NRA JAPAN
Nuclear Regulation Authority

NRA presentation

C3 Characterization of Source Term

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1. Consideration regarding the Source Term

Discussion up to now

TEPCO have sampled & analyzed nuclides in the water after the accidents in 2011 and characterized the nuclides that could exist:

- ✓ Selected 62 nuclides to be removed by ALPS.
- ✓ Identified C-14 by examining the difference between total beta measurement and the sum of analysis results for each nuclides in 2019.

Therefore, NRA understand that there is no considerable gap between the already identified nuclides and nuclides which are really exists in the water

Consideration for the next

Despite this recognition, there is a necessity to ensure the characterization of the nuclides before the discharge with consideration on factors such as elapsed time for decay (11 years after the accidents)

- TEPCO will reconsider the nuclides possibly exist in the water
- NRA will verify the source term of ALPS treated water.

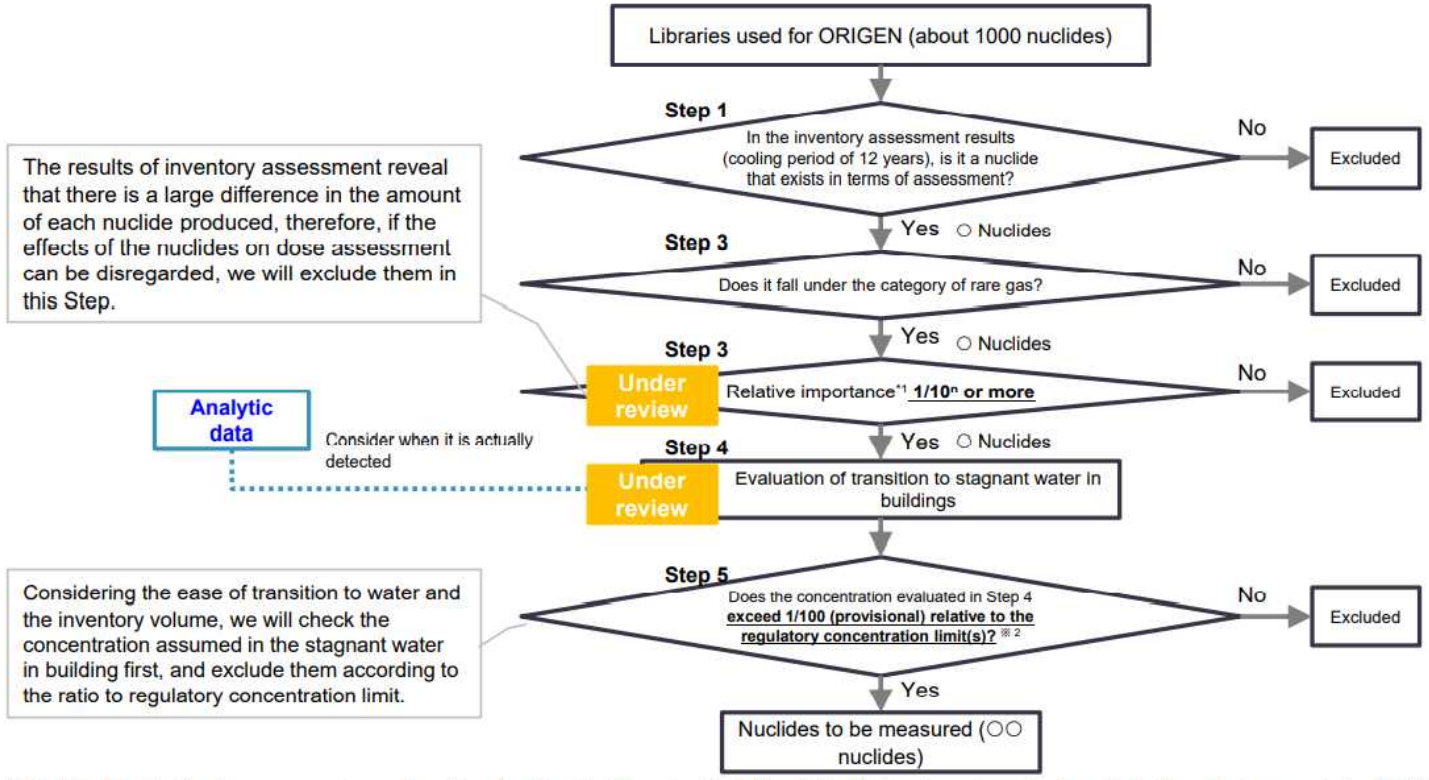
2. TEPCO's plan to characterize the Source Term

TEPCO's plan to selecting the nuclides to be measured

4.1 Concept of selecting the nuclides to be measured for ALPS treated water

TEPCO

- Based on the results of nuclide analysis of contaminated water and treated water and inventory evaluation, we are studying the selection of the nuclides to be measured according to the flowchart below: With the nuclides selected in this flow, discharge criteria will be confirmed.
- In this selection of nuclides to be measured, even if the nuclides to be removed with ALPS are excluded, in order to check the fact that they have been removed with ALPS, TEPCO plans to check these nuclides voluntarily.



*1: Nuclides that affect the dose assessment are confirmed based on the ratio of the value obtained by dividing the inventory volume of each nuclide by the regulatory concentration limit(s) to the sum.

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Explained in 9th Review Meeting of ALPS treated water and details are available on;
https://www.tepco.co.jp/en/hd/decommission/information/committee/pdf/2022/alps_22021501-e.pdf

2. TEPCO's plan to characterize the Source Term

TEPCO's plan to selecting the nuclides to be measured

① Inventory Assessment

TEPCO conducts Inventory Assessment using ORIGEN Code as below;

- Origin of nuclides

  Fission products

  The inventory is calculated based on the condition of burnup of each fuel in Units 1 to 3 reactors induced from the loading period

  Activation products

  The inventory is calculated based on the irradiation period to structures near the reactor (such as reactor internals, fuel assembly, pressure vessel, pedestals)

  Corrosion products generated from Reactor Coolant System is also assessed using the data of metals in feedwater.

- Considering half-life period (12 years after the accidents)

2. TEPCO's plan to characterize the Source Term

TEPCO's plan to selecting the nuclides to be measured

② Radiological impact factor

TEPCO calculates the impact of each nuclide to human with the ratio based on the inventory assessment.

③ Evaluation of transition to stagnant water in buildings

TEPCO assesses the transition to the stagnant water in buildings, based on the results of previous analysis of the stagnant water in buildings and research on decommissioning and disposal facilities etc.

④ Accumulation of measured and analyzed data

TEPCO compares the assessed concentration of nuclides with the data which have been measured and analyzed and evaluates which nuclides exist in fact.

⑤ Decision what nuclides to be measure

TEPCO decides the nuclides to be measured and analyzed.

3. NRA's verification of the Source Term

The NRA is currently planning to conduct analysis of sample taken from ALPS treated water in K4-B tank group.

Schedule

from April 2022 to December 2022 (tentative)

Target Sample

the same water as TEPCO's sample taken from K4-B tank group on 15th February and 23th March

Analytical Institution

TSO (Technical Support Organization) of the NRA
i.e. Nuclear Safety Research Center, Japan Atomic Energy Agency (JAEA)

Target nuclides

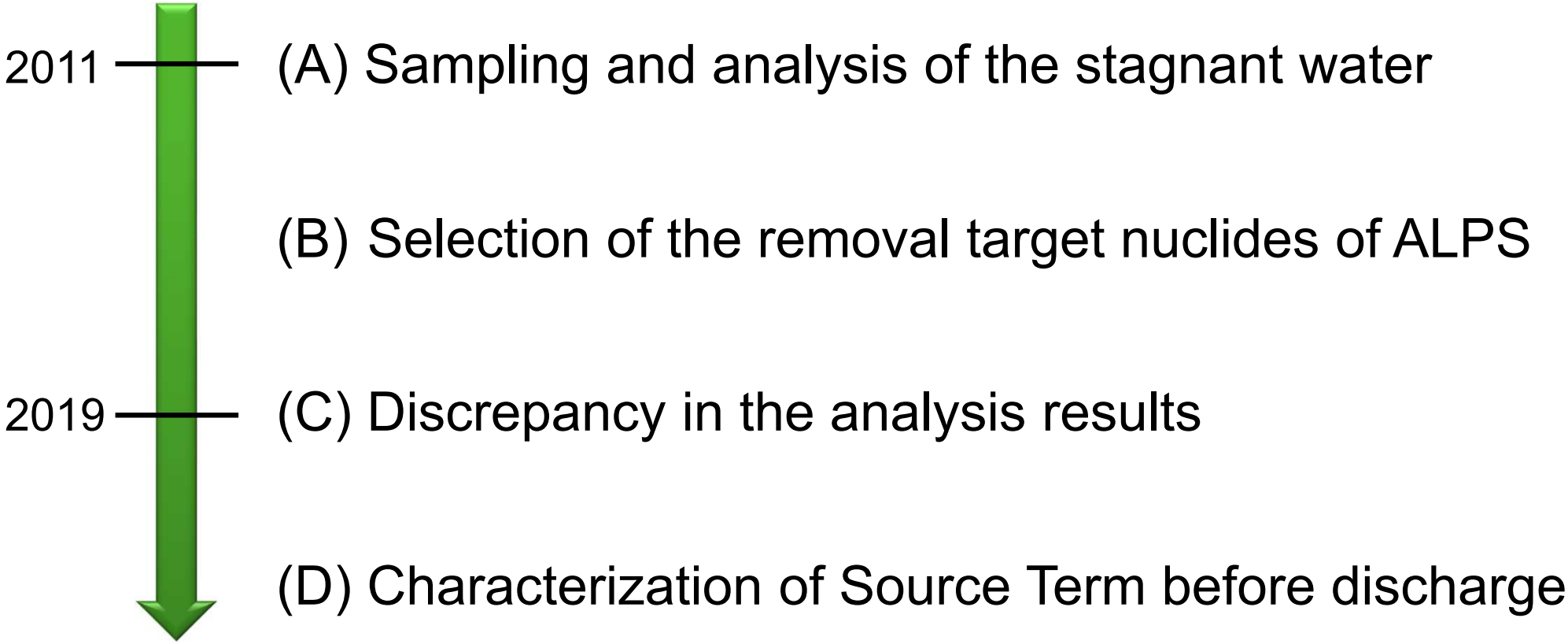
- Nuclides which have relatively high radiological impact e.g. C-14, I-129 (TBD)
- Some nuclides to confirm the existence in ALPS treated water

(Reference) Description regarding source term in IAEA Standards

GSG-9
5.20.
A pre-operational analysis should be carried out to identify the inventories of radionuclides that would result in discharges during the operation of a facility or the conduct of an activity, …

(Reference) Consideration regarding the Source Term

TEPCO and NRA have discussed the nuclides in the ALPS treated water and stagnant water in buildings so far.

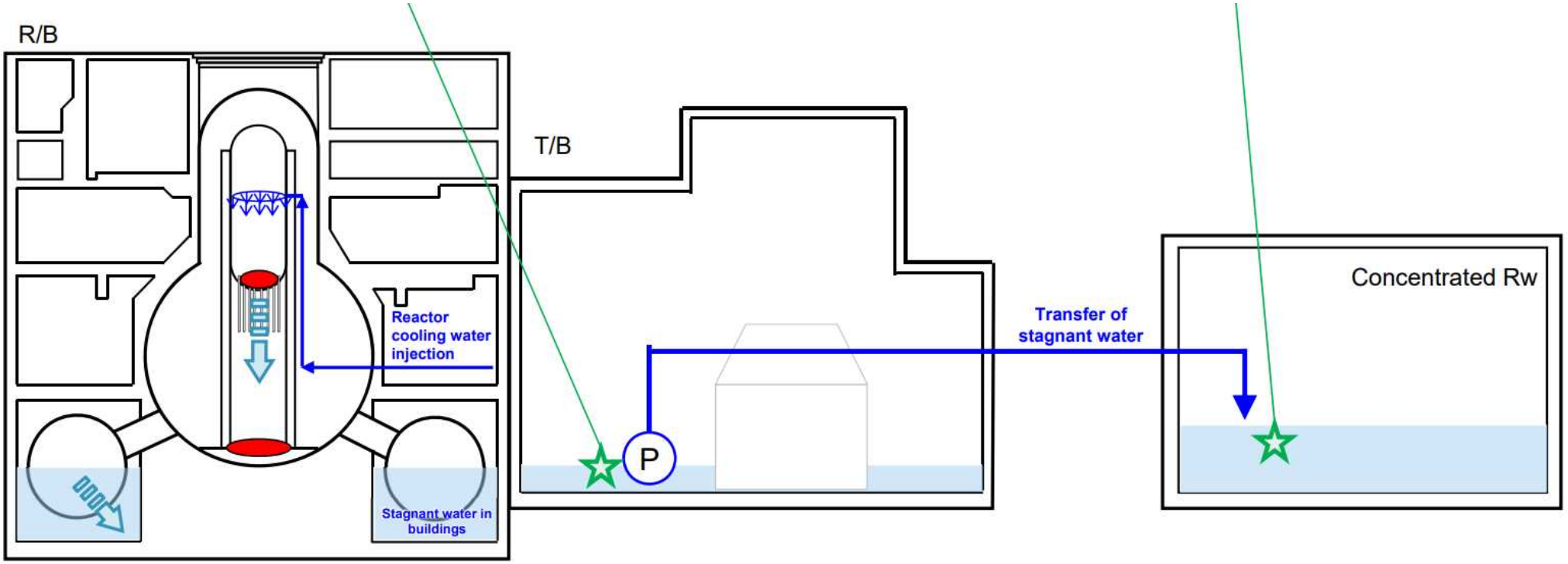


(Reference) Consideration regarding the Source Term

(A) TEPCO sampled and analyzed the stagnant water in buildings.

Build.	Date	I-131	Cs-137	Sr-90
Unit 1 T/B	March 27th, 2011	3.0E+07	1.6E+08	2.1E+04
Unit 2 T/B	March 24th, 2011	2.0E+09	2.8E+08	1.4E+08
Unit 3 T/B	March 27th, 2011	1.6E+09	1.6E+08	1.5E+07

Build.	Date	Co-60	Cs-137	Sr-90
PBM	Aug. 30th, 2011	1.1E+04	9.6E+08	1.1E+08
PBM	Nov. 1st, 2011	4.9E+03	7.4E+08	2.9E+08



(B) TEPCO selected the removal target nuclides of ALPS.

Fission products

① Simulate and list radionuclides contained in fuels of the reactor 30 days after the Accidents by ORIGEN Code calculation
② Exclude tritium, insoluble nuclides and noble gas
③ Estimate concentrations of each nuclide 1 year after the Accidents by using measurement results of Cs-137 in stagnant water and evaluation of MAAP Code

Such nuclides that the ratio with the regulatory concentration limit are big* ➔ 56 nuclides (e.g. Sr-90, Ru-106, Sb-125, I-129, Cs-137)

$$(*)\ \frac{\text{concentration of } \mathbf{nuclide\ X}\ (\mathrm{Bq/L})}{\text{regulatory concentration limit of } \mathbf{nuclide\ X}\ (\mathrm{Bq/L})} > \frac{1}{100}$$

(Reference) Consideration regarding the Source Term

(B) TEPCO selected the removal target nuclides of ALPS.

Activated corrosion products

① Estimate concentrations of nuclides 1 year after the Accidents by using the data of measurement results of nuclides in water in Unit1~3 reactors and condensed liquid waste tanks

Such nuclides that the ratio with the regulatory concentration limit are big* ➔ 6 nuclides (Mn-54, Fe-59, Co-58, Co-60, Ni-63, Zn-65)

$$(*)\ \frac{\text{concentration of } \mathbf{nuclide\ X}\ (\mathrm{Bq/L})}{\text{regulatory concentration limit of } \mathbf{nuclide\ X}\ (\mathrm{Bq/L})} > \frac{1}{100}$$

(Reference) Consideration regarding the Source Term

(C) Discrepancy in the analysis results

In 2018, NRA pointed out the possibility of existence of other nuclides than 62 nuclides (removal target nuclides of ALPS) by comparing the result data of total β measurement and specific nuclide analysis.

In 2019, It turned out that difference in the results are caused by C-14* and Tc-99.

* C-14 is not included in 62 nuclides

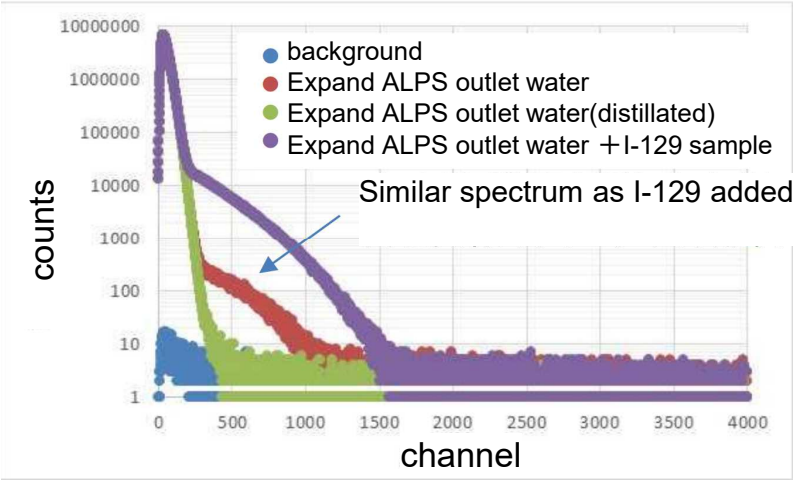
(Reference) Consideration regarding the Source Term

(C) Discrepancy in the analysis results

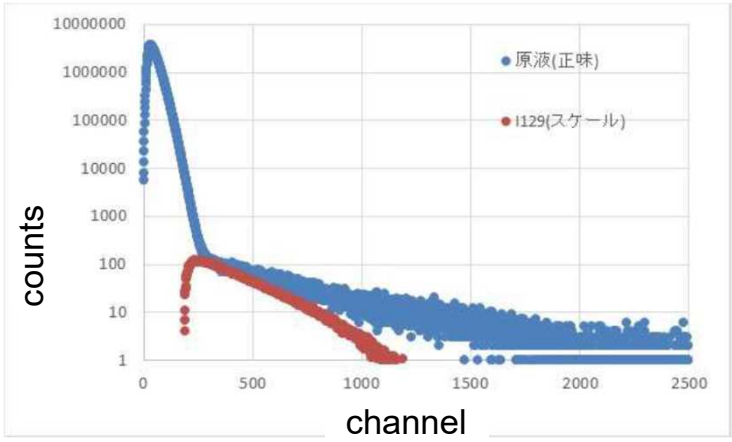
- C-14 was significantly (no less than negligible) detected, where the energy peak from C-14 (157 keV) is near that from I-129 (154 keV).
- Also, Tc-99 was significantly detected, where the energy peak from Tc-99 (294keV) found at higher energy side than the energy band from I-129 (~approx. 300keV).

Analysis results of C-14 and Tc-99

Nuclides	Methods	(a) Concentration (Bq/L)	(b) Regulatory concentration (Bq/L)	Ratio (a/b)
C-14	LSC	45.22	2,000	0.023
Tc-99	ICP-MS	28.72	1,000	0.029



β-ray spectrometry of the water at Expand ALPS outlet



β-ray spectrometry of H4N-A6 tank water

Source: 67th Supervision and Evaluation Committee on Fukushima Daiichi NPS on January 21st, 2019, Document 4-3

(Reference) Consideration regarding the Source Term

(C) Consideration on the discrepancy in the analysis result

- NRA instructed TEPCO to measure nuclides in other several tanks

- Consequently C-14 and Tc-99 were detected in these tanks.
- Other unknown nuclides than 62 nuclides, C-14 and tritium are not found from the result of β-ray energy spectrometry.

- TEPCO will again investigate possibility of other unknown nuclides existence, in the case that the result of β-ray measurement of major 7 nuclides*, C-14 and Tc-99 are below that of total β measurement.

(*Cs-134, Cs-137, Co-60, Sb-125, Ru-106, I-129, Sr-90)

(Reference) Consideration regarding the Source Term

(D) Characterization of Source Term before discharge

- NRA understand that the potential existence of other nuclides than 64 nuclides which may have large radiological impact is inconsiderable so that the fully purified ALPS treated water is satisfied the regulatory requirements of discharge.
- Nevertheless, in ALPS treated water, there may be activated nuclides originated from reactor internal structure or low energy β nuclides which have not been measured and evaluated.
- From this perspective, NRA requires TEPCO to conduct realistic evaluation again considering the decay after the Accidents until the starting point of discharge, and to select measurement target nuclides after analyzing nuclides which can possibly exist in the ALPS treated water.
- NRA will confirm the TEPCO's evaluation and analysis results of nuclides by the beginning of discharge.