8/14/81

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

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

AFFIDAVIT OF SOLOMON M. MICHAELSON
IN SUPPORT OF SUMMARY DISPOSITION
OF CONTENTION 17

City of Washington)
: ss.
District of Columbia)

Solomon M. Michaelson, being duly sworn according to law, deposes and says as follows:

1. I am a member of the faculty of the School of Medicine and Dentistry at the University of Rochester, New York. I am Professor of Radiation Biology and Biophysics, Associate Professor of Medicine and Associate Professor of Laboratory Animal Medicine at that institution. A resume of my professional qualifications and experience, including a list of

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publications relevant to the matters discussed in this Affidavit, is attached as Exhibit "A" hereto. I have personal knowledge of those matters and believe them to be true and correct.

2. I give this Affidavit to support Applicants' Motion for Summary Disposition of Contention 17 in this proceeding, as modified by the Licensing Board's Order of May 20, 1981, and specifically to address the allegation that the 500 kV lines to be utilized for transmitting the electric power produced by the Susquehanna Steam Electric Station ("the Susquehanna lines") create electric fields that may adversely affect humans and animals. This Affidavit will demonstrate that, contrary to the allegations in this contention, the health impact on the public of the electric fields generated by operating those lines at their design voltage will be insignificant.

3. My Affidavit is based upon the calculations of the electric field in the vicinity of the Susquehanna lines contained in paragraphs 44 to 46 of the Affidavit of Robert F. Lehman In Support of Partial Summary Disposition of Contention 17 in this proceeding, dated December 4, 1980. As set forth in that document, and as found by the Licensing Board's Order of May 20, 1981, slip op. at p.10, there will be a maximum electric field gradient of 11 kV/m (kilovolts per meter) at ground level at the point of minimum clearance on the

right-of-way of the Susquehanna lines, and 2.28 kV/m at the edge of the right-of-way.

The Concept of Biological "Effect" and "Hazard"

4. I would like, at the outset, to distinguish between the terms "effect" and "hazard". The fact that a living organism responds to many stimuli is a part of the process of living; such responses are examples of biological "effects." Since biological organisms have considerable tolerance to change, these "effects" may be well within the capability of the organism to maintain a normal equilibrium or condition of "homeostasis" (homeostasis can be defined as the ability of a living organism to maintain stability in the face of external influences). If, on the other hand, an effect is of such a nature and/or duration that it impairs the organism's ability to function properly or overcomes the recovery capability of the organism, then the "effect" is regarded as "hazard." There are two levels in my discussion of the potential for biological "effects" from the electric fields of the Susquehanna lines: (1) we must first determine whether any such "effect" on humans or animals can be anticipated from those fields; and (2) we must then determine whether any such predicted "effect" would be "hazardous."

5. The reason for establishing this distinction at the outset is that, while some biological "effects" on animals and humans have been observed, and others claimed, as a result

of exposure to electric fields of the magnitude and frequency under discussion, I am unaware of any substantiated effects which can be considered hazardous.[1] As will be seen below, all that has been claimed regarding those alleged effects is that it is "probable" that some long-term, subtle adverse consequence will result from them. However, the mechanisms leading to the alleged effects are not specified by those postulating them.

Types of Scientific Evidence Used in Hazard Determination.

6. Scientific knowledge of the biological effects of electric fields from transmission lines comes from theoretical, epidemiological, and experimental evidence. The different types of evidence must be assessed as a whole, because each type possesses advantages as well as shortcomings.

7. Theoretical evidence is concerned with the mechanisms of interaction between the electric fields and the biological tissues or systems under consideration. As will be seen below, the theoretical evidence indicates that the electric fields produced by the Susquehanna lines cannot produce sufficient heating of tissues or molecular polarization

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1 For instance, it has been reported that certain animal species, such as catfish and sharks, are able to detect very small electric fields [36], [43]. Other species, such as swine, pigeons and rats are reported to perceive fields in the range of 30 to 100 kV/m (which is far in excess of that produced by high voltage transmission lines) [20], [25], [35], [60]-[63]. A person standing in the 10 kV/m electric field set up by a high voltage transmission line may experience slight movement in the hair of an upwards-extended hand. Ability to detect the field does not necessarily make the field hazardous.

or deformation to cause significant biological effects. However, it has been postulated by some that there are various adverse effects from exposure to those fields, which effects cannot be explained by standard mechanisms, but result from subtle, yet to be understood phenomena.

8. Epidemiological evidence is derived from analysis of health records of members of the population who are exposed to a substance or agent and comparison of those people with appropriate control groups [36]. Although the epidemiological approach is potentially valuable, it requires careful selection of paired populations which are not loaded with some other bias. The control or comparison group should be analogous to the exposed group in all relevant characteristics except the exposure itself. The sample must also be large enough to make it possible to detect an increased risk. It is often necessary to study a population of many thousands, to get significant results.

In the case of electric fields from transmission lines, a potentially suitable group for epidemiological study are electrical workers exposed to large electric fields in the course of transmission line work.

9. Experimental evidence results from direct exposure of animals or humans to electric fields under controlled conditions and observation of any biological effects. While experimental evidence is in principle a strong indication

of the existence or absence of effects, it may suffer from a number of limitations such as the adequacy of the experimental setup, equipment and methodology, the length of observation, the validity of extrapolating laboratory results to actual exposure conditions, and so on.

Theoretical Evidence

10. It is well known that an alternating electric field, such as that generated by a transmission line, will induce an electric field in the body of a person in the vicinity of the line. The induced electric field within the body, while extremely small (about 100,000 times smaller than the external field) will cause internal body currents to flow. Such currents have been calculated[2] and measured by various authors and found to be very small, on the order of 0.1 to 1 milliamperes ("mA") per square meter, depending on the field strength [43]. Such small currents are well below the perception level and consequently are imperceptible.

11. Calculations also show that, in order for an electric field to produce recognizable effects on tissue[3] the

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2 Assuming a field strength of 10 kV root mean square ("rms") per meter (approximately the maximum field calculated for the Susquehanna lines) at a frequency of 60 Hz, a person standing in the field would have a current density of 0.4 mA/m^2 in the center of the body [56]. This current is about three orders of magnitude below the perception level.

3 The recognizable biological effects of electric fields and the currents they induce consist of tissue heating, stimulated firing of individual neurons, polarization, and/or molecular de-

(footnote continued next page)

field strength would have to be one hundred times larger than the field strength at which air breaks down as an insulator and sparking occurs. A tissue current density of 0.1 mA/cm^2 (the equilibrium point between field released energy and metabolic energy) is often chosen as a conservatively low current limit of safe exposure[36]. For such a current to be induced, an external field strength of 100,000 kV/m would be necessary. This is a very large field, thousands of times larger than the maximum field in the vicinity of the Susquehanna lines. Therefore, it is practically impossible to induce dangerous currents in people by mere exposure to the electric fields produced by transmission lines such as the Susquehanna lines.

12. While the theoretical evidence predicts no recognizable biological effects from exposure to high voltage electric fields, some writers have postulated that behavioral and central nervous system modifications result from such exposure[50]. These effects, however, are not amenable to explanation using traditional theoretical analysis, and if indeed existing, are caused by some yet unknown biophysical mechanism. The majority of the scientists working in this field, myself included, believe such unexplained effects to be highly improbable [51], [53].

(continued)
formation [43]. Potentially dangerous current densities are those that result in heating tissue to the point of causing damage to it or producing molecular polarization or deformation.

Epidemiological evidence.

13. Since some workers in the electrical power industry are exposed to intense electric fields for relatively long periods of time, they are a logical group to study for the detection of possible adverse health effects from such fields [46]. Although epidemiological studies of electrical workers are few and some of them lack statistical rigor, they do provide (especially in conjunction with good animal experiments) a basis for assessment of potential health effects of the electric fields from high voltage transmission lines on man. Assessment of human exposure to electric fields has been reviewed in detail by Mehn [32] and Michaelson [33].

14. The most comprehensive epidemiological studies on electrical workers were performed by scientists at Johns Hopkins University. Kouwenhoven et al. [23] and Singewald et al. [44] have reported on the results of medical surveillance of eleven linemen over a period of 42 months during the time they were performing live-line maintenance work on a 345 kV transmission system. Among the eleven men under observation, there were four who had had many hours of bare hand work during the period of the investigation. Field intensities were determined at various parts of the bodies of those linemen doing bare hand work. They ranged from 0.4 kV/in (20 kV/m) to 12 kV/in (470 kV/m) at the top of the head to 0 to 4 kV/in (200 kV/m) at the knees, depending on whether full or partial bucket

shields were used. After three and one-half years of observation, none of the eleven workers showed any change in his physical, mental, or emotional characteristics [23]. The observation period was then extended to nine years, at the end of which it was concluded that the health of the individuals studied had not been changed in any way by their exposure to high voltage lines [44].

15. Strumza [45] reported on an investigation of medical visits and druggist bills in a population living and working close to high-voltage power lines, compared with a similar, but unexposed population. The maximum distance taken as constituting "exposure" was 25 m (about 80 ft) and voltages varied from 200-400 kV. The control population consisted of persons living more than 125 m (about 400 ft) from the lines. Analysis of the results did not disclose any significant differences between the data for exposed and unexposed persons.

16. In a study reported by Roberge[40] on an evaluation of 56 individuals working in 735 kV switchyards for more than two years, no adverse health symptoms were observed. No clinical pathological changes in general somatic health, neuropsychiatric symptomatology, ECG, X-ray of the lungs, audiometry or visual acuity were found.

17. An epidemiologic study of 110 high voltage workers was started in East Germany in 1971 [18]. Linemen who worked bare-handed on 110-380 kV lines were compared with

electrical maintenance men who were exposed to similar physiological stresses but at field strengths less than 5 kV/m. Both groups were given clinical examinations (eye, ear, nose, locomotor system, cardiovascular, respiration, metabolism, hematopoietic, kidney and liver function) and psychological examinations (risk-taking behavior, motivation, sensorimotor coordination, reaction time, intellectual abilities for technical thinking, and personality). Analysis of the first in a planned series of examinations was reported in 1977. No difference in state of health was seen as compared to the control group [24].

18. Soviet studies have reported measurable biological changes among electrical workers exposed to intense electric fields in electric switchyards. Evaluation of these studies, however, is difficult due to the incomplete nature of the material presented and the variable quality of the reported data. Many investigations do not describe how controls were selected; some do not even mention controls. The lack of objective criteria for assessing many of the reported clinical phenomena, the problems of subject variation and observer variability, and the inadequacies and uncertainties of field measurement and exposure data, make it impossible to establish cause and effect relationships and attribute the reported results to exposure to electric fields.

19. Among the Soviet studies purporting to indicate biological effects on workers exposed to large electric fields,

there is the study by Asanova and Rakov [1] of a group of 45 workers exposed to high voltage electric fields in a 400 to 500 kV electric power switchyard. There were a number of reported physical disorders among the workers, including headache, fatigue, disruptive activity of the digestive tract, and cardiovascular system changes. In a report by Sazanova [42], a number of physiological differences were seen between switchyard "operating personnel" with low electric field exposure and "maintenance personnel" with high electric field exposure. The "maintenance personnel" spent at least 5 hours daily outdoors in a switchyard with an average electric field of 12 to 16 kV/m and a maximum electric field of 20 to 26 kV/m. The "operating personnel" worked primarily indoors and spent no more than 2 hours per day exposed to the electric field in the switchyard. The author states that both groups carried out light work, but that the operating employees' work was mainly indoor work while the maintenance personnel worked outdoors. Based on such sketchy data, it is difficult to determine whether both groups were equivalent in all aspects except exposure to the electric fields.

20. Aside from methodological deficiencies, these Soviet studies deal with exposure to high electric fields in a complex environment (electric switchyard), which is not directly translatable to transmission line conditions [59]. For example, low-frequency (100-120 Hz) noise in switchyards may account for

many of the symptoms reported [28]. The observed changes are also consistent with varying degrees of physical fatigue during the day associated with the individuals' activities.[4] Many other factors in the industrial setting or home environment as well as social interactions can cause similar symptoms.[5]

21. It must also be pointed out that by 1975 the Soviets had already 150,000 kilometer-years of 500 kV transmission line operation, producing fields in the order of 12-15 kV/m near ground level, without having identified any biological effects from the lines' electric fields [27]. The Soviets have instituted standards for the protection of substation workers, but do not apply them to infrequent exposure by the local population or by workers in transmission line rights-of-way [27]. The Soviet standards for transmission line clearance (applicable to lines up to 1100 kV) require clearances to ground that limit the electric field to 12 kV/m at points where

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4 The Soviet investigators Guskova and Kochanova [15] have noted that it is very difficult to make etiological diagnoses of pathology of the circulatory system in groups of workers. Purely psychologic and psychosomatic factors associated with apprehension over receiving unpleasant microshocks or even direct conductor-contact shocks have been invoked to explain some of the reported symptoms of the Soviet switchyard workers, and those must be considered in such evaluations [46].

5 It is interesting to note that a survey has concluded that there is a statistically significant relationship between job dissatisfaction and psychologically induced ailments. These ailments include headaches and fatigue, ailments similar to those identified in the Soviet studies and attributed in the studies to electric field exposure [49].

lines cross roads and to 15 kV/m elsewhere along unpopulated sections of the line routes; in areas of difficult access, a field of 20 kV/m is permitted [3], [27]. The Susquehenna lines would meet the Soviet standards, as well as the more rigorous standards generally utilized by the electric power industry in the United States pursuant to the National Electric Safety Code [33].

22. In 1974, the Swedish State Power Board started physiological, psychological, and physical investigations on the effects of electric fields on personnel in Swedish 400 kV substations. In this study, 53 workers with long-term (more than five years) exposure to the electric fields of 400 kV substations were examined and compared with a matched control group of 52 non-exposed workers from the same power companies [21]. Matching considered age, geographical location and length of employment. The aim of the study was to investigate if there were any persistent, chronic health effects in the exposed group as a consequence of exposure. The investigation included the nervous system (neurasthenic symptoms, psychological tests, EEG), cardiovascular system (symptoms, blood pressure, ECG) and the blood (complete blood count) [26]. The results indicated no differences between the exposed and control groups as a consequence of long-term exposure to the electric fields. The groups differed, however, in that the exposed group had fewer number of children, especially boys.

The difference in number of children was unexplained but was thought to be related to factors other than exposure since the difference in number of children was found to be present 10-15 years prior to employment in 400 kV substations.[6]

23. In summary, epidemiological studies of workers exposed to electric fields set up by high voltage transmission lines have produced no credible evidence of organic injury to man caused by such exposure. This applies both to acute and chronic exposure. Comprehensive biochemical examinations have not indicated any evidence of a "stress" response. No occupational disease or deviation of general morbidity patterns has been reliably reported among high voltage transmission line workers.

Experimental Evidence

a. Human subjects

24. Studies in the laboratory of Dr. Rudolph Hauf [4],[9],[16],[17],[41] involved male and female volunteers and examined reaction time, blood pressure, pulse, ECG, EEG,

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6 A more recent, unpublished Swedish study of genetic risks to power company employees engaged in 400 kV electric substation work appears to indicate that crewmen constantly exposed to intense electric fields run a slightly higher risk of genetic damage than workers who are not [52]. Since this study has yet to be fully reported in the scientific literature, it is impossible to form an opinion on it at the present time. It should be noted that some Swedish investigators such as Nordstrom are not convinced of the reliability of this study [57].

peripheral blood counts, coagulation time and sedimentation rate in the presence of strong electric fields. The undisturbed ground level 50 Hz electric fields in the test runs were 0.585, 9.1 and 11.96 kV/meter. In additional experiments, the exposure time to a ground level field strength of 9.1 kV/meter was prolonged for 2 hours. According to Dr. Hauf, the test conditions were equivalent to conditions under high voltage transmission lines up to a ground field strength of 12 kV/meter [4]. Deviations observed in both control and exposed subjects did not exceed normal physiological limits. Hauf has concluded, based upon these studies, that there are no detrimental biological effects resulting from exposures to fields of these magnitudes [4].

25. In a study by Johansson et al. [19], two test groups, each consisting of 10 males and 10 females, were exposed, in a room equipped with floor and ceiling electrodes, to an electric field strength (50 Hz) of a maximum magnitude between 90 kV/m and 110 kV/m, for 75 minutes and were subjected to a series of psychological tests which measured reaction time, attention, memory and motor preparedness. No statistically significant difference in the performance of the two groups could be observed. The final conclusion of the authors was that if the electrical fields have any biological effect on man, the effect is so small that it cannot be measured accurately unless the tested populations are very large.

26. Another experimental study on humans, limited to serum triglyceride levels, found no differences in triglyceride values 24 hours after subjects had been exposed for 3 hours to a 50 Hz, 20 kV/m electric field combined with a 3 gauss magnetic field [41].

b. Animal Subjects

27. In many areas of scientific research, biological experiments using human subjects have either been few in number or impractical due to the nature of the specific biological parameter one desires to study. It is often important, therefore, to use data obtained from experiments using other biological organisms, such as small animals, to predict the human response to a specific stimulus.

28. In making extrapolations from results of experiments in one organism (an animal) to predicting biological effects in another organism (human), one must be particularly mindful of the limitations in the use of animal experimentation data. Many factors must be considered in the design of experiments using organisms other than man as a test subject. These include the species, strain, sex, age of the animal, the methods of caring for the test animals, the animals' feeding patterns, the roles of seasonal and circadian rhythms, temperature and humidity.

29. The reliability of laboratory studies using experimental models depends on the following considerations:

(1) the selection of the animal model with considerations of its inherent limits, (2) scaling factors associated with the nature of the field in the laboratory investigation of the biological processes using animal models, and (3) the method by which the extrapolation of data gathered using the animal models relates to man.

30. The value of the animal model increases sharply in relation to the physiologic and biochemical similarities of the experimental animal to man.

31. In my analysis of animal experiments, I have taken into account these various factors in evaluating the significance of the studies reviewed as well as the likelihood that the results obtained therefrom may be accurately extrapolated to the human. I have also relied upon my experience as a veterinarian and a research scientist in this field. The most important among the animal studies are evaluated below.[7]

32. Animal experiments performed before 1976 have been extensively reviewed at hearings before the New York State Public Service Commission [38], [53], in a comprehensive report

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7 Eastern European, and especially Soviet, reports suggest that there are biologic effects when animals are exposed to stationary and low-frequency electric fields [10]. Field strengths reputedly causing effects vary from approximately 1 kV/m to 5 kV/m. The work of Soviet investigators in this area is of doubtful validity because of limited statistical analysis of data, inadequate controls and lack of quantification of the results.

by the National Academy of Sciences [37], a monograph by Sheppard and Eisenbud [43], and reviews by Miller and Kaufman [34], EPRI [51], and Michaelson [33], [58]. Since 1976, research into biologic effects and potential hazards of exposure to electric fields has progressed at an accelerated pace. For instance, an ongoing research program sponsored by the Department of Energy ("DOE") on the biological effects from electric fields associated with transmission lines has resulted in the award of numerous research contracts in areas such as cellular and subcellular studies, physiology, behavior studies and environmental effects of electric fields induced by high voltage transmission lines [54]. Another series of studies is being sponsored by the Electric power Research Institute ("EPRI") [60].

33. While the DOE-sponsored research programs have not reached completion, it is worth remarking that there have been no reported significant effects in most organisms and areas studied, with the exception of some "subtle and small" effects reported by one researcher (R.D. Phillips) on the nervous systems of rats and mice exposed for long periods of time to 60-Hz electric fields up to 130 kV/m [54]. The results of the ongoing research projects have so far been consistent with previous studies in finding no significant effects which would adversely influence the health of animals exposed to low-frequency fields up to 100 kV/m.

34. The most numerous animal experiments have involved mice and rats. For example, in a study by Knickerbocker et al. [22], male mice were exposed to a 60 Hz field of 160 kV/m for 1500 hours during the course of approximately 10-1/2 months. No effects were observed on the general health, behavior or reproductive ability of these animals. Necropsies performed after exposure failed to show any pathologic effects. The only observed difference between the exposed group of mice and a parallel control group was a slightly smaller weight in the male offspring of the exposed mice. This difference, although statistically significant, was small and not thought by the authors to be of biological significance.

35. Marino [29] reported the results of a study in which mice were subjected to 10 kV/m horizontal and 15 kV/m vertical electric fields. Marino used weight as the criterion for biologic effects and found that the only groups whose body weights were significantly reduced (and whose mortality rate increased) were the males exposed to the vertical electric field. He points out that the vertically-exposed mice experienced, after weaning, "microcurrents" of the order of 5 microamps when eating or drinking because, under the experimental setup utilized, both acts necessitated touching ground conductors. He also notes "the possibility must, therefore, be considered that the greater weight depressions and increased mortality in the vertical mice may be related to the grounding

microcurrents". The influence of microshocks, lack of data on the survival and weight at various periods during the nursing period, and absence of control over litter size to avoid overnutrition or undernourishment of the nursing pups make the results of this study questionable [43].

36. In a Noval et al. [39] study of mice similar to Marino's, no differences in food consumption, water consumption or adrenal size were noted. Noval, on the other hand, claims marked differences in body weight occurring as early as two-three days (which is most unlikely) after the commencement of exposure, at fields 150-300,000 times lower than those used by Marino. It is most likely that faulty experimental protocols was responsible in the Noval and Marino studies for such disparate results. A committee of the National Academy of Sciences that reviewed the experiments performed by Noval concluded that no reliable data could emanate from a study conducted under the poor conditions in which that study was performed [37].

37. Phillips et al. [35], using rats in the same type of experiment but at field strengths six times higher than Marino, reported no effect. Mathewson et al. [31], using rats, performed an experiment similar to Noval's and reported no effect. As noted above, Knickerbocker et al. [22] used mice at a field strength 16 times greater than Marino (160,000 V/m); Knickerbocker concluded from the study of mice exposed for

approximately 1500 hours over a period of 10 to 12 months to a field of 160 kV/m there were no signs of a detrimental effect of this field on the animals.

38. Another group of animal experiments have involved monkeys. Thus, at the Naval Aerospace Medical Research Laboratory in Pensacola, Florida, several studies have been performed on monkeys exposed to 10, 45, and 75 Hz electric fields of different intensities (up to 7.4 kV/m) for various periods of time up to 42 days. Multiple psychological and behavioral studies did not show any difference between exposed and control monkeys [6], [7], [8], [14].

39. The studies of electric field effects on the nervous system of monkeys by Gavalas et al. [11] have often been cited as indicating the potential for significant biological effects from high voltage transmission lines' electric fields. It should first be noted that these investigators did not conclude that any biological hazards were being indicated by their experiments. Secondly, they suggested that the effects noted (variations in EEG, reaction time and behavior) may be related to the normal biological frequency or biorhythm, as represented by the EEG, and they found that 60 Hz electric fields do not produce the effects noted at other frequencies (7 and 75 Hz). It is quite possible that electrode leads picking up currents due to capacitive coupling, which were injected directly into the brain via the electrodes, caused the results

observed by the investigators. In one experiment where implanted electrodes were not used, the results were inconclusive.

40. Grisset' [12], [13] has worked for a number of years with monkey exposure to electric and magnetic fields. In his most recent study [12], thirty experimental rhesus monkeys were matched with thirty controls and exposed for 3 years to a 20 V/m electric field and 2 Gauss magnetic field. During this period all animals were subjected to comprehensive clinical-pathological and behavioral examinations. There was no evidence of any detrimental affect of the exposure. Although not considered abnormal, the most significant finding was the difference in rate of weight gain between exposed and control males. The exposed males gained weight at a slightly faster rate than the control males and at the end of one year were approximately 11% heavier than the controls. The difference in weight was not accompanied by differences (increase) in bone length measurements. The linear body measurement showing the most agreement with the growth rate difference was chest circumference. In the exposed females serum triglycerides and respiratory quotient were slightly lower than in the female controls. There is no indication that these findings have any clinical significance and both groups of animals appear healthy. All other determinations and measurements were within the normal range and except for this slightly greater weight

among the males, there were no significant differences between exposed and control animals. The following determinations were made in this study: Blood - protein, lipids, hematology, hemocytology, electrolytes, enzymes, glucose, blood urea, nitrogen; thyroid function; oxygen consumption; blood pressure. All of these were normal.

41. Assorted studies on other animals have been reported.[8] Of these, an ongoing research project sponsored by the Electric Power Research Institute and conducted by Battelle Pacific Northwest Laboratories ("PNL") on Hanford miniature swine has received recent attention [55]. PNL has constructed

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8 For example, Marino [30] has reported retarded fracture healing in rats exposed to large electric fields. This study, has been critized on a number of grounds. The results are inconsistent-controls from 5000 V/m exposures are significantly different from controls of 100 V/m; 5000 V/m exposed are comparable to 1000 V/m controls and exposed. The statistical analysis was poorly done. There is also a question of the methodology for producing comparable fractures with consistent healing rates in all animals as well as interpretation of the sections that were presented. A report on aberrant behavior of bees by Warnke [48] is more anecdotal than scientific and therefore is an inappropriate basis for scientific conclusions. The report contains no quantitative data, and does not provide adequate description of the experimental design. There is no discussion of the cable height above the hive, the hive materials or construction, nor noise levels. By contrast, another report on beehives placed under a 765 kV line showed that bees exhibited aberrant behavior (e.g., stinging and biting each other) only when placed in unshielded metal hives resulting in electric shocks to the bees [2]. Another series of studies conducted jointly by Westinghouse Corp. and Pennsylvania State University on chicks, voles and mice showed no adverse effect when the animals were exposed to high voltage electric fields of 50 to 80 kV/m, and only temporary enhancement of growth in chicks exposed to fields as high as 80 kV/m [60], [61], [62], [63].

a specially designed barn in which three generations of female miniature swine have been subjected continuously to an electric field of 30 kV/m, with a matching control group of swine in a similar barn without the field. The results obtained in the experiment indicate no differences among the exposed and control groups in growth rate, hematology, serum chemistry, immunology, cytogenics, or in neurophysiological tests. The experiment found, however, more instances of malformed fetuses among exposed sows than for those on the control group; more prenatal deaths among the control group; and resistance to mating among sows born and raised in the exposed barn.

42. The instances of fetal malformation and mating difficulties cannot be conclusively attributed to the electric field exposure because a serious outbreak of dysentary took place during the course of the experiment, so that the fetal malformations and mating problems (all of which occurred thereafter) may have been the result of the disease and/or its treatment. Also, mating of exposed sows took place in a special pen outside the electric field, thus the resistance to mating may have been due to the change in the sows' environment. Because of the uncertainties, the experiment is being repeated.[9]

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9 A special 10-member panel of experts (myself included) was assembled by EPRI to review the miniature swine experiments. Conclusions and recommendations from this group, which included experts in swine biology and low-frequency electric field effects, were to the effect that the experiment should be repeated and that no clear conclusions could be drawn from the previous experiment [55].

43. In short, most of the animal studies to date have failed to identify any biological effects that could be attributed to low frequency high voltage electric fields. Therefore, the indication from this, as well as other sources of evidence, is that no significant effects exist.

Effects on Animal Life

44. The above described animal experiments demonstrate that there will be no adverse impact on animals that may graze on or otherwise occupy the right of way of a high voltage transmission line such as the Susquehanna lines. Confirmation of the lack of adverse effects from exposure to high voltage transmission lines is given by surveys of animal grazing in transmission line rights-of-way. Surveys conducted in New York [5] and Indiana-Michigan [47] show that livestock graze under 500 and 765 kV lines normally, and exhibit no reduction in growth or milk production or other detrimental effects.

Summary

45. In preparing this Affidavit, I reviewed the body of literature on biologic effects and health implications of exposure to electric fields. There is a sizeable literature which one can study to arrive at a conclusion as to whether the electric fields of high voltage transmission lines would pose a problem to health and safety. An assessment was made as to how cells function in terms of electric current, i.e. what levels of electric current have been demonstrated to be hazardous;

what levels are known to be perceived but not hazardous, and what levels are not perceived. Next, a determination was made as to what are the fields inside a body standing in the transmission line's electric field. The induced electric field inside the human body is very much less than the external or air electric field, and this is often a fact that is lost sight of. There is such a tremendous reduction in terms of the field inside the body that it does not seem reasonable to expect electric field effects. Using a biophysical approach combining physical laws with known biological properties, the conclusion was reached that it was difficult to see how effects could occur from the electric field of the transmission line. Thus, based upon what is known about how cells work and what the fields are inside the body we would not expect that there would be significant effects induced by the transmission line's electric fields.

46. Next, the biological literature in this area was examined to determine whether or not the biophysical considerations were supported by the biological literature. Epidemiological studies and survey studies of animals and people were analyzed. There was a variety of laboratory studies dealing with rats, mice, and other animals; there were behavioral studies, physiological studies, cytological studies, genetic studies, growth studies, and ecological studies. A large number of studies was analyzed to determine whether or not

effects would be anticipated from exposure to electric fields comparable to those of the Susquehanna lines.

47. A careful review of the scientific literature provides a basis upon which to make an informed judgment concerning the health, safety, and general biological effects of high voltage transmission lines. Analysis of the results of field and laboratory studies in man as well as laboratory studies in animals indicate that there are no demonstrable biological effects which may be hazardous to health or safety or to the general biological environment as a result of exposure to electric fields from high voltage transmission lines.

48. There is no evidence of organic injury to man caused by electric fields. This applies both to acute and chronic exposure. Comprehensive biochemical examinations do not indicate any evidence of a "stress" response. No occupational disease or deviation of general morbidity patterns has been reliably reported among high voltage workers. Nor is there evidence that cancer, genetic effects or alterations in growth and development would result from exposure to the electric field (on the order of 10 to 12 kV/m) from 500 kV transmission lines.

49. Thus, electric fields of such lines do not present any threat to health. There is no evidence of specific symptoms in humans due to exposure to electric fields. Consistent with this, no mechanism of action is known by which electric fields produce direct effects on living organisms.

50. In North America, there are currently more than 200,000 circuit miles of overhead transmission lines rated 138 kV or higher, of which 14,000 miles constitute 500 kV and several thousands of miles of 765 kV lines have been operating since 1969. It is noteworthy that there is no evidence of harm to humans or animals from exposure to the electric fields set up by high voltage transmission lines. Based on all of the above, I conclude that the electric fields from the Susquehanna transmission lines will result in no detrimental effects to humans or animals.

Solomon M. Michaelson

Sworn to and subscribed before me this 14th day of August, 1981.

Martha T. Lee
Notary Public
my comm. exp. 10/14/85.

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DATE AND PLACE OF BIRTH* April 23, 1922 SOC. SEC. NO. 089-16-4379
(*N.Y. State law prohibits discrimination based on age)

CITIZENSHIP USA If not U.S. Citizen. please indicate type of U.S. Visa you have, or will have, with expiration date, if any:

ECFMG Certificate No. NA
Date Visa Qualifying Examination taken and passed

EDUCATION

School or College	Field of Study	Degree Earned	Year
College of the City of New York	Biology	B. S.	1942
Middlesex University	Veterinary Medicine	D. V. M.	1945

POSTDOCTORAL TRAINING (Hospital, Research Laboratory, etc.)

University of Arkansas School of Medicine	1947-1948
New York University Graduate School	1948

EXHIBIT A

RECORD OF FELLOWSHIP AWARDS

Predoctoral Fellowship awards? Yes _____ No X

Source of Award*	Institution	Purpose	Year(s)

Postdoctoral Fellowship awards? Yes _____ No X

Source of Award*	Institution	Purpose	Year(s)

(*Specify source, such as NIH Training Grant, NIH Fellowship, NIH Research Grant, other NIH support, trainee or fellow stipend from other extramural sources.)

FACULTY APPOINTMENTS

Institution	Rank	Inclusive Dates
University of Rochester	Professor (Rad. Biol & Biophys.)	1972-present
" "	Assoc. Prof. (Rad Biol & Biophys)	1962-1972
" "	Assoc. Prof. (Medicine)	1967-present
" "	Assoc. Prof. (Lab Animal Med.)	1968-present
" "	Asst. Prof. (Rad Biol & Biophys)	1958-1962
" "	Instructor (Rad Biol & Biophys)	1956-1958
University of Arkansas	Asst. Prof. (Immunology)	1947-1948

New York State Permanent Medical Licensure No. _____ Date _____

Other state licensures, if any D. V. M., Arkansas Dates 1946 _____

Has licensure ever been revoked or suspended? Yes _____ No X

M.D. Board certified? Yes _____ No X 1st Specialty Board Lab Animal Med. Year 1961

2nd Specialty Board Vet. Toxicology Year 1958

PROFESSIONAL HOSPITAL AND ADMINISTRATIVE APPOINTMENTS

Institution	Appointment	Inclusive Dates
National Academy of Sciences	Committee Member	1971-1978
World Health Organization	Consultant	1971-present
Veterans Administration	Veterinary Medical Specialist	1965-present

Have medical staff privileges ever been revoked or reduced? Yes ____ No ____

MEMBERSHIP IN LOCAL AND STATE ACADEMIC AND PROFESSIONAL ORGANIZATIONS

Organization	Inclusive Dates
Sigma-Xi (Rochester Chapter), President	1972-73

MEMBERSHIP IN NATIONAL AND INTERNATIONAL ACADEMIC AND PROFESSIONAL ORGANIZATIONS

Organization	Inclusive Dates
American Physiological Society	1961-present
Sigma Xi	1955-present
Radiation Research Societ,	1956-present
Health Physics Society	1974-present
Research Committee of World Federation of Neurology	1974-present
Bioelectromagnetics Society	1978-present

LECTURESHIPS AND VISITING PROFESSORSHIPS

Institution	Appointment	Inclusive Dates
Cornell University	Visiting Professor	
AIBS	Visiting Lecturer	
NATO/AGARD	Lecture Series Director	1973, 1975
University of Illinois	Distinguished Bioengineer in Residence	March, 1977

Note: Pages 4 and 5 omitted as not relevan

EXTRAMURAL APPOINTMENTS:

Present

Advisor, National Counil on Radiation Protection and Measurements SC-53 Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Radiation

Consultant, Science Advisory Board, U.S. Environmental Protection Agency

Consultant, Board of Scientific Counselors, National Institute of Environmental Health Sciences - NIH/HEW

Consultant and advisor on Working Group of the World Health Organization Regional Office for Europe for Health Effects on Personnel of Ionizing Radiations and Other Physical Factors

Member, Advisory Committee on Biological Effects of Electric Fields for the Electric Power Research Institute

Veterinary Medical Specialist (Laboratory Animal Medicine), Veterans Administration, Washington, D.C.

Member, Editorial Board: Radiation and Environmental Biophysics

Member, Editorial Board: Bioelectromagnetics

Associate Editor for Medical and Biological Sciences, The Journal of Microwave Power

Member of American National Standards Institute Committee C95.4 - Radiofrequency Radiation Hazards, and C105 - Medical Electronics

Veterans Administration, Scientific Review Consultant

Member, Technical Program Committee, International Microwave Power Institute Symposium, May, 1980.

Workshop Organizer - Fifth International Radiation Protection Association, Jerusalem, Israel, March, 1980.

Co-Organizer with Professor Martino Grandolfo (Radiation Laboratory, Rome) in course "Advances in Study of Biological Effects of Non-Ionizing Radiation," Erice, Italy, April 1981.

Former

Member, Technical Program Committee for 1979 International IEEE/APS Symposium, Seattle, Wash.

Member Ad Hoc Committee for U.S. Office of Telecommunications Policy

Visiting Lecturer, American Institute of Biological Sciences

Member Editorial Board, International Union Radio Sciences (1977/1978)

Member NIH Cardiovascular and Pulmonary Study Section (Ad Hoc)

Member National Research Council/National Academy of Sciences Committee on Biosphere Effects of Extremely Low Frequency Radiation

Consultant in Nuclear Medicine, Walter Reed Army Institute of Research, Walter Reed Army Medical Center, Washington, D. C.

Consultant in Radiobiology, Defense Atomic Support Agency, Armed Forces Radiobiology Research Institute, Washington, D.C.

Appointed by AGARD (Advisory Group for Aerospace Research and Development), NATO, as a lecturer on Microwaves/Radiofrequency, June-July, 1973, and Lecture Series Director for Non-Ionizing Radiation Course, September 1975

Consultant, Illinois Institute of Technology Research Institute, Electronics Research Division, Chicago, Illinois

Technical Program Committee and Proceedings Editorial Committee. 1978 IEEE/IMPI Symposium on Electgromagnetic Fields in Biological Systems. Ottawa, Canada. June, 1978.

Expert Witness, Diathermy Compliance - Food and Drug Administration

Member of Technical Guidance Committee, Institute of Laboratory Animal Resources, National Academy of Sciences - National Research Council

Member, Advisory Panel for the National Science Foundation Divison of Undergraduate Education in Science

Consultant NRC-NAS and member of Ad Hoc Committee on the Navy Nonionizing Radiation Research Program and member of Ad Hoc Committee on Electric Stimulation of the Brain

Consultant on National Research Council Commission on Humar Resources - Research Associateship Program

Chairman; site visit team to review research program at New Orleans, Veterans Administration Hospital

Chairman, Committee on Postgraduate Education, American College of Veterinary Toxicologists

Visiting Professor, Academic Year Institute, Cornell University, Ithaca, New York

Member, Radiological Health Ad Hoc Committee, Naional Center for Radiological Health, USPHS

THESES
Supervised by Sol M. Michaelson

Odland, Lawrence T. Injury and Recovery of the Hematopoietic System in dogs Exposed to Varyi g Doses of X-Irradiation Delivered to the Upper, Lower, and Whole Body in a Manner Simulating Some of the Possible Exposures During Manned Space Trave'. Ph.D. Thesis, 1962.

Krasavage, Walter J. The Effects of Antibiotics in Dogs Exposed to Lethal Doses of Ionizing Radiation. M. S. Thesis, 1963.

Gertzog, Jack. The Effect of Ionizing Radiation on the Erythropoietin Titer of Dogs. M. S. Thesis, 1964.

Martin, Barbara A. Exercise Performance of Upper-Body X-Irradiated Dogs. M. S. Thesis, 1965.

Penikas, Vincent T. Fe-59 and Cr-51 Studies of the Effect of Partial-Body X-irradiation on Erythropoiesis in Beagles. Ph.D. Thesis, 1966.

Pulliam, James A. Modifications of the Rat Brain Induced by Localized Beta Radiation During Ontogenesis. Ph.D. Thesis, 1966.

Panke, Thomas. Thyroxine-Binding Proteins in Beagles. M.S. Thesis, 1968.

Kramer, Melvyn W. Late Patho-Physiologic Responses of Dogs to Head X-irradiation. M.S. Thesis, 1969.

Kramer, Melvyn W. Radioimmunoassay for Dog Growth Hormone: Its Application to the Endocrine Study of the Normal and Head X-Irradiated Dog. M.D. with Honors Thesis, 1973.

Martinedes, Barbara A. Response of Upper-Body X-Irradiated Beagle Dogs to Exercise Stress. M.S. Thesis, 1969.

Milroy, William C. Pathophysiologic Effects of Microwave Radiation with Special Reference to the Thyroid-Pituitary Axis. Ph.D. Thesis, 1972

Lu, Shin-Tsu. The Sequential Pathophysiology of Ionizing Radiation on the Beagle Thyroid Gland. M. S. Thesis, 1972.

Kaufman, Gary E. Erythropoietin and Macrocytic Erthropoiesis in Normal and X-Irradiated Dogs. Ph.D. Thesis, 1974.

Magin, Richard L. The Effects of Localized Microwave Exposure on the Dog Thyroid. Ph.D. Thesis, 1976.

Lu, Shin-Tsu. Characteristics of Radiation-Induced Pituitary-Thyroid Functional Disturbance in Relation to Pituitary and Thyroid Tumors in Rats, Ph.D. Thesis, 1976.

Lotz, W. Gregory. Stimulation of the Adrenal Axis in the Microwave Exposed Rat. Ph.D. Thesis, 1976.

Guillet, Ronnie. The Development of the Adrenal Axis in the Neonatal Ra'. Ph.D. Thesis 1977.

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Publications

1. Orcutt, J.A., S.M. Michaelson, P. Prytherch and L.P.Duprey. Pharmacology of N-(2C-Furfuryl)-N-(2-Pyridyl)-N', N'-dimethylethylenediamine fumarate (Methafurylene Fumarate) II. Toxicological Studies. J. Pharm. Exp. Ther. 99:488, 1950.

2. Michaelson, S.M. The use of beta irradiation in veterinary opthalmology. Vet. Med. 49:475, 1954.

3. Michaelson, S.M. and J.W. Howland. The use of vitamins fortified antibiotics in the therapy of the acute radiation syndrome. Antibiot. Annu. pp. 283-294. Med. Encyl. Inc. N.Y. 1956.

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