



Elaboration of an Optimized Source Term Reduction Program for a 58 Reactors Fleet

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CHANGER L'ÉNERGIE ENSEMBLE



Content

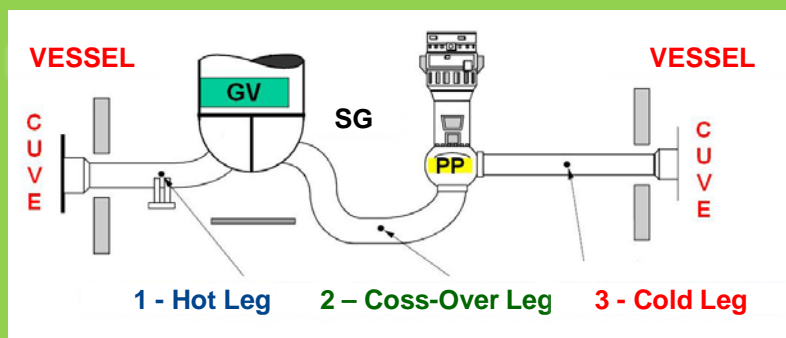
- 1. Systematic measurements of the Optimized Source Term Reduction Program**
- 2. Results of the Source Term Indicators obtained at the beginning of shutdowns.**
- 3. Remedies: curative action proposed**
- 4. Synthesis and conclusions**

Optimized Surveillance : RCS Index



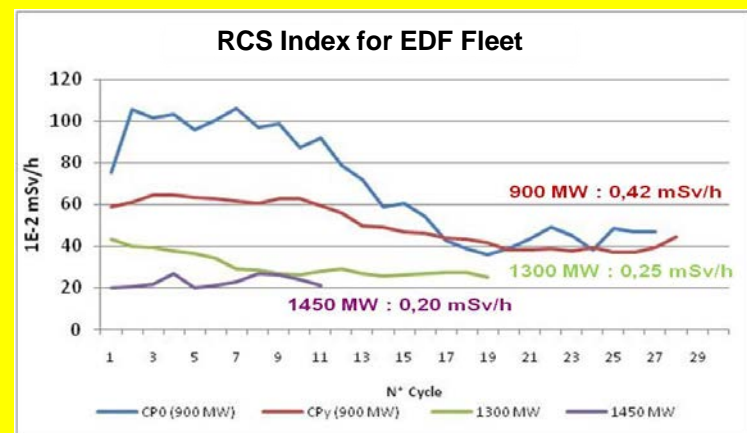
- ❑ It has been implemented at EDF since the origin (Fessenheim 1 NPP), at the beginning of shutdowns. This Index is historical : data are extremely rich for the EDF NNPs.
- ❑ It is obtained by the average of the dose rates measured on the primary loops. It represents the **contamination of the primary circuits**.
- It helps in deciding to inject zinc for RP goals. Curative (high Co60 contamination level) and preventive (SG replacements, ...)

RCS Index Cartography



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

RCS Index trend since the origin



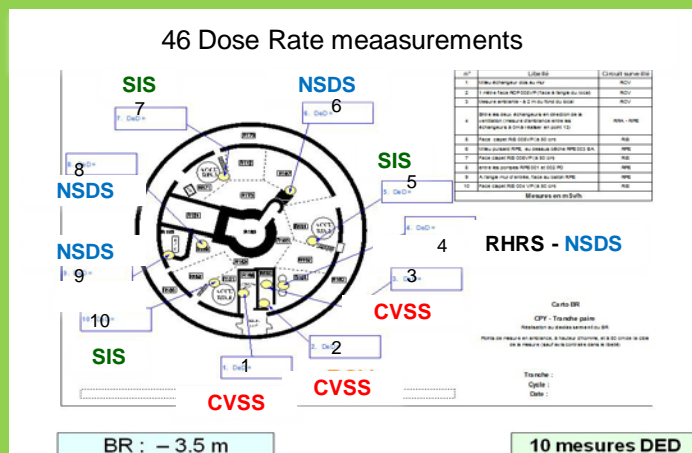
900 MW > 1300 MW > 1450 MW

Optimized Surveillance : RB Index



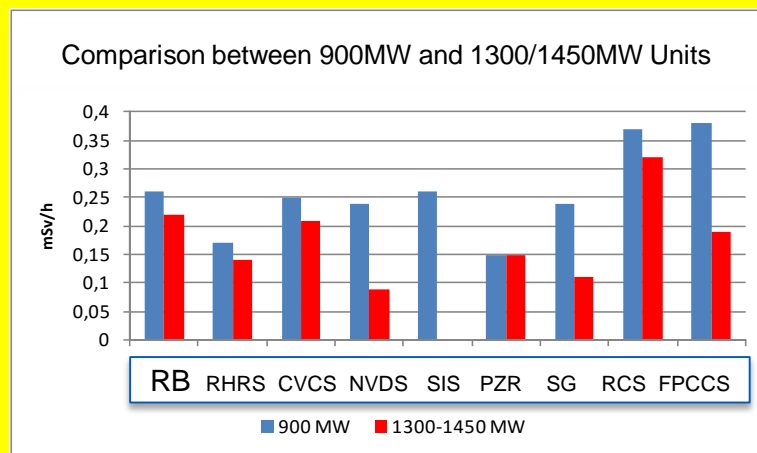
- ❑ It has been implemented for all EDF reactors since 2011 at the beginning of the shutdown
- ❑ It is obtained by the average of the dose rates taken off the auxiliary circuits. It illustrates the **auxiliary circuits contamination** which is complementary to the RCS Index, itself limited to the primary circuit
- It helps in deciding which are the most polluted circuits to be decontaminated

RB Index cartography



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

RB Index and Sub-Index - Averages in 2011



Optimized Surveillance : CZT Gamma Spectrometry

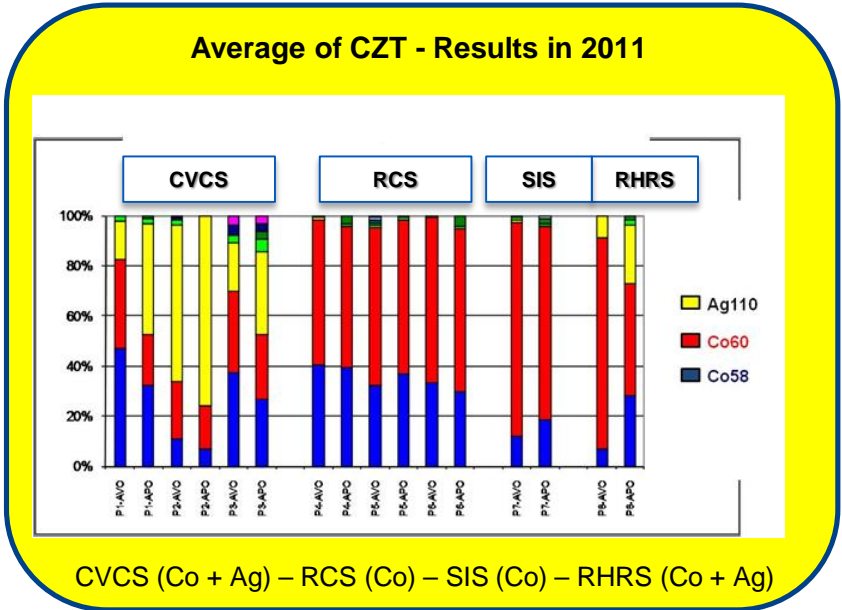


- It has been deployed across the EDF Fleet since 2011 in complement to RB index on each shutdown, before and after oxygenation.
- It characterises the contribution of the principal radioactive elements of the primary and auxiliary Dose Rates.
- It helps to choose the appropriate chemical solution for decontamination (+ to calculate efficiency).

CZT Optimized Program: 8 points

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

a : before oxygenation – b: after oxygenation.



Results of the Source Term Indicators (2014 outages)

The state of Source Term depends on the series.
Dose Rate Indices allow us to develop a Relevant Source Term Reduction Program.
Proposed remedy depends on circuit indices

Example: DR Index state used to develop the second series STR Program
(24 units : 4 loops)

1300 - 1450 MW	2014 outages											Synthesis				
	Dose/hr.RCA	I _{top}	I _{DR}	RB sub-index							Dose rate	Dose/hr.RCA	Evolution			
				RHRS	CVCS	NVDS	PZR	SG	RCS	FPCCS						
1																
2																
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First series (34 units :3 loops)

The Source Term Reduction Program is being defined for the 2015-2021 period
43 Units are concerned

Index is red when > 25 % over the average

Results of the indicators and proposed curative action

Source Term Reduction Program : EDF Methodology

Circuit

Index

Remedy

**Primary
circuit**

If the I_{loop} and/or
RCS and/or **SG**
indices are red, then
the primary circuit is
polluted

**Optimization of
the use of
biological
shielding –
CADOR software**

**RHRS/CVCS
circuits**

If the **RHRS** and/or
CVCS indices are
red, then the RHRS
and/or CVCS
circuit(s) is (are)
polluted

**Chemical
decontamination
of the circuits
using qualified
process**

**Other
auxiliary
circuits**

If the **NVDS** and/or
SIS and/or **PZR**
and/or **FPCS**
indices are red, then
the units are polluted
with hot spots

**Hot spot
elimination**

CURATIVE ACTIONS (1/2)

- **1- Chemical decontamination of Residual Heat Removal System (RHRS) and/or Chemical Volumetric Control System (CVCS)**
 - Objective: implement a qualified chemical process on circuits to dramatically decrease the dose rates
 - Process: oxydo-reduction processes / EMMAg or EMMAC-POA depending on the majority radionuclide (identified through CZT measurements) and materials in the circuit
 - Average dose rate reduction factors of 2 to 3, estimated collective dose saving of many 100 person.mSv over 5 years.



- **2 - Hot spot elimination actions**
 - Implement curative actions (flushing, replacement of valves, etc.) using existing good practices,
 - Identify actions to limit the emergence of new hot spots.

CURATIVE ACTIONS (2/2)

- **3 - Optimization of the use of biological shielding with the CADOR software**
 - Define the biological shielding plan with an optimization analysis depending on the work to be performed,
 - Prepare organization, resources and means,
 - Implement the identified biological shielding options, follow the efficiency and, if necessary, adapt the program,
 - Provide feedback experience.

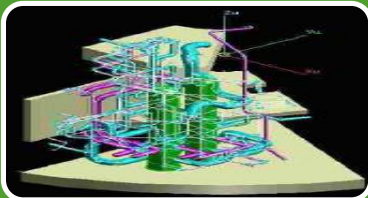


SYNTHESIS AND CONCLUSIONS



Implementation of the CADOR software

- 35 proposed implementations until 2021
- Feedback: 13 implementations since 2011. Average dose saving :
→ 26 person.mSv / standard outage and 71 person.mSv / 10-years outage



Chemical decontamination of RHRS and CVCS

- 27 selected units until 2021
- Feedback: 15 units cleaned up since 2004. Average dose saving :
→ 500 person.mSv estimated over the 5 outages following the decontamination



Hot spot elimination

- 28 priority units

■ As a conclusion, 43 units may be treated to improve their source term: 75% of the units of the French Fleet. The distribution is the following :

- 15 units with only one proposed curative action,
- 14 units with 2 proposed curative actions,
- 14 units with 3 proposed curative actions: chemical decontamination , CADOR and, hot spot elimination.

THANK YOU