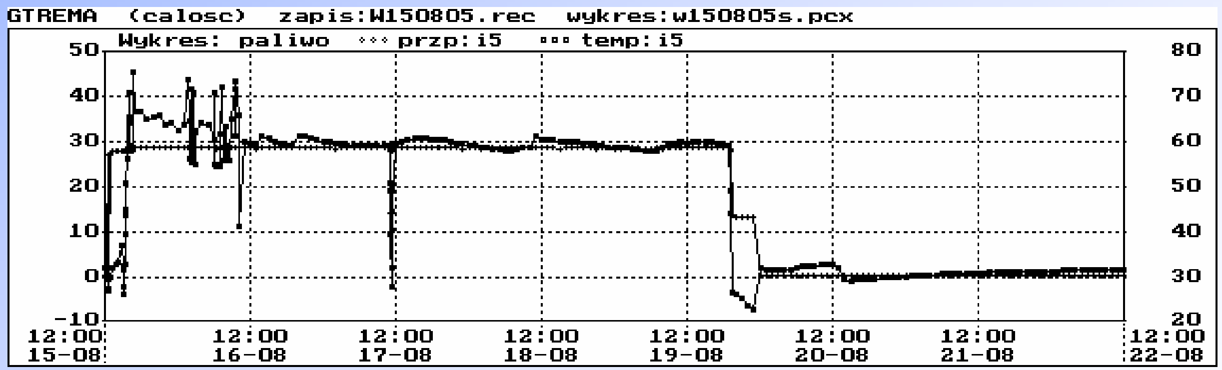
(based on transferred parameters by GTREMA system)

(a) disturbances in fuel channel outlet temperature due equipment failure

(corrected at the beginning of next operational cycle)



Disturbances in outlet temperature from channel i-5(cycle XXII starting August 8, 2005)



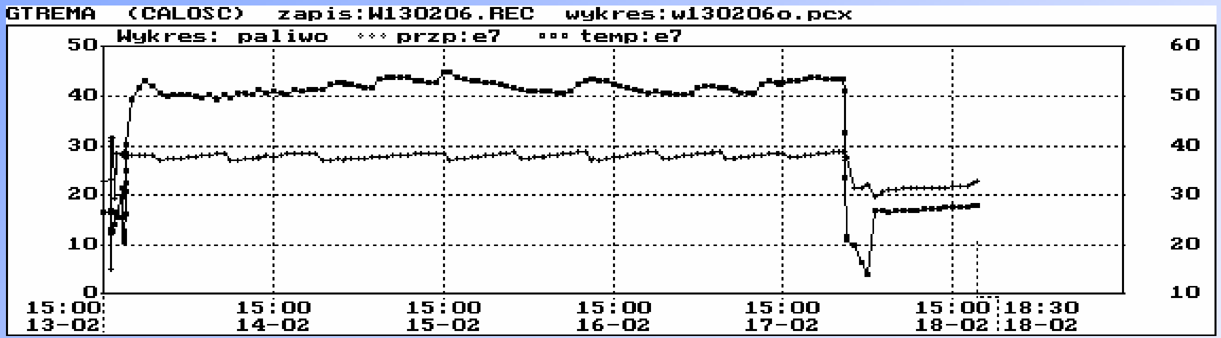
Disturbances in outlet temperature from channel i-5 (cycle XXIII starting August 15, 2005)

Examples of regulatory authority activity

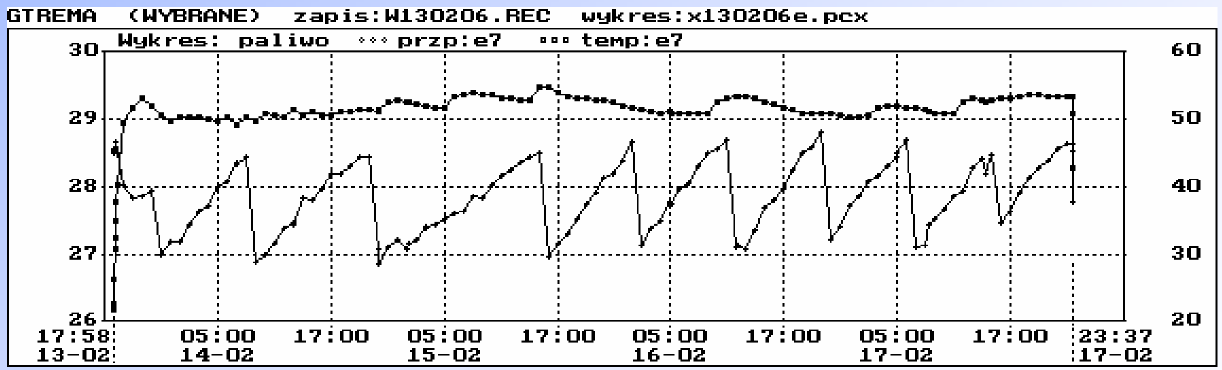
(based on transferred parameters by GTREMA system)

(b) unexpected shape of coolant flow in fuel channel e-7

(after slow increase of flow from 27.0 m^3/h equal about 1.5 m^3/h during 6 hours sharp decreases were observed some times correlated with outlet temperature, the cause was not explained because it disappeared for the next fuel cycle)



Disturbances in outlet temperature from channel e-7 (cycle VII starting August 15, 2005)



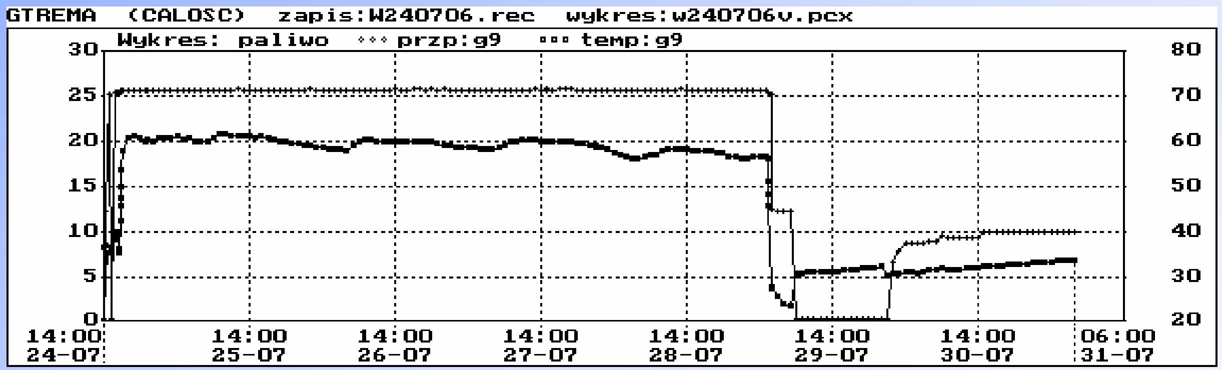
Disturbances in outlet temperature from channel e-7 (detailed presentation) (cycle VII starting August 15, 2005)

Examples of regulatory authority activity

(based on transferred parameters by GTREMA system)

(c) increase of coolant flow to about 10 m^3/h (i.e. 40% of nominal flow in this channel) about 10 hours after switching off pumps and remains constant until end of recording

(operating staff of reactor declares that it is a fictitious flow because pumps are not operating, but this situation must be explained)



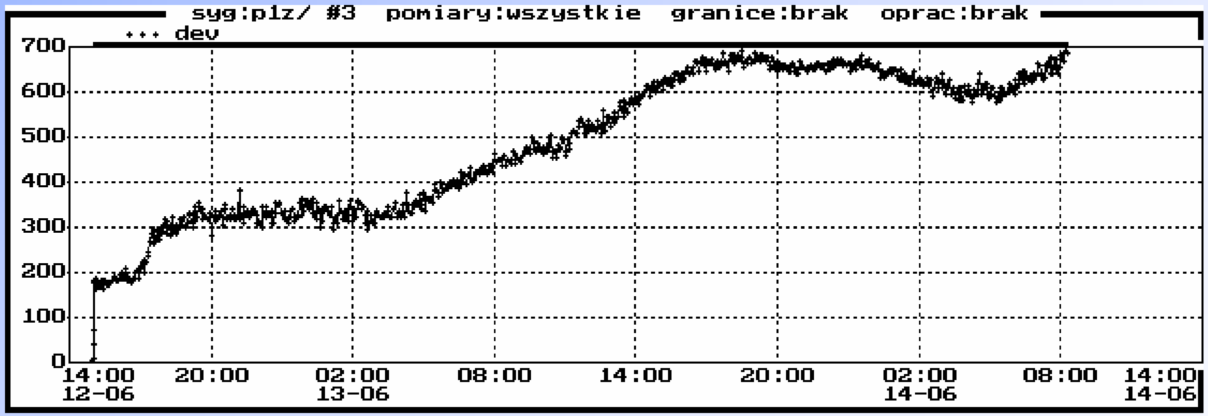
Disturbances in coolant flow rate in g-9 when pumps were not operating (cycle XXV starting July 24, 2006)

Examples of regulatory authority activity

(based on transferred parameters by VMS system)

(a) technical condition of a set pump-engine bearing may be described by analysis of RMS value of acceleration signal

(This is an example when RMS value increased about 3 times in 27 hours after beginning of operational cycle and remained stable for the next 12 hours but in the morning of next day an operator decided to switch-off this pump probably avoiding a more severe damage of a bearing in case a pump would operate a full cycle.)



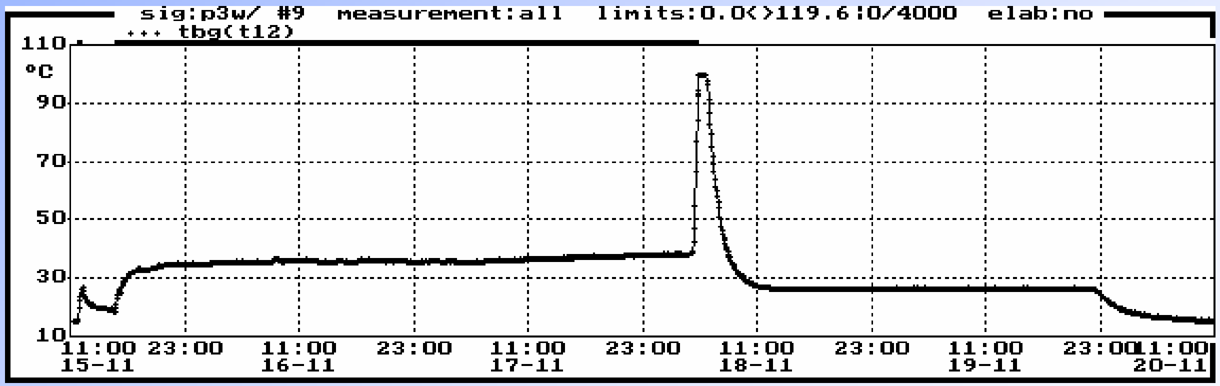
The RMS value of acceleration signal for pump no 1 (cycle XXVII starting June 12, 2000

Examples of regulatory authority activity

(based on transferred parameters by VMS system)

(b) technical condition of a set pump-engine bearing may be also described by temperature of bearing

The bearing temperature increased suddenly very sharply after 56 hours from the beginning of fuel cycle and warning signal by conventional limiting device was generated. But using this diagnostic system a warning signal based on calculation a temperature linear trend of the temperature would be issued at least 12 minutes earlier.



The bearing temperature for pump no 3 (cycle XXIV staring November 15, 1999)

Past and present developments

- transformation from HEU to LEU fuel - first step from 80 to 36% (1999÷2003)
- installation of a special fuel assembly with thermocouples
- installation of new pressure transducers for measurement of flow in fuel channels (2001).
- new neutron flux measuring system for reactor control and safety systems (2002).
- modernization of dosimetric system (2002-2006),
- heat exchangers between primary and secondary cooling system (2006)

Future developments

- transformation to LEU fuel - second step to 20% (started in year 2008)
- new locations in a reactor core for isotope irradiation in higher neutron flux,
- improving of cooling conditions for a natural convection during a decay heat removal from fuel elements, etc.
- revising of written operational procedures,
- reviewing on new version of Safety Analysis Report,
- development of research reactor safety parameter indicators (partially based on similar indicators for nuclear power plants).
- replacement of old graphite and beryllium blocks

Conclusions

- activity of regulatory authority in the field of safety can be never stopped
- knowledge should be always accumulated and passed from one to another generation of inspectors (in Poland such experience was transferred from EWA to MARIA reactor)
- regulatory authority should play active a role in suggesting changes and improvements in safety of a research reactor
- regulatory authority has influence (and also some funds) for improvements in nuclear and radiological safety (as it is in Poland)

THANK YOU FOR YOUR ATTENTION !