IAEA Review of Safety Related Aspects of Handling ALPS Treated Water at TEPCO's Fukushima Daiichi Nuclear Power Station

Additional Measures for Independent Sampling and Analysis Related to Discharges of ALPS Treated Water

– Additional Measures April 2025: Monitoring at Discharge Vertical Shaft/Seawater Pipe Header

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1. INTRODUCTION

The main objective of Additional Measures for Independent Sampling and Analysis Related to Discharges of ALPS (Advanced Liquid Processing System) Treated Water (hereafter referred to as "Additional Measures") is to further increase transparency by facilitating the wider participation of stakeholder countries, through the IAEA's Analytical Laboratories for the Measurement of Environmental Radioactivity (ALMERA[1]) network [1] member laboratories, in independent sampling and analysis related to discharges of ALPS treated water under the framework of the IAEA.

The IAEA and Japan concurred in September 2024, to implement the Additional Measures under the framework of the IAEA. The Agency confirms that this agreement builds upon its existing sampling and monitoring activities in compliance with the IAEA statutory functions.

Therefore, the Additional Measures outlined herein are intended to be a key component of the ongoing IAEA programme and will be executed under the authority of the IAEA. The scope of the Additional Measures encompasses the following activities:

a) **Source Monitoring (Post-ALPS Treatment, Pre-Dilution)**: This involves independent sampling and analysis of ALPS treated water sourced from the measurement and confirmation facility, specifically the tanks where the water is stored, homogenized, and tested prior to release.

b) **Monitoring at Discharge Vertical Shaft/Seawater Pipe Header (Post-Dilution)**: This comprises independent sampling and analysis of the diluted ALPS treated water.

c) **Marine Environmental Monitoring (Post-Discharge)**: This includes independent sampling and analysis of seawater and fishery products.

In April 2025, the IAEA carried out this Additional Measures mission through sampling of diluted ALPS treated water at TEPCO's Fukushima Daiichi Nuclear Power Station (FDNPS). This report presents the results of subsequent analyses for tritium activity concentrations conducted by TEPCO, by the IAEA laboratory in Japan, and by member laboratories of the ALMERA Network from China, the Republic of Korea, the Russian Federation and Switzerland. Additionally, it includes the results of an intercomparison of these measurement results which was carried out by the IAEA according to international best practice for proficiency testing [2].

[1] ALMERA is a network comprising more than 200 member laboratories globally. It provides a platform for maintaining and developing capability on the determination of radionuclides in air, water, soil, sediment and vegetation that can be used for both routine and environmental emergency monitoring in the IAEA Member States.

2. PARTICIPATING LABORATORIES

The participating laboratories are presented in Table 1.

TABLE 1. PARTICIPATING LABORATORIES

Identifier	Participant
IAEA	IAEA Fukushima ALPS Laboratory, Japan
CIRP	China Institute for Radiation Protection, China
IPEM	Institute for Problems of Environmental Monitoring, RPA "Typhoon", Russian Federation
KINS	Korea Institute of Nuclear Safety, Republic of Korea
SPIEZ	Spiez Laboratory (Labor Spiez), Switzerland
TEPCO	Tokyo Electric Power Company Holdings, Inc., Japan

3. SAMPLE COLLECTION AND PRETREATMENT

Samples of ALPS treated water diluted with seawater were collected on 15 April 2025 at the Discharge Vertical Shaft/Seawater Pipe Header at the ALPS Discharge Facility at FDNPS.

Each participating laboratory was provided with a sample comprised of 0.5 L of diluted ALPS treated water for analysis for tritium. The IAEA staff members and experts from the ALMERA member laboratories took the opportunity to fill the container that would subsequently be shipped to their laboratories for analysis.

A unique sample ID and recipient laboratory were recorded to facilitate the traceability of each sample container. The samples were then checked, boxed and shipped to all participating laboratories in April 2025 for analysis.

4. ANALYSES

Participating laboratories were requested to analyse the samples of ALPS treated water diluted with seawater for activity concentrations of ^{3}H using an appropriate analytical method.

Reporting forms and target detection limits were provided by the IAEA. Participating laboratories were requested to submit a single measurement result for each sample and radionuclide analysed, comprised of an activity concentration, standard combined uncertainty (k=1) and detection limit. They were asked to report activity concentrations for a reference time of 15 April 2025 12:00 UTC.

5. STATISTICAL EVALUATION OF THE RESULTS

The IAEA compiled and evaluated the results submitted by all participating laboratories. A comparison reference value x_{ref} was determined as a power-moderated mean of the combined results [3]:

$$x_{ref} = \sum_{i=1}^{N} w_i x_i$$

where x_i is the value reported by the laboratory i, N is the number of results reported and w_i is a normalized weighting factor.

A ζ (zeta) score was then calculated for each laboratory as follows.

$$\zeta = \frac{d_i}{u(d_i)}$$

where $d_i = x_i - x_{ref}$, the difference between the value reported by the laboratory x_i and the reference value x_{ref}, and $u(d_i)$ is the standard uncertainty associated with d_i, taking the correlation between individual results and the reference value into account.

Following the current ISO standard for statistical methods for use in proficiency testing [4], for zeta scores between -3 and 3, the corresponding result was evaluated as agreeing with the reference value at a 99.7% confidence level and for zeta scores greater than 3 or less than -3 the reported result was evaluated as not agreeing at a 99.7% confidence level.

6. RESULTS

The results submitted by the participating laboratories and associated consensus reference values are presented in Table 2 and Figure 1. The uncertainties quoted are combined standard uncertainties, i.e. with a coverage factor of $k = 1$. Table 3 contains the zeta scores.

TABLE 2. ACTIVITY CONCENTRATIONS (BQ L^{-1}) IN SAMPLES OF ALPS TREATED WATER DILUTED WITH SEAWATER

Nuclide	IAEA	CIRP	IPEM	KINS	SPIEZ	TEPCO	Reference
^{3}H	464.0 ± 7.7	455 ± 16	446 ± 27	471 ± 9	505 ± 10	443 ± 20	468 ± 10

TABLE 3. ZETA SCORES FOR ACTIVITY CONCENTRATION OF RADIONUCLIDES IN SAMPLES OF ALPS TREATED WATER DILUTED WITH SEAWATER

Nuclide	IAEA	CIRP	IPEM	KINS	SPIEZ	TEPCO
^{3}H	-0.33	-0.78	-0.83	0.29	**3.09**	-1.26

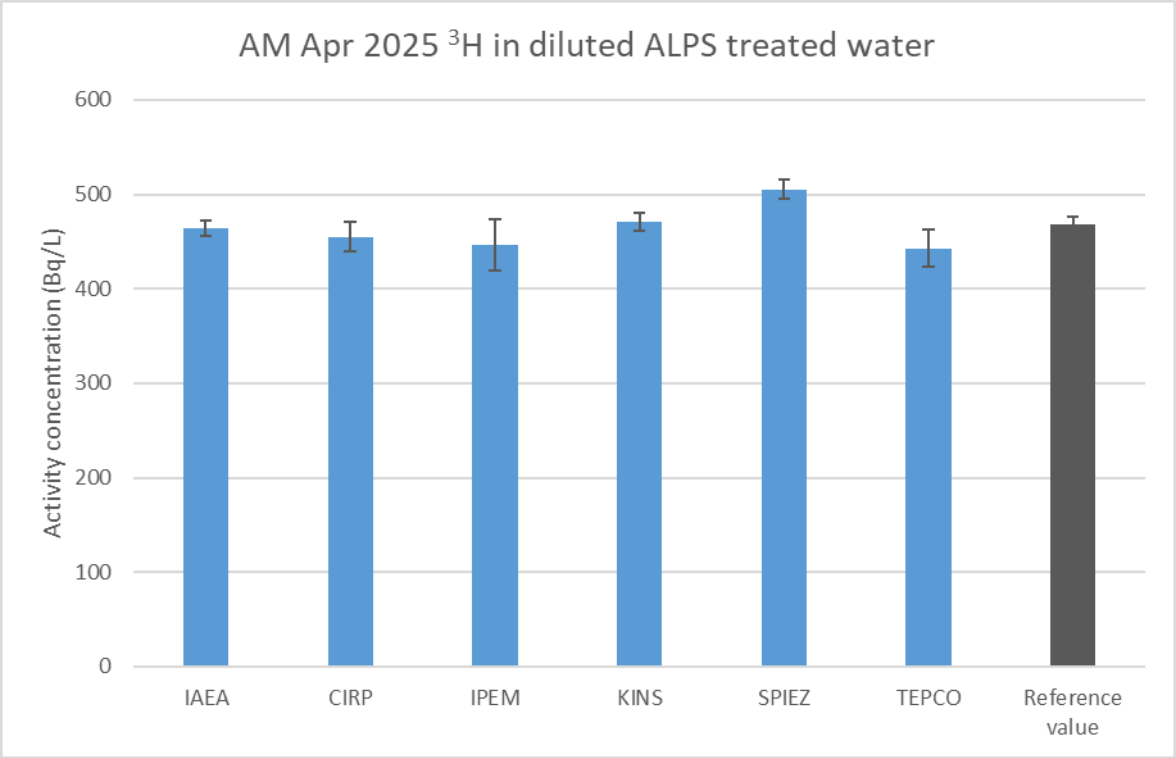

FIG. 1. Activity concentrations of ^{3}H in samples of ALPS treated water diluted with seawater.

7. CONCLUSION

The results of Additional Measures April 2025: Monitoring at Discharge Vertical Shaft/Seawater Pipe Header demonstrate that the measurement results reported by the majority of participating laboratories are in statistical agreement with the consensus reference value derived from their intercomparison. The single exception was the ^{3}H activity concentration reported by Spiez Laboratory which was reported to be statistically significantly higher than the reference value at a 99.7% confidence level. It is important to note that the magnitude of this deviation is modest and detectable primarily due to the rigorous statistical criteria applied in this analysis. Minor discrepancies of this nature are occasionally observed in laboratory performance evaluations. While further investigation by the reporting laboratory is recommended to identify any potential sources of variance, this deviation does not materially affect confidence in the laboratory's technical competence for performing such measurements in practical applications.

These measurement results are consistent with the conclusions of the IAEA Comprehensive Report on the Safety Review of the ALPS-Treated Water at the Fukushima Daiichi Nuclear Power Station [5] released in July 2023, which found that the discharges as planned would have a negligible radiological impact on people and the environment.

REFERENCES

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[3] POMMÉ, S. and KEIGHTLEY, J.D. 2015. Determination of a reference value and its uncertainty through a power-moderated mean. Metrologia **52**, S200-S212.

[4] INTERNATIONAL ORGANISATION FOR STANDARDISATION, Statistical methods for use in proficiency testing by interlaboratory comparisons, ISO 13528:2022, Geneva (2022).

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