R&D Back-Up Activities for the Kurion Media System of the Contaminated Water Treatment in Fukushima Daiichi Nuclear Power Station

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Overview of Water Treatment System in Fukushima Daiichi

Since 6/24

Since6/27

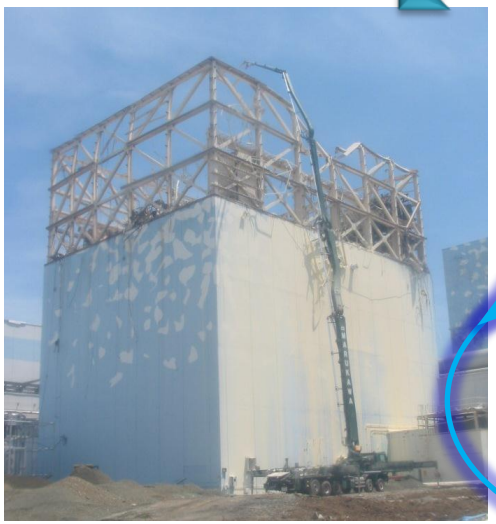
Desalination

Cs Precipitation

AREVA

HITACHI-GE, AREVA

Since 9/14



2nd Cs Adsorption

TOSHIBA/Shaw

Cs Adsorption

KURION

Since 8/18

WATER RECYCLE

Oil Separation

TOSHIBA

Since 6/17

1200 ton/day

Reactor Unit #1

Contaminated Water

Radioactivity > 10^6 Bq/ml

Impurity= sea water, oil

Amount= 100,000m^3 => 250,000m^3

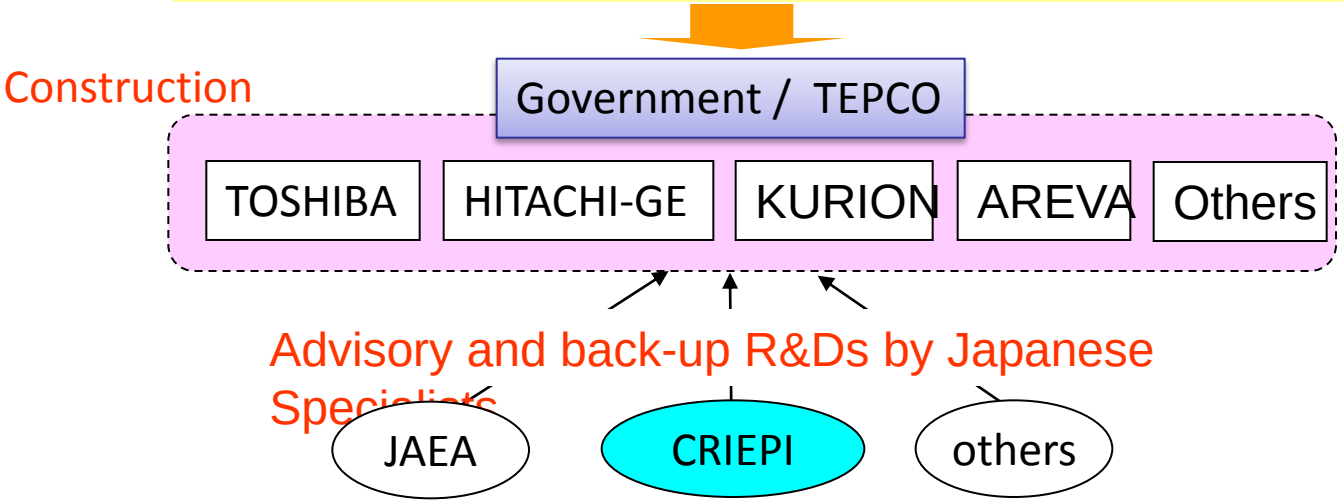
Over flow ?

Basement of Turbine Building

TMI Experience and Fukushima Challenges

Difficulties compared with TMI water treatment system

Composition: -Radioactive elements similar to TMI
-Impurities of sea salt & mechanical oil
Throughput: 250,000ton/year (6,000ton/year for TMI)
Environment: Need to use existing building
-Limitation in weight and function of crane
-No water pool => Individual sielding
Lead time : About 2 months (2 years for TMI)

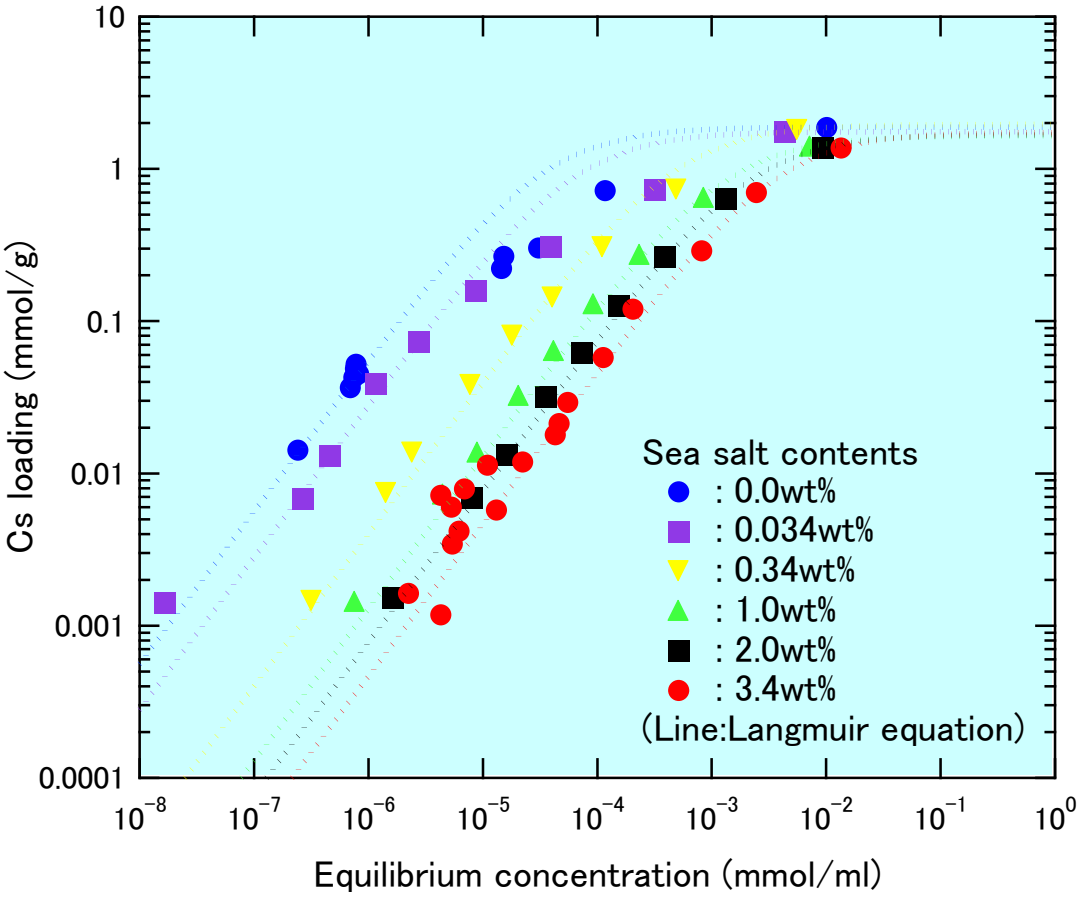


Back-up R&Ds carried out by CRIEPI to optimize design and operation of the KURION system.

1) Ion-exchange property
2) Small columns tests
3) Simulate code development
4) Estimation and optimization of the operation condition

Ion Exchange Property depends on Salt Content

KURION media for Cs absorption: H (Herschelite)



$$Q = \frac{aC}{1+bC}$$

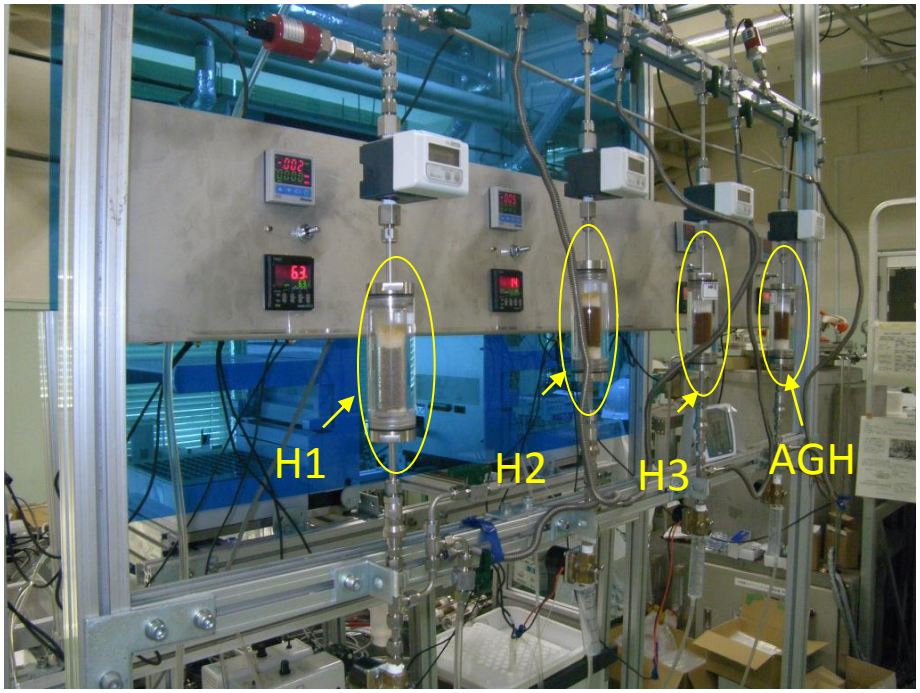
Q : Cs loading (mmol/g)
C : Equilibrium Cs concentration in the solution (mmol/ml)
a , b : Langmuir coefficients

Sea salt (wt%)	Langmuir coefficients	
	a	b
0.0	56,200	29,900
0.034	28,100	16,000
0.34	4,000	2,040
1.0	1,290	782
2.0	777	462
3.4	465	267

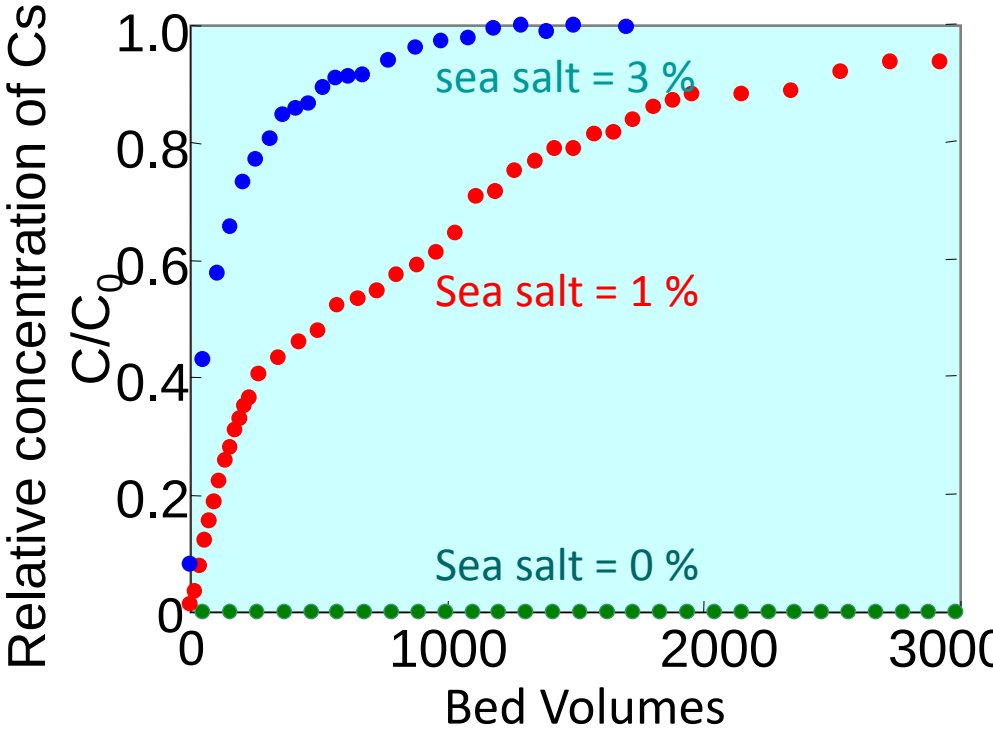
for the simulation code

Small-scale Column Experiments

- In order to simulate experimentally the adsorption behaviors in the KURON media system, a small-scale zeolite column was newly installed.
- It consisted of four zeolite columns of 20 or 30 mm in dia. and 120 mm in length connected in series.
- Specific flow rate is adjusted to around 14 to 81 cm/min for simulating the actual flow rate.

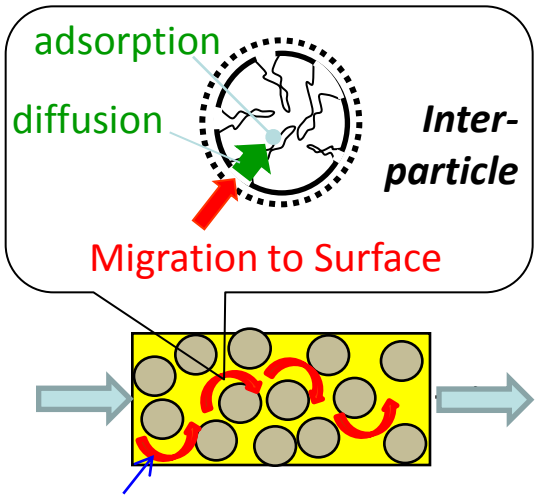


Small-scale column test apparatus



Typical break-through curves

Simulation Code Development for Zeolite Column

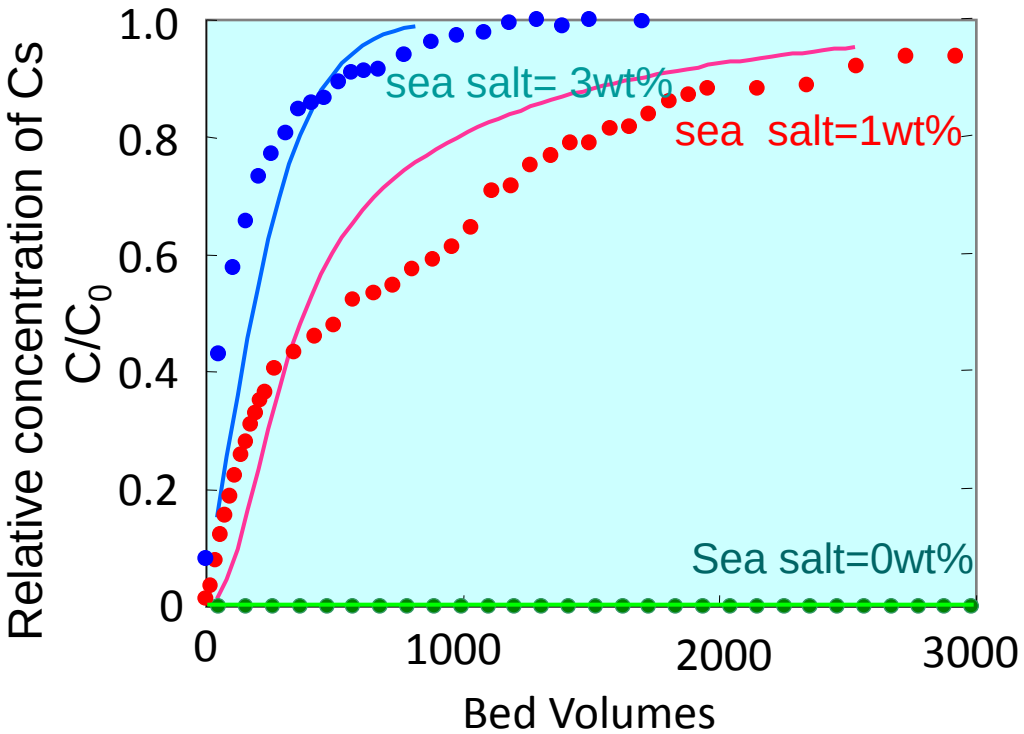


Inter-Particle

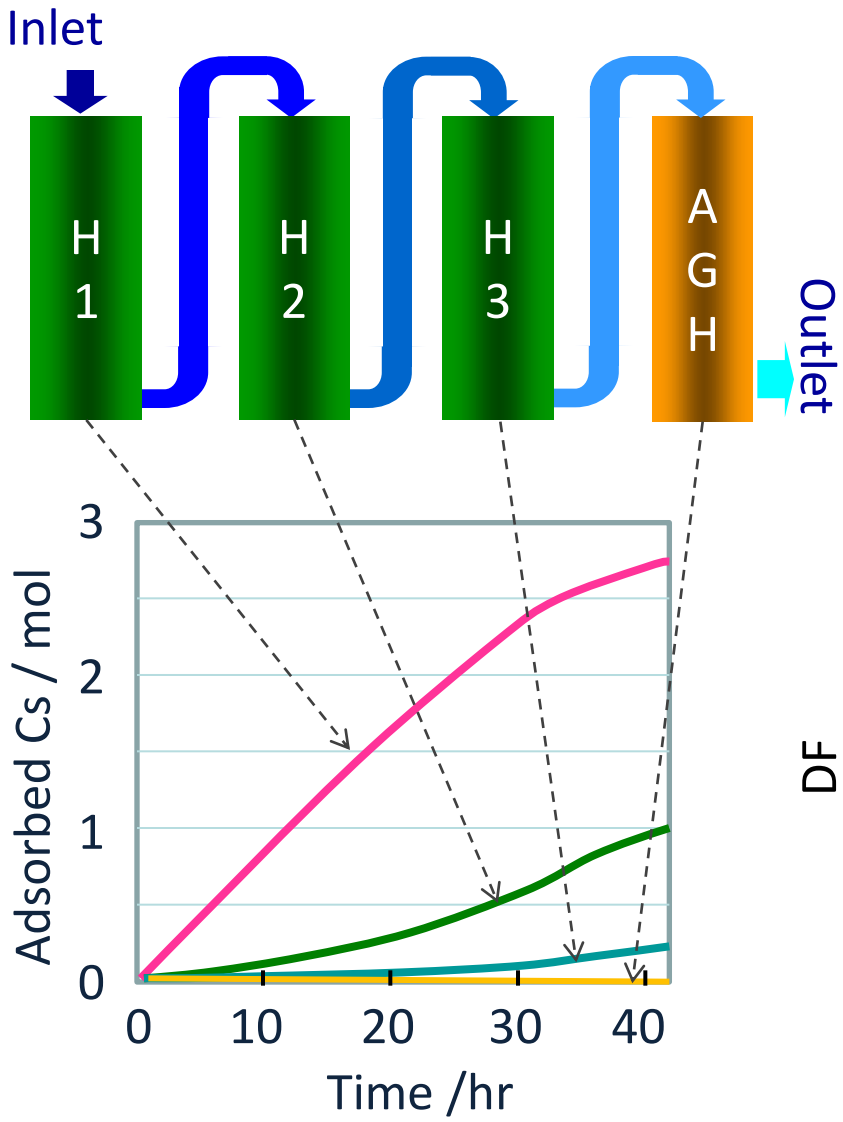
$$\frac{\partial c^b}{\partial t} = \underbrace{D_b \frac{\partial^2 c^b}{\partial x^2}}_{\textit{diffusion}} - \underbrace{u \frac{\partial c}{\partial x}}_{\textit{convection}} - \underbrace{\frac{3k_f(1-\varepsilon_b)}{R\varepsilon_b}(c^b - c^p|_{r=R})}_{\textit{migration to surface}}$$

Intra-Particle

$$\frac{\partial c^p}{\partial t} = \underbrace{\frac{1}{\left(\varepsilon_p + (1-\varepsilon_p)\rho \frac{\partial Q}{\partial c^p}\right)}}_{\textit{adsorption}} \times \underbrace{\varepsilon_p D_p \left(\frac{\partial^2 c^p}{\partial r^2} + \frac{2}{r}\frac{\partial c^p}{\partial r}\right)}_{\textit{diffusion}}$$

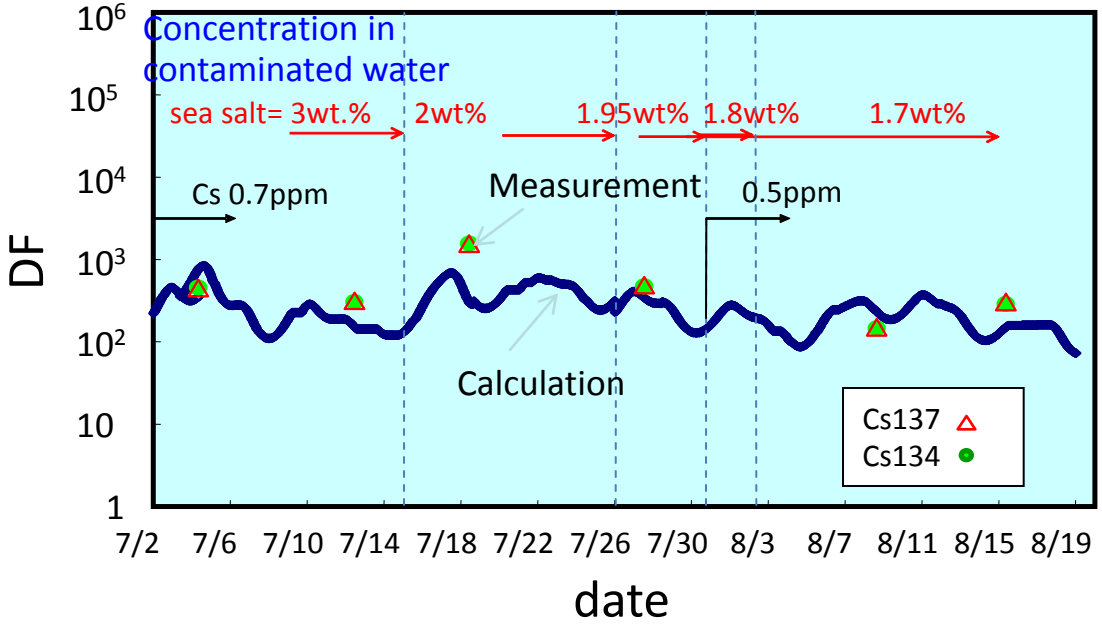


Adaptation of Code to Actual KURION System



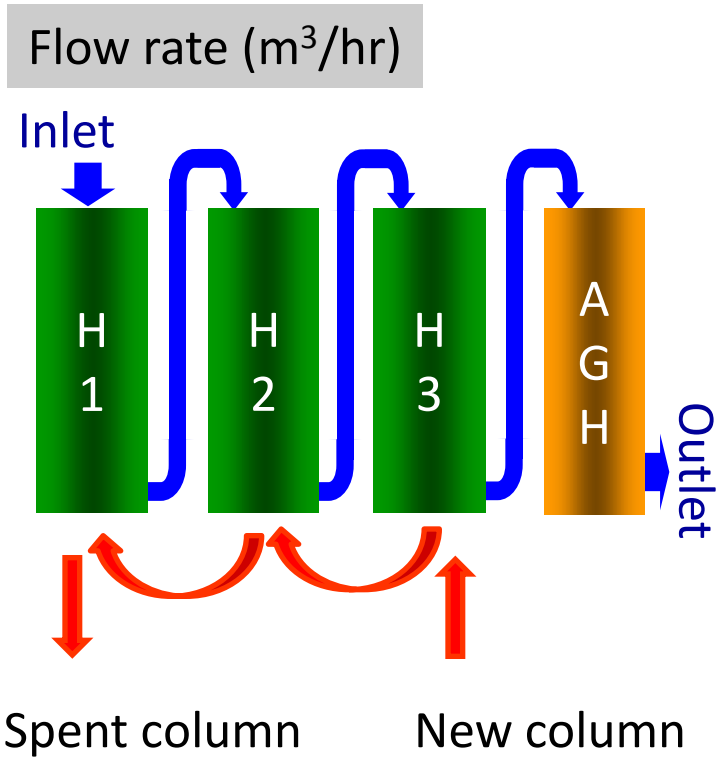
Cs adsorption behavior

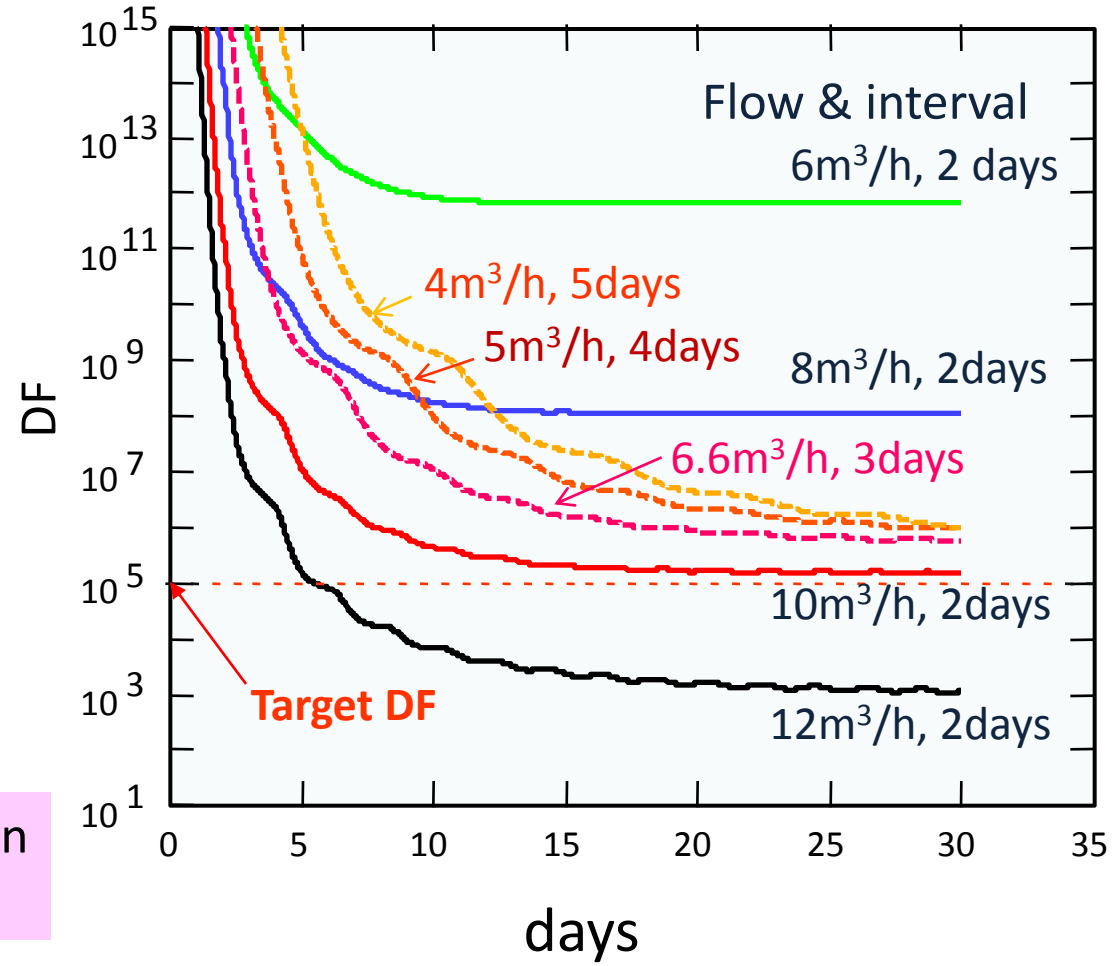
Kinetic properties were expected to be same as those obtained in small-scale column tests, because specific flow rate is same.
Simulation code agreed well with measured DF in KURION System



Optimization of the Operational Plan

Actual operation plan was optimized with an assistance of code.



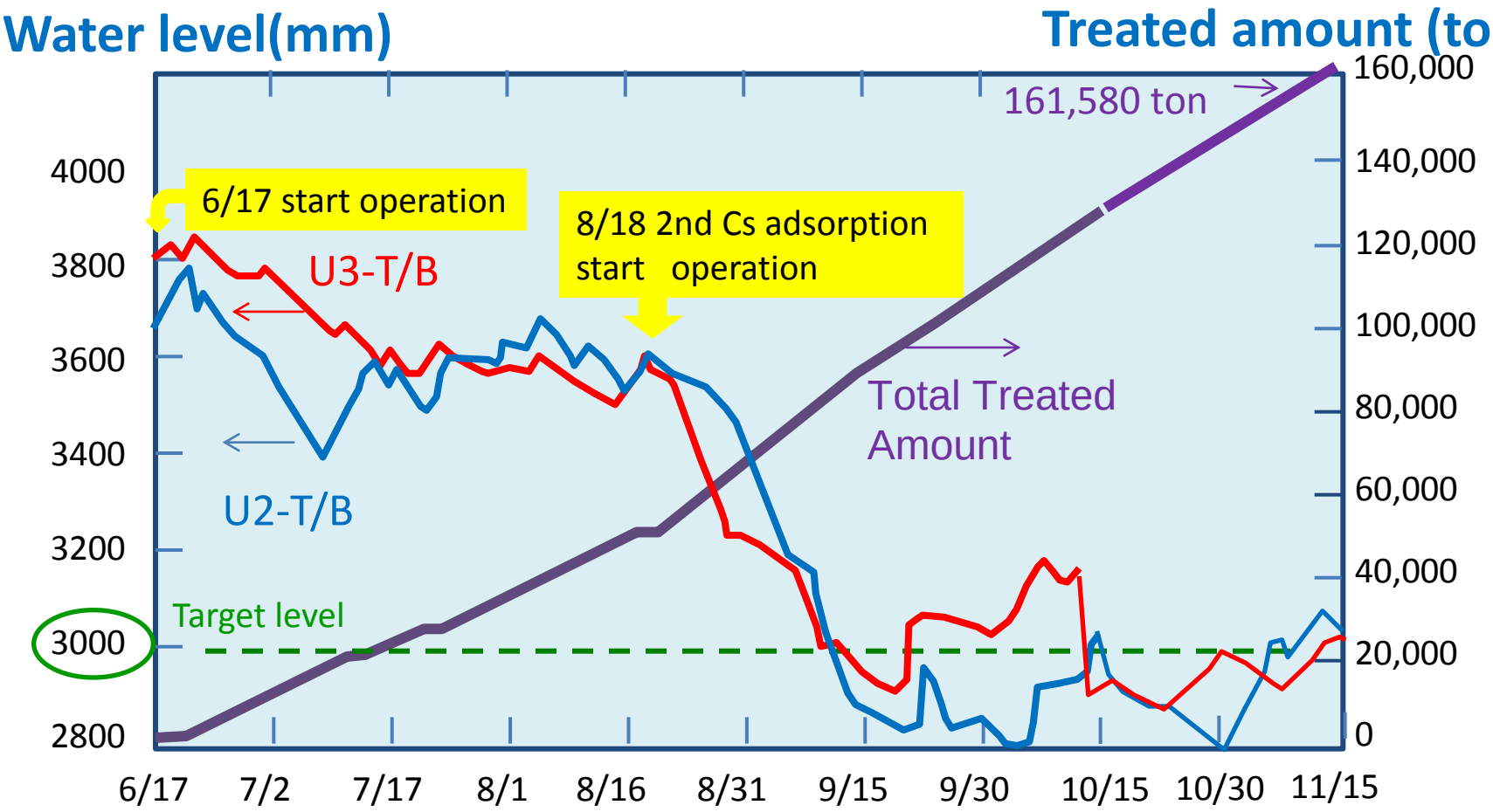


Operational Parameters

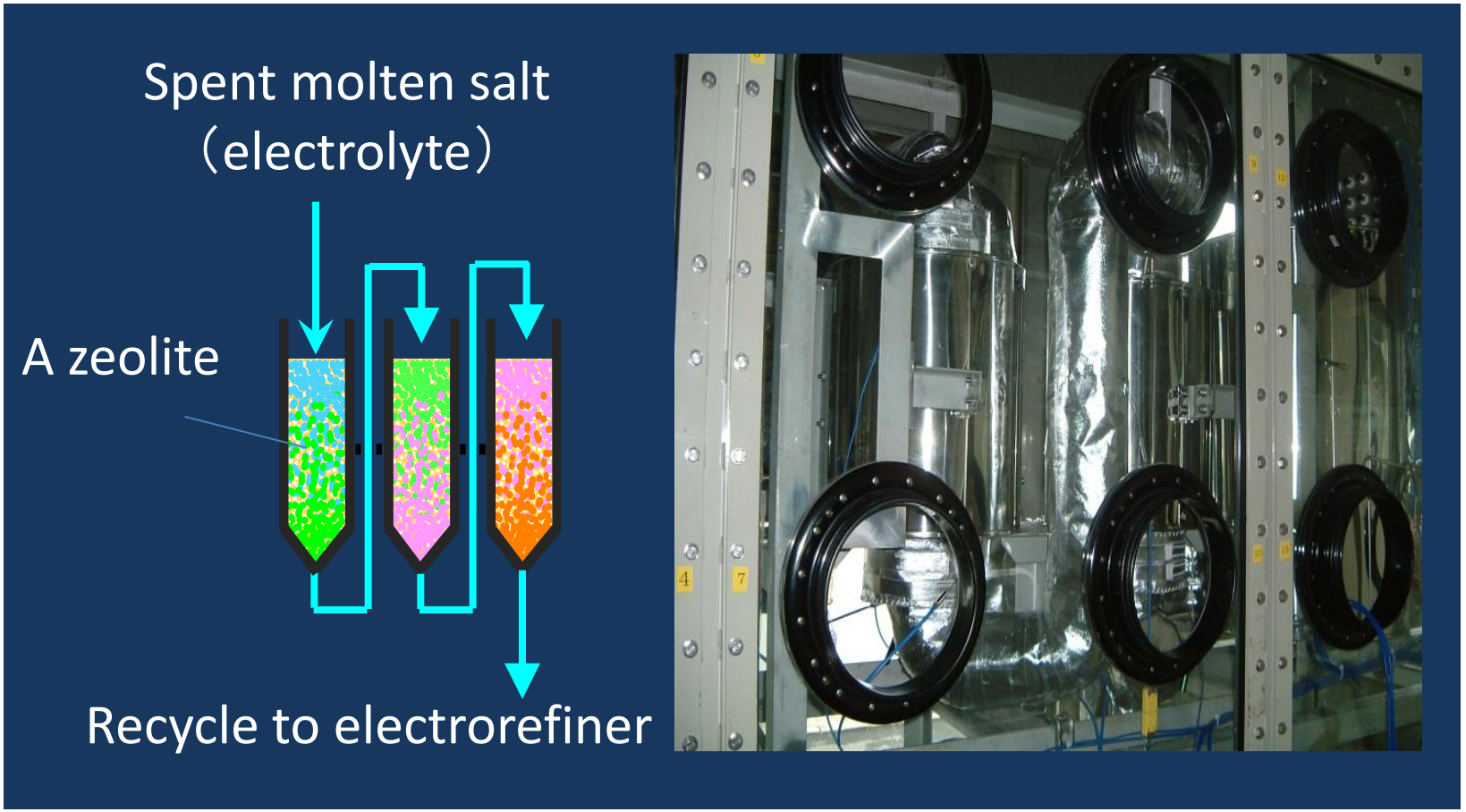
Estimation of DF

(as Conclusions) How Much Water Has Been Treated ?

- 161,580 ton in total till Nov.14th
- Since September, water level has kept around 3,000 mm O.P., where overflow can be avoided even for strong rainfall.



Appendix:
Zeolite column engineering for dry-reprocessing technology



Long experience in zeolite column engineering as dry-reprocessing technology for spent nuclear fuels.