

Management of radiological contamination – Feedback experience from several ISOE utilities

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- Radiological contamination control in nuclear power plants is essential to prevent personnel contamination and the spread of radiological contamination towards clean areas .

- 2018-2019 : the ISOE European Technical Center (ETC) carried out a collection of feedback experiences from utilities.

- ETC performed a survey on the management of radiological contamination addressing a number of sub topics including:
 - rules for the classification of areas,
 - means for controls of contamination,
 - management of PCEs,
 - organization and performance indicators.

- Dedicated questionnaire sent to RPM of ISOE community.
- Ten answers were collected and analysed.

Country	Plant	Number of units
France	Parc EDF	58
Spain	Almaraz	2
Spain	Vandellòs II	1
Sweden	Ringhals	4
Finland	Loviisa	2
UK	Sizewell	1
South Africa	Koeberg	2
China	Qinshan 3	2
China	Tianwan Nuclear Power Plant (TNPP)	2
USA	Prairie Island	2
USA	Exelon	19

- This presentation aims at providing highlights from the survey with regards to the actual controls of contamination (levels and devices), the management of PCEs and actions implemented for preventing the spreading of contamination
- This presentation focuses on control of contamination on workers rather than equipment, except in the case of controlled area exits

- Classification of areas

Plant	$\beta \gamma$ Contamination (Bq/cm ²)				
	<0,4	0,4->4	4->40	40->400	>400
EDF	Clean: NP	Contaminated: NC			
Almaraz	Supervised area	Controlled area with free access	Controlled area with limited access	Controlled area with regulated access	Controlled area with forbidden access
Vandellòs II	Non contaminated	Green	Yellow	Orange	Red
Loviisa	Clean area		Orange	Red	
Rinhals	Blue		4->100		>100
			Yellow		Red
Sizewell	Clean		Contamination controlled area		
Koeberg	Non contaminated	Green		Yellow	Orange
Qinshan 3	Non contaminated	Contaminated			
TNPP	Non contaminated			Contaminated	
United States	<0,17 Bq/cm ²	0,17-> 16,7 Bq/cm ²		>16,7 Bq/cm ²	
Prairie Island	Non contaminated	Contaminated		Very Contaminated	
Exelon	Non contaminated	Contaminated			

Means of control of contamination Workplace exits – control of workers

Utility	Radiation	Nature of control	Device	Alarm
EDF	β	Hands, clothes, skin	Portable MIP DL : 4 Bq/cm ²	A1: 0,4 or 4 Bq/cm ² A2: 10-40 kBq (part.)
Almaraz	β, γ, α	Hands, clothes, feet	Portable devices	-
Vandellòs II	γ, β	Whole body	RTM-870 PRE DL = 65 Bq or 1 Bq/cm ²	250 Bq 0,3 Bq/cm ²
Loviisa	β, γ	Hands, feet	Hand-foot monitor	Hands: 3 Bq/cm ² Feet : 6 Bq/cm ²
Koeberg	β	Whole body	-	> Background
Ringhals	β	-	Hand-foot monitor	8 Bq/cm ²
Qinshan 3	β, γ	Clothes	CoMo 170	0,4 Bq/cm ²
TNPP	β, γ	Clothes	-	-
Prairie Island	No control			
Exelon	β, γ		Portable devices	16,7 Bq

- Control by workers alone except in Almaraz.
- In case of important contamination risk : supervision by a RP technician (EDF, Qinshan)
- Different practices for control, all utilities (except Prairie Island) perform at least beta contamination control.
- Alarm threshold in coherence with contamination zones limit.

Means of control of contamination Reactor building exits – control of workers

Utility	Radiation	Nature of control	Device	Alarm
EDF	β	Hands and shoes	MIP 4 Bq/cm ² when possible	A1 : 4 Bq/cm ² A2 : 10-40 kBq (particulate)
Almaraz	$\beta, \gamma (\alpha)$	Hands, feet, clothes	Portable device	4 Bq/cm ²
Vandellòs II	γ, β	Whole body	RTM-870PRE LD : 65 Bq / 0,1 Bq/cm ²	300 Bq 0,35 Bq/cm ²
Loviisa	α, β, γ	Hands, feet	Hand-foot monitor	Hands : 3 Bq/cm ² Feets : 8 Bq/cm ² α : 2 Bq/cm ²
Koeberg	β, γ	Hands, face, feet (β) Whole body (γ)	Contamination monitor and & gamma portal	Any contamination > background and 800 Bq.
Ringhals	γ	Whole body	Fast fiber	200 kBq
Sizewell			Frisker	
Qinshan 3	β, γ	Partial / Whole body, clothes	Rados Handfoot Fibre™	0,4 Bq/cm ²
TNPP	β, γ	Hands, shoes and clothes.	Surface contamination monitoring instrument 0-9999 Bq/cm ²	4 Bq/cm ² (BCM1 ^a) 0,4 Bq/cm ² (BCM1)
Prairie Island	β	Min. Hands feet Regularly whole body	Portable device (hands) Hand-foot monitor Eberline PCM-1B	0 ,03 Bq/probe - 0,83 Bq/cm ²
Exelon/Sizewell			No control	

- Most often control by workers alone.
- Vandellòs, Qinshan : supervision by RP technician during outage
- Tianwan : control under RP supervision.

Means of control of contamination

Controlled area exits – control of workers

Utility	Radiation	Nature of control	Device	Alarm
EDF	γ (C1) β, γ (C2)	C1 : w/ clothes C2 : w/out clothes	2 portal monitors (C1 and C2)	C1 A1 : 15 kBq, C1 A2: 40 kBq C2 A1: 200 Bq hands, 800 Bq localized, 400 Bq for others ; C2 A2: 3 kBq
Almaraz	β (L1) β, γ (L2)	Whole body	2 portal monitors (L1 and L2)	L1 : 4 Bq/cm ² L2 : 0,4 Bq/cm ²
Vandellòs II	β, γ	Whole body	β : RTM-860, γ : GEM-5	β : 250 Bq, 0,6 Bq/cm ² γ feet : 550 Bq and 0,25 Bq/cm ² γ Whole body : 1500 Bq and 0,7 Bq/cm ²
Loviisa	β, γ	Whole body + ATP	2 portal monitors (Before and at exits)	Before exits : 3 Bq/cm ² hands and 8 Bq/cm ² feet. At exits : 2 Bq/cm ² and 1000 Bq γ
Koeberg	β, γ	Whole body	Portal monitor	80% of INPO reference levels
Ringhals	β & γ (feet)	Skin	Personal Monitor	-
Sizewell		Hands, feet, whole body	Rados RTM870	85 Bq
Qinshan 3	α, β, γ	Skin	Rados TSE II	190 Bq/485 cm ² (\approx 0,4 Bq/cm ²)
TNPP	β, γ	Clothes and shoes Whole body	BCM 1 for clothes BCM2 for skin	BCM1 : 4 Bq/cm ² BCM2 : 0,4 Bq/cm ²
Prairie Island	β, γ	1 : whole body γ 2 : whole body β	1 : Eberline PM-7 2 : Rados 2 steps exit monitor	1 : 2775 Bq ¹³⁷ Cs γ 2 : 0,83 Bq/cm ² β , 2775 Bq ¹³⁷ Cs γ
Exelon	β, γ		Portal monitors	5000 dpm or 83,3 Bq

Means of control of contamination

Controlled area exits – control of workers

- Controls at controlled area exits:
 - Worker alone (EDF, Koeberg, Ringhals, Sizewell, Prairie Island, Exelon)
 - Under RP technician supervision:
 - During the day: Almaraz, Loviisa
 - During outage: Qinshan, Tianwan, Vandellòs
 - In case of alarm: worker contaminated take in charge by RP technicians.

- Controls:
 - Whole-body beta/gamma control for all utilities.
 - Ringhals: gamma only for feet,
 - Qinshan: alpha

- 2 controls: one with clothes and the second without clothes with different alarm thresholds.

- Almaraz, Qinshan et TNPP: only surface contamination threshold.

Means of control of contamination

Controlled area exits – control of workers

- Thresholds for whole body contamination, punctual contamination, hands or feet or total activity depending on plants.
 - Lowest thresholds in surface contamination: 0,4 Bq/cm² (2nd portal monitor - TNPP, Qinshan and Almaraz).
 - Very low threshold in total activity for Exelon (83,3 Bq) and Sizewell (85 Bq).
 - Loviisa: 1000 Bq total) and Prairie Island (2775 137Cs éq. Bq).
 - Vandellòs: for body threshold in gamma fixed activity at 1500 Bq (250 Bq in beta) combined with surface contamination alarm at 0,7 Bq/cm² in gamma (0,6 Bq/cm² in beta)

Means of control of contamination

Controlled area exits – control of equipment

Utility	Radiation	Nature of control	Device	Alarm
EDF	β, γ	Direct or indirect measure	CPO/CGO Surface contamination probe + smears	CPO/CGO : 800 Bq Surface contamination probe or smears: 0,4 Bq/cm ²
Almaraz	α, β, γ		Portable device, CPO	0,4 Bq/cm ²
Vandellòs II	α, β, γ	Any object	RTM-610 FHT-111M WIMP-60 SCINTO	RTM-610: 120 Bq, 4 Bq/cm ² FHT-111M: 0,4 Bq/cm ² WIMP-60: α -0,04 Bq/cm ² , $\beta\gamma$ -0,4 Bq/cm ² SCINTO : γ 0,4 Bq/cm ²
Loviisa	β, γ	Surface or total activity	Portable device Object controllers	4 Bq/cm ² 400 Bq
Koeberg	β, γ	Surface or total activity	Surface contamination probe, objects controllers Spectroscopy	DL for surface contamination probe . 87 Bq for controllers.
Ringhals	γ	-	CPO	1 kBq
Sizewell			MPO MPG	75 Bq 150 Bq
Qinshan 3	β, γ		Rados RTM690	0,4 Bq/cm ²
TNPP	β, γ	Equipment and tools	MPO (CPO) 0-9999 Bq/cm ²	≈ 0,4 Bq/cm ²
Prairie Island	γ		SAM-11	≈ 81 Bq
Exelon	β, γ	-	CPO. In case of positive : control of surface contamination	5000 dpm ≈ 83 Bq

Means of control of contamination

Controlled area exits – control of equipment

- Control of all materials entered in Controlled area at the exit. Most often by RP technicians. Except Loviisa (CPO), Vandellòs (only during operation) and Sizewell.
- Beta and gamma emitters except Prairie Island et Ringhals (gamma). Also alpha for Almaraz and Vandellòs.
- Activity thresholds between 75 Bq at Sizewell (MPO) and 1 kBq at Ringhals.
- Surface contamination thresholds between 0,4 Bq/cm² (mainly) and 4 Bq/cm².
- Loviisa (4 Bq/cm²) : in practice no contamination of a material at controlled area exit.

- Procedure in case of a single alarm:
 - Graded approach, procedures depending on contamination level.
 - Most often worker perform a second (and sometimes a third) control to confirm or not the contamination.
 - Radiation Protection service called depending on contamination level. Worker remove his clothes and shower before new control.
 - Identification of working area to avoid other contaminations and if necessary control and cleaning.

- Procedure in case of several contaminated workers
 - Same procedures as for single alarm.
 - **But** investigation to identify activity and areas concerned are responsive and advanced. In some cases, activity is stopped (more than 3 workers contaminated, .
 - Usually, area is concerned by complementary measures and cleaning or decontamination
 - Preventive measures are reinforced depending on observations.

- Several alarms for the same worker
- Different type of actions depending on plants:
 - Interview with radiation protection department or management to identify causes, remind RP objectives,...
 - Training to be done again: systematically or for a specific lack of competence
 - Disciplinary actions:
 - access to controlled area forbidden temporary or definitely.
 - Can be up to plant access forbidden depending on gaps natures or voluntary non-respect of instructions

Means to prevent the spread of contamination

- Technical means in addition to decontamination or purification before the activity.
- Use of temporary containment depending on level of contamination : Almaraz, Koeberg, Ringhals, Qinshan et Exelon.
- Koeberg et Ringhals : also dynamic containment
- Radiation protection good practices on work places to limit spread of contamination outside work place:
 - Demarcation of workplace and signalling,
 - Use of trap mats at area exit
 - Area protection with vinyl,
 - Use of mats for knees when job requires kneeling or lying down (Sizewell).
 - Use of carpets for work that needs kneeling or lying down (Sizewell), use of bags to collect leaks and drips when opening loops (Exelon, EDF),
 - Use of PPEs and PCEs adapted to work conditions (Loviisa, Ringhals)
 - Importance of monitoring and cleaning of transit areas (Almaraz, Tianwan)
 - EDF : use of a fixative for contamination on ventilated suit during unclothing

- The international study made possible, based on feedback from 10 RPM, to detail modalities of zoning contamination and practices in terms of radiological controls.
- It was not simple to compare practices and performances : organisations are radically different, notably in terms of implication of RP management and more broadly human resources. The zoning criteria are various, as well as nature of controls on workers and equipment.

Thank you for your attention !

Information on control of equipments

Means of control of contamination Workplace exits – control of equipment

Utility	Radiation	Nature of control	Device	Alarm
EDF	β	Direct or indirect measure	MIP	4 Bq/cm ² when possible
Almaraz	$\beta, \gamma (\alpha)$	-	Portable device	-
Vandellòs II	γ, β	Equipment, tools	FHT-111M DL : 0,25 Bq/cm ²	4 Bq/cm ²
Loviisa	β, γ	Surface	Portable device	4 Bq/cm ²
Koeberg	β, γ	100% surface	Portable device	DL
Ringhals	α, β, γ	-	Portable device and smears	-
Qinshan 3	β, γ	-	CoMo 170	0,4 Bq/cm ²
TNPP	β, γ	Equipment, tools	-	-
Exelon	β, γ	If needed, zip bag and control in low background zone	Portable device	1000 dpm 16,67 Bq

- Difference from one site to another :
 - Control by worker (EDF, TNPP)
 - Control by worker under RP technician supervision (Exelon, Qinshan, Vandellòs)
 - Control by RP technicians (Almaraz, Koeberg, Loviisa, Ringhals)
- Systematic control of beta/gamma emitters
- Sometimes control of alpha depending on works
- Most often threshold 4 Bq/cm²

Means of control of contamination

Reactor building exits – control of equipment

Utility	Radiation	Nature of control	Device	Alarm
EDF Everest	β, γ	Direct or indirect measure	MIP and CP0	MIP : 4 Bq/cm ² CP0 : 800 Bq
EDF non-Everest	β	-	MIP and Hand-foot monitor	Hands 580 Bq and 7,5 kBq Shoes 3 kBq et 40 kBq
Almaraz	No control			
Vandellòs II	γ, β	Equipment and tools	FHT 111-M LD: 0,25 Bq/cm ²	4 Bq/cm ²
Loviisa	β, γ	Surface	Portable device	4 Bq/cm ²
Koeberg	β, γ	100% external surface	Surface contamination monitoring instrument	LD
Ringhals	α, β, γ	-	Portable device and smears	-
Sizewell	α, β, γ		Portable device	85 Bq β and 400 Bq γ
Qinshan 3	β, γ			0,4 Bq/cm ²
TNPP	β, γ	Surface of tools and equipments	Surface contamination monitoring instrument 0-9999 Bq/cm ²	$\approx 0,4$ Bq/cm ²
Prairie Island	β, γ et α if needed		Surface contamination monitoring instrument (SAM-11 or equivalent)	≈ 81 Bq
Exelon	No control			

Means of control of contamination

Reactor building exits – control of equipment

- Exit of RB :
 - EDF : control by worker
 - Under supervision of a RP technician during outage : Vandellòs, Qinshan et TNPP
 - Control by RP technicians at Prairie Island, Ringhals, Koeberg, Sizewell and Loviisa

- Majority of utilities perform beta/gamma contamination measurements except :
 - Almaraz and Exelon : no controls
 - Ringhals and Prairie Island also alpha