^{60}Co contamination overview on EDF Fleet

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Radiation protection context at EDF

Dose reduction : a strategic challenge

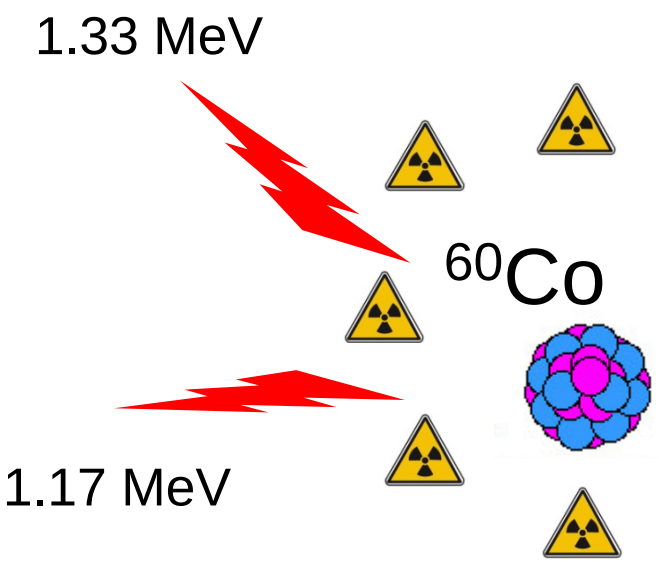
- ❑ **<u>Workers protection</u> : EDF and contractors staff**
- ❑ **<u>Regulation conformance</u> : collective and individual doses**
- ❑ **<u>Nuclear industry acceptability</u>**

Ambitious Radiation Protection objectives

- ❑ **Prospect of major works for the future outages (I.P.M.M., post Fukushima)**
- ❑ **Voluntary approach as regard to radiation protection control**
  - ▪ ***A 2014 annual collective dose less than 0.82 man.Sv/unit for EDF Fleet***
  - ▪ ***An annual collective dose target less than 0.35 man.Sv/unit for EPR***
  - ▪ ***A continuous reduction of individual doses, with a specific effort made toward the most severely exposed workers***

^{60}Co main characteristics

$^{59}Co + n \rightarrow {}^{60}Co + \gamma$



^{60}Co contribution to dose rates is between 50% and 80%

EDF methodology against ^{60}Co

Comprehension

- ***Origin of contamination***
- ***Speciation (chemical form)***
- ***Contamination mechanisms***

Characterization

- ***Dose rates measurements (RCS and RB index)***
- ***Gamma scans (EMECC and CZT measurements)***
- ***Volume activity measurements***

Prevention

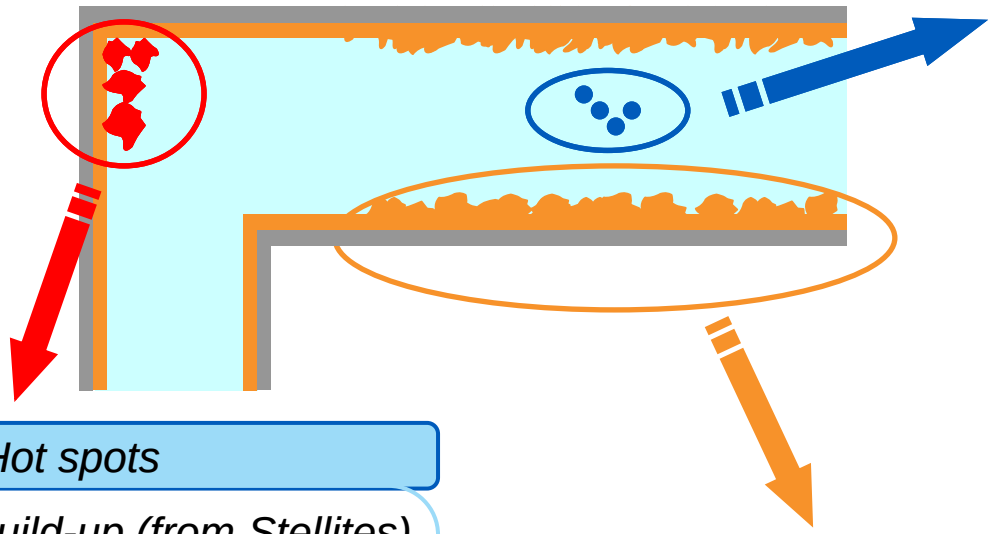
- ***Chemical conditioning***
- ***Design modifications***
- ***Maintenance practices optimization***

Remediation

- ***Chemical cleaning***
- ***Flushing***

^{60}Co Contamination Mechanisms Comprehension

Where is located ^{60}Co ?



Volume activity

Ions :
- *Release from metal*
- *Oxide dissolution*

Particles :
- *Oxide erosion*
- *Normal operation wear*

Hot spots

Big particles build-up (from Stellites)
- *Natural or accidental wear (valves, CVCS pumps)*
- *Bad maintenance procedures (grinding/lapping)*

Localized contamination

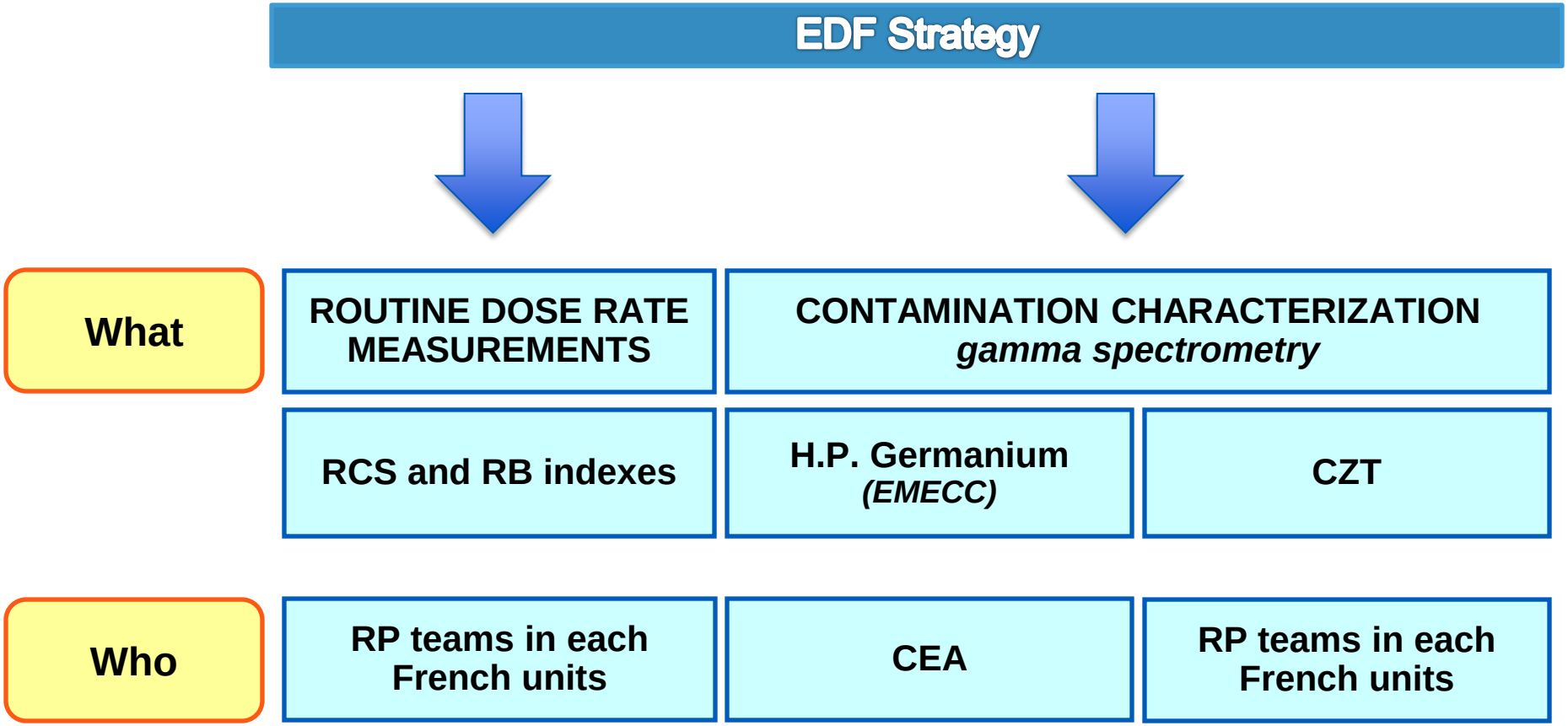
Fixed and homogeneous contamination

- *Surface precipitation of ions (from metal release)*
- *Small particles deposition (from normal operation wear : stellites, Inconel 718, fuel grids)*

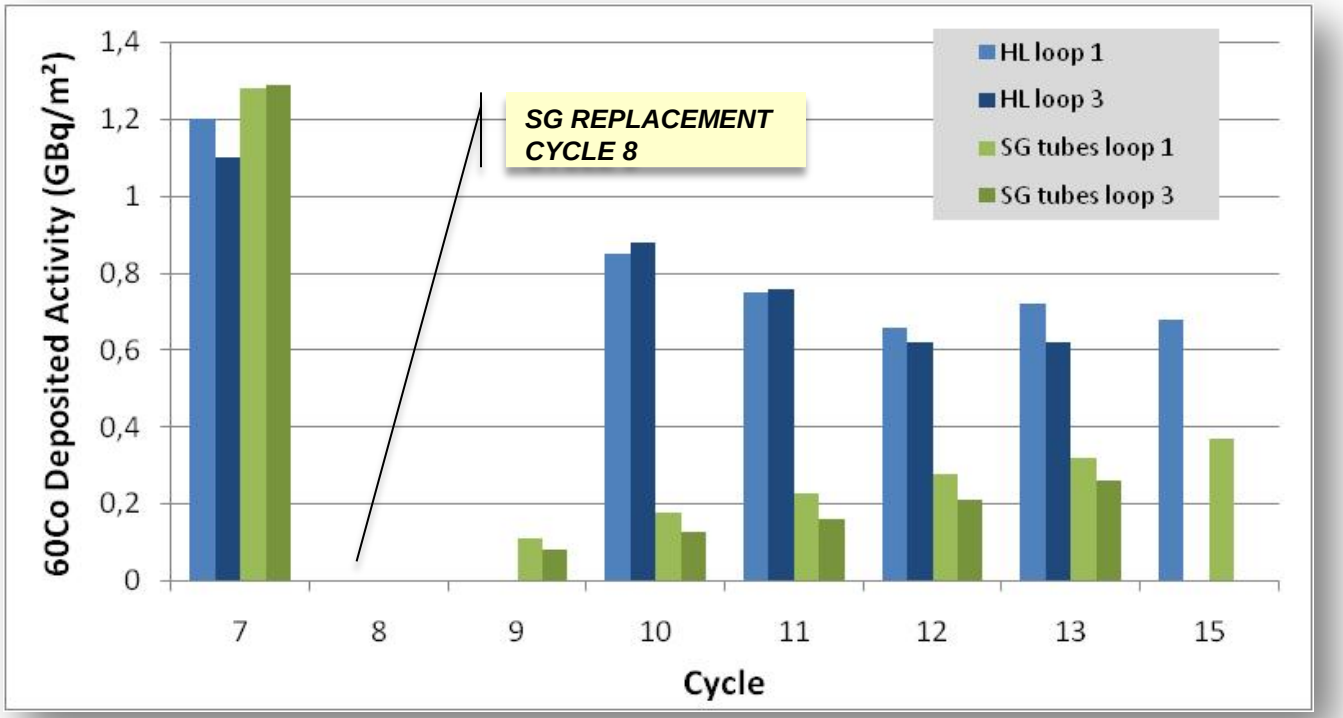
On the whole wet surface

^{60}Co Characterization

Know your enemy !!



SG replacement impact on ^{60}Co deposits



- **DIFFERENT TRENDS BETWEEN SG TUBING AND HOT LEGS**
  - ***Deposited activity on SG tubing tends to increase over cycles***
    Lower Co content and manufacturing process improvement lead to a slower contamination of new generation SG tubing
  - ***Deposited activity on loops tends to decrease***
    Memory effect due to the long ^{60}Co radioactive half-life

Remediation solutions

Mitigation : Curative actions

❑ FIXED DEPOSITS REMOVAL : CHEMICAL DECONTAMINATION

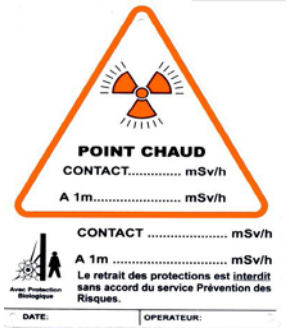
- ***Soft chemical decontamination processes : CVCS + RHRS***
  - 3 available processes according to material type and radionuclides
  - EMMAC : Stainless Steel and Ni-base alloy
  - EMMAC POA : Presence of Stellites
  - EMMAg : Presence of a contamination in ^{110m}Ag

- ***Full System Decontamination***
  - Feasibility study in progress

❑ LABILE DEPOSITS : MECHANICAL DECONTAMINATION

- ***Wipes / Smear***
- ***Brushing***
- ***High pressure water injection***
- ***Robots (pool decontamination)***

Mitigation : Curative actions



- **^{60}Co HOT SPOTS IN CIRCUIT PIPES (RCS, CVCS, RHRS, SIS)**
  - Mainly flushing
  - Pipes alignment toward a pre-contained filtration device (mobile or not)
  - Filters located in concrete containers (hull) or in a barrel/drum (solid waste) according to the site policy
  - Effluent discharge by usual effluent treatment systems (Vent and Drain System)

CONCRETE CONTAINERS
(Embeded filter inside)

WASTE BARREL
(pre-filter inside)

Mitigation : Preventive actions

Chemical conditioning

- *Optimal pH (300°C) = 7.2*
  - *Limited generalized corrosion*
- *Hydrogen*
  - *Limited Co release in coolant from material impurities*
- *Zinc injection*
  - *Preventively before SGR better than curatively*

Design modifications

- *SG channel head electropolishing*
  - *Applied to all next SGR*
- *SG tubing Co content*
- *Stellites reduction*
  - *Feasibility study (safety)*
  - *Economical study*
- *Socket welding removal*

Maintenance practices

- *Lapping/grinding : protection (plastic film, pipe blocking), cleaning (suction), checking before reassembly*
- *CVCS pumps :*
  - *Start-up procedures to avoid hydrostatic bearing destruction*
  - *Restart procedures after damage to avoid dissemination*

Conclusion

^{60}Co source term reduction is an important matter of concern for radiation protection

Ambitious EDF policy in terms of radiation field reduction
- R&D, Characterization, Operational practices -

Curatively ***Preventively***

EDF New-Built NPPs **In operation EDF fleet**

THANK YOU