EDF Feedback on the management and the treatment of Ag-110m contamination

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Silver 110m is a 253 days half live and it is a strong gamma emitter (main rays : 658 and 884 KeV)

Many PWRs have problems of silver contamination during shutdowns, with significant consequences on radiation protection and maintenance programs

Ag-110m behavior is badly known. It contaminates preferentially cold circuits : CVCS and sampling circuits.

At EDF, the contribution of Ag-110m to the dose is estimated at about 15 % (in the units contaminated by silver)

The sources of the silver release in PWRs could either be a leaking hole in the silver-indium-cadmium (AIC) control rods or a wear of some silver-coated seals.

The aim of this presentation is to answer to the following questions :

1 – How important is the contribution of each source of silver release ?

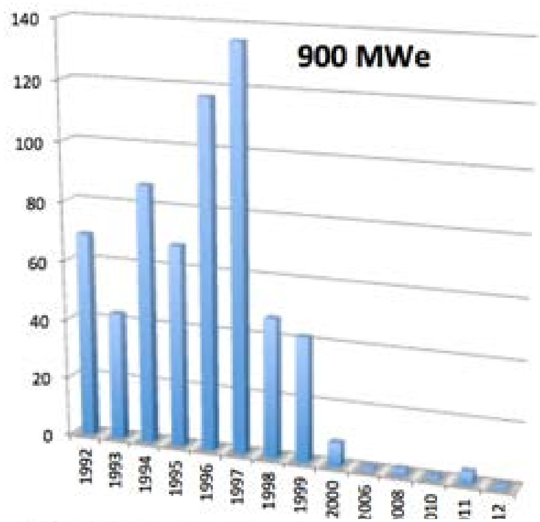
2 – Are there easy and quick ways to identify the cause of the silver release ?

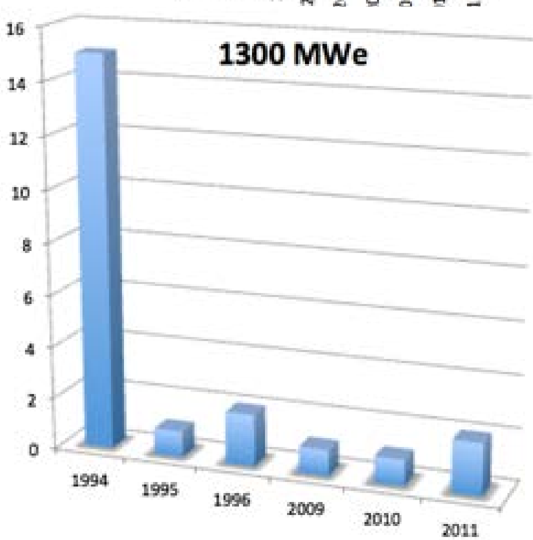
3 – As a curative solution, how efficient is the chemical decontamination in the cases of Ag-110m pollution ?

1 – How important is the contribution of each source of silver release ?

Contribution of damage of Ag-In-Cd control rods to circuit contamination by Ag-110m

Number of AIC control rods with disseminating damage





- **900 MWe Fleet :**
  Control rods have been replaced progressively (1992-2006) by rods with anti-wear treatment (Cr plating or nitride treated).

- **1300 MWe Fleet :**
  - the cladding is twice thick compared to that of 900
  - larger gap between the absorber and the cladding
  - the rods contain two types of absorber : AIC, B_4C
  - anti-wear treatment

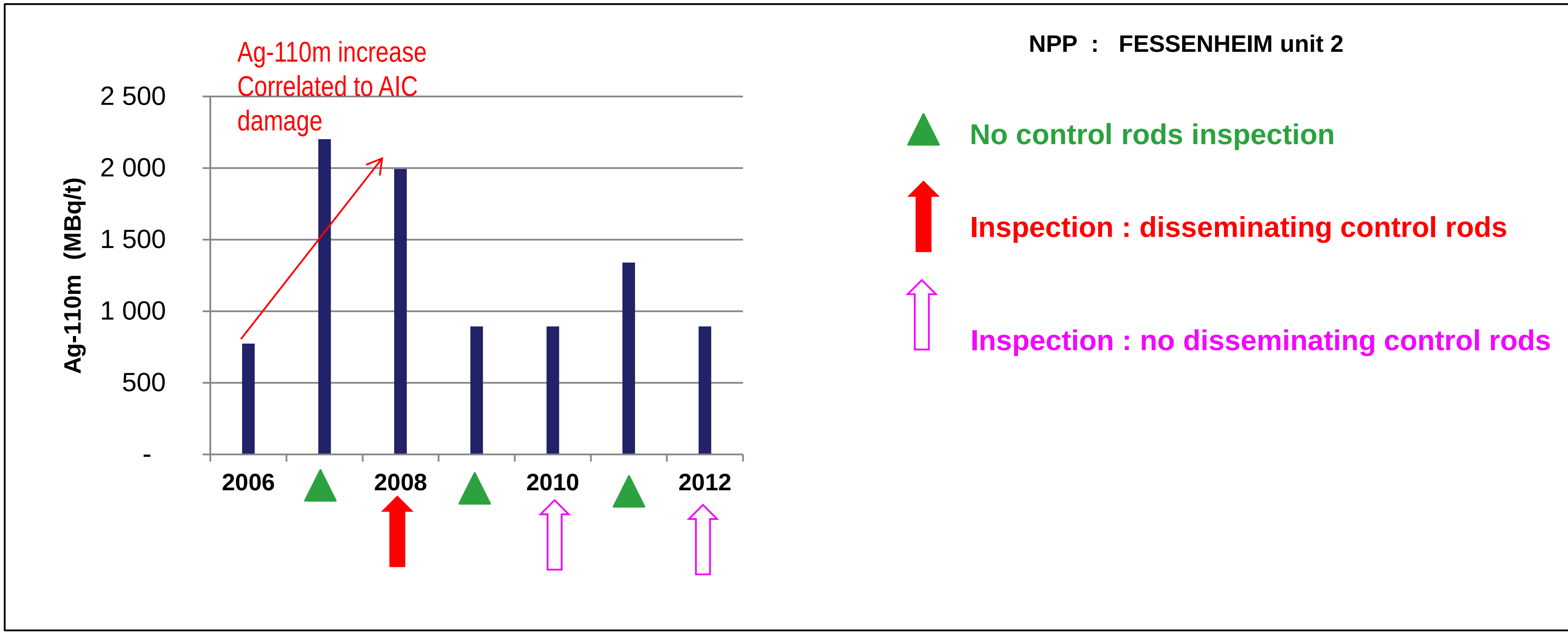
Control rods of 4-loops fleet have been less effected by the wear than those of 3-loops fleet

Since 2006, all control rods at EDF units have had an anti-wear surface treatment.

How important has the contribution of the control rods been to the silver contamination since 2006?

Contribution of damage of Ag-In-Cd control rods to circuit contamination by Ag-110m

How important has the contribution of the control rods been to the silver contamination since 2006 ? → **Correlation between Ag-110m coolant activity at the shutdown and the inspection results of the control rods**



At EDF, since 2006, almost 25% of the cases of silver activity increase have been correlated to AIC control rod damages

2 – Are there easy and quick ways to identify the cause of the silver release ?

Method of Determination of the Silver Release Source in the PWR Primary Coolant

- The determination of the source of the released silver is an important challenge for the improvement of radiation protection, maintenance, and safety in a PWR..

- How can we make a distinction between :

  a leaking hole in the silver-indium-cadmium (AIC) control rods

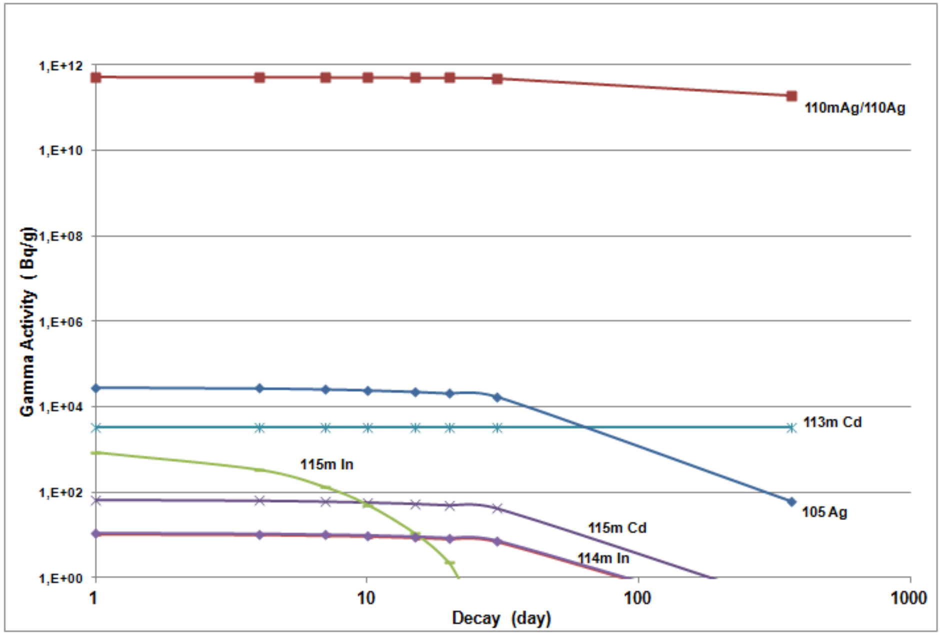
  and

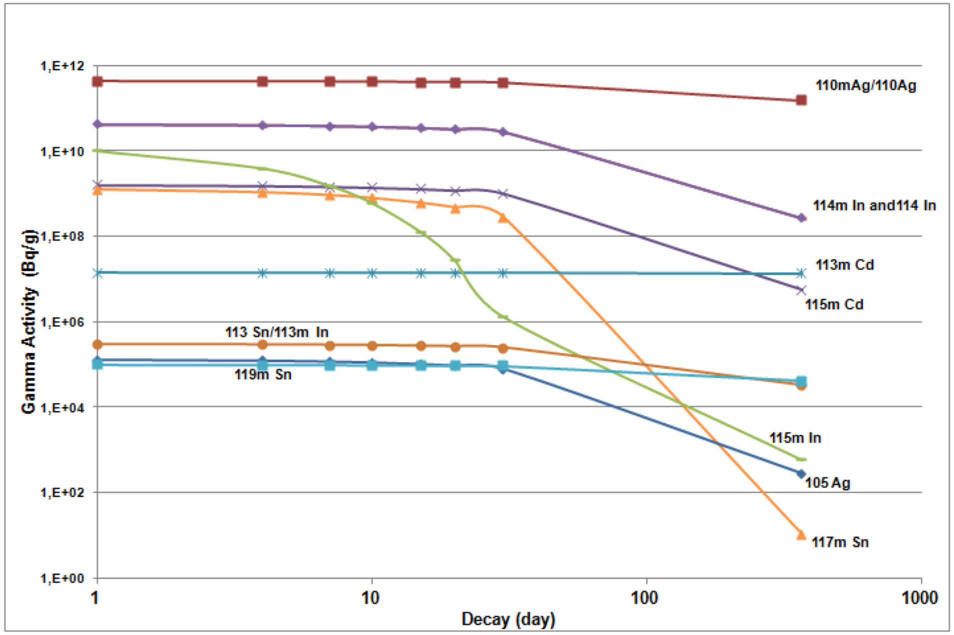
  a wear of some silver-coated seals which may be in contact with the coolant

? ? ?

Method of Determination of the Silver Release Source in the PWR Primary Coolant

Calculation of the isotopes resulting from the activation of 1 g of silver and 1 g of AIC in a typical 900 MWe PWR (DARWIN code)

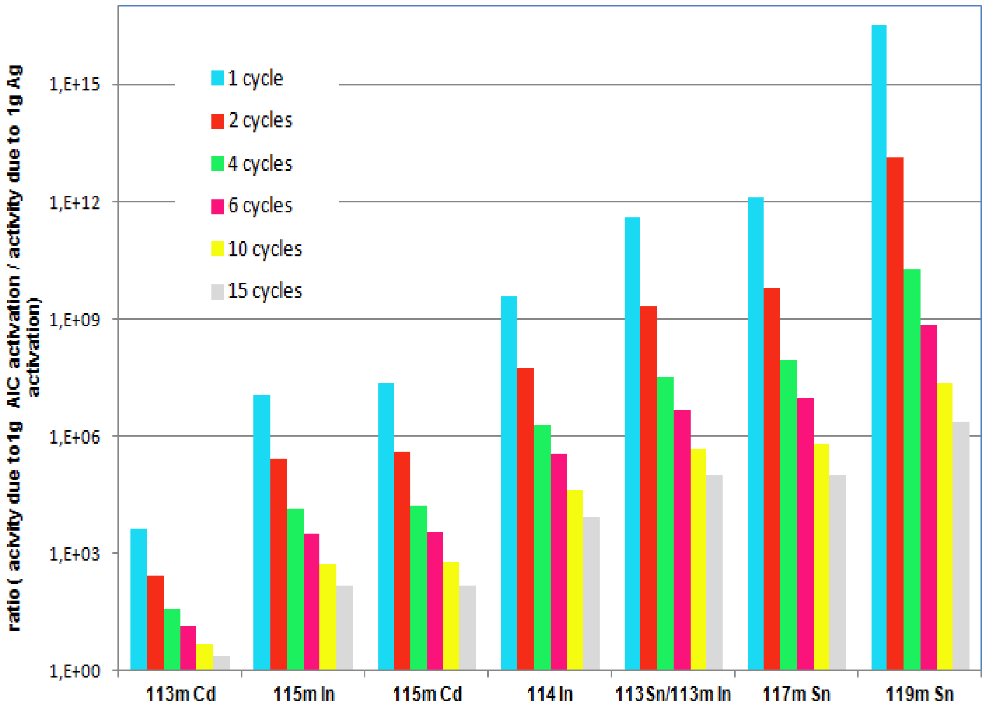




1 cycle activation of 1g Silver

1 cycle activation of 1g AIC

Method of Determination of the Silver Release Source in the PWR Primary Coolant



RATIO = (AIC activation) / (Ag activation

- few units for ^{113m}Cd
- few hundred for ^{115m}In ; ^{115m}Cd
- few thousands for ^{114}In
- **10^5 for ^{113}Sn/^{113m}In ; ^{117m}Sn**
- **10^6 for ^{119m}Sn.**

The higher the ratio is, the more selective the indicator is. consequently, a relevant tracer of an AIC control rod leaking can be selected among the following isotopes: ^{119m}Sn, ^{117m}Sn and ^{113}Sn /^{113m}In.

Method of Determination of the Silver Release Source in the PWR Primary Coolant

- We have analyzed gamma spectroscopy data of EDF fleet.
- ^{119m}Sn is not indexed in the EDF data because it has never been detected. Therefore, ^{119m}Sn can not be selected as a tracer.
- All the cases of the detection of ^{117m}Sn or ^{113}Sn /^{113m}In correspond to a simultaneous detection of ^{110m}Ag.
- We have not found any case of ^{117m}Sn or ^{113}Sn /^{113m}In detection without ^{110m}Ag detection.

	Gamma spectroscopy			AIC control rod inspections	
Unit	Cycle	$^{113}Sn/^{113m}In$ (MBq/t)	Reactor	Cycle	Number of disseminating rod
A	12	1.64	Shutdown	12	2
	15	4.25	Shutdown	15	9
	16	0.08	Shutdown	17	4
B	8	12.4	Shutdown	8	4
C	8	0.04	Full power	8	3
D	12	0.05	Full power	12	6

EDF Feedback of cases of AIC control rod leaking

Method of Determination of the Silver Release Source in the PWR Primary Coolant

- Theoretical calculations, as well as feedback data have shown that ^{117m}Sn or ^{113}Sn /^{113m}In are **relevant indicators** of the source of a silver contamination :

A simultaneous increase of (^{110m}Ag) and (^{117m}Sn or ^{113}Sn /^{113m}In) activities confirms that the source of the silver contamination is an AIC control rod leaking.

- To improve the practical use of ^{117m}Sn or ^{113}Sn as a tracer, it will be necessary to carry out the speciation of tin in the primary coolant conditions and the evolution of soluble and insoluble tin during the full power and the shutdown chemical conditions.

3 – As a curative solution, how efficient is the chemical decontamination in the cases of Ag-110m pollution ?

Chemical decontamination of the circuits polluted by Ag-110m

- The target of the decontamination is the RHRS and/or CVCS, and especially the heat exchangers and the associated valves.

- A large amount of the fixed activity is removed by the circulation of an adapted chemical solution.

- The choice of the chemical process depends on the contaminants.

- EDF has developed a specific chemical process for the decontamination of circuit pollution by Ag-110m

EMMAg process

Chemical decontamination of the circuits polluted by Ag-110m

EMMAg process

OXYDATION

HNO_3

$KMnO_4$

pH = 2,5

T = 80°C

RINCING

HNO_3

pH = 2,5

T = 80°C

REDUCTION

HNO_3

Ascorbic acid

pH = 2,5

T = 80°C

FINAL RINCING

Pure water

until

σ < 25 µS/cm

Chemical decontamination of the circuits polluted by Ag-110m

EXAMPLE

- During the shutdown 28 of Bugey 4, there was a significant increase of the dose rates on the discharge line and on the rooms containing CVCS components.

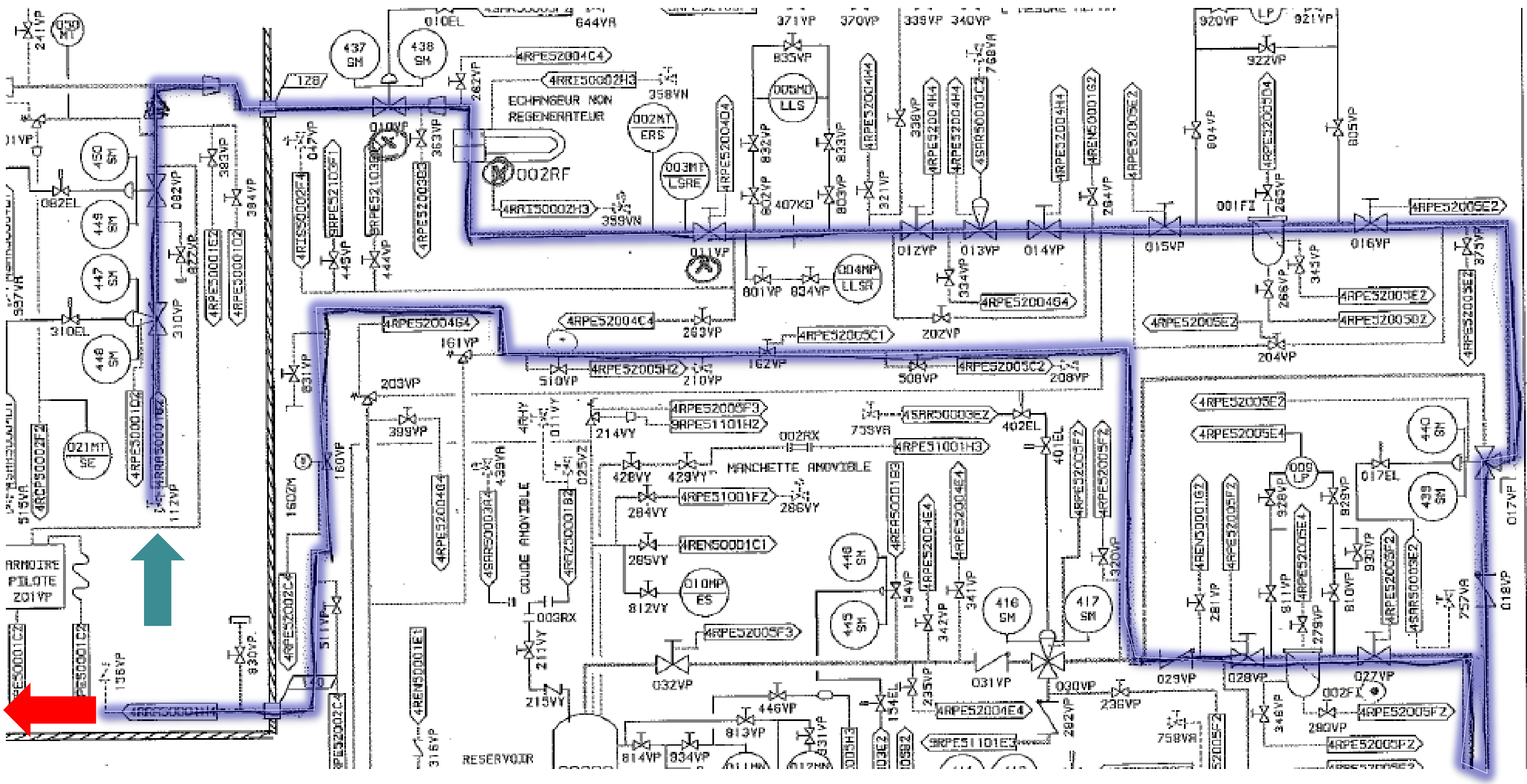
- These elevated dose rates prevent the realization of several important maintenance activities (exp : hydraulic test of the CVCS heat exchangers)

- The CZT measurements have confirmed Ag-110m contamination

- Decision to proceed with a chemical decontamination of the CVCS using EMMAg process

Chemical decontamination of the circuits polluted by Ag-110m

Part of the CVCS circuit decontaminated at BUG4-28 (includes heat exchanger and valves)



Chemical decontamination of the circuits polluted by Ag-110m

CVCS circuit decontaminated at BUG4-28 : **Results**

Material	DR before (mSv/h)	DR after (mSv/h)	Ratio (before/after)
Heat exchanger	51	6	8.5
Valve A	49	5	9.8
Valve B	20	3.6	5.5
Valve C	40	10	4

Average ratio = 7

Room	DR before (mSv/h)	DR after (mSv/h)	Ratio (before/after)
Room 1	1.8	1	1.8
Room 2	3.2	0.9	3.5
Room 3	3.5	0.9	3.9
Room 4	1.2	0.7	1.7

Chemical decontamination of the circuits polluted by Ag-110m

CVC circuit decontaminated at BUG4-28 : **Results**

- Dose due to the decontamination = 70 Man.mSv
- Total removed activity = 200 GBq
- Average Dose Rate Reduction Factor = 7
- Cost / profit ratio estimation = 520 K€/Man.Sv

CONCLUSIONS

1- How important is the contribution of each source of silver release ?

The use of AIC control rods which have

- thicker cladding
- larger gap between the absorber and the cladding
- surface with anti-wear treatment

reduce considerably the contribution of AIC control rods to silver contamination

EDF estimation : almost 25 % of the cases of silver contamination are due to the control rod damages

2 – Are there easy and quick ways to identify the cause of the silver release ?

A simultaneous increase of (^{110m}Ag) and (^{117m}Sn or ^{113}Sn or ^{113m}In) activities in the coolant confirms that the source of the silver contamination is an AIC control rod leaking.

To improve the practical use of ^{117m}Sn or ^{113}Sn as a tracer, it will be necessary to study tin behavior in the coolant during the full power and the shutdown conditions.

3 – As a curative solution, how efficient is the chemical decontamination in the cases of Ag-110m pollution ?

EDF has developed and has applied a specific chemical process for the curative treatment of CVCS and RHRS circuits in the case of an important contamination by Ag-11m. EDF experience has shown that EMMAg process is actually efficient to decontaminate Ag-.110m

Thank you