Tellurium-123m in Liquid Effluents

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Agenda

- Introduction and Background
- Half-Life Study
- Source of Te-123m?
- Off-Site Dose Impacts
- Summary

Introduction and Background

- R.E. Ginna Nuclear Power Plant is located on Lake Ontario in the town of Ontario, Wayne County, about 16 miles east of Rochester, NY.
  - 580 Megawatt Pressurized Light Water Nuclear Reactor plant of Westinghouse design.
  - Generating electricity for western New York for 46 years.

Introduction and Background

- Tellurium-123 metastable, (Te-123m), has been identified in liquid effluent releases and in the Spent Fuel Pool.

- Te-123m shares its only gamma emission energy line at 159 kev with Tin-117m (Sn-117m), leading to potential misidentification.

Introduction and Background

- The 159 kev energy line began to show up in liquid waste treatment effluent samples about a year ago, mid-cycle.
- Initially our gamma spec system identified it as Sn-117m.
- Our count room technicians questioned the 13 day half-life activation product of Sn-117m in a low flow waste system – weeks away from a neutron flux.

Introduction and Background

- Initiated a decay study and identified that the half-life of the nuclide emitting the 159 kev gamma was much greater than 13.6 days – approximately 100 days.

- Understand the counting statistics for the very low net counts would carry uncertainty in determining the half-life, but clearly this was not Sn-117m.

- Te-123m has a half-life of 119.7 days

Half-life Study

- Reviewed “Atomic Data and Nuclear Data Tables”, Gamma Rays Ordered by Energy Table 1, (February 1974).
- Found no other radionuclide with the energy line at 159 kev and an approximate 100 day half-life.
- Also possible that a small amount of Sn-117m in with Te-123m is decreasing the apparent half-life at 159 kev.
- The half-life study did not conclusively identify Te-123m, but strongly suggested it.

Half-life Study

- We next plan to precipitate the tellurium and filter it to get concentration and more consistent geometry for a cleaner half-life determination.

- But remember, there are resource limits on science projects in operating nuclear plants that now must compete against subsidized wind and solar.

- So we move on with the issue of small quantities of Te-123m in our liquid effluents.

Source of Te-123m?

- Tellurium is one of the rarest elements – occurring in the Earth's crust at about 1 ug/kg – platinum is about 4 ug/kg.
- Looking at the Chart of the Nuclides, Te-123m is blocked by stable Sb-123 for any typical fission product decay chain production.
- There are published tables of fission yields for Pu-239 (JENDL-4.0) with finite probabilities for independent fission production of Te-123m.

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20.1 h
ε
γ 350.1, 148.6, 416.6,···
E 0.9

2.00 h
ε, β+ 1.51,···
γ 148.9, 178.0, 330.2,···
E 2.68

Xe124
0.09
σγ (~28 + 1.4E2), (6E2 + 2E3)
123.905896

9/(−) Xe125 1/(+)
57 s
IT 140
γ 112
17.1 h
ε
β+ .47 (ω), ···
γ 188.4,···
σα < .03
E 1.653

Xe126
0.09
σγ (.4 + 3), (8 + 5E1)
125.90427

9/− Xe127 1/+
1.15 m
IT 172.5, e−
γ 124.7
36.4 d
ε
γ 202.9, 172.1, ···
σα < 0.01
E 0.662

Xe12
1.92
σγ (.5 + ?), (4E1 + ?)
127.903

I121 5/+
2.12 h
ε
β+ 1.2,···
γ 212.2,···
E 2.27

I122 1+
3.6 m
β+ 3.1,···, ε
γ 564.1,···
E 4.23

I123 5/+
13.2 h
ε
γ 159.0,···
E 1.234

I124 2−
4.176 d
ε, β+ 1.54, 2.14,···
γ 602.7,···
E 3.160

I125 5/+
59.4 d
ε
γ 35.49, e−
σγ 9E2, 1.4E4
E .1858

I126 2−
13.0 d
ε
β− .87,···
γ 388.6,···
β+ 1.13 (ω),···
E +2.155 E−1.26

I127
100
σγ 6.2, ~1.50
126.9044

Te120
0.09
σγ (.3 + 2)
119.90402

11/− Te121 1/+
~154 d
IT 81.8, e−
γ 212.2, ε
γ 1102.2, 37.1 (e−), ···
β+ ω
16.8 d
ε
γ 573.1, 507.6, ···
E 1.04

Te122
2.55
σ̂γ ~ 2.4, 8E1
121.903047

11/− Te123 1/+
119.7 d
IT 88.5, e−
γ 159.0
0.89
> 6E14 a
ε, no γ
σγ 3.7E2, 4.5E3
σα .05 mb
E .053 122.90427

Te124
4.74
σγ (.05 + 7), 5
123.902819

11/− Te125 1/+
58 d
IT 109.3, e−,···
γ 35.5 e−
7.07
σ̂γ 1.6, 21
124.904425

Te12
18.84
σ̂γ (.13 + .9), (? + 8)
125.9033

Sb119 5/+
38.1 h
23.9, e−
E .59

8− Sb120 1+
5.76 d
ε
γ 1171.4, 1023.1, 197.3D, 89.8,···
15.89 m
ε, β+ 1.72,···
γ 1171.4, ···
E 2.68

Sb121 5/+
57.21
σγ (.1+5.9), 2.0E2
120.903818

(8) Sb122 2−
4.191 m
IT 26.1, e−
γ 61.4D, 76.1D
2.72 d
β− 1.414, 1.980, ···
γ 564.1, ···
ε
β+ .57
E +1.616 E −1.983

Sb123 7/+
42.79
σγ (.02 + .04 + 4.0), 1.3E2
122.904216

8− Sb124 3−
20.2 m
IT 26.0, e−
γ 10.9D, e−
60.20 d
β− .61, 2.301,···
5+ 1.6 m
IT 10.9, e−
β− 1.2,···
γ 602.7, 645.8, 498.4,···
γ 602.8, 1691.0, 772.8,···
σ̂γ 17
E 2.904

Sb12
2.758
β− .302, .13,···
γ 427.9, 600.
635.9, 463.
E .767

Sn118
24.22
γ (4mb + ?), 5
117.901606

11/− Sn119 1/+
293 d
IT 65.7, e−
γ 23.9
8.59
σ̂γ 2, 4
118.903309

Sn120
32.58
σγ (.001+.16), 1.2
119.902197

11/− Sn121 3/+
44 a
IT 6.3, e−
β− .36
γ 37.15, e−
1.128 d
β− .383
no γ
E .390

Sn122
4.63
σ̂γ (.15 + .001), (.8+?)
121.903440

3/+ Sn123 11/−
40.1 m
β− 1.26,···
γ 160.3,···
129.2 d
β− 1.42,···
γ 1088.6, ···
E 1.428 E 1.403

Sn12
5.79
σγ (.13 + .004) (8+?)
123.90527

In117 9/+

8− In118 1+

1/− In119 9/+

(8−) In120 1+

1/− In121 9/+

8− In122 1+

1/− In123

Source of Te-123m?

- Looked at fission production because of a time associated event – discharge of the first leaking fuel assembly to our spent fuel pool in 14 years around the time that Te-123m appeared.
- Also looked at activation.
- Antimony metal is a common contaminant and there are possible p,n reactions with 43% abundant Sb-123 to Te-123m.
- This is possible, but a very low probability.

Source of Te-123m?

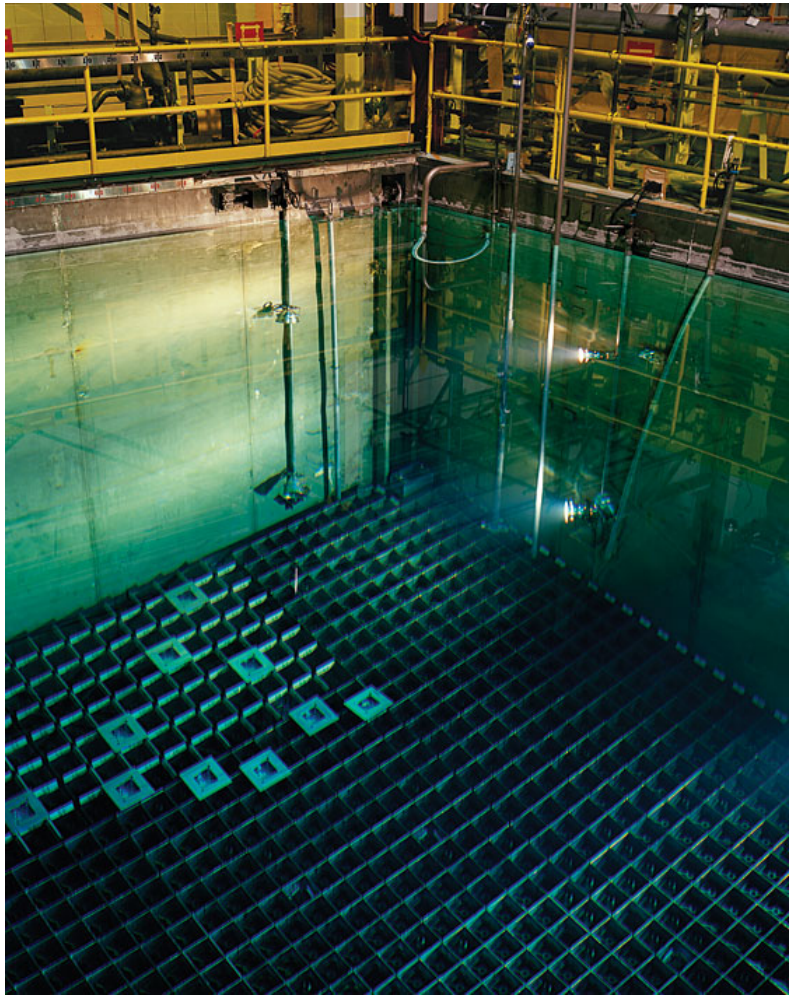
- The most likely source of Te-123m is neutron activation of Te-122.

- Te-122 is a 2.5% abundant isotope of a very rare element, so where would it come from?

Source of Te-123m?

- A little digging revealed Ginna had a leaking secondary startup source stored in the SFP – this source leaks Sb-124 and Sb-122, which decays to Te-122.

- That is enough for a reasonable explanation of where the Te-123m came from.



Source of Te-123m?

So why did it show up now? There are several possible reasons:

- Like antimony, tellurium is not effectively removed or held by anion exchange resins not specifically designed to be selective for it.
- Shifts in waste treatment system chemistry including pH shifts or loading of the anion beds with non-radioactive anions from increases in service water leakage to the drains, can allow tellurium to pass through.

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Off-site Dose Impacts

- Ginna is committed to Reg. Guide 1.109
- Reg. Guide 1.109 does not list ingestion dose factors for Te-123m.
- Ingestion dose factors are listed in RG 1.109 for Te-127m.
- Compared Te-127m dose factors to Te-123m dose factors using EPA-520/1-88-020 and found that Te-127m is a reasonable and conservative surrogate for Te-123m with regard to ingestion dose factors.

Off-site Dose Impacts

- Liquid effluent dose at Ginna is dominated by tritium, which is >99% of Curies released.

- Dose due to liquid effluent releases at Ginna is also >99% due to tritium.

Off-site Dose Impacts

- No significant effect on reported off-site dose at Ginna had we not identified Te-123m.
- However, the same could be said for Co-58 which is released in liquid effluents at concentrations similar to Te-123m.
- If we detect it, we report it.

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Summary

- The 159 kev energy line in liquid effluent releases at Ginna is Te-123m, with the possibility of a small amount of Sn-117m.

- It most likely is coming from neutron activation of Te-122 which is a decay product of Sb-122 from a leaking secondary startup source in the spent fuel pool.

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Summary

- Te-127m ingestion dose factors from Reg. Guide 1.109 are appropriate and conservative surrogates to use for Te-123m in our off-site dose calculations.

- Any misidentification of Te-123m in the past did not result in a non-conservative reporting of offsite dose due to liquid effluents.

- Thanks to Dr. Robert Litman and to Larry Wolfe of ChemStaff for technical assistance with this discussion.

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Questions?