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EPRI Project

Hard-to-Measure Nuclides in Effluents

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Hard-to-Measure Nuclides in Effluents

- Definitions:

Hard-to-Detect, HTD, nuclides are those nuclides that cannot be detected by a given counting method. Also known as Difficult-to-Detect.

Hard-to-Measure, HTM, nuclides are those nuclides that cannot be easily quantified by direct counting methods such as gamma spectroscopy. This can be due to the energy, type, or abundance of the radiation emitted. Also known as difficult-to-measure.

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Examples:

Hard-to-Detect:	Fe-55 using gamma spectroscopy Zn-65 using a beta detector
Hard-to-Measure:	F-18 no gamma emitted, but positron annihilation can be used to estimate activity Pr-144 gamma emitted, but abundance is low, 1.48%

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Hard-to-Measure Nuclides in Effluents

- Project is a continuation and expansion of previous EPRI project Environmental Radiation Doses From Difficult-to-Measure Nuclides, EPRI NP-3840, January 1985.

- Objective:

Identify HTM nuclide monitoring gaps, estimate the significance of these gaps and provide technical guidance and best practices for accurately reporting HTM nuclides in nuclear power plant effluents.

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– The project will:

Identify Hard-to-Measure Radionuclides produced at both light and heavy water reactors.

Evaluate the release and dose impact of Hard-to-Measure nuclides

Identify gaps and best practices in reporting Hard-to measure nuclides

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– Sources of Hard-to-Measure Nuclides

Fission process

Activation of structural materials, RCS, and/or compounds dissolved in RCS.

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– Fission Process

Current literature, both domestic and international will be reviewed to determine those hard-to-measure nuclides produced from fission.

From this set of nuclides, those of sufficient abundance and with a sufficiently long half-life as to pose a credible risk will be evaluated to determine dose consequences from both liquid and gaseous effluents.

Finally, these nuclides will be evaluated to determine best measurement method.

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– Activation Products

Samples will be analyzed to determine presence of HTM nuclides.

Effluent reports, both domestic and international will be reviewed to determine those hard-to-measure nuclides currently reported or are being measured

10CFR61 analyses will be reviewed to determine which nuclides are being measured and reported

Finally, these nuclides will be evaluated to determine best measurement method for a given nuclide

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Reactor	2007						2008					
	Liquid Effluents		Resins/Sludges		DAW		Liquid Effluents		Resins/Sludges		DAW	
	Co-58:Fe55	Co-60:Fe-55	Co-58:Fe-55	Co-60:Fe-55	Co-58:Fe-55	Co-60:Fe-55	Co-58:Fe55	Co-60:Fe-55	Co-58:Fe-55	Co-60:Fe-55	Co-58:Fe-55	Co-60:Fe-55
1	2.65	1.18	2.12	6.81	2.42	1.12	0.72	0.44	0.61	2.40	2.59	0.93
2	0.27	0.32	0.36	0.82	12.50	4.28	0.29	0.08	0.28	1.07	8.01	1.10
3	2.93	0.16	6.36	0.15	1.39	0.07	0.41	0.19	0.01	0.05	0.01	0.05
4	1.30	3.63	2.00	6.20	0.30	0.55	2.66	5.36	2.98	7.50	0.86	3.48
5	0.03	0.15	N/A	N/A	0.00	0.07	0.00	0.15	0.00	0.08	0.17	0.13
6	0.77	9.12	0.03	4.83	1.05	0.87	0.81	21.22	0.00	1.41	0.00	2.01

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– Potential Measurement Methodologies

Scaling from a parent or daughter nuclide that is easy-to-measure:

Example: Pr-144 activity can be measured by determining Ce-144 activity.

Since the half-life of Ce-144, 284.3 days, is significantly longer than the half-life of Pr-144, 17.8 minutes, the two are in secular equilibrium and the activity of Pr-144 is equal to Ce-144.

For this methodology branching ratio and half-life relationships must be utilized.

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– Activity of Daughter and Parent are related by the following equation:

$$A_D = f \frac{(\lambda_D - \lambda_P)}{\lambda_D} A_P (e^{-\lambda_P t} - e^{-\lambda_D t})$$

The term f is the branching ratio, i.e., what fraction of all parent decays result in the daughter of interest.

The term $(\lambda_D - \lambda_P)/\lambda_D$ provides the relationship between the activity of the daughter and parent at equilibrium if f is 1.

In these cases the apparent half-life of the daughter is the parent's half-life

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– Potential Measurement Methodologies

Scaling directly from an unrelated nuclide.

Example in waste stream measurements TRUs are often scaled from an unrelated nuclide such as Ce-144

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– Potential Measurement Methodologies

Calculation from other radiation emitted

Example: F-18 does not emit any gammas. However, its activity can be measured by allowing for the sample to decay for a period of time, say an hour, to eliminate short-lived interferences.

The activity of F-18 can be determined using the twice the abundance of its positron emission, or 193.46% as the abundance of the annihilation gammas.

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– What can you do to help?

May need to have RCS and effluent samples analyzed to assist in determining HTM from several plants to determine relationships.

Will need data regarding MCA use to assess feasibility of scaling from parent-daughter relationships and scaling from non-related nuclides.

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