1 of 1

2
July 28, 1993

WSRC-RP-93-1060

Retention: Permanent

Key Words

Radionuclide	Seepage Basins
Monitoring	Fission Product
Well	Beta Emitter
Soil	Non-Volatile Beta
Migration	Analysis

**Sr⁸⁹ - AN UNNECESSARY CONTAMINANT OF CONCERN
IN SRS ENVIRONMENTAL SAMPLES (U)**

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WESTINGHOUSE SAVANNAH RIVER COMPANY
INTER-OFFICE MEMORANDUM

WSRC-RP-93-1060

July 28, 1993

TO: M. A. EBRA, 992-4W

FROM: H. P. HOLCOMB, 992-4W (644-6745) *HPH*

**Sr⁸⁹ - AN UNNECESSARY CONTAMINANT OF CONCERN IN SRS
ENVIRONMENTAL SAMPLES (U)**

INTRODUCTION AND SUMMARY

This report documents the technical and time bases used to conclude that the fission product, Sr⁸⁹, should no longer be considered as a contaminant of concern and an analyte in SRS environmental samples. This conclusion is the basis for hard-dollar cost savings suggestions to eliminate its analysis in F/H Areas Seepage Basin monitoring wells and in future soil, sediment and water environmental samples for which the analytical contract is to be awarded prior to October 1, 1993. Environmental Restoration should proactively pursue regulatory approval for the elimination of Sr⁸⁹ as an analyte in appropriate environmental samples.

Three primary factors enter into this conclusion. The first is the relatively short half-life of Sr⁸⁹, 50.55 days; the second, the relatively long time frame since cessation of SRS reactor irradiations

M. A. EBRA

July 28, 1993

Page 2

that could have produced Sr^{89} together with the correspondingly long time before these undissolved reactor components can be processed; and the third is the much greater risk contribution from the much more abundant activity of the longer-lived (28.5 years) fission product, Sr^{90} . I am assuming that the fission products within the fuel/target elements cannot enter the ecosystem until after dissolution when wastes containing them would be produced and potential source terms therein released.

Reactor operation at SRS ceased on July 30, 1992 when the K Reactor reduced-power test ended. Those reactor components contain the most recently produced fission products at SRS and would, therefore, contain the highest activity ratio of Sr^{89} to Sr^{90} . The $\text{Sr}^{89}/\text{Sr}^{90}$ activity ratio currently in those unprocessed fuel/target assemblies is about unity. Processing of those is not expected for at least two years. At that time, the ratio will have fallen to about $6\text{E}-05$. All current canyon solution inventory, including off-site material in H-Area, and awaiting processing was produced in reactor campaigns that ended at least 5 years ago. The $\text{Sr}^{89}/\text{Sr}^{90}$ ratio in that material is no more than $3\text{E}-09$.

Sr^{90} remains a most important contaminant of concern due to its much longer half-life, 28.5 years. Monitoring of it should continue. There is no technical or risk basis for further monitoring of Sr^{89} under current and predicted time frames for SRS operations. Timing of these result in a miniscule contribution by Sr^{89} activity because of its relatively rapid rate of decay. Hard dollar cost savings can result from eliminating it as an analyte in environmental samples. Regulatory approval for deletion of Sr^{89} in samples from POC wells should be proactively pursued in a timely manner.

DISCUSSION

Isotopic and Chemical Properties of Sr^{89} and Sr^{90}

Both Sr^{89} and Sr^{90} are principally beta-emitting fission products resulting from fissioning of U^{235} , U^{233} , or Pu^{239} . Sr^{89} also has a small gamma component occurring less than 0.01% of the time.¹ The

M. A. EBRA

July 28, 1993

Page 3

average beta energies are 583 keV for Sr^{89} and 196 keV for Sr^{90} .² The resulting mass yield ratio from fissioning is approximately 0.82 for either U^{235} or Pu^{239} and about 0.93 from U^{233} .³ The main difference between these isotopes is their half-lives, 50.55 days for Sr^{89} and 28.5 years for Sr^{90} .² Sr^{89} decays to stable Y^{89} while Sr^{90} decays to the beta-emitting Y^{90} which in turn decays to stable Zr^{90} .

Since these are isotopes of the same chemical element, they will behave the same (i. e., undergo no isotopic separation) in all SRS processes and in the environment. Since no isotopic separation occurs, their activity ratios cannot vary from those produced by radioactive decay.

Determining the $\text{Sr}^{89}/\text{Sr}^{90}$ Activity Ratio

Tables 1, 2, and 3 show the methodology used to calculate the activity ratios for the strontium fission products produced by fission of U^{235} , U^{233} , and Pu^{239} , respectively. This methodology is based on that already documented⁴ and used in estimating Ni^{63} , Pu^{241} , Pu^{242} , and Am^{243} activities from those of Co^{60} , Pu^{239} and Cm^{244} . Published fission yields³ were used to determine mass ratios at time equals zero ($t = 0$), which is what was present at the instant irradiation ceased, fission product production ceased, and decay began. Because of the shorter half life for Sr^{89} , the ratio would be at a maximum at that time.

The standard decay equation, $n = n_0 e^{-\lambda t}$, was used to calculate the mass quantities present following yearly decay. The activities for Sr^{89} and Sr^{90} were calculated by multiplying the calculated mass quantities following yearly decay by the respective specific activities (d/m/g) listed at the bottom. The final column in each table results from dividing the former by the latter which yields the $\text{Sr}^{89}/\text{Sr}^{90}$ activity ratio.

Table 4 summarizes these calculations using the last column from each of the three tables. The summary shows that there is little difference in the activity ratios versus time that would be expected from these three different fission sources. Figure 1 graphically displays how the activity ratio decreases rapidly with time for fission

M. A. EBRA

July 28, 1993

Page 4

product Sr^{89} and Sr^{90} produced by U^{235} fission. In SRS Reactors, the major sources would be from fissioning of the enriched (in U^{235}) uranium drivers processed in H-Area and from fissioning of the plutonium product and the U^{235} component in the depleted uranium targets processed in F-Area.

RESULTS

Worst-Case Ratio

The source producing the largest $\text{Sr}^{89}/\text{Sr}^{90}$ activity ratio would be those reactor components that comprised the K Reactor test charge for which irradiation ceased on July 30, 1992.⁵ This date was the last time any SRS reactor was critical. Now, one year after shutdown, the $\text{Sr}^{89}/\text{Sr}^{90}$ activity ratio in that charge is essentially unity as determined from the Tables. Processing these materials in F and H canyons is at least two years away since the distinct possibility exists that an EIS must be approved before fuel/target dissolution can take place in the canyons.⁶ Two years from now, the $\text{Sr}^{89}/\text{Sr}^{90}$ activity ratio will be about $6\text{E}-05$. Even if processing of the K Reactor material were to occur just one year from now, the ratio would only be $8\text{E}-03$, or the Sr^{89} activity would be less than 1% of the Sr^{90} activity in waste generated. Strontium from such a source term would also have to appear immediately in environmental samples, a very unlikely occurrence.

Dates for Previous Reactor Criticality⁷

The following lists the last date that the specific SRS reactor was critical.

K	-	July 30, 1992 (Prior to 7/30/92 - April 10, 1988)
P	-	August 17, 1988
L	-	May 23, 1988

M. A. EBRA
July 28, 1993
Page 5

C - May 21, 1985

R - May 15, 1964

Therefore except for the K Reactor test charge discussed previously, all SRS irradiated material has not seen a neutron flux for at least 5 years.

Sources In Solution Awaiting Processing in the Canyons^{8,9}

Materials currently in solution awaiting processing in F or H canyon are at least 5 years past reactor irradiation. Processing of these could begin as early as the end of this calendar year.

F Canyon has three sources of material awaiting processing through one of the Purex cycles: targets from L reactor, TRR (Taiwan Research Reactor) material, and redissolved SRS plutonium buttons. The last time L Reactor was critical was on May 23, 1988, more than 5 years ago. The TRR material was dissolved in March, 1988, so it has to be greater than 5 years old. SRS plutonium buttons have already had the fission products removed. Therefore, the maximum Sr⁸⁹/Sr⁹⁰ activity ratio in any of these is about 3E-09 at present. Undissolved material awaiting processing in F Canyon has not seen irradiation for at least 5 years. So the strontium ratio in those would currently be similar to the 3E-09 value. Processing of the undissolved feed material is also an additional 1-2 years away, as well.

H Canyon has Sterling Forest oxide in solution awaiting processing. This material was recovered by Cintichem at Tuxedo Junction, NY. The oxide had previously undergone processing to remove fission products. The Sterling Forest reactor at the same location has been down for at least 5 years. Undissolved bundled material awaiting dissolution in H Canyon is from P Reactor. The last time P Reactor was critical was 5 years ago next month. This bundled fuel is at least 1-2 years away from processing.

M. A. EBRA

July 28, 1993

Page 6

Therefore, dissolved or undissolved materials to be processed in F Canyon or H Canyon last underwent reactor irradiation a minimum of 5 years ago and have $\text{Sr}^{89}/\text{Sr}^{90}$ activity ratios currently no greater than $3\text{E}-09$.

F Area and H Area Seepage Basins (Closed)

The latest that either F Seepage Basins or H Seepage Basins could have received waste was Nov. 7, 1988.¹⁰ Even if the strontium source term for waste received on that date were freshly irradiated, the $\text{Sr}^{89}/\text{Sr}^{90}$ activity ratio from it would only be about $8\text{E}-09$ currently.

Therefore, analysis of Sr^{89} in samples from POC wells in both F Area and H Area Seepage Basins is unnecessary due to its extremely low activity as compared with that of Sr^{90} .

CONCLUSIONS

1. Due to the very low $\text{Sr}^{89}/\text{Sr}^{90}$ activity ratios currently in material awaiting processing in F Canyon and in H Canyon, there is no need to analyze for Sr^{89} as a separate radionuclide in future environmental samples in which the source term for such would originate in this or in other material discharged from SRS reactors other than K. Sampling and analysis for Sr^{90} should continue since its activity will be a risk factor contributor.
2. Due to the very low $\text{Sr}^{89}/\text{Sr}^{90}$ activity ratios currently in source terms from F Area and H Area Seepage Basins, analysis for Sr^{89} alone is unnecessary and should be terminated as soon as regulatorily possible. Sampling and analysis for Sr^{90} should continue.
3. It is very unlikely that the K Reactor test charge components will be dissolved and processed in SRS facilities within the next one to two years. Since the $\text{Sr}^{89}/\text{Sr}^{90}$ activity ratio, currently at unity, will be $8\text{E}-03$ in one year and $6\text{E}-05$ in two, it is unnecessary to monitor

M. A. EBRA

July 28, 1993

Page 7

for Sr⁸⁹ in any environmental samples that might have strontium from source terms produced from such processing. Again, sampling and analysis for Sr⁹⁰ should continue.

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TABLE 1

Sr-89/Sr-90 Fission Product Ratio From U-235 Fission						
Yrs since Rx Irradiation Ceased	Calendar Yr	% yield Sr-89	% yield Sr-90	Sr-89 Activity	Sr-90 Activity	Sr-89 Activity/ Sr-90 Activity
0 (t = 0)	1992	4.8	5.89	3.0912E+17	1.82E+15	1.70E+02
1	1993	0.03210941	5.74850732	2.0678E+15	1.7763E+15	1.16E+00
2	1994	0.00021479	5.61041365	1.3833E+13	1.7336E+15	7.98E-03
3	1995	1.4369E-06	5.47563734	9.2534E+10	1.692E+15	5.47E-05
4	1996	9.6118E-09	5.3440987	619001147	1.6513E+15	3.75E-07
5	1997	6.4298E-11	5.21571995	4140783.66	1.6117E+15	2.57E-09
10	2002	8.613E-22	4.61863066	5.5467E-05	1.4272E+15	3.89E-20
15	2007	1.1537E-32	4.08989542	7.4301E-16	1.2638E+15	5.88E-31
20	2012	1.5455E-43	3.62168916	9.9529E-27	1.1191E+15	8.89E-42
25	2017	2.0702E-54	3.20708258	1.3332E-37	9.9099E+14	1.35E-52
30	2022	2.7732E-65	2.83993966	1.7859E-48	8.7754E+14	2.04E-63
35	2027	3.7147E-76	2.51482681	2.3923E-59	7.7708E+14	3.08E-74
40	2032	4.976E-87	2.22693249	3.2046E-70	6.8812E+14	4.66E-85
45	2037	6.6656E-98	1.97199596	4.2927E-81	6.0935E+14	7.04E-96
50	2042	8.929E-109	1.74624426	5.7502E-92	5.3959E+14	1.07E-106
100	2092	1.661E-217	0.51771969	1.07E-200	1.5998E+14	6.69E-215
250	2242	0	0.01349161	0	4.1689E+12	0.00E+00
500	2492	0	3.0904E-05	0	9549282251	0.00E+00
750	2742	0	7.0788E-08	0	21873546.7	0.00E+00
1000	2992	0	1.6215E-10	0	50103.4563	0.00E+00
	Half-Life	Spec. Activity				
	(t1/2)	(d/m/g)				
Sr-89	50.55 d	6.44E+16				
Sr-90	28.5 yr	3.09E+14				

TABLE 2

Sr-89/Sr-90 Fission Product Ratio From U-233 Fission						
Yrs since						
Rx Irradiation		% yield	% yield	Sr-89	Sr-90	Sr-89 Activity/ Sr-90 Activity
Ceased	Calendar Yr	Sr-89	Sr-90	Activity	Activity	
0 (t = 0)	1992	6.33	6.83	4.0765E+17	2.1105E+15	1.93E+02
1	1993	0.04234428	6.66592614	2.727E+15	2.0598E+15	1.32E+00
2	1994	0.00028326	6.50579376	1.8242E+13	2.0103E+15	9.07E-03
3	1995	1.8949E-06	6.34950816	1.2203E+11	1.962E+15	6.22E-05
4	1996	1.2676E-08	6.19697693	816307763	1.9149E+15	4.26E-07
5	1997	8.4793E-11	6.04810989	5460658.46	1.8689E+15	2.92E-09
10	2002	1.1358E-21	5.35572961	7.3148E-05	1.6549E+15	4.42E-20
15	2007	1.5215E-32	4.74261218	9.7984E-16	1.4655E+15	6.69E-31
20	2012	2.0381E-43	4.19968369	1.3125E-26	1.2977E+15	1.01E-41
25	2017	2.7301E-54	3.718909	1.7582E-37	1.1491E+15	1.53E-52
30	2022	3.6571E-65	3.29317281	2.3552E-48	1.0176E+15	2.31E-63
35	2027	4.8988E-76	2.91617438	3.1548E-59	9.011E+14	3.50E-74
40	2032	6.5622E-87	2.58233428	4.226E-70	7.9794E+14	5.30E-85
45	2037	8.7903E-98	2.28671178	5.6609E-81	7.0659E+14	8.01E-96
50	2042	1.177E-108	2.02493179	7.5831E-92	6.257E+14	1.21E-106
100	2092	2.19E-217	0.60034389	1.411E-200	1.8551E+14	7.60E-215
250	2242	0	0.01564477	0	4.8342E+12	0.00E+00
500	2492	0	3.5836E-05	0	1.1073E+10	0.00E+00
750	2742	0	8.2085E-08	0	25364401.4	0.00E+00
1000	2992	0	1.8802E-10	0	58099.5936	0.00E+00
	Half-Life	Spec. Activity				
	(t _{1/2})	(d/m/g)				
Sr-89	50.55 d	6.44E+16				
Sr-90	28.5 yr	3.09E+14				

TABLE 3

Sr-89/Sr-90 Fission Product Ratio From Pu-239 Fission						
Yrs since						
Rx Irradiation		% yield	% yield	Sr-89	Sr-90	Sr-89 Activity/
Ceased	Calendar Yr	Sr-89	Sr-90	Activity	Activity	Sr-90 Activity
0 (t=0)	1992	1.74	2.12	1.1206E+17	6.5508E+14	1.71E+02
1	1993	0.01163966	2.06907224	7.4959E+14	6.3934E+14	1.17E+00
2	1994	7.7863E-05	2.0193679	5.0144E+12	6.2398E+14	8.04E-03
3	1995	5.2086E-07	1.97085758	3.3544E+10	6.0899E+14	5.51E-05
4	1996	3.4843E-09	1.9235126	224387916	5.9437E+14	3.78E-07
5	1997	2.3308E-11	1.87730497	1501034.08	5.8009E+14	2.59E-09
10	2002	3.1222E-22	1.66239338	2.0107E-05	5.1368E+14	3.91E-20
15	2007	4.1823E-33	1.4720846	2.6934E-16	4.5487E+14	5.92E-31
20	2012	5.6024E-44	1.30356214	3.6079E-27	4.028E+14	8.96E-42
25	2017	7.5046E-55	1.15433193	4.8329E-38	3.5669E+14	1.35E-52
30	2022	1.0053E-65	1.02218541	6.4739E-49	3.1586E+14	2.05E-63
35	2027	1.3466E-76	0.90516687	8.6721E-60	2.797E+14	3.10E-74
40	2032	1.8038E-87	0.80154446	1.1617E-70	2.4768E+14	4.69E-85
45	2037	2.4163E-98	0.70978462	1.5561E-81	2.1932E+14	7.09E-96
50	2042	3.237E-109	0.62852934	2.0844E-92	1.9422E+14	1.07E-106
100	2092	6.021E-218	0.18634393	3.877E-201	5.758E+13	6.73E-215
250	2242	0	0.00485606	0	1.5005E+12	0.00E+00
500	2492	0	1.1123E-05	0	3437093102	0.00E+00
750	2742	0	2.5479E-08	0	7872991.35	0.00E+00
1000	2992	0	5.8362E-11	0	18033.8417	0.00E+00
	Half-Life	Spec. Activity				
	(t1/2)	(d/m/g)				
Sr-89	50.55 d	6.44E+16				
Sr-90	28.5 yr	3.09E+14				

Sr-89/Sr-90 Fission Product Activity Ratio				
Yrs since		U-235 Fission	U-233 Fission	Pu-239 Fission
Rx Irradiation		Sr-89 Activity/	Sr-89 Activity/	Sr-89 Activity/
Ceased	Calendar Year	Sr-90 Activity	Sr-90 Activity	Sr-90 Activity
0 (t = 0)	1992	1.70E+02	1.93E+02	1.71E+02
1	1993	1.16E+00	1.32E+00	1.17E+00
2	1994	7.98E-03	9.07E-03	8.04E-03
3	1995	5.47E-05	6.22E-05	5.51E-05
4	1996	3.75E-07	4.26E-07	3.78E-07
5	1997	2.57E-09	2.92E-09	2.59E-09
10	2002	3.89E-20	4.42E-20	3.91E-20
15	2007	5.88E-31	6.69E-31	5.92E-31
20	2012	8.89E-42	1.01E-41	8.96E-42
25	2017	1.35E-52	1.53E-52	1.35E-52
30	2022	2.04E-63	2.31E-63	2.05E-63
35	2027	3.08E-74	3.50E-74	3.10E-74
40	2032	4.66E-85	5.30E-85	4.69E-85
45	2037	7.04E-96	8.01E-96	7.09E-96
50	2042	1.07E-106	1.21E-106	1.07E-106
100	2092	6.69E-215	7.60E-215	6.73E-215
250	2242	0.00E+00	0.00E+00	0.00E+00
500	2492	0.00E+00	0.00E+00	0.00E+00
750	2742	0.00E+00	0.00E+00	0.00E+00
1000	2992	0.00E+00	0.00E+00	0.00E+00

FIGURE 1

Sr-89/Sr-90 Activity vs Time

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