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Recontamination Reduction Techniques in BWR

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2. Formation and migration of radioactivity in BWR

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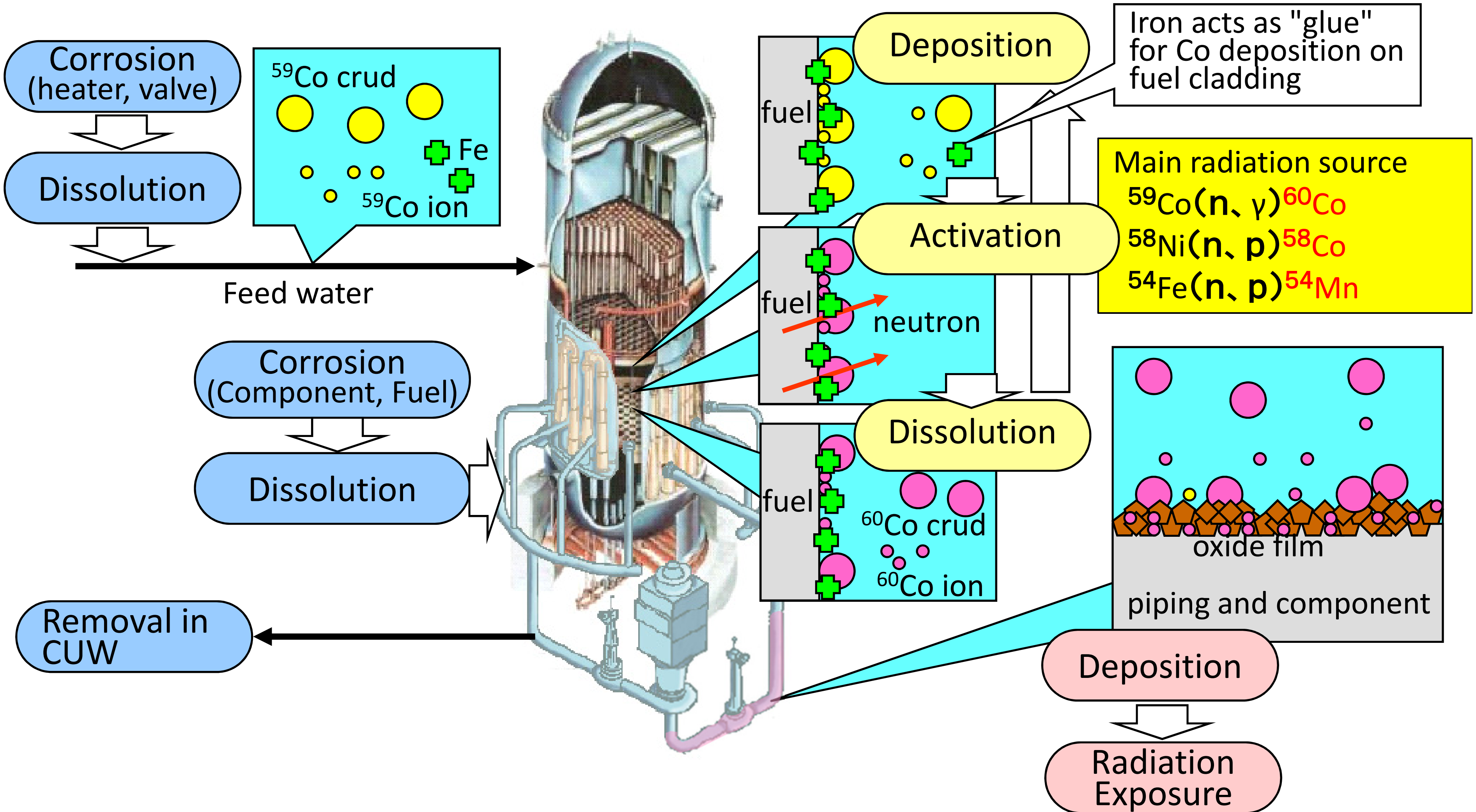
Generation
Structural Material

Radio-activation
Fuel Rod

Deposition
RRS、RWCU piping



2. Basic Concept of Dose Rate Reduction

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Occupational Exposure

Person-Sv=Σ(Dose rate × Number of workers × Working time)

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Dose Rate-Governing Equation

Radioactivity deposition rate on piping and components
= Radioactivity in reactor water × Deposition rate coefficient

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Requirement for Dose Rate Reduction

- Reduce radioactivity in reactor water
- Diminish deposition rate coefficient of piping and components
- Remove deposited radioactivity at beginning of outage

Chemical Decontamination has been widely applied to remove deposited radioactivity

3. Recontamination after Chemical Decontamination

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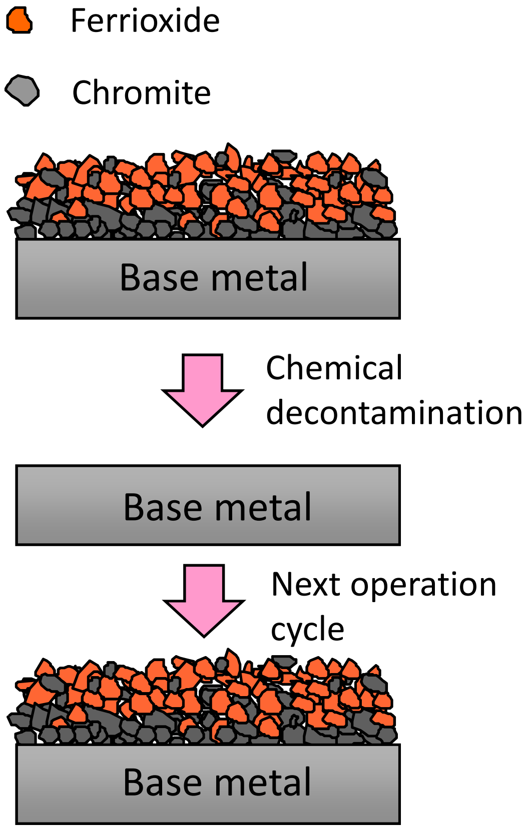
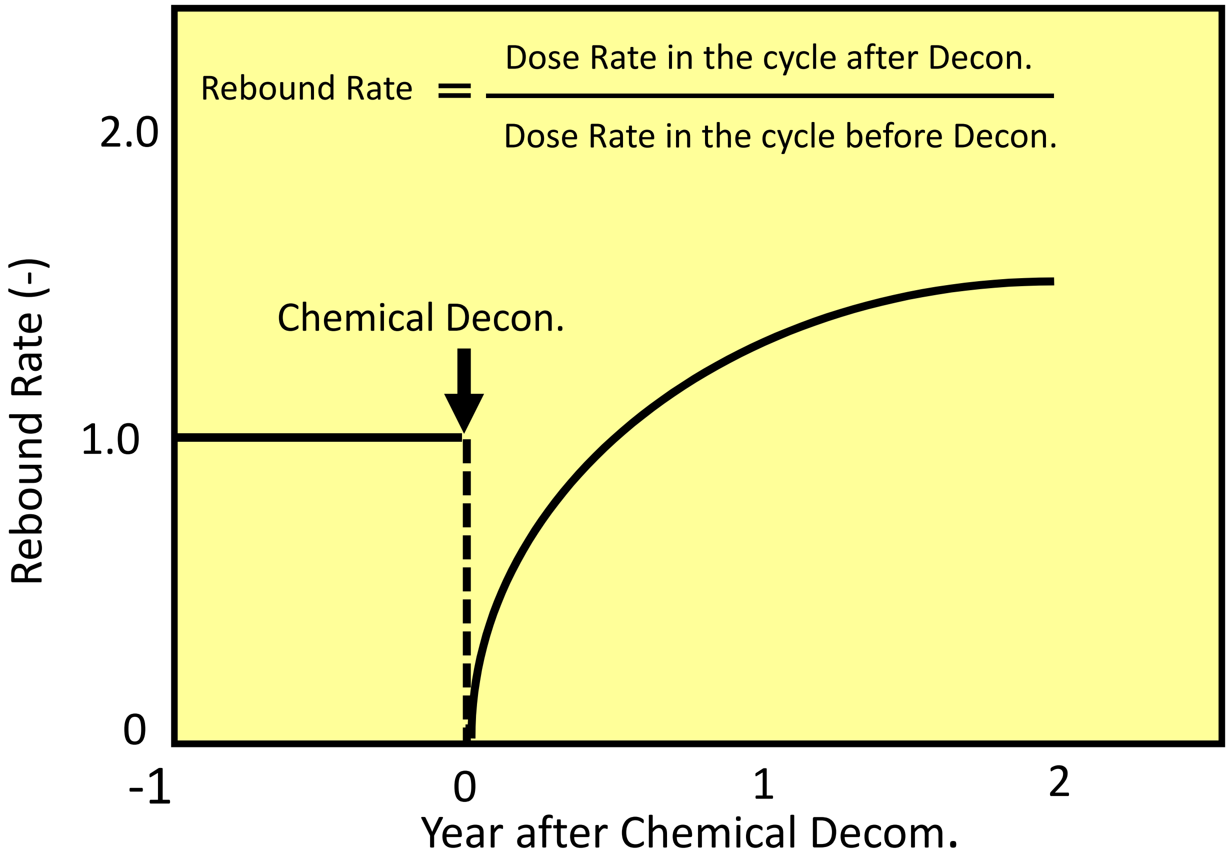




After the chemical decontamination, the surface of the piping is restored to the original condition as time elapses.

In the operation cycle after chemical decontamination, oxide layer is grown up rapidly and the recontamination (re-bound) of dose rate is occurred.

4. Status of recontamination reduction techniques developed by Hitachi-GE

Recontamination techniques	Development status	Application experience
Hitachi Ferrite Coat (Hi-F coat)	Developed	2 BWRs (2007, 2012; Japan)
Platinum coat (Pt coat)	Developed	1 BWR (North America)
Nickel and Platinum coat (Ni + Pt coat)	Under development	-

Hitachi-GE have developed the recontamination reduction techniques for BWR.

These techniques are carried out after chemical decontamination during refueling outage.

5. Hitachi Ferrite Coat (Hi-F coat)

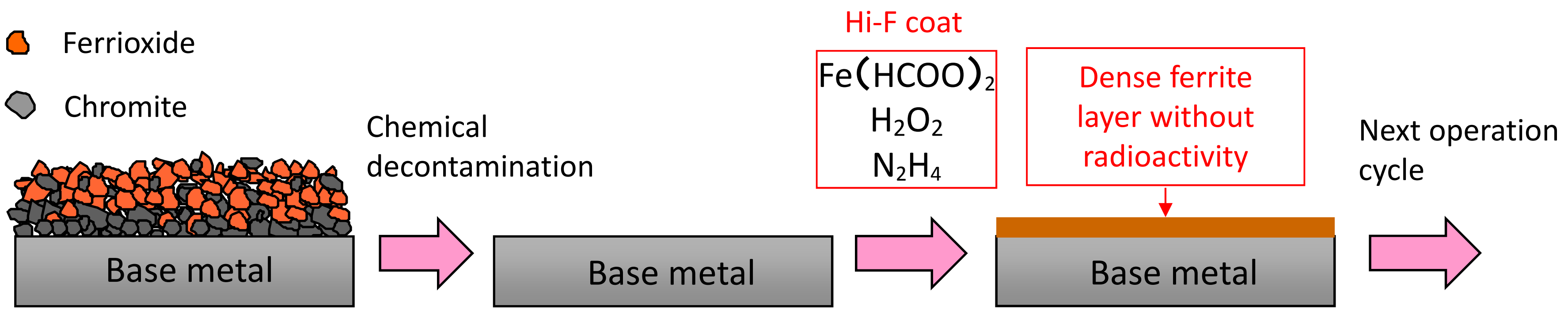
Technical summary

- Hitachi Ferrite coat (Hi-F coat) is to form the dense oxide layer of ferrite (Fe_3O_4) after chemical decontamination.
- Hi-F coat can prevent the rapid oxide formation and subsequent radioactivity uptake in the next operation cycle.
- For carbon steel, Hi-F coat is effective in the condition that concentration of nickel (Ni) ion in reactor water is low.

Applicable chemistry regime : Normal water chemistry (NWC), Hydrogen water chemistry (HWC)

(It is noted that Noble metal chemistry is not applicable)

Applicable material : Stainless steel, Carbon steel (Low Ni ion concentration in Reactor water)



5. Hitachi Ferrite Coat (Hi-F coat)

The detail information about the application procedure and application results in the actual plant are available at;

http://www.nsra.or.jp/isoe/alarasymposium/pdf/atc2009-3-3pp.ppt

6. Platinum coat (Pt coat)

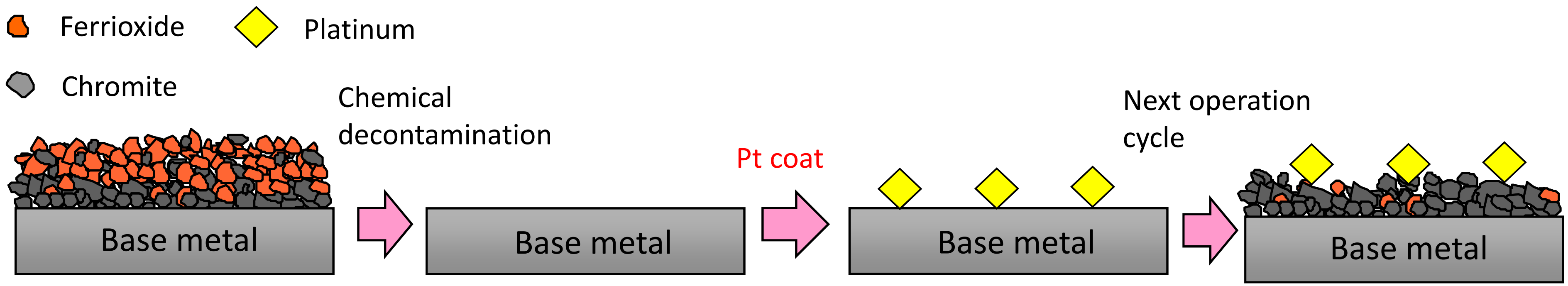
Technical summary

- Platinum (Pt) is deposited on the "fresh" surface of the piping after chemical decontamination.
- Deposited Pt can dissolve and prevent the formation of Ferrioxide layer in the next operation cycle.
- Depleted zinc oxide (DZO) injection is required to prevent the radioactivity uptake in the chromite layer.

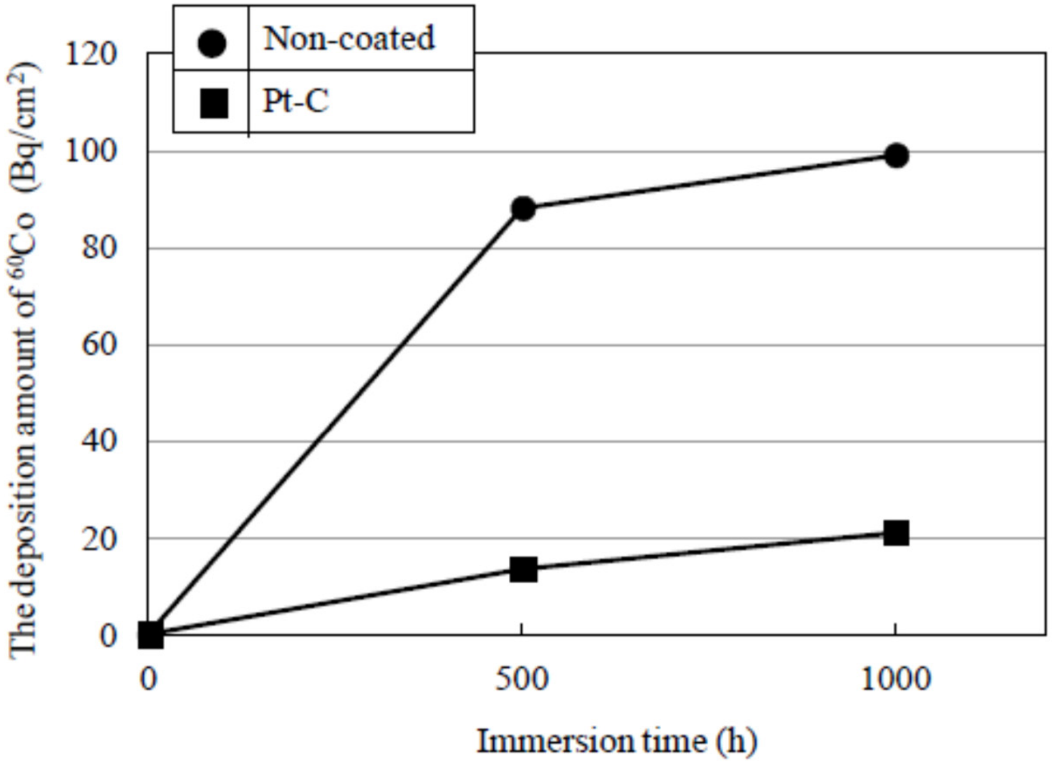
Applicable chemistry regime : Noble Metal Chemistry (HWC + OLNC* + DZO)

* On-Line NobleChem™

Applicable material : Stainless steel



6. Platinum coat (Pt coat)



Parameters	Conditions
Pt coat	0.2µg/cm^2
Dissolved oxygen	< 5 ppb
Dissolved hydrogen	< 50 ppb
Co-60	6.7 Bq/kg
Temperature	553 K
Pressure	7 MPa
Hydrogen peroxide	~130ppb
Zinc	5 ppb

The immersion time dependency of ^{60}Co deposition amount under BWR condition .

Co-60 deposition with Pt coat is about 1/5 that of non-coated specimen in the laboratory test

Ref. T. Kawasaki et.al., NPC 2016, Brighton, UK (2016)

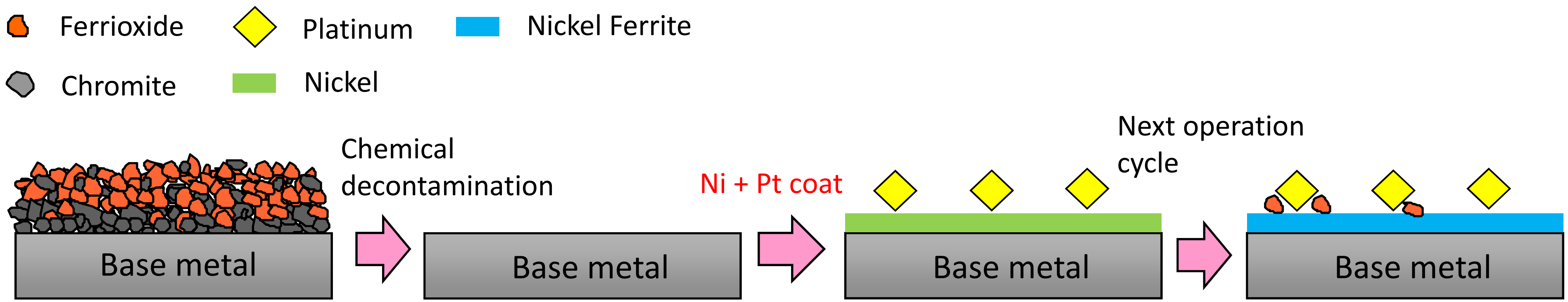
7. Nickel and Platinum Coat (Ni + Pt coat)

<u>Technical summary</u>

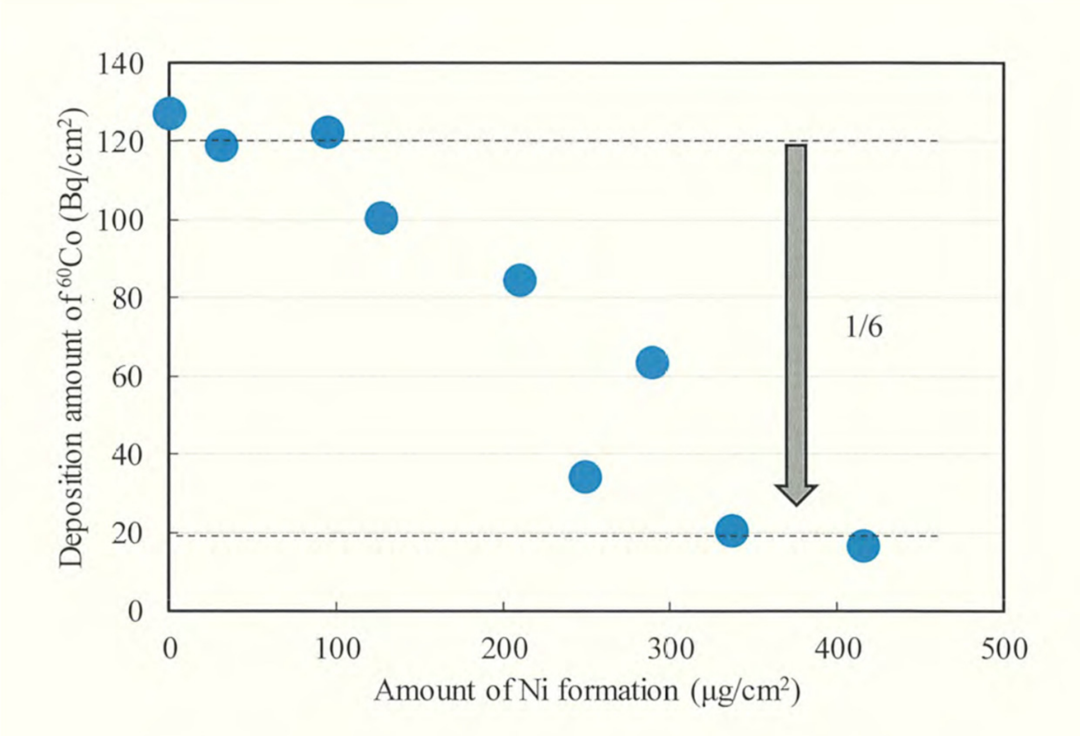
- Nickel (Ni) is coated on the “fresh” surface of the piping after chemical decontamination and platinum is deposited on it.
- Coated Ni is changed to Nickel Ferrite ($NiFe_2O_4$) and act as protective layer of radioactivity uptake.
- Deposited Pt can dissolve and prevent the formation of Ferrioxide layer in the next operation cycle.

<u>Applicable chemistry regime</u> : Noble Metal Chemistry (HWC + OLNC + DZO)

<u>Applicable material</u> : Carbon steel



7. Nickel and Platinum Coat (Ni + Pt coat)

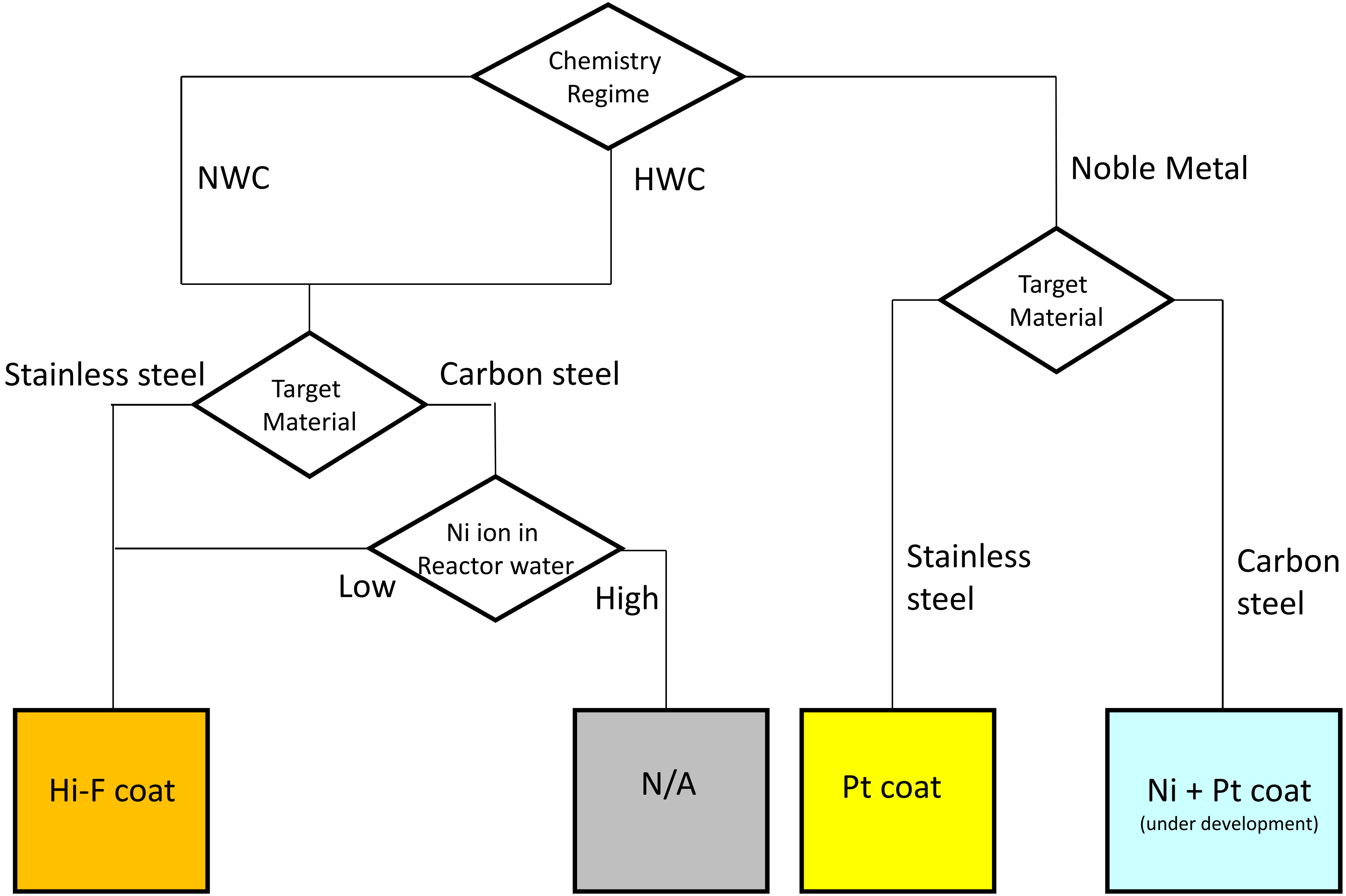


Parameters	Conditions
Pt coat	0.5 – 1.2μg/cm^2
Ni coat	30 - 420μg/cm^2
Dissolved oxygen	< 5 ppb
Dissolved hydrogen	< 50 ppb
Co-60	6.7 Bq/kg
Temperature	553 K
Pressure	7 MPa
Hydrogen peroxide	~130ppb
Zinc	5 ppb
Time	500 h

Co-60 deposition with Pt coat is about 1/6 that of non-coated specimen in the laboratory test

Ref. T. Ito et.al., NPC 2018, San Francisco, US (2018)

8. Structured Flow chart



9. Conclusion

- Hitachi-GE has developed / is developing the following recontamination reduction techniques for BWR plants.

  - Hitachi Ferrite Coat (Hi-F coat)
  - Platinum Coat (Pt coat)
  - Nickel and Platinum Coat (Ni + Pt coat):under development

- Hi-F coat is applicable both in NWC and HWC condition. For carbon steel Hi-F coat is effective only in the condition that concentration of nickel (Ni) ion in reactor water is low.

- Pt coat is applicable in Noble Metal Chemistry condition, and effective for Stainless steel.

- Ni + Pt coat is under development and will be applicable in Noble Metal Chemistry condition, and effective for carbon steel.