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

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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
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
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

**Optimized Surveillance : RB Index**

### RB Index Cartography

- 46 Dose Rate measurements
- 6 RB Levels: - 3.5 / 0 / 4 / 8 / 11 / 20 m

### RB Index and Sub-Index - Averages in 2011

Comparison between 900MW and 1300/1450MW Units

- 900 MW > 1300 – 1450 MW
- 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**

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<th>Power operation after fuel download</th>
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<td>P8b</td>
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<td>Hot shutdown</td>
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a: before oxygenation – b: after oxygenation.

**Average of CZT - Results in 2011**
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)

First series (34 units : 3 loops)

The Source Term Reduction Program is being defined for the 2015-2021 period. 43 Units are concerned.
Results of the indicators and proposed curative action

### Source Term Reduction Program: EDF Methodology

#### Circuit

- **Primary circuit**
  - If the $I_{loop}$ and/or RCS and/or SG indices are red, then the primary circuit is polluted
  - Remedy: 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
  - Remedy: Chemical decontamination of the circuits using qualified process

- **Other auxiliary circuits**
  - If the NVDS and/or SIS and/or PZR and/or FPCCS indices are red, then the units are polluted with hot spots
  - Remedy: 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

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.

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
THANK YOU