cepn

CENTRE D'ÉTUDE SUR L'ÉVALUATION DE LA PROTECTION DANS LE DOMAINE NUCLÉAIRE

Radiological protection issues at the decommissioning stage of nuclear power plants

Laure-Anne BELTRAMI
CEPN, France

ISOE International Symposium

Kyoto, 1-3 October 2024

Introduction

Decommissioning of NPPs is a subject of importance for the nuclear industry, associated with some economical, technical and organizational challenges.

Number of nuclear facilities in decommissioning is increasing and will increase in the coming years.

Dismantling projects are moving forward and feedback experience can be used for future projects.

Risks during decommissioning may differ from those encountered during operation.

ISOE WGDECOM

WGDECOM was created in 2014.

Objective: improve sharing and collection of operational RP experience through benchmarking visits of nuclear facilities under decommissioning or in preparation of decommissioning.

Topics of interest:

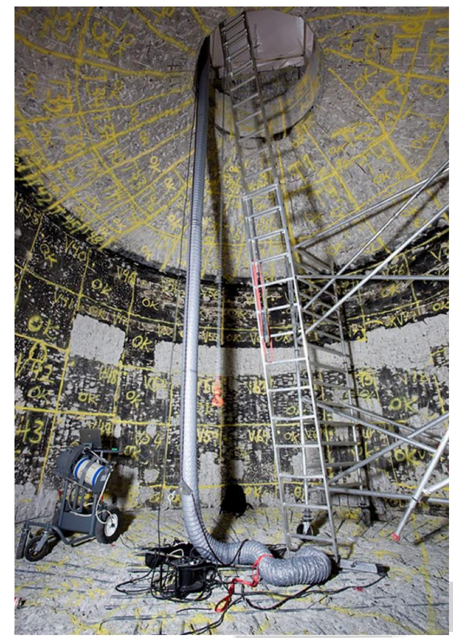
- Areas of RP most relevant for management of occupational exposure, good RP practices in decommissioning
- Collection of operational data,
- Creation of a network of RP experts in decommissioning activities.

ISOE WGDECOM - Topics of interest

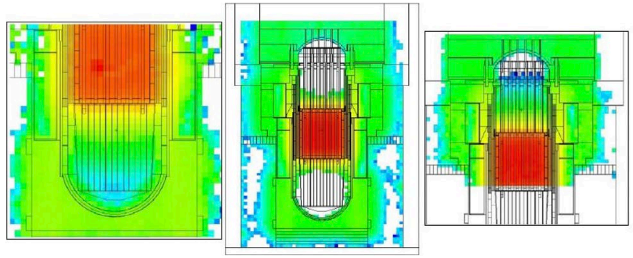
- Initial context and characterisation
- Collective doses analyses for high doses works
- Management of internal exposures
- Radioactive waste management
- Integrated risk management

Characterisation

- Characterization strategy during the transition phase (operating to decommissioning) and when work will start is of key importance for the success of the project:
  - Contribute to selection of dismantling scenario (RP one criteria among others)
  - Quantification of risk level (radiological conditions for workers) and graded approach for parades selection and monitoring procedures
  - Definition of waste management strategy
  - Evaluation of release in the environment (normal operation and accidents) and associated impacts



- Analysis of plant history and initial characterization by measurements and calculations to identify areas contaminated during operation (particularly with alpha emitters)



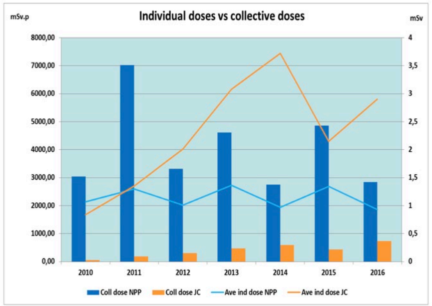
Collective doses for high doses work

- PWR decommmissioning : collective exposures easily reach a few man.Sv per reactor
  - José Cabrera : 3 man.Sv (7 to 8 years)
  - Zion : 4 to 5 man.Sv (8 years)
  - SONGS 1 : 3 man.Sv (8 years)
- Dismantling of highly activated components (vessel, internals)

ACTIVITIES	Collective dose (mSv-p)	
Plant Modifications & General Works	157,84	5,8%
Maintenance & Surveying	384,16	14,2%
Main Components	846,00	31,3%
In situ decontamination(tanks/components)	31,96	1,2%
Spent Fuel Pool conditioning & decontamination	95,79	3,5%
Components dismantling - Containment building	197,47	7,3%
Components dismantling - other buildings	266,43	9,9%
Biological shielding	141,79	5,2%
Contaminated concrete removal	316,92	11,7%
Walls & floors decontamination	36,07	1,3%
Decontamination workshop	29,38	1,1%
Rad Waste management	199,12	7,4%
Site restoration	0,00	0,00
total	*2702,93*	

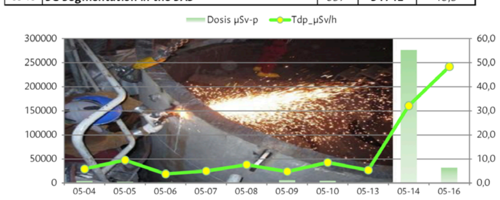
Individual doses

	Number of persons 10 mSv -20 mSv	
	NPP	José Cabrera
2010	1	0
2011	73	2
2012	2	0
2013	18	15
2014	0	24
2015	20	5
2016	0	22



ACTIVITY:	Collective Dose mSv	Man- man-h
Main Components_STEAM GENERATOR	329,71	12090

	05 MAIN COMPONENTS : Steam Generator	H-p	Dosis µSv-p	Tdp_µSv/h
05-04	Scaffolding	704	4143	5,9
05-05	Isolation removal	278	2655	9,6
05-06	Stem pipe removal	364	1381	3,8
05-07	Water supply pipe removal	163	815	5,0
05-08	Instrumentation removal	104	796	7,7
05-09	Steam section removal	1294	6191	4,8
05-10	Supports removal	551	4724	8,6
05-13	Confinement & filtration equipment	187	1006	5,4
05-14	SG Segmentation in situ	8605	276252	32,1
05-16	SG Segmentation in the SAS	657	31742	48,3



ACTIVITY:	Collective Dose mSv	Man- man-h
SURVEILLANCE & MAINTENANCE	384,16	191550

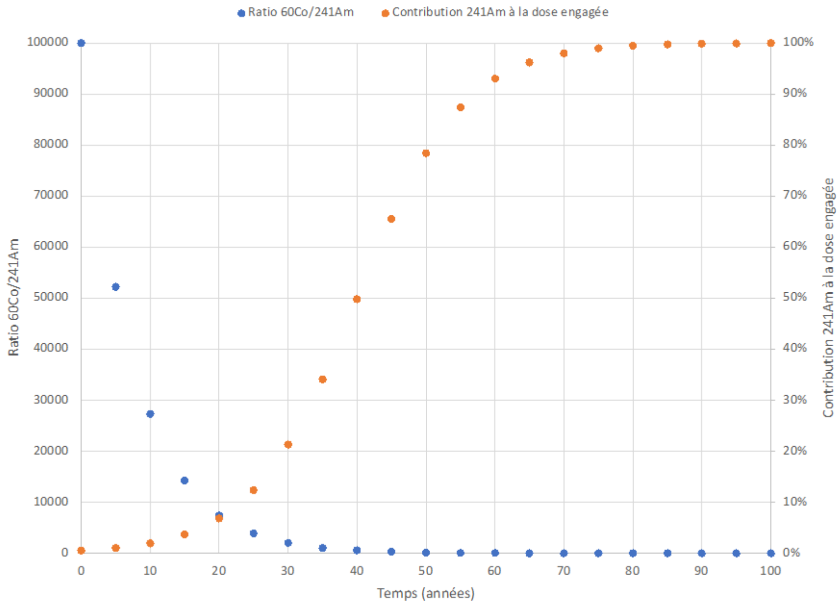
	02 - SURVEILLANCE & MAINTENANCE	H-p	Dosis µSv-p	Tdp_µSv/h
02-01	Ocupational Health & Safety	11443	16251	1,4
02-02	Medical Services	58	104	1,8
02-03	Instrumentation Maintenance	4294	9982	2,3
02-04	Mechanical Maintenance	6136	26270	4,3
02-05	Electrical Maintenance	4403	10254	2,3
02-07	Security	1440	1032	0,7
02-08	Radiation Protection	69444	204044	2,9
02-09	Fire Protection	13283	6532	0,5
02-10	Decontamination & Housekeeping	73890	104538	1,4
02-11	General Services	5883	5155	0,9

Management of internal exposure and alpha risk (1)

- Dismantling activities present an important risk of particles resuspension (cutting, drilling,…) => increase the risk of internal exposure
- Evolution of source term during dismantling than can lead to modification of source term => impact on internal dose in case of internal contamination.
- α emitters on plant: U, Pu, Am, Cm (high radiotoxicity). Half-life much longer than $\beta\gamma$ emitters

Radionuclides	Emitter	Half life (year)	Dose coefficient ($Sv.Bq^{-1}$)	DAC ($Bq.m^{-3}$)
^{60}Co	γ	5,27	3,1 10^{-8}	269
^{239}Pu	α	2,41 10^{+4}	2,5 10^{-5}	0,33
^{241}Am	α	432,2	1,7 10^{-5}	0,49

- To evaluate impact of mixed radionuclides, use of ratio $\beta\gamma/\alpha$.
- Ratio 5000:1 and below: ^{241}Am contribute to 10% committed dose in case of inhalation. Ratio de 50:1: ^{241}Am contribute to more than 90% of committed effective dose



Management of internal exposure and alpha risk (2)

- Collective protection:
  - Cleaning and decontamination before work,
  - Engineering barriers,
  - Glove box, containment
- Individual protection:
  - Protective clothes (full plastic suits),
  - Respiratory protection: to be defined by taking into account radiological and other occupational risks (lead, asbestos, activity duration, thermal constraint,…)
  - Gloves.
- Monitoring:
  - Monitoring of air alpha contamination in dusty atmosphere may be difficult.
  - Monitoring of individual exposures with PAS.
- Internal versus external:
  - Working with protective clothes will increase working time and thus external exposure,
  - Need (in theory) to balance between internal and external exposure but internal exposure is usually not well accepted by Authority, utilities and workers.

Radioactive waste management

- National context and practices:
  - Regulations on waste management
  - Waste disposal and storage available

- Plant in decommissioning:
  - Production of wastes and radioactive materials
  - Identify possibility of storage depending on waste category

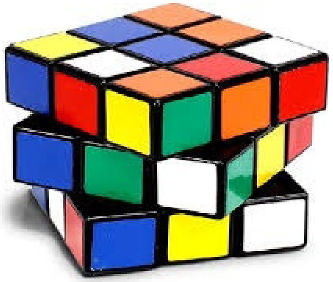
- Mixed wastes:
  - Management in accordance with real risks of wastes
  - Identify way of management and storage

Integrated risk management

- Specificities of decommissioning works lead to radiological as well as industrial risks:
  - Removal and cutting of big components, structure dismantling, works on concrete (cutting, drilling, …)
  - Presence of multiple pollutants (asbestos, lead, chemicals,…)

- Selection of PPE (and particularly respiratory protection) suitable for all risks encountered during the tasks: radiological, dust, lead, asbestos,…

- Waste management: not always possible to dispose mixed wastes in existing disposals



- Global approach of RP, industrial safety and waste management is required.

Integrated risks - Example of combined risks radiological/asbestos in France

- No unique applicable regulation exists for interventions with combined asbestos and radiological risks
- But two different regulations not compatible :
  - Water is required for decontamination and to decrease dust level in asbestos worksite
  - Water is to be avoided in nuclear worksite

ASBESTOS PROTECTION KIT	NUCLEAR WORKWEAR	RESPIRATORY PROTECTION « ASBESTOS »	RESPIRATORY PROTECTION « NUCLEAR »
Depending on the dust level. Linked with respiratory protection	Depending on the volumic activity level - Linked with respiratory protection	Depending on dust level – Regulatory constraint (decree of 08/04/2023)	Depending on activity level
A single intervention suit	Principle of layering clothing	P3 Cartridge (for particles)	Combined Hazard Cartridges
Non-woven disposable garment with hood (dustproof)	Reusable woven garments (washable)	Few cartridges for combined risks (pressure loss, weight)	Negative pressure filtering full face mask
Ventilated suit for high dust levels	Ventilated suits or disposable suits	Full-face mask with assisted ventilation (min 160l per min)	Cartridges are stored at the end of the activity. Radiological control of the mask after intervention.
Suit decontaminated from asbestos by taking a shower	No cleaning of the suit before exiting	Cartridges are saturated with water and discarded at the end of each activity	Use of air supply for high contamination levels. (adjustableflow rate : 160 to 300 liters per minute).
Decontaminated suit disposed of as asbestos waste after use	Ventilated suits or disposable suits disposed as nuclear waste after use	Use of air supply for high dust levels	
		Minimum flow rate of 300l per min (continuous flow)	

Lessons learned and more in-depth needs

Feedbacks collected on tasks to be performed thanks to WGDECOM and other exchanges

- Feedback from all types of facilities (research reactors, NPPs, waste facilities,..)
- Feedback from big maintenance works (SGR, replacement of primary circuit parts,…)

Presence of **multiple pollutants** (asbestos, lead, chemicals,…) with a need of global risk analysis

Start **characterization** as soon as possible

Evolving environment (radiological conditions, removal of components,…)

Specific attention to management of **internal exposure**

Dose data available but difficult to establish a **dose database** for comparison because data is:

- Not sufficiently available;
- Not comparable;
- Not unique / not unambiguous.

Thank you for your attention!

For more information on ISOE WGDECOM:
www.isoe-network.net

If you have any questions:

laure-anne.beltrami@cepn.asso.fr