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50-388 Susquehanna Steam Electric Station, Unit 2, Pennsylva 05000388
AUTH.NAME AUTHOR AFFILIATION
LOCHSTET,W.A. Affiliation Unknown
RECIP.NAME RECIPIENT AFFILIATION
Division of Site Safety & Environmental Analysis

SUBJECT: Submits comments on DES,NUREG-0564.Evaluation of RA-222 emission is incorrect.Only proper evaluation is w/no temporal cutoff.Such an evaluation indicates underestimation of health consquences.

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EXTERNAL:	03 LPDR	1	1	04 NSIC	1	1
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104 Davey Laboratory
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University Park
Pa., 16802

19 August 1979

Director, Division of Site Safety
and Environmental Analysis
U.S. Nuclear Regulatory Commission
Washington, D.C.
20555

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Sincerely,

William A. Lochstet

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7908280614

The Long Term Health Consequences of
Susquehanna Steam Electric Station
by

William A. Lochstet
The Pennsylvania State University*
August 1979

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The health consequences of radon-222 releases from the uranium fuel cycle are estimated for the first 1000 years in section 4.5.5. In evaluating the radon-222 emissions from the coal fuel cycle in section 8..4.4 , (item #7 on page 8-10), the staff recognizes that the emissions continue for "millions of years". Neither approach is correct. Footnote 12 of NRDC v. USNRC, 547 F.2d 633 (1976) requires that the wastes be considered for their entire toxic life. Thus, the only proper evaluation is with no temporal cutoff. Such an evaluation is attached as an appendix to this statement ("Comments on NUREG - 0332"). This evaluation shows that the Staff has underestimated the health consequences of both the coal and uranium fuel cycles.

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Comments on NUREG-0332

by

Dr. William A. Lochstet
The Pennsylvania State University
November 1977

In the document NUREG-0332 (Draft), the NRC estimates the excess deaths per 0.8 gigawatt-year electric (GWy(e)) to be about 0.5 for an all nuclear economy and about 15 to 120 for the use of coal(Ref. 1). These estimates are much too small because they ignore the health effects due to the slow release of radon-222 resulting from the decay of radioactive components of the coal, uranium mill tailings, and of the tailings from the uranium enrichment process. If the health effects are estimated by the procedure used by the NRC, then the excess deaths are about 600,000 in the nuclear case and twentythousand for coal. The estimates presented here are all based on the production of 0.8 GWy(e).

<u>Radon Produced by the Uranium Fuel Cycle</u>

The production of 0.8 GWy of electricity by a LWR will require about 29 metric tons of enriched uranium for fuel. With uranium enrichment plants operating with a 0.2% tails assay, 146 metric tons of natural uranium will be required. In the absence of the LMFBR, 117 metric tons of depleted uranium would be left over. With a uranium mill which extracts 96% of the uranium from the ore (Ref. 2), a total of 90,000 metric tons of ore is mined, containing 152 metric tons of uranium. The uranium mill tailings will contain 2.6 kilograms of thorium-230 and 6 metric tons of uranium. As Pohl has pointed out (Ref.3) the thorium - 230 decays to radium - 226, which in turn decays to radon - 222. This process results in the generation of 3.9×10^{8} curies of radon-222, with the time scale determined by the 8×10^{4} year half life of thorium - 230.

The 6 metric tons of uranium contained in the mill tailings decay by several steps to radon - 222 thru thorium - 230. This process occurs on a time scale governed by the 4.5×10^{9} year half life of uranium - 238, the major isotope present (99.3%). The total amount of radon - 222 which will result from this decay is 8.6×10^{11} curies.

The 117 metric tons of depleated uranium from the enrichment process is also mainly uranium - 238 which also decays. The decay of these enrichment tailings results in a total of 1.7×10^{13} curies of radon - 222. This is listed in Table 1, along with the other radon yields.

It is instructive to compare these quantities of activity to the activity of the fission products which result from the use of the fuel which they are associated with. The total fission product inventory resulting from 0.8GWy(e) with half lives of 25 years or more is about 10^{7} curies. This is much less than any of the numbers in Table 1. We should be more careful with these tailings.

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Item 2 i of Appendix A of NUREG-0332 (Ref. 1) assumes a 75% capacity factor, which for a 1000 MWe plant would produce only 0.75 GWy(e). A capacity factor of 80% will be used here. The production of 0.8 GWy(e) by a coal plant operating at 40% efficiency, using 12,000 BTU per pound coal would require 2.5 million short tons of coal. This is close to the value of 3 million tons suggested on page 9 of NUREG-0332 (Ref. 1).

There is great variability in the amount of uranium contained in coal. An analysis of coal samples at one TVA plant reported by the EPA (Ref. 4) indicates a range of almost a factor of ten in uranium content. Eisenbud and Petrow (Ref. 5) report a value of about 1 part per million. A recent survey by the USGS based on several hundred samples suggests that in the United States coal contains an average of 1.8 part per million of uranium(Ref. 6). Both values of 1.0 and 1.8 ppm will be used here. Thus 2.5 million tons of coal will contain between 2.3 and 4.1 thousand kilograms of uranium. Using the assumption of NUREG-0332 (Ref. 1) that there is 99% particulate removal from plant emissions, 1% of this uranium will be dispersed into the air and the remainder carted away as ashes for land burial. Table 1 indicates that with 1.0 ppm coal the uranium in the resulting ash will decay to a total of 3.2×10^{11} curies of radon - 222, while the stack emissions will lead to 3.2×10^9 curies. For 1.8 ppm coal the values are 5.8×10^{11} curies from ash and 5.8×10^9 curies from emissions.

Evaluation of the Health Effects

It is necessary to evaluate the number of deaths which result from the release of one curie of radon - 222. For the purpose of this evaluation the population and population distributions are assumed to remain at the present values. This should provide a good first estimate.

NUREG-0332 (Ref. 1) suggests that a release of 4,800 curies of radon - 222 from the mines (page 11) would result in 0.023 excess deaths (Table 1a, page 18). This provides a ratio of 4.8×10^{-6} deaths per curie. Data from Chapter IV of GESMO (Ref. 7) suggests a value of 1.7×10^{-6} deaths per curie as a lower limit. The value of 4.8×10^{-6} deaths per curie will be used here as the NRC estimate. It is understood that this is very approximate.

The EPA has evaluated the health effects of a model uranium mill tailings pile. They estimate a total of 200 health effects (Ref. 8, page 73) for a pile which emits at most 20,000 curies of radon - 222 for 100 years. The resulting estimate is 1.0×10^{-4} deaths per curie and will be used here as the EPA estimate.

Evaluation of Health Effects - Nuclear

At present some recent uranium mill tailings piles have 2 feet of dirt covering. In this case the EPA estimate (Ref. 8) is that about 1/20 of the radon produced escapes into the air. This factor of 20 is listed in Table 1 and is used to find the effective releases. Thus the 3.9×10^{8} curies of radon which results from thorium in the mill tailings results in a release of 1.9×10^{7} curies into the atmosphere, which with the NRC estimate of 4.8×10^{-6} deaths per curie results in 90 deaths. With the EPA estimate 1900 deaths result. A similar treatment applied to 8.6×10^{11} curies of radon from the uranium in the mill tailings results in 200,000 dead for the NRC estimate and 4.3 million for the EPA estimate. It is here assumed that no future generation will see fit to take any better care of the mill tailings than is presently practiced.

The uranium enrichment tailings are presently located in the eastern part of the country. It is assumed that these are buried near their present locations. Radon will not escape so easily through wet soil. A reduction factor of 100 is used to estimate this effect. The accuracy of this estimate depends on the particulars of the burial which can only be projected. An additional factor of 2 is used to reduce the effect due to the fact that much of this radon would decay over the ocean rather than populated land areas. No compensation is taken for the greater population density near the point of release as compared to the uranium mill tailings piles of the western states. With this total reduction factor of 200 the NRC estimate is 400,000 dead while the EPA value is 8 million.

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It is assumed that the ashes from the coal plants will be buried in a manner similar to the tailings from the uranium enrichment process. Thus a reduction factor of 200 is used in this case also. Again the higher population density is ignored.

The particulate which is released into the air by the coal plant is taken to contain 1% of the contained uranium. Since most such plants are in the eastern part of the country it is estimated that half will fall into the ocean rather than onto land. A second factor of 2 is used to reduce the effect of the resulting radon due to the fact that some of this radon will decay over ocean as with the radon from the uranium in the enrichment tailings. Again no compensation is taken for the greater population density near the point of release. This gives the total reduction factor of 4 shown in table 1.

With these reduction factors applied to the radon released by the ashes and emissions, in the two cases of 1.0 ppm and 1.8ppm uranium content coal, the health effects are calculated. These are shown in Table 1, and range from 7,700 dead from ashes and 3,800additional dead from airborn emissions for 1.0 ppm coal in the NRC estimate to 290,000dead from ashes and 140,000 dead from airborn releases in the case of 1.8 ppm coal in the EPA estimate.

Discussion

It is obviously very difficult to estimate with any precision how many health effects result from the release of a given curie of radon - 222 from some specific site in the west. The estimates presented here differ by a factor of 20. This might best be used as a range of expected deaths. The reduction factors used here are crude estimates in some cases, and could be improved upon. Changes in public policy could also change the manner in which this material is disposed, thus greatly changing these factors. In particular deep burial could practically eliminate the escape of radon to the atmosphere (Ref. 8).

It is important to compare Table 1 here with Table 1 of NUREG-0332 (Ref. 1), which shows 0.47 dead for the nuclear case and at most 120 dead for coal. These last numbers totally ignore the effects of long term radon emissions, which result in at least 100 times higher mortality. These long term effects are not only significant, but dominate the effect.

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Acknowledgment

The above comments were inspired by the 5 July 1977 testimony of Dr. Chauncey R. Kepford in the matter of the Three Mile Island Unit 2 (Docket No. 50-320) operating license entitled: " Health effects Comparison for Coal and Nuclear Power".

Table 1

Energy Source Excess Mortality per 0.8 GWy(e) due to Radon - 222 emissions

Origin of Radon	Radon Generated Curies	Reduction Factor	Deaths NRC	Deaths EPA
Nuclear				
Thorium in Mill Tails	3.9×10^{8}	20	90	1900
Uranium in Mill Tails	8.6×10^{11}	20	200,000	4.3×10^{6}
Uranium in Enrichment Tails	1.7×10^{13}	200	400,000	8×10^{6}
Coal 1.0 ppm U				
Ashes	3.2×10^{11}	200	7,700	1.6×10^{5}
Air Particulate	3.2×10^{9}	4	3,800	8×10^{4}
Coal 1.8 ppm U				
Ashes	5.8×10^{11}	200	14,000	2.9×10^{5}
Air Particulate	5.8×10^{9}	4	6,800	1.4×10^{5}

References

1 "Health Effects Attributable to Coal and Nuclear Fuel Cycle Alternatives" NUREG-0332, Draft, U.S. Nuclear Regulatory Commission (September 1977)

2 "Environmental Analysis of The Uranium Fuel Cycle, Part I - Fuel Supply" EPA-520/9-73-003-B, U.S. Environmental Protection Agency, (October 1973)

3 R.O. Pohl, "Health Effects of Radon - 222 from Uranium Mining" Search, 7(5),345-350 (August 1976)

4 P.H. Bedrosian, D.G. Easterly, and S.L. Cummings,"Radiological Survey Around Power Plants Using Fossil Fuel" EERL 71-3, U.S. Environmental Protection Agency, (July 1970)

5 M. Eisenbud, and H.G. Petrow," Radioactivity in the Atmospheric Effluents of Power Plants that Use Fossil Fuels," Science 144,:288-289 (1964)

6 V.E. Swanson et al,"Collection, Chemical Analysis, and Evaluation of Coal Samples in 1975", Open-file report 76-468, U.S. Department of the Interior, Geological Survey, (1976)

7 "Final Generic Environmental Statement on the Use of Recycle Plutonium in Mixed Oxide Fuel in Light Water Cooled Reactors," NUREG-0002. U.S. Nuclear Regulatory Commission, (August 1976)

8. See Ref. 2

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19 August 1979

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Origin of Radon	Radon Generated Curies	Reduction Factor	Deaths NRC	Deaths EPA
Nuclear				
Thorium in Mill Tails	3.9×10^{8}	20	90	1900
Uranium in Mill Tails	8.6×10^{11}	20	200,000	4.3×10^{6}
Uranium in Enrichment Tails	1.7×10^{13}	200	400,000	8×10^{6}
Coal 1.0 ppm U				
Ashes	3.2×10^{11}	200	7,700	1.6×10^{5}
Air Particulate	3.2×10^{9}	4	3,800	8×10^{4}
Coal 1.8 ppm U				
Ashes	5.8×10^{11}	200	14,000	2.9×10^{5}
Air Particulate	5.8×10^{9}	4	6,800	1.4×10^{5}

References

1 "Health Effects Attributable to Coal and Nuclear Fuel Cycle Alternatives" NUREG-0332,Draft, U.S. Nuclear Regulatory Commission (September 1977)

2 "Environmental Analysis of The Uranium Fuel Cycle, Part I - Fuel Supply" EPA-520/9-73-003-B, U.S. Environmental Protection Agency, (October 1973)

3 R.O. Pohl, "Health Effects of Radon - 222 from Uranium Mining" Search, 7(5),345-350 (August 1976)

4 P.H. Bedrosian, D.G. Easterly, and S.L. Cummings,"Radiological Survey Around Power Plants Using Fossil Fuel" EERL 71-3, U.S. Environmental Protection Agency, (July 1970)

5 M. Eisenbud, and H.G. Petrow," Radioactivity in the Atmospheric Effluents of Power Plants that Use Fossil Fuels," Science 144,:288-289 (1964)

6 V.E. Swanson et al,"Collection, Chemical Analysis, and Evaluation of Coal Samples in 1975", Open-file report 76-468, U.S. Department of the Interior, Geological Survey, (1976)

7 "Final Generic Environmental Statement on the Use of Recycle Plutonium in Mixed Oxide Fuel in Light Water Cooled Reactors," NUREG-0002. U.S. Nuclear Regulatory Commission, (August 1976)

8 See Ref. 2