On the cleaning system incident at the Paks NPP

Presented

by

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#2 Presentation from mid-2003

Release (1)

Contents

- ⌘Event sequence (early phase)
- ⌘Layout of the device
- ⌘Releases
- ⌘Event sequence (later phase)
- ⌘Measured I-131 activities
- ⌘A possible explanation
- ⌘Next steps
- ⌘Report by the NPP
- ⌘HAEA investigation

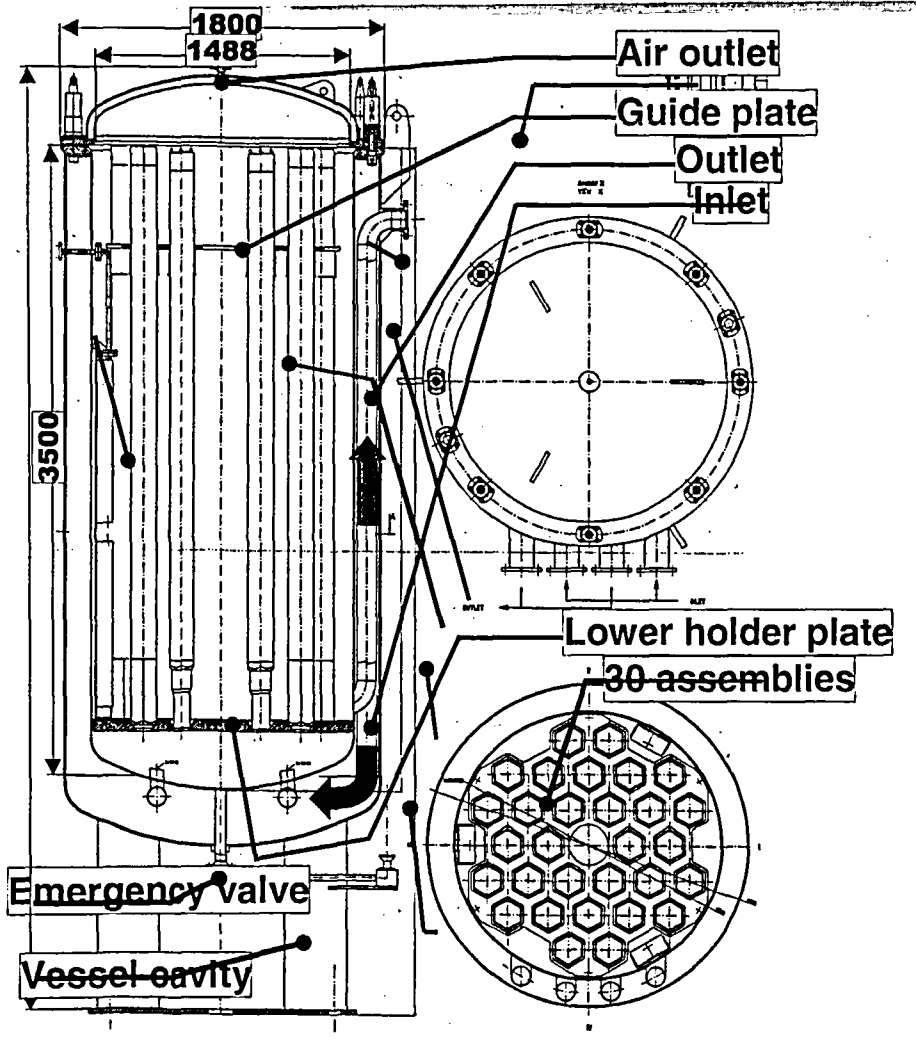
Event sequence (early phase)

- Crud deposition on fuel assemblies in three units due to earlier decontamination procedures
- 15.03. - installation of fuel assembly cleaning device (Framatom ANP)
- Cleaning of two loads (30 assemblies each)
- 29.03. - shutdown of unit 2
- Cleaning of three loads from unit 2
- 09.04 - start of cleaning the fourth load from unit 2
- 10.04. 16:30 - end of cleaning
- Opening of cleaning tank postponed for other activities on the critical path

Event sequence (early phase)

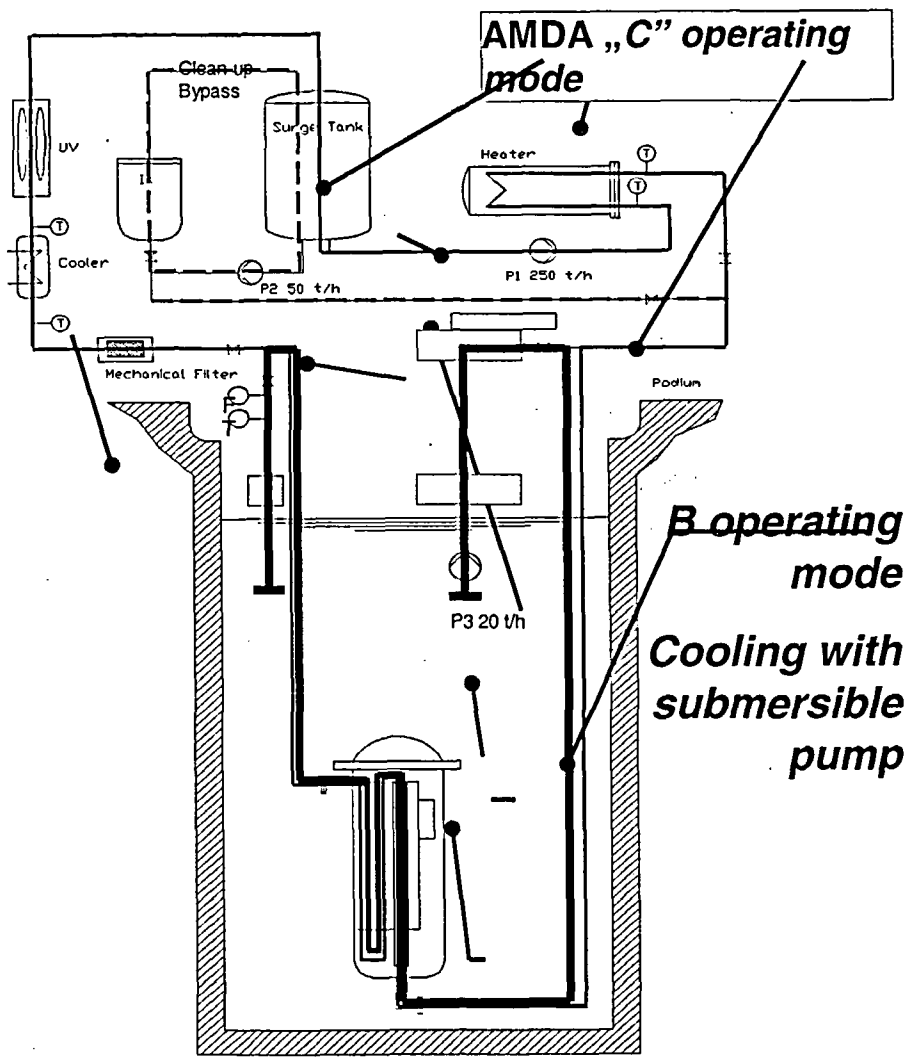
- 10.04. 22:00 - increase of Kr-85 dose rate detected
- 11.04. 02.15 - Lid lock opened, bubble outburst
- 11.04. 04:20 - unsuccessful attempt to open the vessel-lid (rope rupture), vessel semi-open
- Elevated release of noble gases and iodine through the NPP stack
- Elevated, but <500 nSv/h dose rate at one of the 9 near-station monitors for a short period (background value: ~ 100 nSv/h)
- No other off-site effect detected
- Classified to INES level 2
- Extensive field exploration and monitoring initiated

Structure of the tank

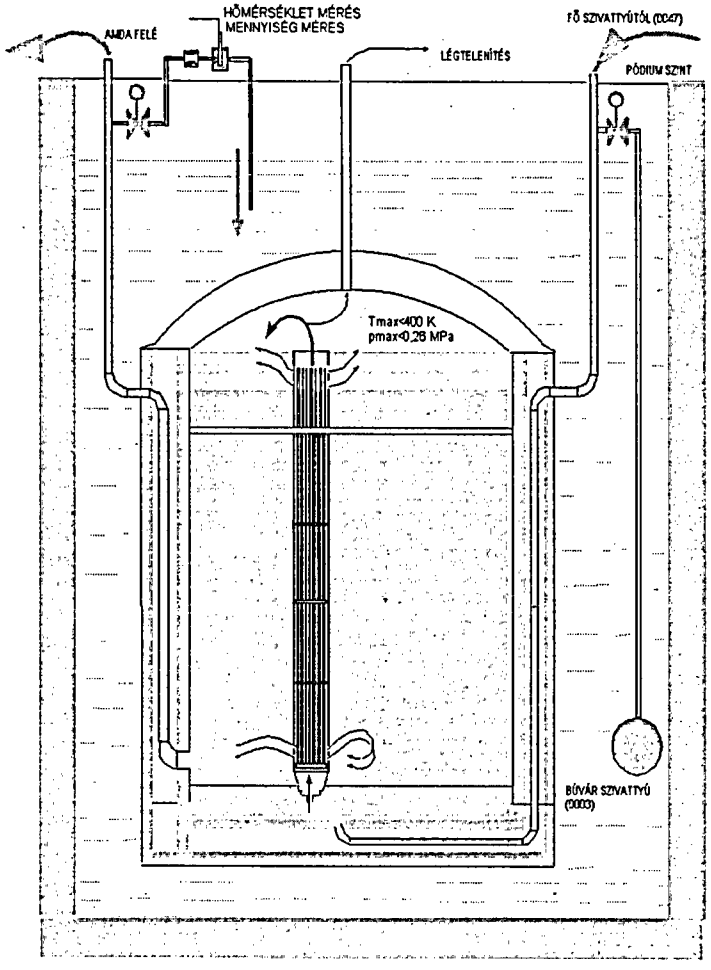


3rd figure

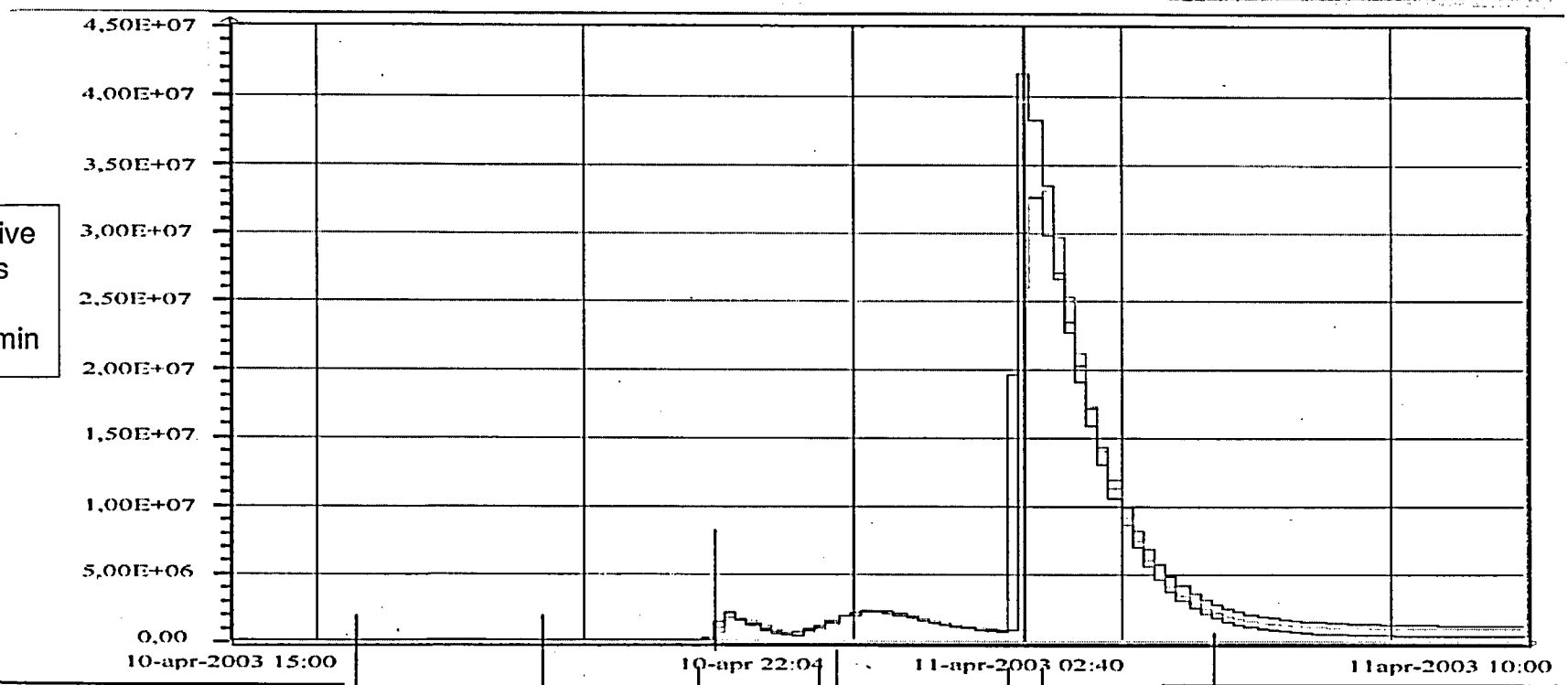
Functional layout of the system



Layout of the B operating mode



Events during the incident



End of cleaning 16:00

Start of submersible pump 16:40

Discharge wash.c. 16:56

Elevated water-level of spent fuel pool 19:20

KR-85 activity increased in cleaning system 21:50

Cover lifting unsuccesful

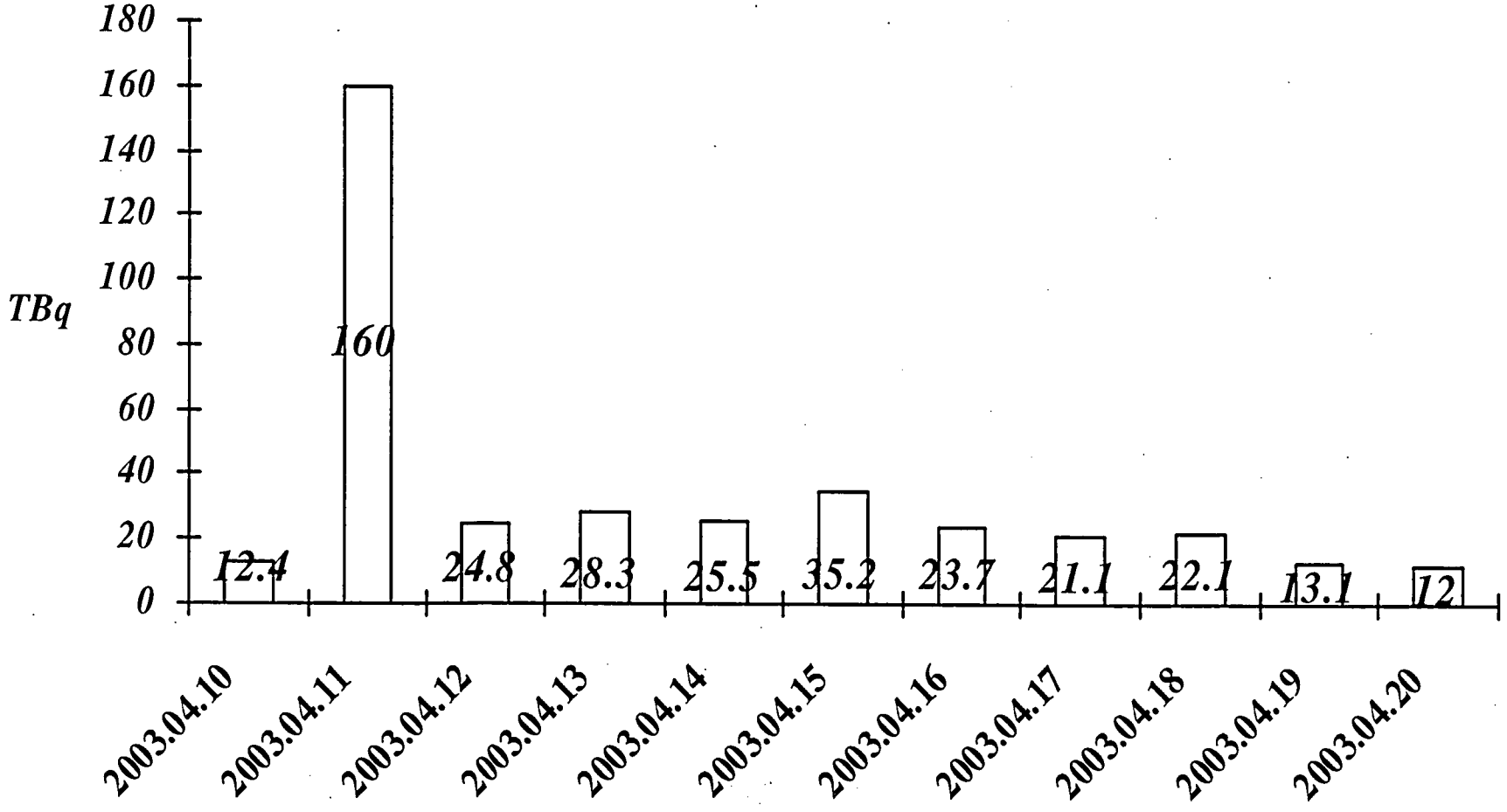
Surroundings of spent f. p. 12 mSv/h 02:45

The lock is opened, big bubble outbursts 02:15

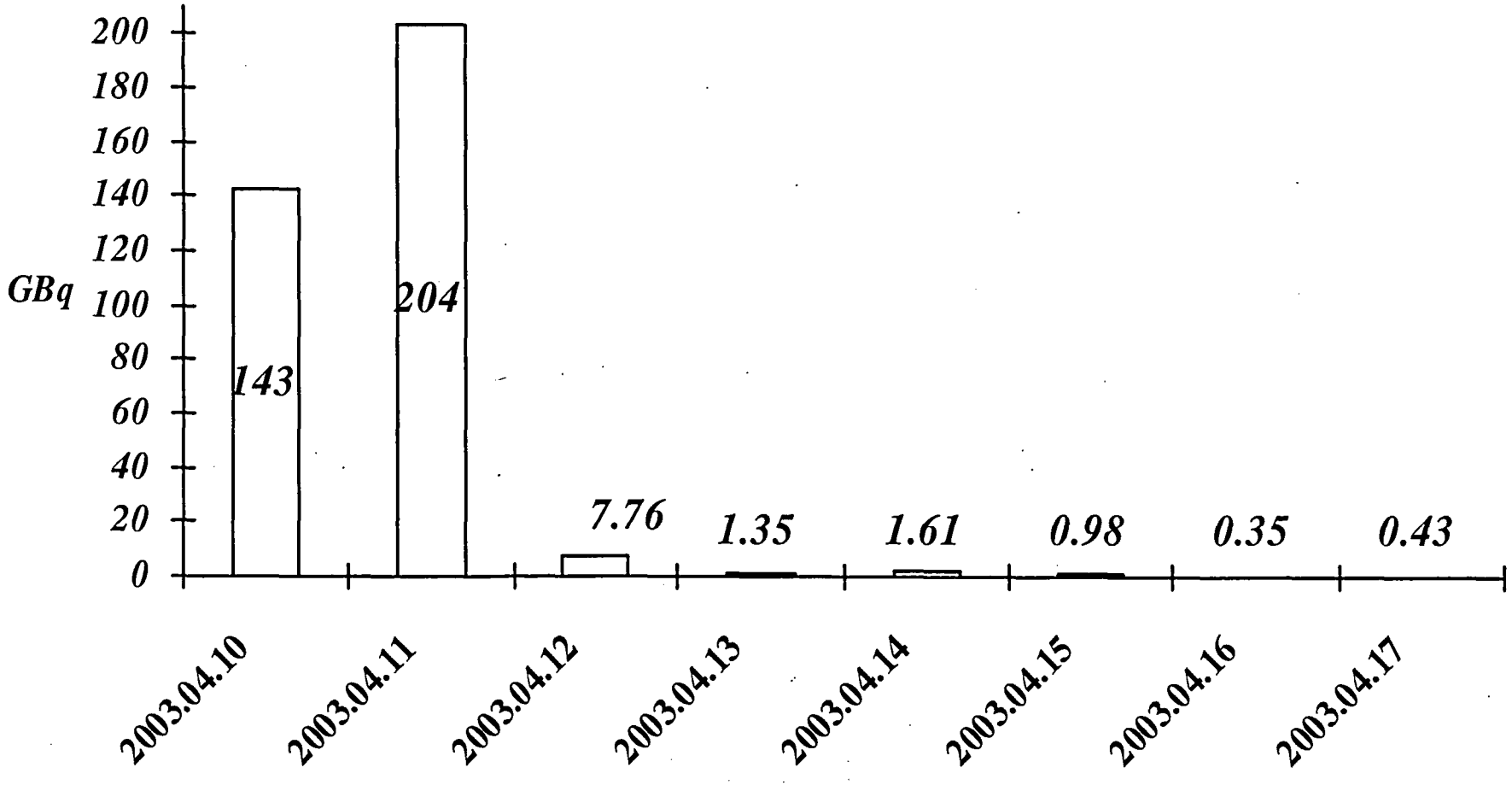
Venting fans started 23:45

DE ordered the leaving of rect. hall 23:30

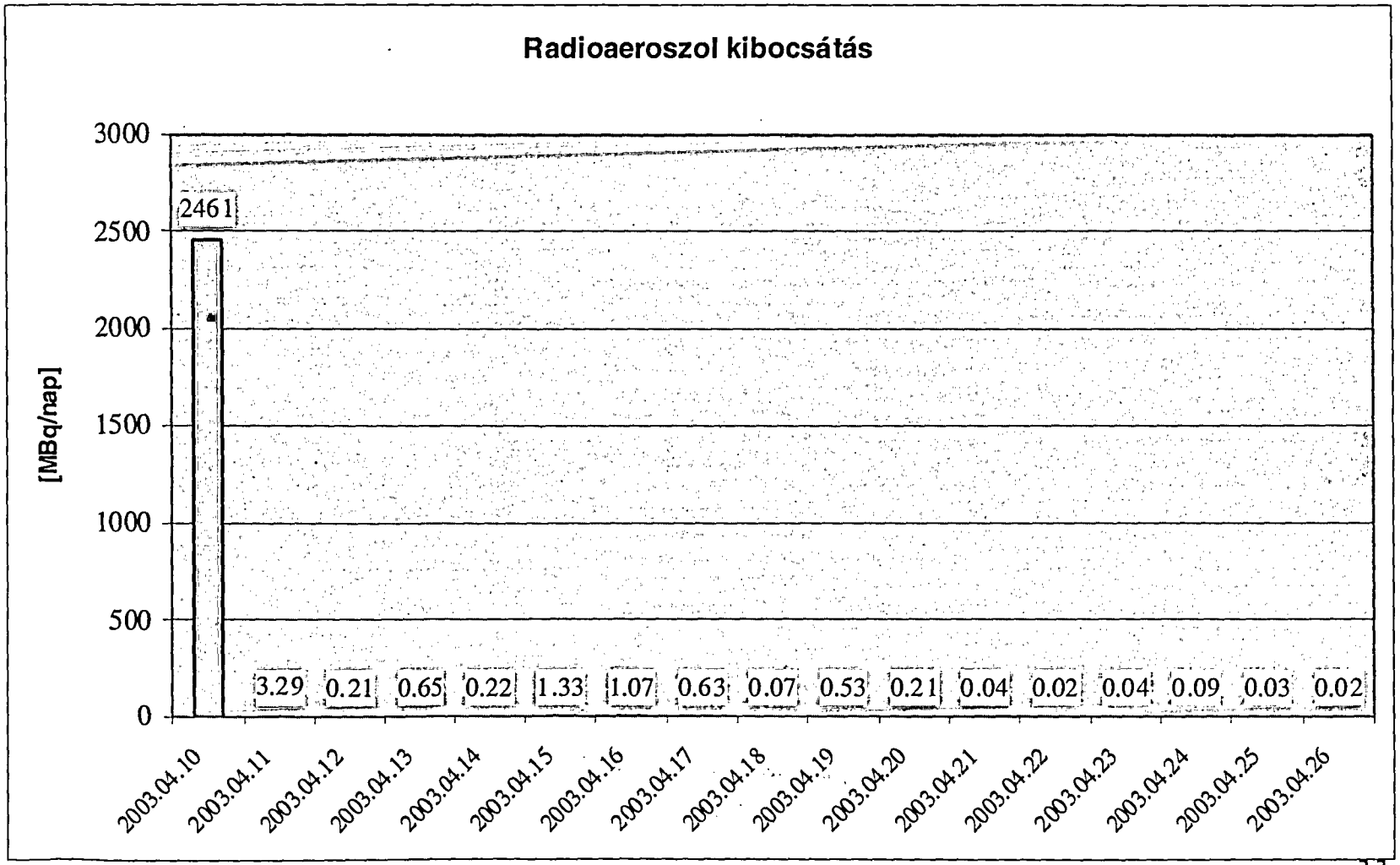
Noble-gas release



^{131}I-equivalent release



Aerosol release



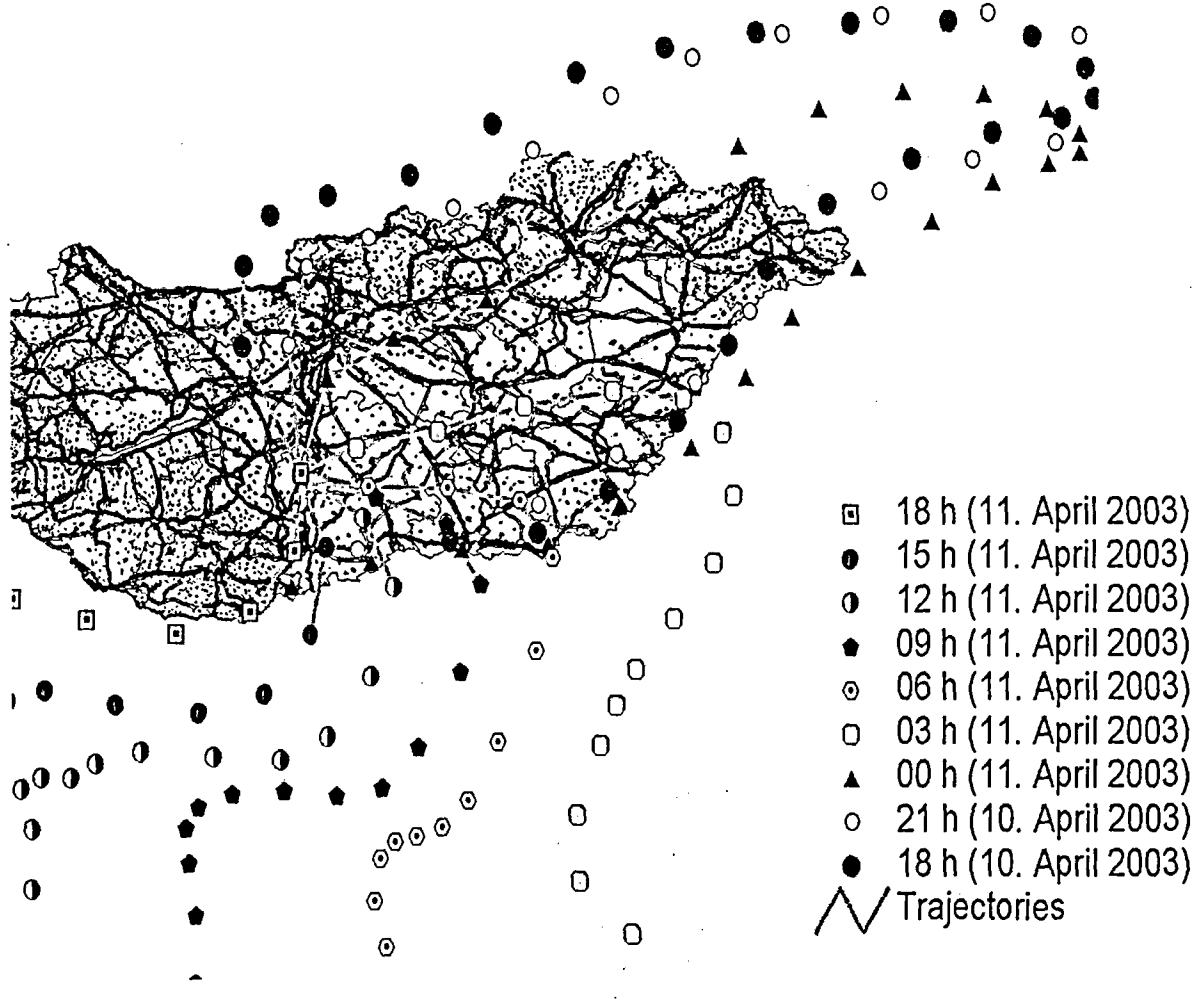
Event sequence (later phase)

- 16.04 - successful attempt to remove lid
- remote camera-snapshot taken
- fuel assemblies highly damaged but not melted
- NPP Emergency Preparedness Organisation alerted, HAEA notified
- HAEA NERO alerted, IAEA and neighbouring countries notified
- "Communication emergency"
- Reclassification to INES 3
- Analysis of possible scenarios, no change in plant status nor in radiation circumstances

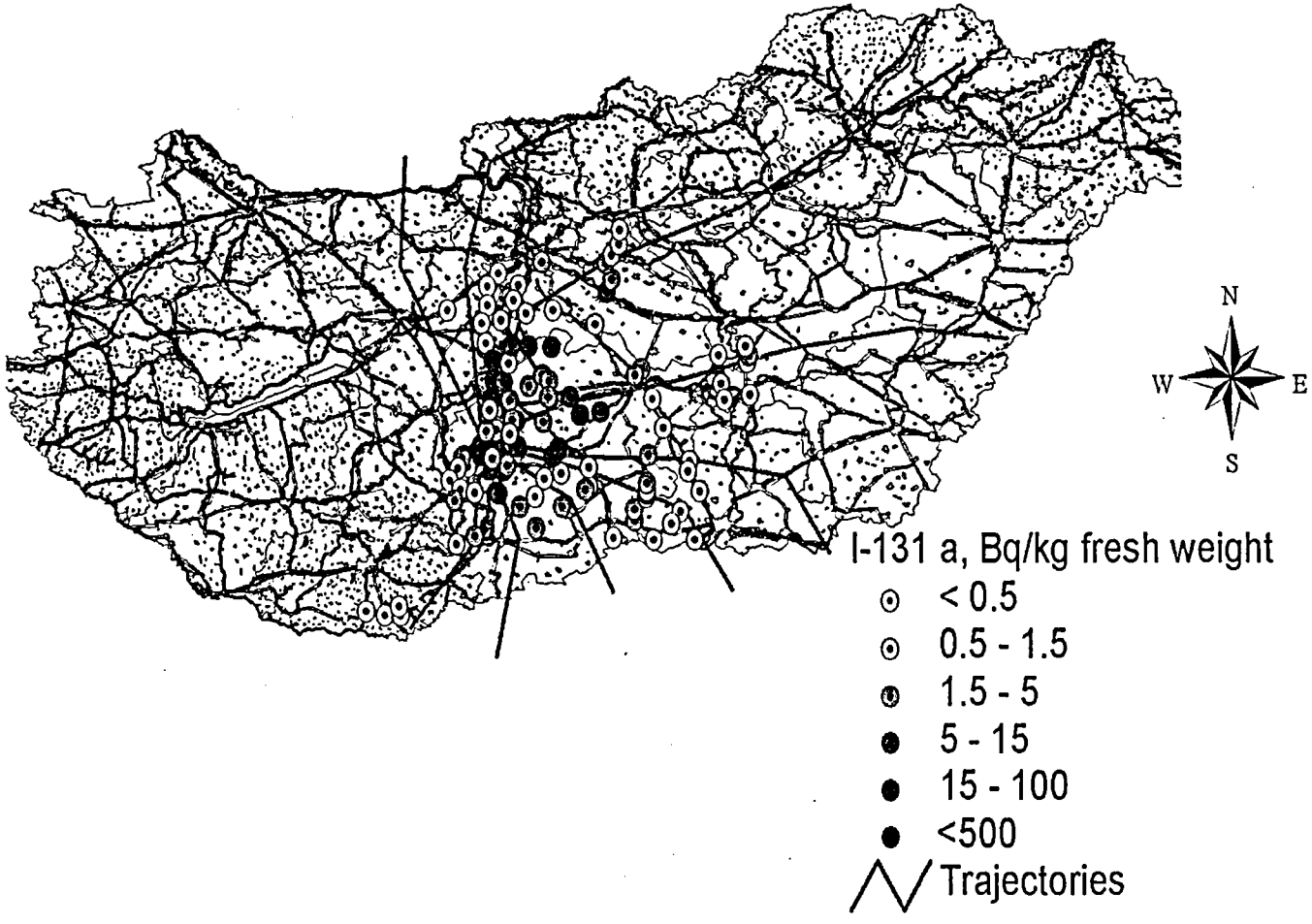
Event sequence (later phase)

- Framatom and Russian experts invited
- Radiation evaluation three times a day - continuos decrease (c.f. figures above)
- Noble gas overestimation for deposition in device
- Analysis of possible criticality - k_{eff} is below 0.95 if c_{Boron} is about 16 g/kg (actual value was 15.3 g/kg)
- Addition of boron acid, installation of neutron and thermal measurements
- 20.04. 09:00 - emergency state called off, EPO alert is terminated
- Intensive media, professional and political interest

Wind-trajectories



Specific activity of I-131 in plants



Specific activity - near Paks

A possible explanation

- Post-cleaning cooling insufficient for coolant by-pass
- Evolution of a steam-cushion
- Gap release due to assembly dry-out
- Thermal shock or steam explosion after lid opening crushes the assemblies

Investigation and verification is still underway

Next steps

- Dedicated team of NPP for consequence management
- Keeping stabilised the assembly
- Isolation and safe deposition of waste
- Decontamination of the pools
- Restart of Unit 2
- Lessons learned, drawing conclusions
- Reporting

Report submitted by the NPP

- Submission: 11. May 2003. to HAEA
- Main chapters:
  - Short summary of the incident
  - Evaluation of the incident covering radiation protection, technological circumstances, activity of the staff, documentation, efficiency of self-inspections, causes of fuel damage
  - Non-conformities detected during the investigation,
  - Consequences and safety impacts of the incident
  - Necessary countermeasures

Main conclusions of the NPP

- Immediate cause: insufficient cooling
- Plans have not secured sufficient cooling for every possible case
- Safety analysis has not covered in-vessel flow-patterns for B-mode cooling
- Plans for system-parameter control have not garanteed recognition of insufficient cooling

Independent HAEA investigation

- Data collection phase (interviews, minutes, op. data, records) closed
- Report to be ready by end of May
- Shall also include the regulatory assessment of the NPP reports
- Accounts also for the activity of the regulatory body

Contents of the HAEA report

- Characteristic data of the incident
- Preceding events and their evaluation
- Event sequence of the incident
- Process followed by the HAEA
- Causes of the incident
- Deviations (malfunctions) leading to the incident
- Evaluation of related operator's actions
- Nuclear and environmental safety assessments
- Necessary countermeasures

Summary

of the serious incident on the unit 2 of Paks NPP, set in on the 10th April 2003

The Unit 2 of Paks NPP was shut down for yearly refuelling and maintenance works on 29th March. In addition to the routine operations, maintenance works included chemical cleaning of the fuel assemblies unloaded from that unit. This operation has been performed in a dedicated tank housing 30 assemblies, about one tenth of the full load of the reactor. The same cleaning system has previously been used without any troubles for cleaning 5 charges of assemblies. Cleaning of fuel assemblies has been carried out at the plant for two years because of excessive deposition of corrosion-type material in the assemblies. The cleaning process applied is not a routine process and it is not part of the regular activities of the outage.

The cleaning of the sixth charge was started on 9th April 2003 and was terminated in the afternoon of 10th April 2003. On the same day, late in the evening, the radiation monitoring system indicated the presence of radioactive gases. Leakage in one or a few fuel assemblies was assumed. Consecutively the removal of the lid of the cleaner tank was decided. The removing operation was unsuccessful due to the break of the lifting rope, and the lid remained in a partially lifted position on the cleaning tank.

Paks NPP issued a press release about the event and notified also the Hungarian Atomic Energy Authority (HAEA). The event has been rated Level 2 on the International Nuclear Event Scale (INES). The HAEA notified the International Atomic Energy Agency and issued a press release with its own evaluation of the situation.

The Paks NPP and the Hungarian Atomic Energy Authority have started independent investigation of the incident. Contrary to its routine practice the Nuclear Safety Directorate of the HAEA established a Special Event Investigating Team.

After several attempts, on 16th April the lid of the fuel-cleaning tank was successfully removed. Thereafter, following a predefined programme, they performed visual inspection in the cleaning tank using a video camera. In spite of the original suppositions, the visual inspection gave evidence of all of the 30 assemblies being damaged and a number of heavily damaged assemblies were observed. Having studied the pictures, the NPP declared the site emergency state and the severity of the incident was increased to Level 3.

The radioactive materials released from the plant have been measured continuously. Furthermore a concise sample collecting field activity has been initiated soon after the release in order to scan the near and broader vicinity of the plant.

According to the plant measurements the release of airborne radioactivity can be characterised by the following values:

Period	Noble gases [TBq]	Iodine (^{131}I) equivalent [GBq]
10th April	12	143
11th April	160	204
12th April	25	7.0
13-19 April	179*	5.7*
20-26 April	38*	0.8*

(*Attention: The figures stand for 7 days. For getting the daily average, it should be divided by 7).

The monitoring stations located within the 1.5 km vicinity of the plant (consisting 9 stations measuring gamma-dose-rates) have not shown any increase above the daily fluctuations related to the circa 100 nSv/h average value, except for one station showing a marked increase up to 260 nSv/h, for a short time on 11th April. However, the value remained much lower than the warning limit of 500 nSv/h. Such values often occur in the environment after a heavy rain because of the natural radioactivity. As a matter of fact this is negligible from the point of view of possible human exposure.

Field measurements in the plant and in the surrounding area yield as typical values of I^{131} surface contamination between a few Bq/m^2 and a few hundred Bq/m^2. The highest level detected in the close vicinity of the plant was less than one thousandth of the average contamination in Hungary following the Chernobyl accident. No activity due to the event has been found in milk samples.

Correspondingly no countermeasures whatsoever have been introduced or are foreseen on-site or out of the site.

On 20th April 9:00 a.m. in view of the stabilised and safe condition of the cleaning system the NPP has declared the end of the emergency state and terminated the activity of its emergency preparedness organisation.

The power plant continues elaborating measures for decreasing the radioactivity release as well as for reinforcing the safety of the damaged fuel assemblies in the cleaning tank. Calculations and measurements prove that at the present level of boric acid concentration (16g/kg) in the tank and the surrounding water pool the fuel-coolant system in the cleaning tank is safely sub-critical and its cooling is sufficient. Redundant measurements and pumps have been installed. The power plant formed a working group for mitigation of the consequences of the incident (removal, management and storage of damaged fuel assemblies and possible other fragments arising from the incident and transportation of the cleaning tank).

As part of its independent investigation of the incident the HAEA carried out several site inspections at the Paks NPP. During the inspections the authority asked for additional written and video documents from the NPP and interviews were made with the employees taking part in the activities related to the incident. The investigation focused on the following issues:

- event sequence of the incident, activities after the incident and measures for mitigating the consequences
- cleaning technology applied, condition of the equipment and devices, processes
- decisions, persons making the decisions and their competencies

A resolution issued by the HAEA requires the Paks NPP to revise its plans of the outage of the second unit in the light of the present situation and also requires the NPP to submit the modification to the HAEA for approval.

On 11 May 2003 the Paks NPP submitted its report to the HAEA in accordance with its legally stipulated obligations.

The report of the NPP consists of the following main chapters:

- Short summary of the incident
- Evaluation of the incident covering radiation protection, technological circumstances, activity of the staff, documentation, efficiency of self-inspections, causes of fuel damage

- Non-conformities detected during the investigation,
- Consequences and safety impacts of the incident
- Necessary countermeasures

In order to thoroughly evaluate the report the HAEA started studying it without any delay.

The data collection phase of the HAEA's independent investigation has been completed. The results will be summarised in a report and it is due by the end of May. It will also include the regulatory evaluation on the operator's report. Other main topics of the HAEA's report will be the following:

- Characteristic data of the incident
- Preceding events of the incident and their evaluation
- Event sequence of the incident
- Process followed by the HAEA
- Causes of the incident
- Deviations (malfunctions) leading to the incident
- Evaluation of the operator's actions in connection with the incident
- Nuclear and environmental safety assessments in connection with the incident
- Necessary countermeasures

On the basis of the HAEA's preliminary evaluation of the event the incident can be attributed to several independent, however, interfering causes. Further investigations are needed to reveal the fundamental technical reasons of the incident.

Budapest, 14 May 2003.