Radiological Characterization of V1 NPP Technological systems & Buildings - Activation

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V1 NPP at Jaslovske Bohunice site

V1 NPP decommissioning:

- 2 WWER type reactor 440/230 units
- Operation: Unit 1 in 1978 – 2006, Unit 2 in 1980 - 2008,
- Since 2001 D&D preparation supported by Bohunice International Decommissioning Support Fund (BIDSF)
- At present: units finally shutdown, since July 2011 under decommissioning license

BIDSF Project B6.4
"Decommissioning Database"

Project purpose: Physical and radiological inventory database development to support V1 NPP decommissioning

Performed by: EWN GmbH, STM Power and AMEC Nuclear Slovakia

Project period: 2008 – 2011

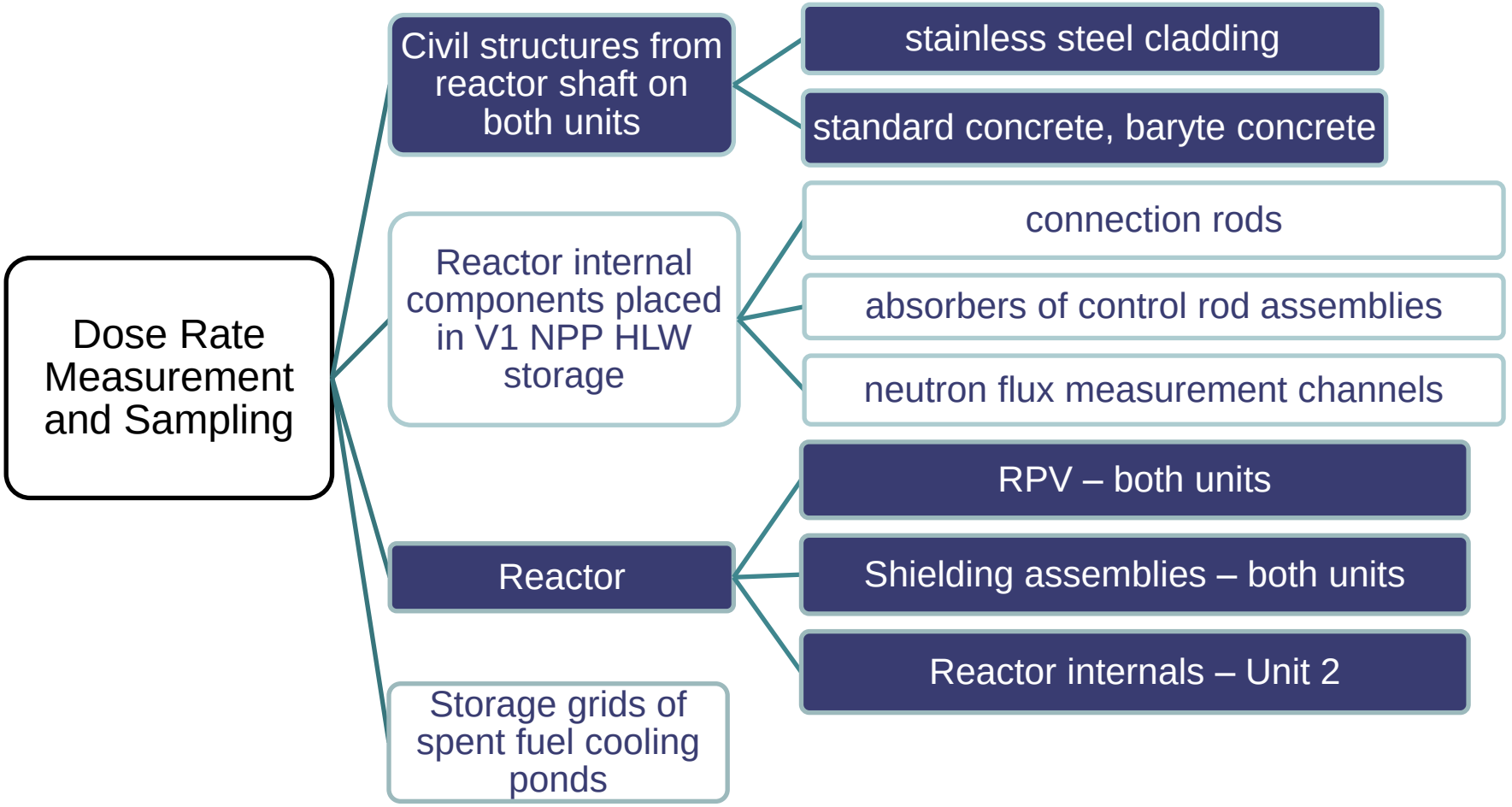
Scope of inventory:

- Nearly 100 civil objects
- 175 technological systems
- Over 40 parameters for each DDB item - identification, physical and radiological properties

Project tasks:

1. DDB design
2. Historical site assessment
3. Physical inventory – plan and performance
4. Sampling and analysis - plan and performance
5. Hazardous material inventory
6. **Activation inventory -** Characterization of Activated Components Based on Measurement and Sampling
7. Radiological inventory

Subject of Activation Inventory



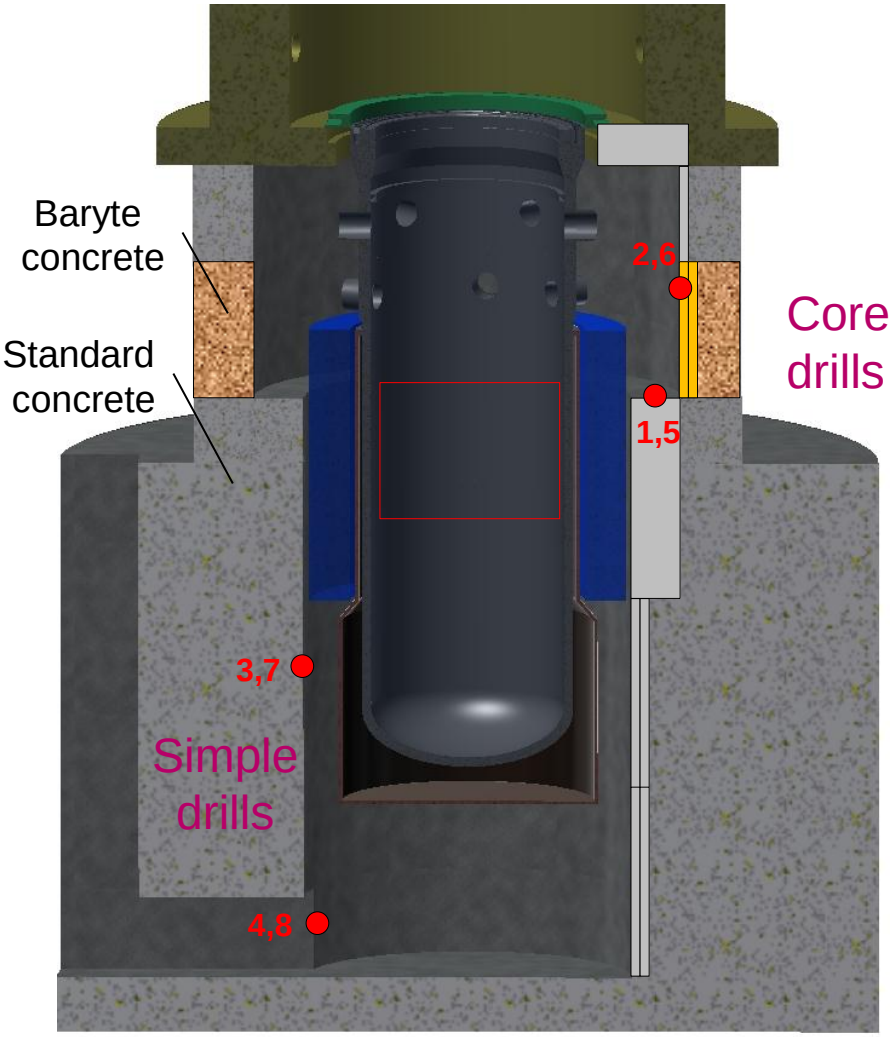
Works carried out in period from 04/2011 to 12/2011

Radiological Characterization of Activated Components

Scope of services:

1. Categorization of activated components – totally 112 samples planned
2. Development of single working programs for radiological monitoring and sampling
3. Preparation of sampling device & revision of NPP handling equipment
4. Dose rate monitoring and sampling
5. Analyses of samples: gammaspectrometry, radiochemical analyses; γ RA nuclides & limited RA nuclides for Mochovce repository
6. Determination of radiological inventory: activation values (Bq), RNV, dose rates
7. Import of radiological data for activated components into DDB

Sampling of activated civil structures in reactor concrete shaft of Unit 1 and 2



Number of drills: 8
(1- 4 at Unit1, 5-8 at Unit 2)

Sampling depth: 20 – 40 cm

Manual drilling device

Results:

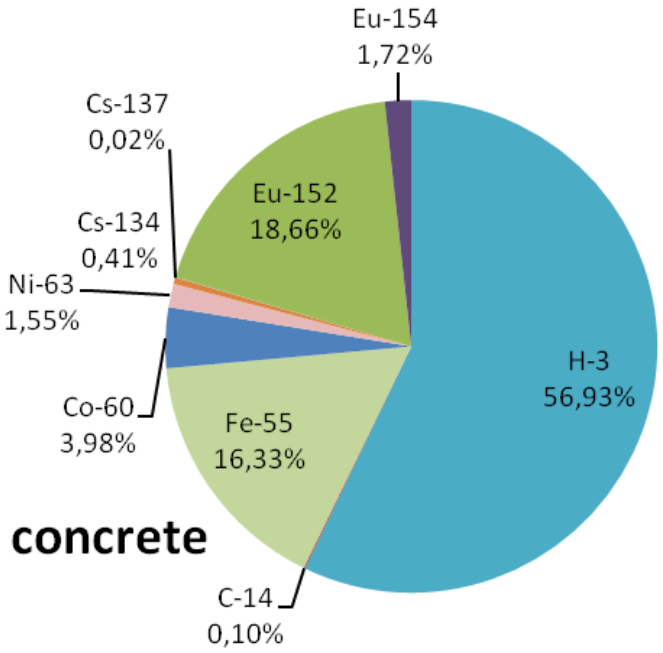
- major activation RA nuclides: Fe-55, H-3, Co-60, Eu-152, Eu-154, Cs-134, Ba-133, Ni-59, Ni-64, C-14
- contamination of concrete by Cs-137
- Division of concrete to **9 layers**/ unit (along RPV concrete shaft height)

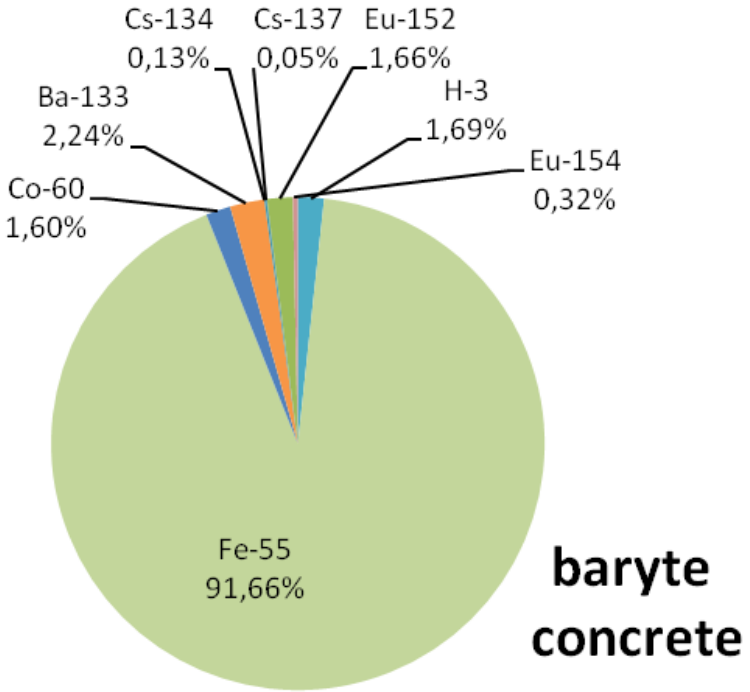
Sampling of activated concrete – results

V1 NPP concrete radiological inventory determined for 1.1.2010:

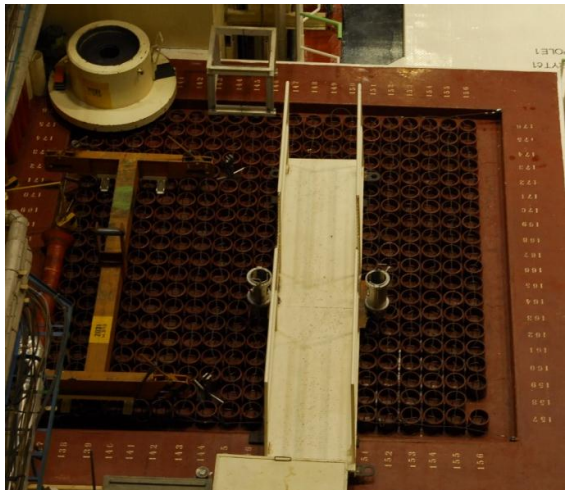
Material	Standard concrete	Baryte concrete	Total
Activity (Bq)	1,58E+09	6,41E+08	**2,22E+09**
Mass (kg)	344 166	86 490	**430 656**

RNV – activated concrete for Unit 1:





Sampling of activated components in V1 NPP HLW storage (1)



V1 NPP HLW storage (399 cells):

- 157 absorbers of safety and control rod assemblies (ABS)
- 217 connection rods of safety and control rod assemblies (CR)
- over 330 pc of neutron flux measurement channels (KNI)

Procedure:

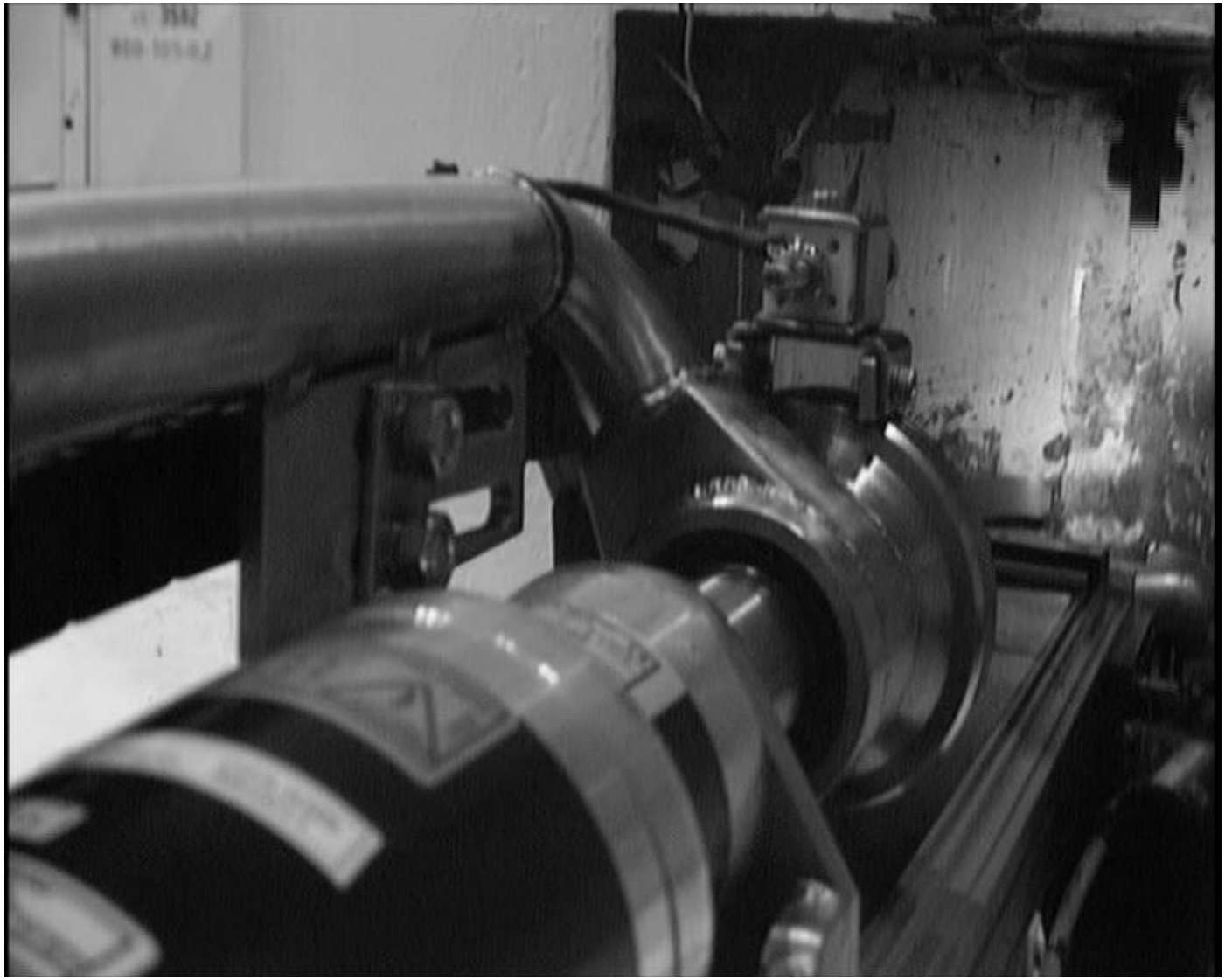
1. Categorization of stored components – **40 components selected**
2. Remotely controlled sampling equipment used
3. Existing NPP equipment for manipulation – transport containers for components

Sampling of activated components in V1 NPP HLW storage (2)

Sampling procedure in HLW storage:

- Remote-controlled equipment with drilling head on linear guiway, sample suction into carrousel
- **80 samples taken** from selected components (ABS, CR, KNI) – swarfs
- Sample mass from 0.6 mg to 900 mg
- Dose rate monitoring along the height of component – up to 30 Sv/h at sampling spot

Sampling of activated connection rod in V1 NPP HLW storage - video



Sampling of activated components in V1 NPP HLW storage – results (1)

Category	Dose rate interval [mSv/h]	Assignment of activated component part into category			
		CR A-type	CR B-type	Absorber	KNI channel
MOG1	$10^3 – 10^2$	Bottom part 0 – 60 cm	-	Bottom part 0 – 60 cm	-
MOG2	$10^2 – 10^1$	Part 60 – 120 cm from the bottom	Bottom part 0 – 60 cm	Part 60 – 120 cm from the bottom	Bottom part 0 – 250 cm
MOG3	$10^1 – 10^{-1}$	CR rest part (360 cm)	CR rest part (420 cm)	ABS rest part (140 cm)	KNI rest part (up to 350 cm)

CR A-type: from group VI. of controlled rod assemblies – inserted partially in the core

CR B-type: CR from other groups of controlled rod assemblies – occasionally in the core

Absorber

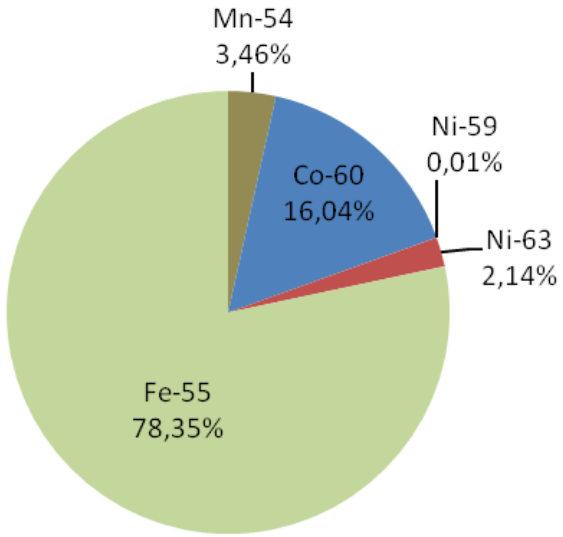
KNI channel

Sampling of activated components in V1 NPP HLW storage – results (2)

Total inventory of CR, ABS and KNI channels placed in V1 NPP HLW storage on due date 1.8.2011:

Material	Connection rods		Absorbers		KNI channels		Total	
	Activity [Bq]	Mass [kg]	Activity [Bq]	Mass [kg]	Activity [Bq]	Mass [kg]	Activity [Bq]	Mass [kg]
MOG1	1,07E+15	273	1,94E+15	4 023	-	-	3,01E+15	4 296
MOG2	2,22E+14	1 526	3,65E+13	4 023	2,63E+14	495	5,21E+14	6 044
MOG3	8,36E+13	11 717	1,01E+13	10 637	2,63E+12	495	9,64E+13	22 849
TOTAL	1,38E+15	13 516	1,99E+15	18 683	2,66E+14	990	**3,63E+15**	**33 189**

RNV valid to date of component unloading from the core and putting to HLW storage



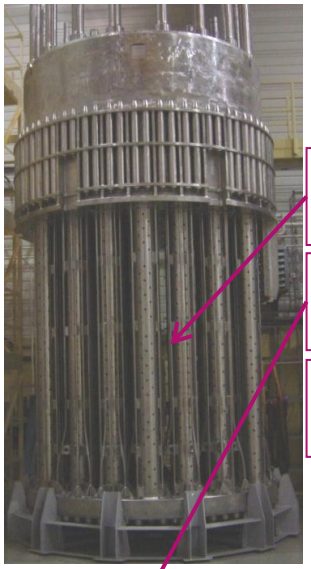
Sampling of reactor and its internals

Subject of sampling:

1. Internals of RPV, Unit 2:
   - Protective tube unit
   - Core basket
   - Reactor cavity
2. Selected shielding assemblies, both units
3. RPV:
   - Basic material sampled from outer side in reactor shafts – bottom part, Unit 1, 2
   - Internal cladding of RPV, Unit 2

- In total **34 samples taken** – swarf with mass from 0.1 mg to 125 mg
- Depth of sampling: 2 – 5 mm
- Remote controlled sampling equipment (the same for HLW storage sampling)
- Manual drilling with sample capture – only in case of basic RPV material

Sampling of reactor internals, Unit 2



Protective tube unit

Core basket

Reactor cavity

- Container for transport of reactor internals
- Remote controlled sampling carried out on air in refuelling pond above the RPV
- **15 samples taken**

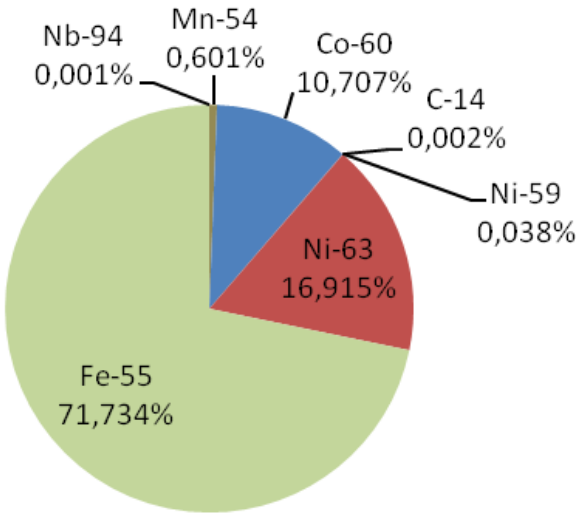
- Dose rate at 50 cm distance:
  Protective tube unit : 0.44 - 110 mSv/h
  Core basket: 2400 – 37000 mSv/h
  Cavity: 0.5 – 4200 mSv/h

Sampling of reactor internals, unit 2– results

Total inventory of reactor internals determined on due date 30.9.2011:

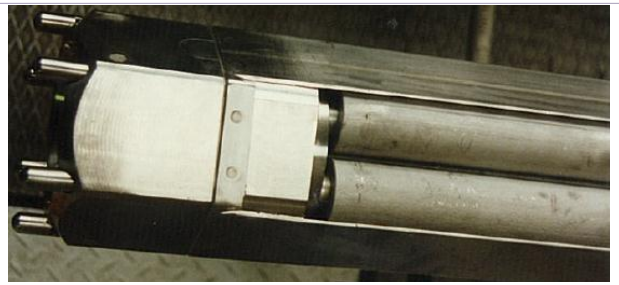
Component	Parameter	Unit 1	Unit 2	Total
Protection tube unit	Activity [Bq]	5,69E+14	8,37E+14	1,41E+15
	Mass [kg]	27 304	27 304	54 608
Core basket	Activity [Bq]	5,84E+16	8,59E+16	1,44E+17
	Mass [kg]	22 480	22 480	44 960
Reactor cavity	Activity [Bq]	7,41E+15	1,09E+16	1,83E+16
	Mass [kg]	61 250	61 250	122 500

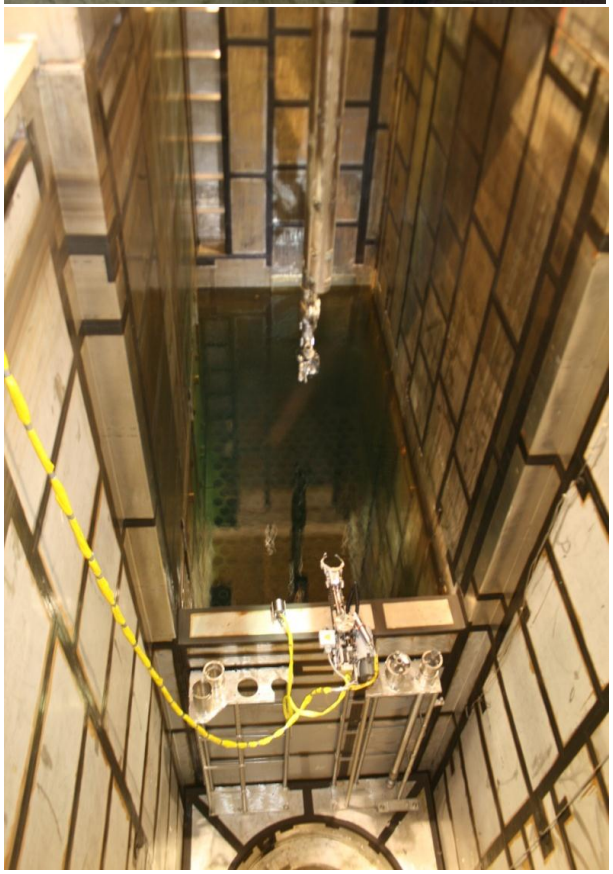
RNV Unit 2



Inventory and RNV for Unit 1 recalculated considering different final shutdown

Sampling of shielding assemblies, both units (1)



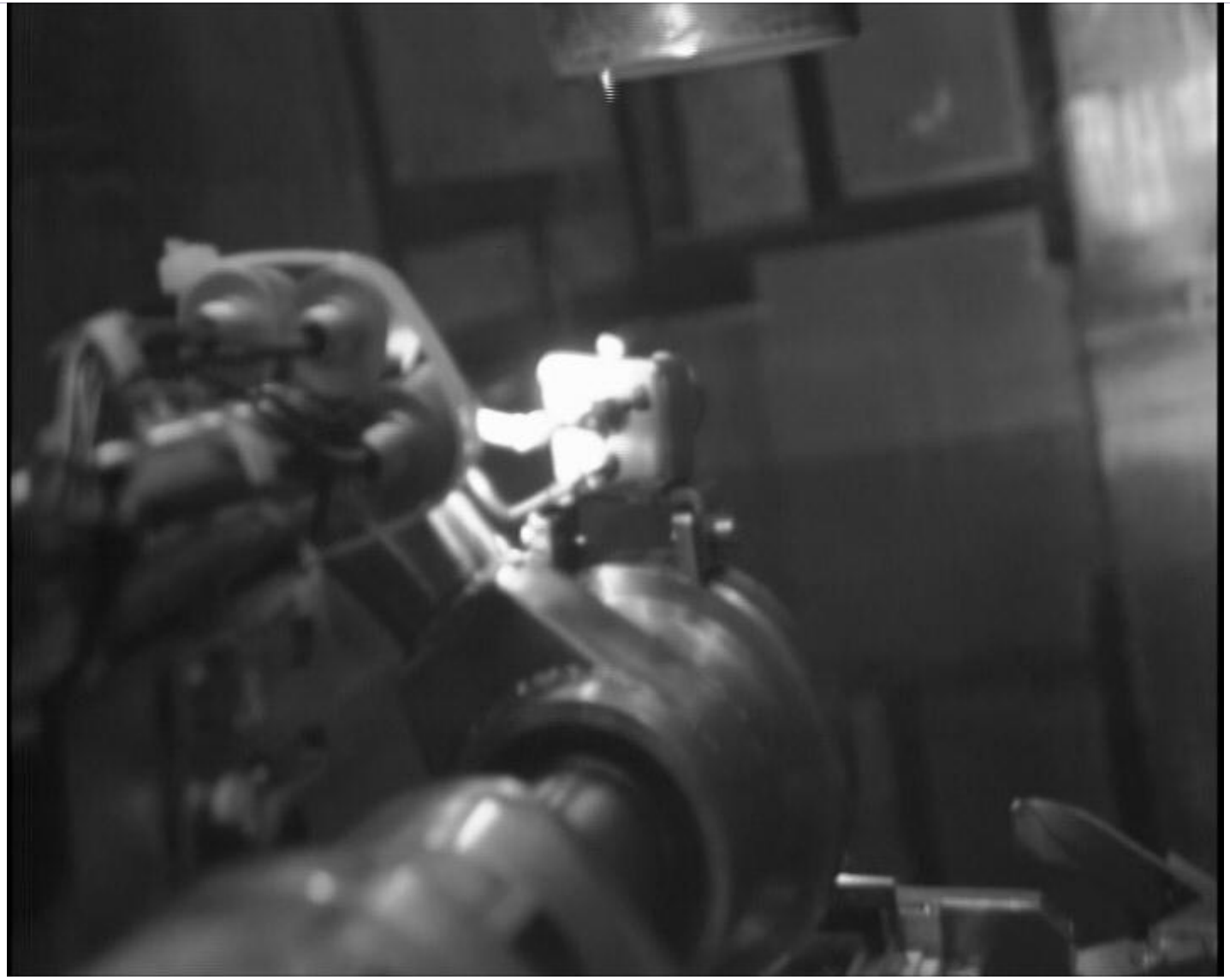


- Shielding assemblies = 36 replaced fuel assemblies in peripheral core position – reduced RA impact on RPV
- Refuelling machine for transport of shielding assemblies used
- Remote controlled sampling carried out on air in spent fuel storage pool
- Selected 3 assemblies/unit based on their position in the core
- **6 samples taken**

- Dose rate at 50 cm distance: 3.1 – 110 Sv/h

- Confirmed measured dose rates carried in 2008, dose rate at 1cm distance: > 2000 Sv/h

Sampling of shielding assemblies - video

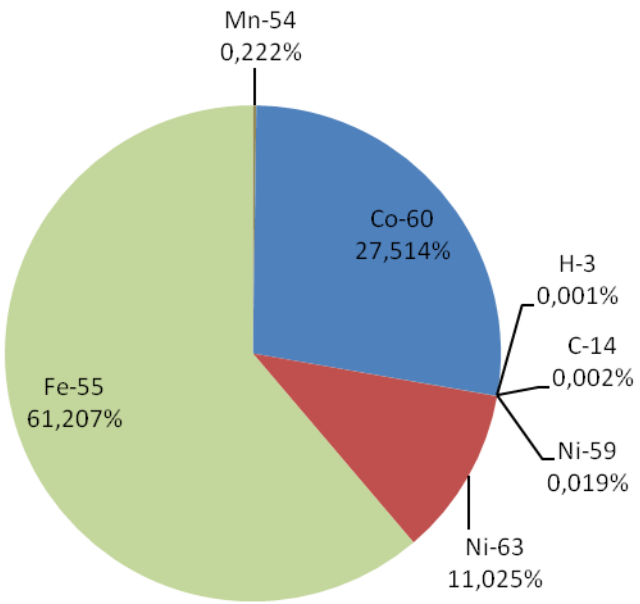


Sampling of shielding assemblies – results

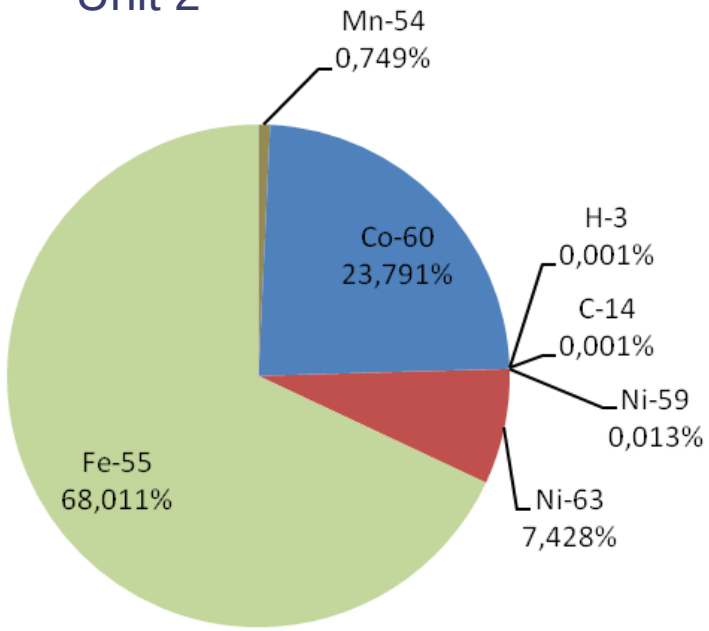
Total inventory of shielding assemblies determined on due date 30.9.2011:

Component	Parameter	Unit 1	Unit 2	Total
Shielding assemblies	Activity [Bq]	4,63E+16	4,63E+16	9,27E+16
	Mass [kg]	10 800	10 800	21 600

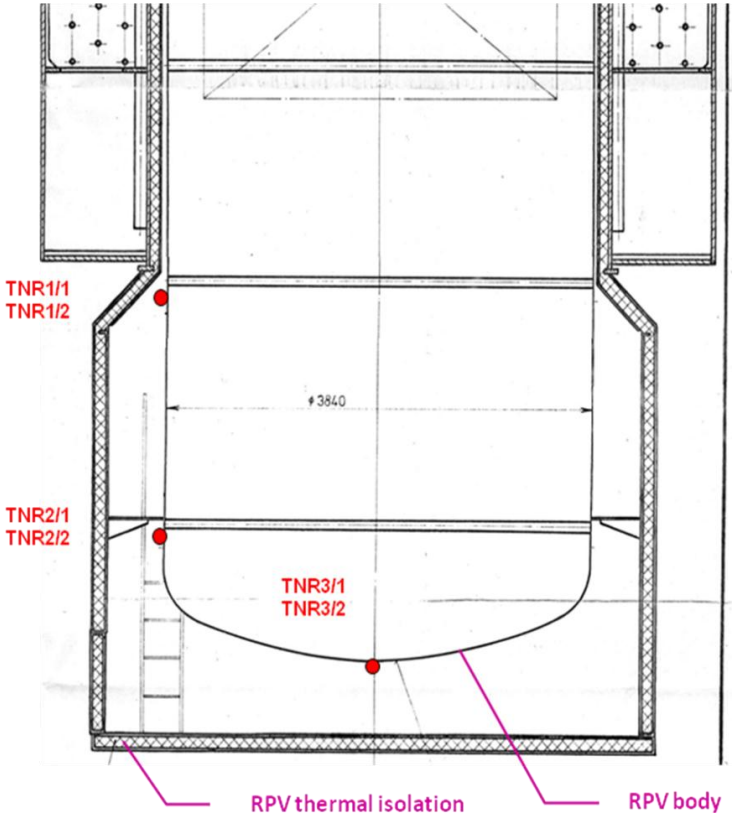
Unit 1



Unit 2



Sampling of RPV – basic material & cladding



Sampling of RPV basic material, both units:

- Manual drilling - **6** taken samples
- Average dose rate: 100 – 300µSv/h

Sampling of RPV internal cladding, Unit 2:

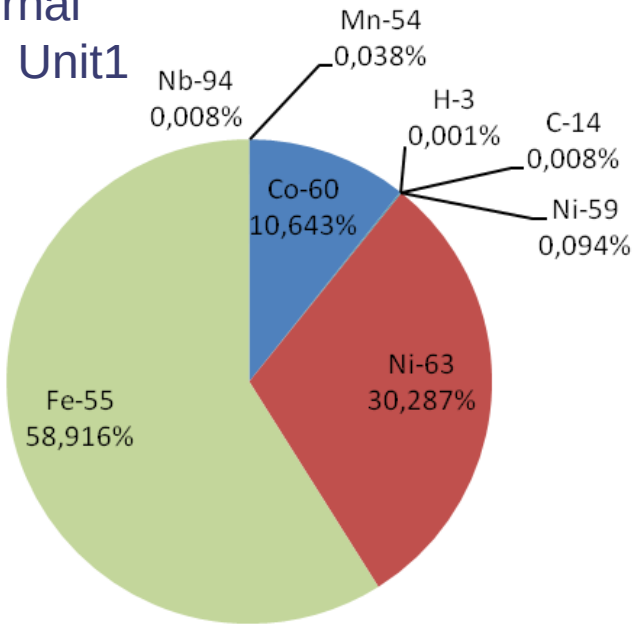
- Concrete container inside RPV
- Remote controlled equipment – **7** taken samples
- Dose rate at 50 cm: 1 – 1010 mSv/h

Sampling of RPV – results

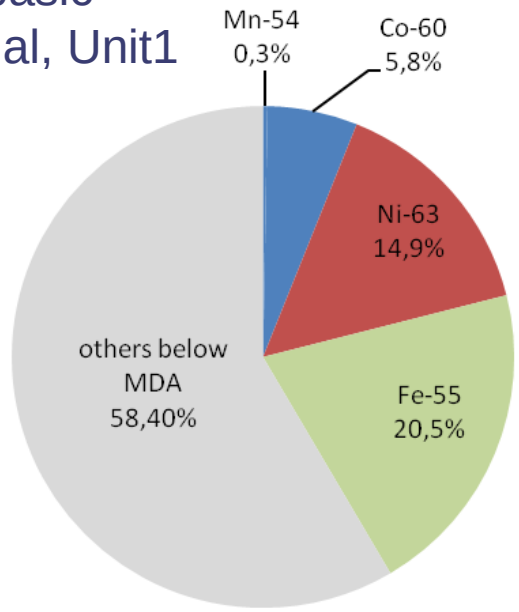
Total inventory of RPV material determined on due date 30.9.2011:

Component	Parameter	Unit 1	Unit 2	Total
RPV basic material	Activity [Bq]	3,36E+14	3,97E+14	7,33E+14
	Mass [kg]	247 800	247 800	495 600
RPV internal cladding	Activity [Bq]	1,23E+14	1,76E+14	2,99E+14
	Mass [kg]	17 300	17 300	34 600

RPV internal cladding, Unit1

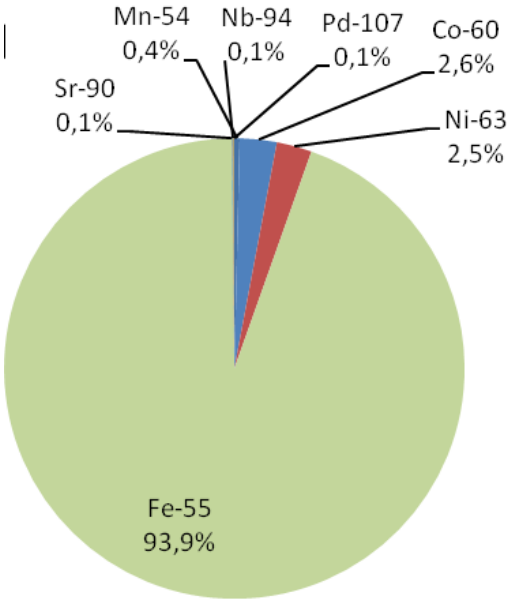


RPV basic material, Unit1



Sampling of storage grids in spent fuel cooling pond, Unit 1

- Manual drilling with sample capture on air
- **3** taken samples
- Average dose rate: 350µSv/h
- RNV, Unit 1



Total inventory of storage grids determined on due date 30.9.2011:

Component	Parameter	Unit 1	Unit 2	Total
Storage grids of spent fuel cooling pond	Activity [Bq]	4,61E+11	7,63E+11	1,22E+12
	Mass [kg]	4 700	4 700	9 400

Radiological Characterization of V1 NPP - Activation

- Same approach for all activated components:
  - Working program
  - Work implementation: dose rate measurements, sampling, analyses
  - Report - evaluation of working program (including DVD)
  - DDB import: **1130** modified or new items
- Total number of samples: **125**
- Total inventory: **2,61E+17 Bq**
- Analyses:
  - All samples – gamma-spectrometry
  - 13 samples – analysis of hard-to-detect radionuclides:

    C-14, Ca-41, Ni-59, Ni-63, Fe-55, Se-79, Sr-90, Mo-93, Zr-93, Nb-94, Tc-99, Pd-107, Sn-126, I-129, Cs-135, Sm-151, Pu-238, Pu-239+240, Am-241, Cm-244 (RA nuclides limited for RAW repository in Mochovce)

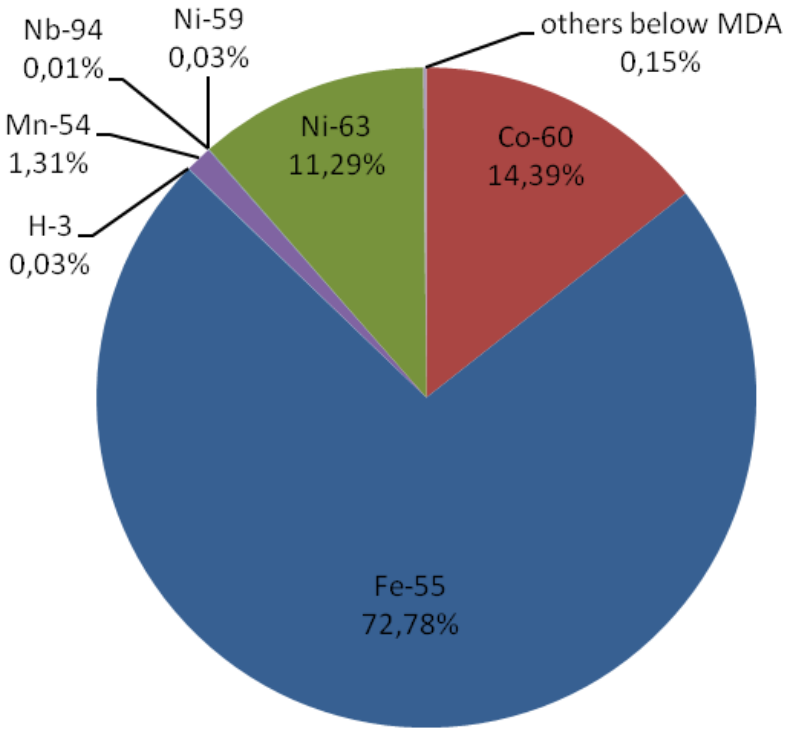
Radiological inventory results – activation (1)

Final list of 19 RNV for activation:

- RPV cladding – Unit1, Unit 2
- RPV basic material, water biological shielding - Unit1, Unit 2
- RPV internals - Unit1, Unit 2
- Shielding assemblies - Unit1, Unit 2
- RPV Serpentinite - Unit1, Unit 2
- RPV Thermal insulation - Unit1, Unit 2
- Activated standard concrete - Unit1, Unit 2
- Activated baryte concrete - Unit1, Unit 2
- Grids of spent fuel storage pool, stainless steel cladding of reactor shaft - Unit1, Unit 2
- High level waste storage (Mogilnik) – control rods, absorbers, neutron flux measurement channels

Radiological inventory results – activation (2)

Percentage contribution of radionuclides to the NPP V-1 activation:



Other identified activation products:

Radionuclide	Contribution (%)
Ba-133	4,24E-09
Cs-134	4,23E-09
Eu-152	1,10E-07
Eu-154	1,08E-08

Thank you for your attention.

Any questions?