

Water Radiolysis Study for Hydrogen Recombination System

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H₂ Production Issue

- H₂ production by water radiolysis

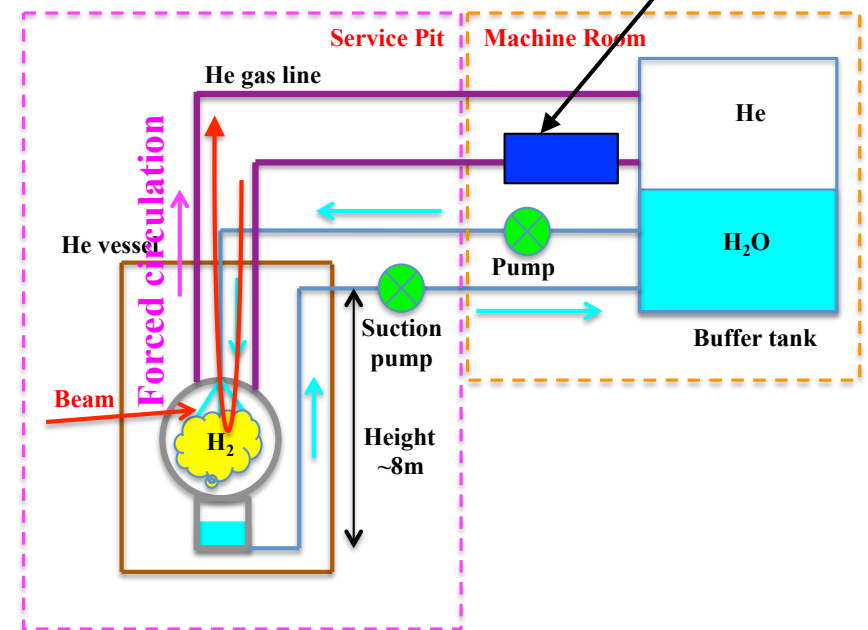
- Final products : H₂, H₂O₂, O₂ (=1.3 : 1 : 0.1)
- Measured production rate @ 750 kW
 - 260 L (5%) /10¹⁹ POT (~1day)

- H₂ recombination (2H₂ + O₂ → 2H₂O)

- Recombination by a catalyst (alumina pellet w/ 0.5% Pd)
- Forced He flow inside the horns
 - Recombination should work efficiently

- Status

- Can keep H₂ concentration below 1%
 - Weekly He flushing 1% → 0.1%



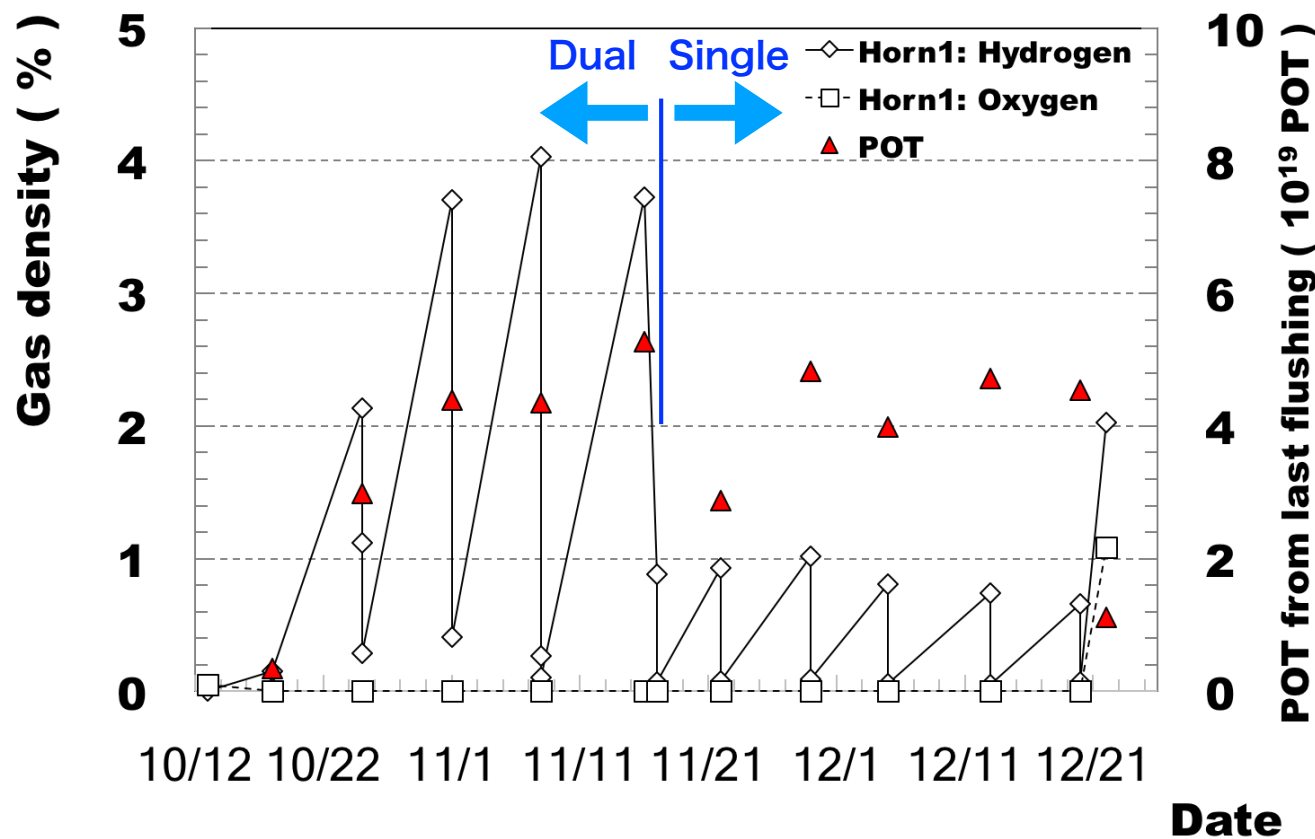
Effect of Ion Exchanger

- From fall 2017

- Dual ion-exchangers (IE) are used \Rightarrow H_2 concentration increased to 4% level.

- Back to the single IE operation

- H_2 concentration was reduced by 1/2~1/4
- IEs cause the higher H_2 concentration.



IE may be damaged by H_2O_2



Is H_2 produced due to oxidization of resins by H_2O_2 ?

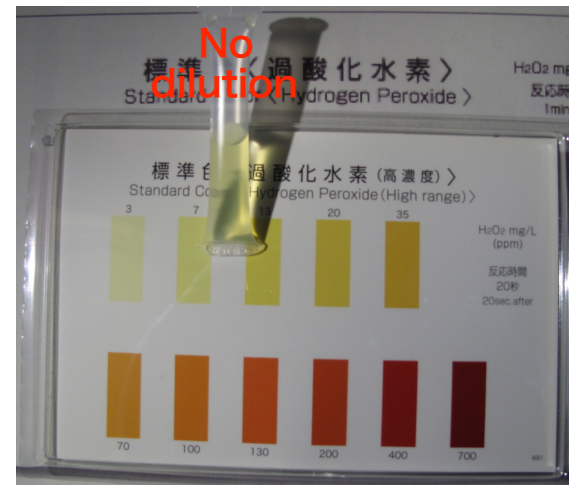
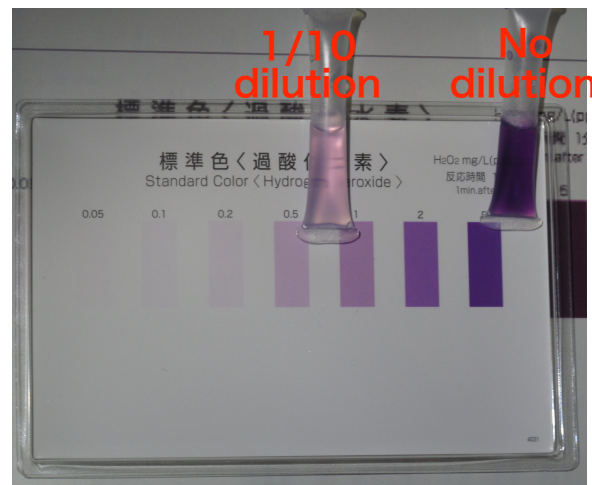
Effect of H₂O₂

• Hydrogen peroxide (H₂O₂)

- Production rate is close to that of H₂ (H₂ : H₂O₂ = 1.3 : 1)
- It **corrodes** IE resins ⇒ degradation of IE with presence of H₂O₂
- Can be **decomposed naturally** : $2\text{H}_2\text{O}_2 \Rightarrow 2\text{H}_2\text{O} + \text{O}_2$
 - Catalyst can accelerate the decomposition
 - Resultant O₂ can work as a source O₂ for the recombination

• Measurement of H₂O₂ concentration

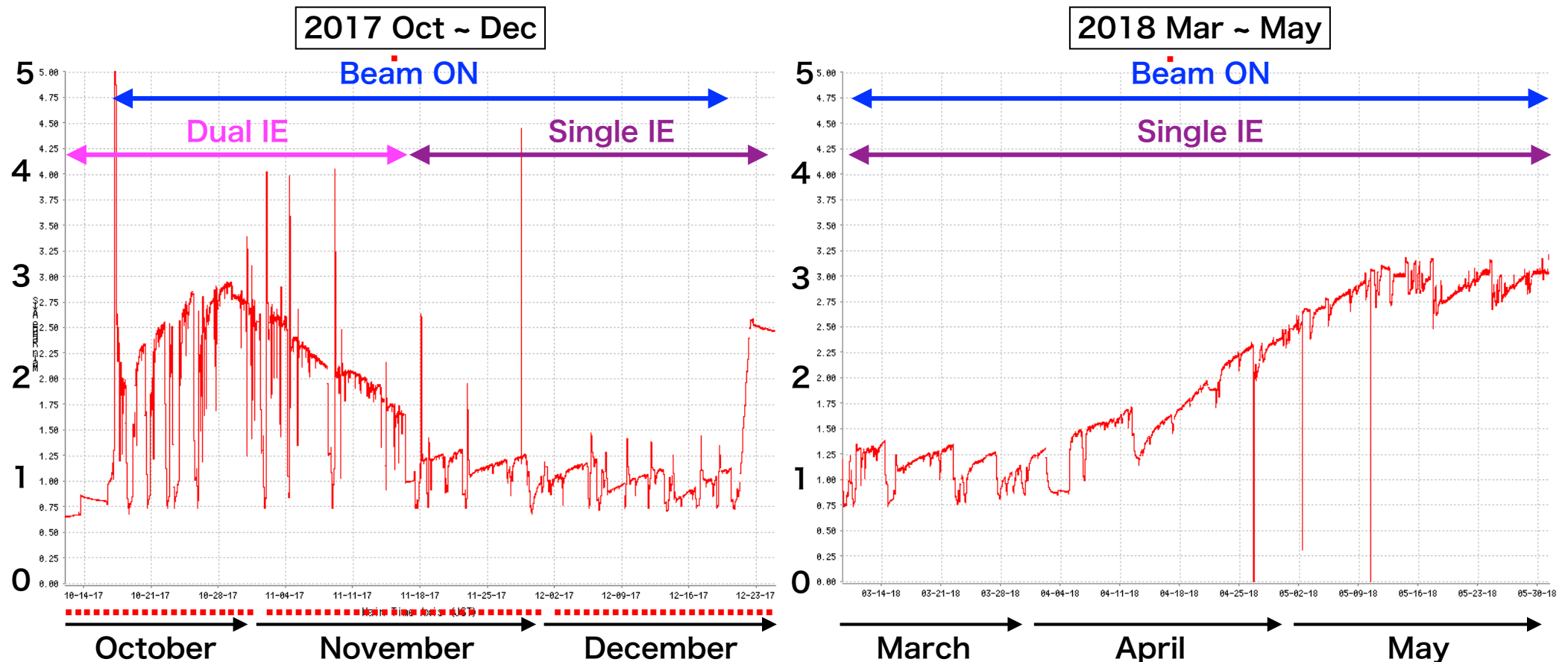
- **~10 mg/L** ⇔ estimated : **~500 mg/L** @ 3.9×10^{20} POT
 - This indicates that most of H₂O₂ produced was decomposed
- Even this small concentration of H₂O₂ can affect the IE resins



Water Conductivity Trend

• Water conductivity

- A strange behavior during dual IE operation
- Low conductivity during single IE operation
- Conductivity got increased around middle of April
 - This indicates lifetime of IE $\Rightarrow \sim 6.0 \times 10^{20}$ POT



H₂O₂ Resistant Ion Exchanger

- H₂O₂ is problematic for nuclear reactor business
 - H₂O₂ resistant ion exchanger developed for reactor
 - Pd-doped ion exchanger can decompose H₂O₂ and ⇒ Pd works as a catalyst
 - therefore can extend lifetime of ion exchanger

Award Paper

T. Izumi et al (2018)

Prolongation Technology of Life Time of Ion Exchange Resins in Nuclear Power Plants

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Abstract

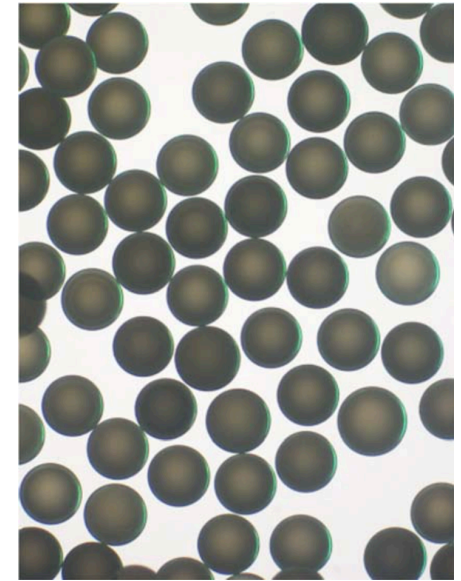
From the viewpoint of the minimizing the corrosion of the reactor's structural material in the nuclear power plants, the ion exchange resins are generally used as one of purification system in order to keep water quality clean. Hydrogen peroxide generated by the radiolysis of water exists in the reactor water and it accelerates the oxidation decomposition of the ion exchange resins and finally, it becomes the cause to shorten the resin life. To solve this problem, the application of Pd doped resins which can decompose hydrogen peroxide catalytically at the surface has been considered. It was confirmed by the cold test that Pd doped resins overlaid on the ion exchange resins or mixed with the ion exchange resins decomposed hydrogen peroxide contained in the reactor water and inhibited the oxidative degradation of the ion exchange resins. We report the results of these tests.

Keywords: Pd doped resins, Hydrogen peroxide, Ion exchange resins, Nuclear power plants

Status

- **New resin**

- I contacted the developer
- He was very interested in the application of this resin
- As a trial, this resin was put into one IE bottle for a test
 - 4L of the old resins were replaced with new ones
- To be used during next beam time



Remove old resins



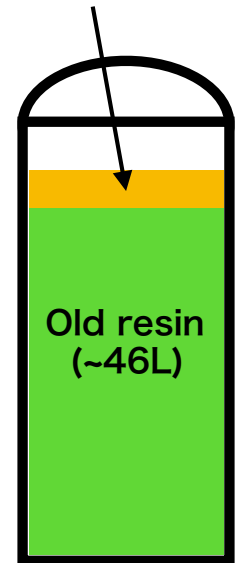
Put new resins



Completed IE bottle



New resin (~4L)
is overlaid



50 L in total

Summary

- **Water radiolysis**

- Final products are H_2 , H_2O_2 , O_2
- H_2 production rate @ 485kW : 260 L (5%) / 10^{19} POT
- H_2 recombination to remove $H_2 \Rightarrow 1\%$ / week
- Ion exchanger condition affects H_2 production rate
- H_2O_2 affect the performance of ion exchangers

- **H_2O_2**

- Degradation of ion exchanger lifetime was observed around 6×10^{20} POT
 - Oxidization of the resins by H_2O_2
- Pd-overlaid ion exchanger resins can work as a catalyst for H_2O_2 decomposition
- Ion exchanger bottle with new resins will be tested during next beam time to check its performance