EDF's Radioprotection Strategy for an Opimized RHRS and CVCS Circuit Decontamination Plan

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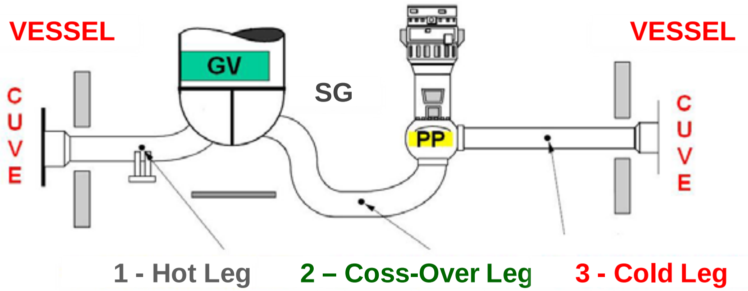
1. RADIOLOGICAL SURVELLANCE PROGRAM (I)

Dose rate measures

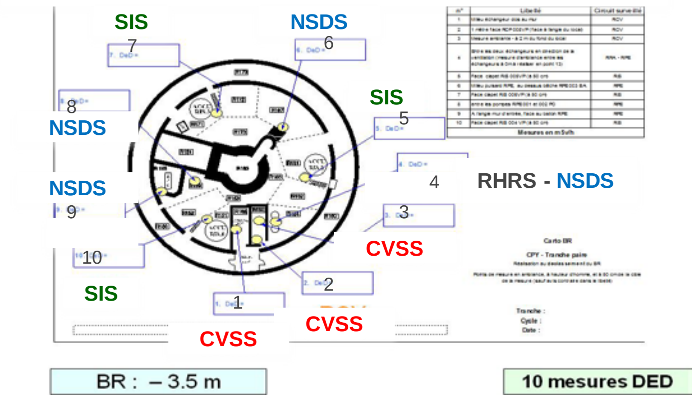
LOOP Index Cartography



9 or 12 measurement points: 900 MW or 1300-1450 MW

RB Index Cartography

46 Dose Rate meaasurements



6 RB Levels : - 3,5 / 0 / 4 / 8 / 11 / 20 m

Primary circuit : RCS

Auxiliary circuits: RHRS, CVCS, …

1. RADIOLOGICAL SURVELLANCE PROGRAM (II)

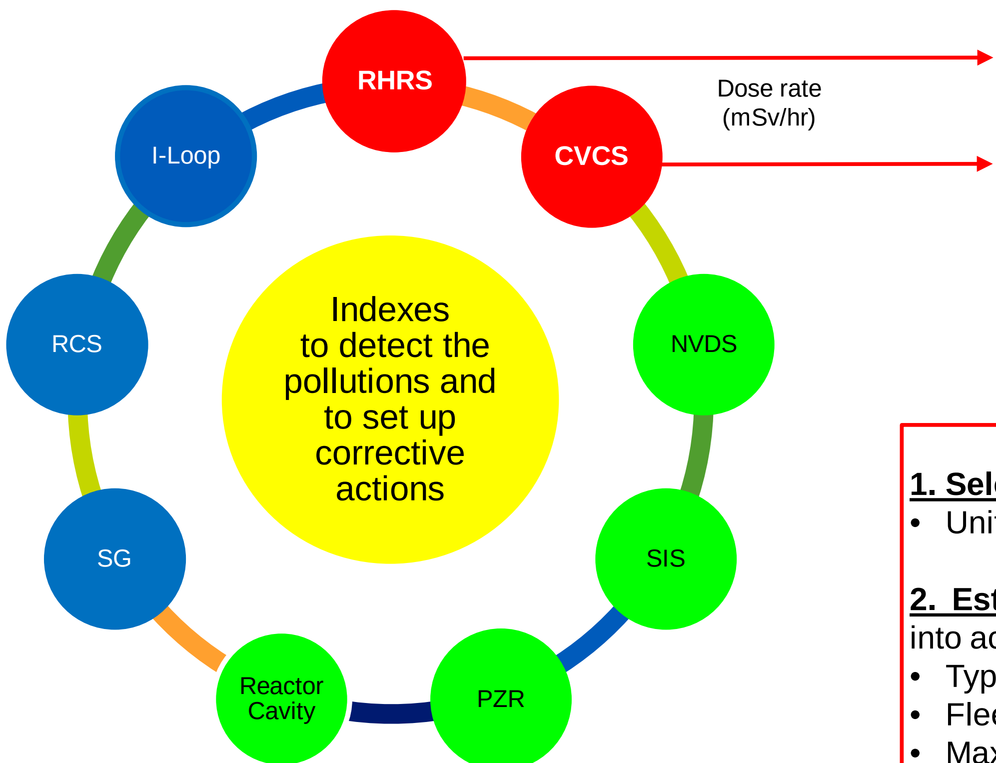
CZT spectrometry measures

CZT optimized program			
P1a **P1b**	CVCS	Before purification system	Power operation After fuel download
P2a **P2b**	CVCS	After purification system	Power operation After fuel download
P3a **P3b**	CVCS	Exchanger	Power operation After fuel download
P4a **P4b**	RCS	Crossover leg	Hot shutdown Pool flooding beginning
P5a **P5b**	RCS	Hot leg	Hot shutdown Pool flooding beginning
P6a **P6b**	RCS	Cold leg	Hot shutdown Pool flooding beginning
P7a **P7b**	SIS	Valve	Hot shutdown Pool flooding beginning
P8a **P8b**	RHRS	Exchanger	Hot shutdown Pool flooding beginning

→ CVCS, RCS, SIS & RHRS circuit characterization

2. INITIAL METHODOLOGY TO PLAN DECONTAMINATION

- Based on the analysis of 2 radiological indexes, so as to establish the contamination state of the circuits : RHRS and CVCS respectively
- When an index is higher than 25% of the average of it series, it appears in red in the matrix.



	2									
	ILoop	IRE	AUXILIARY CIRCUIT INDEXES							
			RHRS	CVCS	NVDS	SIS	PZR	SG	RCS	RC
Unit A		↘	↘	↘	↘	↘		↘		
Unit B	↘	↘	↘	↘	↗	↗	↗	↘		
Unit C	↗		↗			↗	↗		↘	
Unit D	↘						↘		↗	
Unit E		↗	↗	↗	↗	↘	↗		↗	↘
Unit F	↗	↗	↗	↗	↗	↘	↗	↗		↗

1. Selection of eligible unit for decontamination

- Unit with RHRS and/or CVSC red indexes.

2. Establishment of a decontamination program taking into account the following 3 parameters :

- Type of outage (standard , ten-year, …)
- Fleet outage schedule (no decontamination in parallel)
- Maximum number of decontaminations (4 per year)

Only RHRS/CVCS are decontaminable

The implementation of a decontamination requires a draining of the circuits up to the invert level

The goal is to bring back the most polluted units to the average of their series.

3. INITIAL METHODOLOGY LIMITS & FUTURE DEVELOPMENTS

LIMITS

Initial metodology

- L1: RHRS and CVCS indexes are able to change year to year, which leads to the possibility of reevaluating the ongoing program.
- L2: The main maintenance activities of the RHRS and CVCS circuits are not taken into account in the preparation decontamination schedule.

DEVELOPMENTS

Future developments ➩ New methodology

- D1: To take into accout the average of the RHRS/CVCS indexes calculated over the last 4 consecutive years, which allows a consolidation of these indexes.
- D2: To consider the maintenance programm focusing on RHRS and CVCS circuits for 5 years following the decontamination

  →Result: To optimize RHRS and CVCS decontamination date, prior to major maintenance activities, in order to increase dosimetric gains.

4. New methodology applied to optimizing a decontamination program

STEP 1: Consolidation of the RHRS/CVCS indexes, taking into account their evolution over the last 4 consecutive years

Year Index	RHRS				CVCS			
	2013	2014	2015	2016	2013	2014	2015	2016
UNIT A								

Eligible Unit, from a total of 2 red indices

STEP 2: Consideration of RHRS & CVCS maintenance activities, for the 5 years following the decontamination.

RHRS/CVCS Red Indexes			Year of Maintenance Activities				Number of Activities f (Year of Decontamination)				Product of Red Indexes & Number Activ.			
RHRS	CVCS	Total	HT*/ RHRS	MR*/ RHRS	HT*/ CVCS	MR*/ CVCS	2019	2020	2021	2022	2019	2020	2021	2022
2	3	5	2019		2025	2025	1	2	2	2	**5**	**RO**	**10**	**RO**

This weighting allows the choice of the optimal year for decontamination

***HT: hydrostatic test – RM: material replacement**

CONCLUSION: In this case, unit A is eligible. The optimal year for decontamination is 2021

5. 2019-2022 RHRS/CVCS DECONTAMINATION PROGRAMMING (I)

Selection of eligible units, and determination of an optimal date for decontamination

Classification by increasing red index number

Unit	Number of red index	Optimal year for decontamination	
		Choice # 1 (matrix weight)	Choice # 2 (matrix weight)
Unit 1	5	2021 (15)	2023 (15)
Unit 2	5	2022 (15)	2024 (20)
Unit 3	4	2019 (8)	2021 (8)
Unit 4	4	2022 (12)	2024 (12)
Unit 5	4	2020 (8)	-
Unit 6	3	2019 (12)	-
Unit 7	3	2022 (9)	-
Unit 8	3	No shutdown	
Unit 9	2	No shutdown	
Unit 10	2	2019 (6)	2023 (4)
Unit 11	2	2024 (4)	2024 (4)
Unit 12	2	2021 (6)	2023 (6)
Unit 13	2	2020 (4)	2024 (4)
Unit 14	2	2020 (6)	2024 (4)
Unit 15	2	2019 (6)	2024 (4)
Unit 16	2	2022 (8)	2024 (6)
Unit 17	2	Hot spot pollution. Priority to eradicate this pollution, before decontamination.	
Unit 18	2	2024 (6)	2021 (4)
Unit 19	2	2019 (4)	2024 (4)

Tool extraction to determin the optimized decontamination year

UNIT	Prog. 2019	Prog 2020	Prog 2021	Prog 2022	Prog 2023	Prog 2024
UNIT 9	8	-	*RO	2	2	-
UNIT 10	6	RO	2	RO	4	RO
UNIT 11	RO	4	RO	0	RO	4
UNIT 1	5	RO	15	RO	15	RO
UNIT 12	0	RO	6	RO	6	RO
UNIT 2	RO	10	RO	15	RO	20
UNIT 6	12	RO	3	RO	3	3
UNIT 13	RO	4	RO	0	RO	4
UNIT 3	8	RO	8	RO	8	RO
UNIT 14	RO	6	RO	2	RO	4
UNIT 7	6	RO	-	9	RO	-
UNIT 8	RO	9	-	RO	0	-
UNIT 15	6	RO	2	-	RO	4
UNIT 16	4	RO	-	8	RO	6
UNIT 17	8	-	0	RO	-	0
UNIT 18	RO	-	4	RO	-	6
UNIT 4	4	-	RO	12	-	12
UNIT 19	4	RO	0	-	RO	4
UNIT 5	RO	8	-	0	RO	-

* RO: Refuiling Outage

5. 2019-2022 RHRS/CVCS DECONTAMINATION PROGRAMMING (II)

OPTIMAL YEAR OF RHRS/CVCS CIRCUIT DECONTAMINATION							
2019		2020		2021		2022	
UNIT 6	April 4th	**UNIT 5**	August 8th	**UNIT 1**	January 5th	**UNIT 2**	February 7th
UNIT 3	March 3rd	**UNIT 11**	June 6th	**UNIT 12**	October 10th	**UNIT 7**	January 1st
UNIT 15	May 1st	**UNIT 13**	February 5th	**UNIT 18**	March 3rd	**UNIT 16**	May 3rd

↓ **UNIT TO BE DECONTAMINATED**

↓ **DATE OF THE BEGINING OF THE SHUTDOWN**

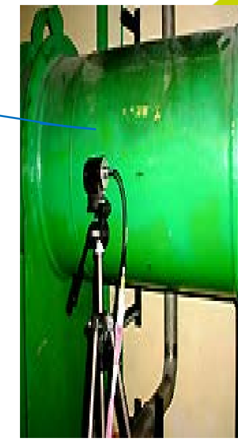
GAIN IN DOSE WITH RHRS/CVCS DECONTAMINATION ?

- **Objective**: Implement a qualified chemical process on circuits to significantly decrease the dose rates.

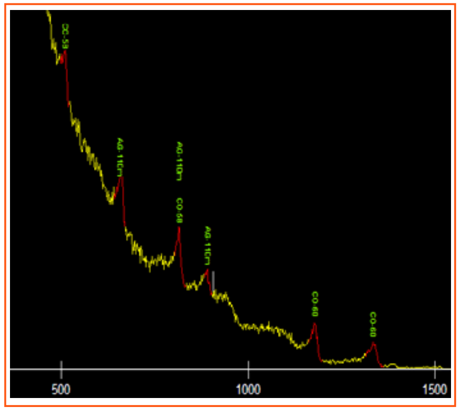
- **Process**:Oxydo-reduction process / EMMAg or EMMAC-POA depending on the majority radionuclide (identified through CZT measures) and materials in the circuit.

- **Feedback experience**: The dose rate reduction factor varies between 2 and 4, and the estimate of the collective dose saved is several hundred person.mSv over 5 years.

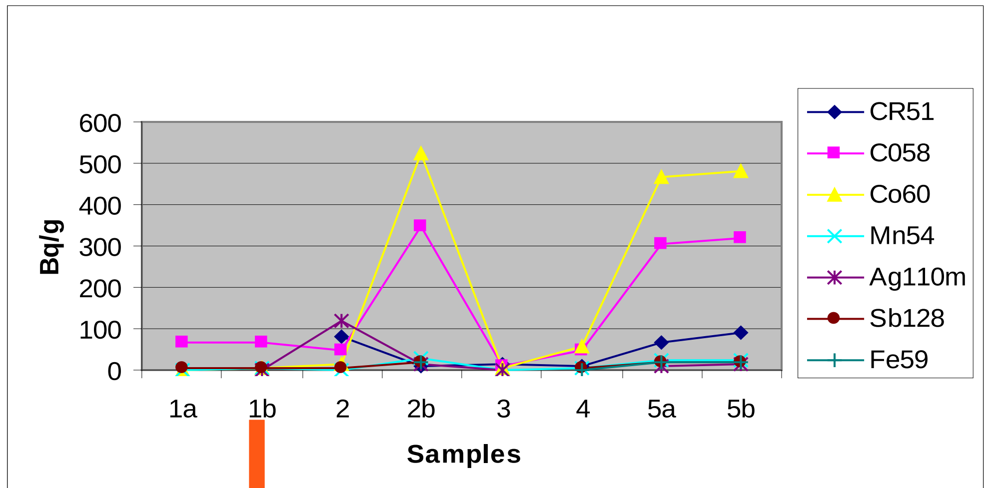
OPTIMISATION OF THE DECONTAMINATION PROCESS



Decontamination process depends on the radioelement to be removed



DR : 70% Ag110m
+ 20 %Co60 + 10% Co58



EMMAg process

EMMAg = Qualified process :
Ag removal

Ag110m
Dissolution

RESULT

Dose Rate Reduction
Factor > 3 (average)

SYNTHESIS

Selection of eligible units for decontamination on the basis of the consolidated indexes → Eligible unit: Total RHRS & CVCS red indexes ≥ 2.

The prioritization for implemented decontamination is based on the number of red indexes

Distribution of the eligible units according to:

- The fleet outage planning
- The weight associated with maintenance activities according to the year chosen for decontamination.

Taking into account logistical and budgetary considerations:

- One decontamination at a time, with 5 weeks delay between 2 decontaminations (currently, just a single contractor) .
- Due to budgetary resources, 3 or 4 decontaminations will be implemented per year

6. CONCLUSIONS & PROSPECTS

The EDF industrial program of maintenance and modifications will have a significant impact on collective doses.

For already 4 years, EDF has evaluated the impact on doses and performs actions in order to manage the increase of doses:

- Decontamination of the most polluted units is one of the main technical ALARA actions applicable to the entire fleet to save collective doses.
- Today, feedback experience shows that the estimated collective dose saving is higher than hundred person.mSv per decontamination (typically, between 200 and 800 person.mSv over 5 years).

From now on, the treatment of hot spots becomes a priority. EDF has developed a strategy adapted to this treatment which will be enriched by good practices resulting from NPP international feedback experience. I suggest presenting this information at the next congress.

Thank you
For your attention

2019-2022 RHRS/CVCS DECONTAMINATION PROGRAMMING

- **2019** (3 decon. Max) **: UNIT 6** and **UNIT 3** are a priority (3 and 4 red indexes respectively). Concerning the 3rd candidate, 2 possibilities: UNIT 10 and UNIT 15, with 2 red indexes and a weight of 6 given by the excel tool. The selected choice is **UNIT 15** which has a pollution of RHRS and CVCS circuits, while that the UNIT 10 is located on the RHRS circuit only.

- **2020** (3 decon. Max) : **UNIT 5** is a priority (4 red indexes).
  + 3 units to be split (2 red indexes): UNIT 11 , UNIT 13 and UNIT 14.
  Having regard to the overlap between UNIT 14 and UNIT 5 shutdowns (les than 5 weeks), UNIT 14 is postponed until 2024. Consequently, **UNIT 11** and **UNIT 13** are maintained in 2020.

- **2021** (4 decon. Max) : 3 Units: **UNIT 1** (5 red indexes), **UNIT 12** and **UNIT 18** (2 red indexes). + 1 vacant place.

- **2022** (4 decon. Max) **: UNIT 2 (**5 red indexes), **UNIT 4** (4 red indexes), **UNIT 7**(3 red indexes) and **UNIT 16** (2 red indexes). However, UNIT 4 decontamination is postponed until 2024, because of overlap with UNIT 2 schutdown (higher number of indexes).