August 7, 1981

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
PENNSYLVANIA POWER & LIGHT COMPANY	)	Docket Nos. 50-387
	)	50-388
and	)	
	)	
ALLEGHENY ELECTRIC COOPERATIVE, INC.	)	
	)	
(Susquehanna Steam Electric Station, Units 1 and 2)	)	

APPLICANTS' STATEMENT OF MATERIAL FACTS AS TO WHICH THERE IS NO GENUINE ISSUE TO BE HEARD (CONTENTION 1) (RADON)

Pursuant to 10 C.F.R. § 2.749(a) Applicants state, in support of their Motion for Summary Disposition of the radon portion of Contention 1 in this proceeding, that there is no genuine issue to be heard with respect to the following material facts:

1. Radon-222 is one of the products resulting from the radioactive decay of uranium-238, an isotope with a half-life of 4.5 billion years. Uranium-238 decays into radon-222 by a series of intermediate steps. Two of the intermediate precursors of radon-222 are thorium-230, with a half-life of approximately 80,000 years, and radium-226, with a half-life of 1,600 years. Radon-222 is a noble (*i.e.*, inert)

gas with a short half-life, 3.8 days. Because of its gaseous nature and its lack of chemical activity, radon-222 may diffuse through porous media such as soil and, once in the atmosphere and depending on prevailing weather conditions, it can be transported considerable distances before decaying. Affidavit of Morton I. Goldman in Support of Summary Disposition of Contention 1 (Radon) ("Goldman Aff."), para. 3; Philadelphia Electric Company et al. (Peach Bottom Atomic Power Station, Units 2 and 3), ALAB-640 (May 13, 1981) slip op. at 10-14 ("ALAB-640").

2. The potential health hazard of radon-222 lies not so much with radon itself as with its decay products. When radon-222 decays, it produces in quick succession four very short-lived isotopes (polonium-218, lead-214, bismuth-214, and polonium-214) ("the radon daughters"). The radon daughters are chemically heavy metals that become attached to small airborne particles or aerosols and are easily deposited in man's respiratory tract, particularly the bronchial epithelium, where they may decay emitting high-energy alpha and beta particles. Goldman Aff., para. 4; ALAB-640 at 14.

3. Radon-222 is constantly being generated and released to the environment through natural processes. It is estimated that about 100 to 240 million curies ("Ci") of radon-222 emanate each year from the soil in the contiguous U.S., leading to an average outdoors radon concentration between 100 and $200 \times 10^{-12} Ci/m^3$. Goldman Aff., para. 5; ALAB-640 at 14-15.

4. Other radon isotopes are of lesser importance since their half lives are so short that virtually none escapes to the atmosphere. Goldman Aff., para. 6.

5. Exposure to radon and its progeny may be enhanced by human activities that redistribute the naturally occurring sources of radon, such as tillage of soils; mining and combustion of coal; production and use of natural gas; processing of liquified petroleum gas; mining and milling of phosphate ore, use of phosphate products and byproducts, and use of reclaimed phosphate lands for residential and commercial development; production and use of building materials, such as granite, brick, concrete block and pumice stone; and mining and milling of uranium ore. Goldman Aff., para. 7; ALAB-640 at 15.

6. Radon-222 is emitted at the "front end" of the nuclear fuel cycle as a result of the operations of mining uranium ore and milling the ore to produce uranium fuel. The amount of radon-222 produced during the remainder of the fuel cycle is very small in magnitude and negligible in comparison to the amounts resulting from the mining and milling of uranium. Goldman Aff., para. 8; ALAB-640 at 15.

<u>Radon emissions from uranium mining</u>

7. The two most common methods of obtaining uranium in the U.S. are by underground mining and surface ("open-pit") mining. Over the period of 1971 to 1979, about 42% of the uranium was produced from underground mining, 52% from surface mining, and 5% from other sources. Goldman Aff., para. 9.

8. Radon-222 may be released from uranium mines both during active mining and, after mining operations cease, from abandoned mines that have remained unreclaimed. No significant radon emissions result from other production means. Goldman Aff., para. 9.

9. During active mining, radon-222 is released to the atmosphere from an underground mine by the mine's ventilation system. Radon-222 is released by an open-pit mine during the active mining period as exhalation from the ore, overburden and the walls and floors of the mine pit. Goldman Aff., para. 10.

10. After mining ceases, the amount of radon-222 emitted by underground and open-pit mines depends on whether the mines are reclaimed. Inactive underground mines can be reclaimed by sealing the mine openings with earth and/or concrete plugs. If the mine openings are sealed, essentially no radon will escape to the atmosphere from them. Goldman Aff., para. 10; ALAB-640 at 27-28. Inactive open-pit mines can be reclaimed by backfilling. Goldman Aff., para. 22.

11. If an abandoned mine remains unreclaimed, radon-222 which emanates from the walls of the mine may find its way to the environment outside the mine. Goldman Aff., para. 11; ALAB-640 at 23. An unreclaimed open-pit mine will release radon from the overburden and subore exposed in the worked-out mine pits and from overburden and subore piles on the surface. Goldman Aff., para. 23.

Emissions during active period of underground mines

12. Based on a recent report of a comprehensive sampling of 27 underground mines accounting for 64% of the uranium produced in the United States in 1978 from underground mining, the active mining source term for underground mines is approximately 8000 Ci of radon-222 per reference reactor year ("RRY"). Goldman Aff., para. 13; ALAB-640 at 47.

Emissions from abandoned, sealed underground mines

13. Abandoned underground mines can be sealed in ways which are simple and effective in minimizing radon releases. Goldman Aff., para. 14; ALAB-640 at 27-28. With proper sealing, the radon emission rates from mine shafts will be negligible. The only measurable radon releases associated with a sealed underground mine will come from waste rock remaining on the surface after the mine is abandoned, at an estimated rate of approximately 10 Ci/year per RRY. Goldman Aff., para. 15; ALAB-640 at 28.

Emissions from unsealed underground mines

14. During normal operation of an underground mine. the radon removed by the ventilation system balances that emanated from the mine walls. When the mine is closed and mechanical ventilation ceases, radon continues to emanate from the mine walls; the only mechanism for the removal of the radon from the mine air to the outside atmosphere is whatever natural circulation air flow may be established. Resistance to the

flow is created by mine drifts, bulkheads, dead-end rooms, flooding, the size of and the distance between vents, possible blockages due to collapses, etc. Natural circulation air flow, to the extent it exists, is quite variable in magnitude and may reverse direction as frequently as twice a day in a mine having several openings. Goldman Aff., para. 16.

15. Measurements taken at a "worst case" abandoned mine showed radon emissions in the order of 70-80 Ci/year per RRY. Another, more typical abandoned mine released radon at a rate of 1.2 Ci/year per RRY. Goldman Aff., para. 17, n.5; ALAB-640 at 24-25.

16. A computation of radon releases from a model mine representing the average of 2,100 inactive mines gives a radon emission rate of 36.2 Ci/year per RRY. Goldman Aff., para. 17.

17. A realistic upper limit to radon releases from abandoned, unsealed underground mines is 80 Ci/year per RRY. Goldman Aff., para. 18; ALAB-640 at 27. Another 10 Ci/year per RRY would be added to account for releases from waste rock remaining on the surface. The upper-limit radon release from unsealed underground mines would therefore be approximately 90 Ci/year per RRY. Goldman Aff., para. 18; ALAB-640 at 27.

Emissions during active period of open-pit mines

18. A recent report provides information on radon exhalation rates from open-pit mines and contains analyses of

mining methods and practices which are then used to develop mine models and radon releases. According to the report, the radon releases from an open-pit mine during the active mining period are approximately 945 Ci/RRY. Goldman Aff., para. 19.

19. A more recent report by Argonne National Laboratory ("ANL") provides results of extended radon measurements at both active and inactive pits of a uranium mine operation. These results indicate substantially lower radon exhalation rates than those giving rise to the 945 Ci/RRY estimates. The ANL report suggests a representative estimate of radon flux from active open-pit mines that is only 7.2% of the value used as the basis for the 945 Ci/RRY value. Goldman Aff., para. 20.

20. In view of ANL's measurements, a rounded-off 1000 Ci/RRY estimate of radon releases from active open-pit mines is high and quite conservative. Goldman Aff., para. 21; ALAB-640 at 38.

Radon emissions from reclaimed open-pit mines

21. A model of a reclaimed open-pit mine reflecting current conditions is a compromise between complete reclamation (anticipated for present and future mining operations) and no reclamation (the case in many mining operations in the past). One such model was developed based on average statistics for eight major open-pit uranium mines in the Casper, Wyoming area. Goldman Aff., para. 22. For this model partially-reclaimed

open-pit mine, the long-term radon releases would be about 40 Ci/year per RRY. This partially-reclaimed mine represents conditions leading to higher radon releases than those that will result from completely reclaimed mines; therefore, the 40 Ci/year per RRY estimate of radon emissions from reclaimed open-pit mines arrived at using this mine as a model is conservatively high. Goldman Aff., para. 23.

Radon emissions from unreclaimed open-pit mines

22. The model open-pit mine can also be utilized to compute the long-term radon releases assuming no reclamation whatsoever. The model unreclaimed open-pit mine would release radon at the rate of approximately 80 Ci/year per RRY, about half of which would come from the unfilled pits. Goldman Aff., para. 23.

23. Another estimate of radon releases from abandoned, unreclaimed open-pit mines can be obtained from a model established by EPA based on annual ore and waste production statistics for 944 surface mines. Goldman Aff., para. 25. Such a model mine would be estimated to release radon at the rate of 100 Ci/year per RRY. Goldman Aff., para. 26. This value represents an appropriate upper bound to the radon releases from unreclaimed open-pit mines. Goldman Aff., para. 27; ALAB-640 at 39.

Combined radon released from uranium mining

24. Over the period 1971-1979, 42% of the uranium produced in the United States came from underground mines, 52%

from open-pit mines, and 6% from other sources. Since the upper-limit radon releases during the active mining period are, respectively, 8000 Ci/RRY for underground mines, 1000 Ci/RRY for open-pit mines, and zero from other sources, the combined, upper-limit release from the active mining period using the average production figures given above is approximately 3,880 Ci/RRY. Similarly, since the upper-limit long term release from underground mines is 90 Ci/yr-RRY, that from open-pit mines is 100 Ci/yr-RRY, and that from other sources is zero, the combined, upper limit long-term radon release from mining is approximately 90 Ci/yr-RRY. Goldman Aff., para. 28.

Radon releases from uranium milling

25. Uranium leaves the mine in the form of crude ore. The crude ore is delivered to a mill where it undergoes a series of mechanical and chemical processes to separate the U_3O_8 from the other materials. Radon may be released at various points in the milling process, from the initial stockpiling of the ore to await processing to the crushing, roasting, grinding, and chemical treatment of the ore. Goldman Aff., para. 29; ALAB-640 at 15-16.

26. After the U_3O_8 is separated out at the mill, the residual materials ("mill tailings") are a mixture of solids and solutions. Goldman Aff., para. 30.

27. The mill tailings are usually disposed of in a tailings pond. Because the tailings contain thorium and radium

(radon's precursors) and some residual uranium, they continue to emit radon for thousands of years. Some of the radon emitted by the dry portion of the tailings will diffuse to the surface of the tailings pile, and if the pile is not treated to minimize radon releases, will escape to the atmosphere. Goldman Aff., para. 31; ALAB-640 at 48.

Releases during active milling period

28. Using the model mill parameters presented in the Final Generic Environmental Impact Statement on Uranium Milling ("Final GEIS") and realistic values for tailings depth and diffusion coefficients, an active milling period radon release rate of about 890 Ci/RRY is obtained. Goldman Aff., para. 32.

29. During the five years period assumed after mill operations cease for the tailings to dry sufficiently to permit stabilization, there is a radon release of about 350 Ci/RRY. The total radon emissions attributable to uranium milling prior to tailings stabilization are therefore 890+350=1240 Ci/RRY. Goldman Aff., para. 33.

Long term radon releases from mill tailings

Releases from stabilized tailings piles

30. The Uranium Mill Tailings Radiation Control Act of 1978 (P.L. 95-604, 92 Stat. 3021) ("the Act") gives authority to the NRC to license and regulate uranium mill tailings, and requires reclamation and Federal or State ownership of tailings and their disposal sites. Goldman Aff., para. 34; ALAB-640 at 62.

31. Under the Act, any licensee authorized to operate a uranium mill is required to maintain mill tailings in such a manner as will protect the public health, safety and the environment. The same requirement will apply to the Federal or State authorities upon transfer of control of the tailings to them after mill operations end. Goldman Aff., para. 35.

32. Implementation of the reclamation provisions of the Act will require long-term stabilization of mill tailings piles. Such stabilization can be achieved by below-grade disposal or by covering of the tailings above ground with sufficient amount of covering material. Even a minimum amount of cover (e.g., three feet of well-compacted earth) will reduce radon emissions by at least a factor of two. Goldman Aff., para. 36.

33. Technical capability exists for isolating large volumes of tailings for long periods of time. The tailings isolation can be carried out by straightforward earth moving operations. Adequate economic resources to meet the cost of stabilizing mill tailings piles are assured by the Act's authorization to the NRC to require prospective mill operators to provide adequate financial sureties. Goldman Aff., para. 37.

34. Properly stabilized piles should remain stable for many thousands of years without reliance on institutional controls and without need for active maintenance. Goldman Aff., paras. 38-40. Stabilized piles with a minimum amount of cover will emit radon at a rate of no more than 40 Ci/year per RRY. Goldman Aff., para. 38.

Emissions from unstabilized piles

35. The radon emissions from an unstabilized tailings pile depend mainly on three factors, which are: a. the radium concentration, which is related to the ore grade; b. the diffusion coefficient for radon through the mass of tailings; and c. the area-depth product for the tailings pile. Goldman Aff., paras. 41-43.

36. Of these, the ore grade is not a significant factor because the tailings surface area is only slightly dependent on the ore grade. Goldman Aff., paras. 44-45. A reasonable value for the diffusion coefficient is 0.019 cm^2/sec, and is based on the experimental measurement of radon flux from acid-leached tailings. Goldman Aff., para. 46. The appropriate depth of tailing piles to use in the radon release computations is 12 to 13 m Goldman Aff., paras. 46-47.

37. A conservative estimate of the radon exhalation rate per RRY from dry uncovered tailings is about 75-80 Ci/yr. Goldman Aff., paras. 49, 50; ALAB-640 at 57-59. If the higher value of diffusion coefficient assumed in theoretical analyses is utilized, the radon emission rate attributable to unstabilized piles is approximately 140 Ci/yr per RRY. Goldman Aff., para. 50; ALAB-640 at 59.

38. Based on the dispersion rate that has occurred on existing inactive tailings piles, the dispersion of unstabilized tailings should not result in significant addition to tailings radon exhalation over any reasonable near term period.

For example, assuming erosion to continue at the same rate for 200 years would increase the current estimate of radon releases from the inactive tailings piles by only 25%. This very slow rate of dispersion indicates that there should be ample opportunity for taking remedial action to correct the effects of erosion or other destabilizing agents. Goldman Aff., para. 58.

39. In the unlikely event that tailings piles became completely dispersed, the tailings would not remain exposed on the surface releasing radon to the atmosphere for long periods of [illegible] but instead would either be carried by surface waters to [illegible] ocean or would be covered or deposited upon by other soil [illegible]terials, thus minimizing radon releases. Goldman Aff., para. 59.

Summary of milling emissions

40. The radon emissions associated with milling of uranium are as follows:

1. Approximately 890 Ci/RRY during the period of active operation of a mill.

2. Approximately 350 Ci/RRY during the five years after the mill closes and prior to tailings stabilization.

3. On the order of no more than 40 Ci/yr per RRY for stabilized mill tailings piles. Stabilized mill tailings piles should remain in that condition for many thousands of years.

4. Approximately 75-80 Ci/yr per RRY from undispersed tailings piles after loss of their stabilizing cover. Goldman Aff. para. 60.

Summary of radon source terms

41. The Susquehanna units will require a total of 64 RRYs during the period of their licenses. Therefore, the upper-limit radon source terms associated with the Susquehanna facility are as follows:

Short-term mining releases: 3,880 Ci/RRY x 64 RRY = 248,320 Ci

Long-term mining releases: 90 Ci/yr-RRY x 64 RRY = 5,760 Ci/yr

Short-term milling releases: 1240 Ci/RRY x 64 RRY = 79,360 Ci

Long-term milling releases: 80 Ci/yr-RRY x 64 RRY = 5,120 Ci/yr.

Total upper-limit radon releases associated with the Susquehanna facility:

Short term:	327,680 Ci
Long term:	10,880 Ci/yr.

Goldman Aff., para. 61.

42. These upper-limit estimates are extremely conservative on the high side, particularly with respect to long-term releases. A set of radon release values representing more realistic conditions can be obtained assuming reclamation of inactive mines and stabilization of mill tailings piles. Under those conditions, the radon source terms associated with the Susquehanna facility would be as follows:

Short-term mining releases:	248,320 Ci
Long-term mining releases (reclamation assumed):	25 Ci/yr-RRY x 64 RRY = 1,600 Ci/yr

Short-term milling releases: 79,360 Ci

Long-term milling releases
(stabilization assumed): 40 Ci/yr-RRY x
64 RRY = 2,560 Ci/yr.

Total radon releases with the Susquehanna plant assuming reclamation of mines and stabilization of mill tailings piles:

Short term: 327,680 Ci

Long term: 4,160 Ci/yr.

Goldman Aff., para. 62.

Significance of radon releases

43. The significance of the radon releases associated with the Susquehanna facility can be best appreciated by estimating the increase in radioactive dose that the average person will receive as a result of the operation of Susquehanna over the dose that this person would receive from other sources of radon. Goldman Aff., para. 63.

44. The most significant of the doses resulting from radon releases is that to the bronchial epithelial tissues of the lung which arises predominantly from the decay of the short-lived daughters. Goldman Aff., para. 64.

45. Both outdoor and indoor radon concentrations are highly variable and site-dependent. The measured concentrations of radon-222 in open air in western areas of the U.S. have ranged between 60 pCi/m^3 to 2000 pCi/m^3, giving a range of

lung doses between 39.5 and 1,350 mrem/year; the National Committee on Radiation Protection has selected 150 pCi/m^3 as the "standard concentration" for outdoor air, giving an individual lung dose equivalent of 94 mrem/year from natural sources. Goldman Aff., para. 63.

46. The indoor radon concentrations depend, among other things, on the materials used in building construction, the degree of ventilation in the building, and the location within the structure. An estimate of the average lung dose from indoor radon exposures is 430 mrem/yr. Energy conservation practices will cause the amount of ventilation in a building to decrease from typical past values of 2-5 air changes per hour to 0.1 - 0.9 air changes per hour. Utilization of energy conservation practices and the resulting reduced ventilation could increase the radon dose commitment inside a building by an order of a magnitude. Goldman Aff., para. 66.

47. Assuming, very conservatively, that all of the "short-term" radon associated with the total operation of the Susquehanna facility is released in only one year, the resulting average individual bronchial epithelial dose would increase by less than 0.1 mrem in that year. Similarly, the upper limit "long-term" release of 10,880 Ci/year would increase the average individual lung dose by 0.003 mrem/year. Goldman Aff., para. 67. This yearly lung dose commitment received by the average individual in the U.S. from upper limit "long-term"

radon releases attributable to the Susquehanna facility would be approximately 0.005% of the dose received from just breathing average outdoor air. Alternatively, the total yearly dose that an average individual would receive as an upper limit attributable to the Susquehanna plant would be equivalent to that which he would receive by spending less than four additional minutes a year indoors. Goldman, Aff., para. 68.

48. The upper limit radon releases attributable to the Susquehanna facility are a very small fraction of the naturally-occurring radon releases to which the public is subjected constantly, and the fluctuations in radon releases in natural background are in themselves greater than the contribution attributable to the Susquehanna facility. Goldman Aff., para. 69.

49. The increase in the radon releases that would be produced by operation of the Susquehanna facility would be undetectable and such releases would have insignificant impact on the health and safety of the public. Goldman Aff., para. 69.

Dated: August 7, 1981.

Respectfully submitted,

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