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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

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Before the Atomic Safety and Licensing Board

OFFICE OF SECRETARY
DOCKETING & SERVICE
BRANCH

In the Matter of	)	
	)	
Philadelphia Electric Company	)	Docket Nos. 50-352
	)	50-353
(Limerick Generating Station,	)	
Units 1 and 2)	)	

APPLICANT'S PROPOSED FINDINGS OF FACT
AND CONCLUSIONS OF LAW IN THE FORM
OF A PARTIAL INITIAL DECISION

Philadelphia Electric Company, Applicant in the captioned proceeding, in accordance with 10 C.F.R. §2.754 and the Atomic Safety and Licensing Board's "Memorandum and Order Establishing Format of Proposed Findings of Fact and Conclusions of Law" (December 9, 1983), hereby submits the attached Proposed Findings of Fact and Conclusions of Law in the form of a partial initial decision with respect to Contention V-4.*/

Respectfully submitted,

CONNER & WETTERHAHN, P.C.

Mark J. Wetterhahn

Nils N. Nichols

Counsel for the Applicant

February 16, 1984

*/ Applicant recognizes that the Board may wish to combine consideration of this matter with other completed contentions and may not issue a separate decision.

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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

Before Administrative Judges:

Lawrence Brenner, Esq., Chairman
Dr. Richard F. Cole, Member
Dr. Peter A. Morris, Member

In the Matter of	)	
	)	
Philadelphia Electric Company	)	Docket Nos. 50-352-OL
	)	50-353-OL
(Limerick Generating Station,	)	
Units 1 and 2)	)	

APPEARANCES

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ANN P. HODGDON, Esq. and BENJAMIN VOGLER, Esq., Office of the Executive Legal Director, U.S. Nuclear Regulatory Commission, Washington, D.C. for the NRC Staff.

FRANK ROMANO, *pro se*, for the Air and Water Pollution Patrol.

PARTIAL INITIAL DECISION

(On Carburetor Icing, AWPP Contention V-4)

OPINION

I. PRELIMINARY STATEMENT

On March 17, 1981, Applicant Philadelphia Electric Company ("Applicant" or "PECO") applied for operating licenses for the Limerick Generating Station ("Limerick"). Pursuant to notice of receipt of application published in the Federal Register,[1/] Air and Water Pollution Patrol ("AWPP" or "intervenor") filed a petition for leave to intervene on September 8, 1981. At a prehearing conference held January 6-8, 1982, this Atomic Safety and Licensing Board ("Licensing Board" or "Board") found that AWPP had standing to intervene and admitted a contention relating to the potential for increased carburetor icing in airplanes as a result of the operation of the Limerick cooling towers.[2/] This contention, as litigated, states that:

> Neither the Applicant nor the Staff have adequately considered the potential for, and the impact of, carburetor icing in aircraft flying into the airspace

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1/ 46 Fed. Reg. 42557 (1981).

2/ Philadelphia Electric Company (Limerick Generating Station, Units 1 and 2), LBP-82-43A, 15 NRC 1423, 1438 (1982).

that may be affected by emissions from the Limerick cooling towers.3/

Evidentiary hearings on this matter were held on January 11-13 and 17-18, 1984 in Philadelphia, Pennsylvania.

Summary

The Board has analyzed this contention from a number of perspectives and determined that it has no merit. Initially, it examined whether cooling tower plumes from the Limerick Generating Station could cause conditions significantly different from those otherwise present in the atmosphere such that carburetor icing potential could be attributable to cooling tower emissions and, if so, whether pilots are sufficiently trained and equipped to deal with such incidents. The Board examined the conditions within cooling tower plumes and found that while plumes contain great variations in temperature and humidity relative to the surrounding ambient air immediately after leaving the tower orifice, such variations subside quickly and do not persist beyond one-quarter mile. Thus, the Board was able to conclude that the carburetor icing potential of the airspace affected by the Limerick cooling tower plume emissions was

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3/ "Memorandum and Order Denying Applicant's Motions for Summary Disposition of Contentions V-3a & V-3b and V-4" (November 8, 1983) (slip op. at 3). The Applicant had moved for summary disposition of this contention on September 27, 1983. Its motion was supported by the NRC Staff, but opposed by AWPP. The Board denied the motion.

not different than the surrounding airspace. The Board also examined the height to which plumes can be expected to rise and found that if they are visible at all, they will not level off below 1,000 feet and are unlikely to do so before reaching 1,200 feet, and therefore will not affect local airport traffic patterns.

While finding that conditions within and surrounding plumes do not differ significantly from the ambient air in terms of carburetor icing potential, the Board additionally examined the effect of flying through and across plumes up to ten miles in length. It is satisfied that such plumes would not allow enough time to form carburetor icing sufficient to significantly affect the performance of aircraft, even assuming that pilots did not utilize carburetor heat and that plumes present carburetor icing potential different from the surrounding airspace in the first place.

The Board has also found that aircraft are equipped and pilots trained to accommodate carburetor icing. Thus, even if there were an increased potential for carburetor icing as a result of cooling tower operation, pilots are sufficiently trained to deal with it and there is sufficient time for reasonably attentive pilots to detect and take the prescribed corrective actions necessary to safely eliminate the problem. Pilots must and do contend on a regular basis with much larger variations in atmospheric conditions, i.e., temperature and humidity, than will be presented by the

cooling tower plumes. As discussed below, we therefore conclude that the Limerick cooling tower plumes will not increase the potential for carburetor icing in aircraft flying in the area affected by the plumes.

Introduction

1. The Applicant presented the testimony of two meteorologists, Messrs. Smith and Seymour, related to the contention. Both have excellent qualifications in that field and, as part of their experience, have conducted studies related to cooling tower plume behavior which are specifically applicable to this contention. Smith (Statement of Professional Qualifications), ff. Tr. 6234; Seymour (Statement of Professional Qualifications), ff. Tr. 6234; Smith and Seymour, ff. Tr. 6234 at 1-4, 6-7. In addition, Mr. Seymour is an experienced pilot and FAA certified ground instructor who is familiar with the operation of aircraft and has conducted cooling tower research from light aircraft. Smith and Seymour, ff. Tr. 6234, at 2-3. The Board has observed their demeanor on the stand and has relied heavily on their testimony.

2. This is equally true of the Staff's witnesses. In addition to Mr. Markee, an experienced meteorologist, the Staff also presented the testimony of Mr. Geier, Manager, General Aviation and Commercial Division, Office of Flight Operations, Federal Aviation Administration, who is a pilot well versed in aviation regulations, requirements and good practices with 41 years experience, and Mr. Krug, also a

pilot holding a commercial rating. Markee (Professional Qualifications), ff. Tr. 6883; Geier (Professional Qualifications), ff. Tr. 6883; and Krug (Professional Qualifications), ff. Tr. 6883.

3. In contrast is the testimony of Mr. Romano, sole witness for AWPP. The Board granted him the opportunity to testify on the basis of his experience as a pilot in the local Limerick area, including aspects of meteorology as it could affect flying conditions.[4/] After reviewing his qualifications and responses to questions about those qualifications, the Board has concluded that Mr. Romano has no expertise on the subject at hand and has discounted his testimony. While Mr. Romano is a licensed pilot, the Board has carefully observed his demeanor and answers to particular questions regarding proper pilot actions and contrasted them to the other experienced pilots. See, e.g., Tr. 6768, 6769-71, 6808-09, 6810-15, 6858-60, 6861-63 (Romano). We have found that his testimony is not entitled to any weight with regard to particular pilot actions, or as representative of what light plane pilots would do or know and, consequently, have discounted his testimony in this area as well.

4/ "Memorandum and Order Ruling on Motions to Strike Testimony" (December 1, 1983) (slip op. at 9).

4. The matters examined during the evidentiary hearing which are not discussed in these findings of fact were considered by the Board and found either to be without merit or not to affect our decision herein. In preparing its Findings of Fact and Conclusions of Law, the Board reviewed and considered the entire record, those exhibits admitted into evidence (See Appendix A) and the Findings of Fact and Conclusions of Law proposed by the parties. Those proposed findings not incorporated directly or inferentially in this Initial Decision are rejected as being unsupported by the record of the case or as being unnecessary to the rendering of this decision.

Cooling Tower Design and Operation

5. The twin 507 feet tall Limerick cooling towers were designed to dissipate heat resulting from the operation of the two facility generating units and ensure that the resulting plumes rise into the atmosphere. Tr. 6335-36 (Boyer). The water vapor emitting from the towers will condense to form visible plumes approximately 50-80% of the time, but will evaporate rapidly under normal circumstances. Markee, ff. Tr. 6883, at 3-13, 3-16. The height of the towers plus their natural buoyancy will enable the plumes to rise through the entire range of meteorological conditions which could occur at the site. Tr. 6336 (Boyer).

6. Because of the addition of heat and moisture resulting from the operation of the facility, the air constituting the plume exiting the Limerick cooling towers

will always be of a greater temperature and contain more moisture then the ambient air itself. Markee, ff. Tr. 6883, at 3-13; Tr. 6296, 6320, 6324 (Smith). The exact temperature and humidity content of the plume will depend on the temperature of the air drawn into the plume, the amount of heat being dissipated from the plant's condensation system and plant operating levels. Tr. 6317, 6322 (Smith). For example, the Applicant established that colder air cannot hold as much water vapor as warmer air. Thus, to reject a given amount of heat, since evaporation will be less of a factor than when the ambient air is warmer, the relative exit temperature would be greater. Tr. 6517 (Seymour).

7. The plume will exit the cooling tower at a velocity of 1,100 to 1,600 feet per minute during full power operation. Tr. 6630 (Boyer). The degree to which the plume will rise is related to many other factors as well, including atmospheric conditions and conditions within the plume itself. Tr. 6297, 6301 (Smith).

8. Temperature is one such factor that plays a significant role in overall plume rise. Tr. 6297 (Smith); Markee, ff. Tr. 6883 at 3-13; Tr. 7062 (Markee). A temperature differential of as little as tenths of 1° F. over the ambient air will result in a buoyant plume. Tr. 6681 (Smith).

9. Water vapor also plays an important part in the height to which plumes will rise. Tr. 6297 (Smith); Tr. 7062 (Markee). Air containing larger amounts of water vapor

will always be lighter than air containing lesser amounts of water vapor at the same temperature and, consequently, will rise through the heavier air. Tr. 6337 (Smith). The air rising from the Limerick cooling towers will either be saturated or very close to saturation at its point of exit. Tr. 6639 (Smith). The plumes produced at Limerick will always have sufficient water vapor and temperature difference over the ambient air that they will rise. Tr. 6298-99 (Smith).

10. The temperature and humidity structure of the ambient air is important to plume rise as well. Tr. 6295, 6300, 6301, 6316, 6407 (Smith). For example, if the ambient temperature increases with height, plume rise will be somewhat less than if the ambient temperature decreased with height. Tr. 6333 (Smith).

11. Wind speed also affects plume rise. Tr. 6407 (Smith). Strong winds expedite the mixing process and reduce the plume's buoyancy as its warmer, wetter air is dispersed. Tr. 6299 (Smith). On the other hand, if the atmosphere is relatively still, plumes will rise almost vertically until reaching a layer in which temperature increases with height, i.e., an inversion layer. Tr. 6299-300 (Smith). Normally as a plume rises under nearly calm conditions it generates its own turbulence and mixing and either dissipates while rising vertically or reaches a layer in which there is transport wind and is carried away. Tr. 6302-03 (Smith).

12. As indicated by both the Applicant and Staff, and uncontested by the intervenor, it is extremely rare for cooling tower plumes to assume a lateral orientation before reaching an altitude of 1,000 feet. Tr. 6894, 6908-09 (Markee); Tr. 6298 (Smith). In their studies of cooling tower plumes, Applicant's witnesses did not find a single plume whose rise leveled off below 1,000 feet. They found only one bent over plume between 1,000 and 1,200 feet. Tr. 6298, 6334, 6619 (Smith). Additionally, the Staff testified that there is only an extremely small probability that a plume waft might reach the ground in the vicinity of Limerick. Such an event could only occur as a result of very turbulent, hurricane-type conditions, which would be conducive to plume dispersion in any event. Tr. 6894-95 (Markee).

<u>Plume Mixing</u>

13. The dynamics of plume interaction with the atmosphere are well understood. Heat and moisture contained within plumes is diluted by the physical interaction of the plume with the ambient air, turbulent fluctuations combining heated and ambient air and evaporation of liquid droplets. Tr. 6290, 6292 (Smith). There is never a situation existing in the atmosphere in which this mixing process does not take place. Tr. 6288 (Smith).

14. As discussed by the Applicant, very rapid integration always occurs in the area above the tower orifice as a result of the natural turbulence caused by the vigor with

which plumes exit the tower. Tr. 6288-89, 6291-93, 6297 (Smith). Plumes the size of the Limerick plume generate mixing simply by passing through the atmosphere, most of which occurs within the first few hundred feet of the plume's point of exit. There is a very rapid interchange within this distance that would be present in the stillest atmosphere imaginable. Tr. 6291, 6293-94 (Smith). Tower generated turbulence will affect the plume for up to one mile, after which the rate of dispersion, if any, will be dependent upon the natural atmosphere. Tr. 6294-95 (Smith).

15. The ambient temperature also has a considerable effect on heat dissipation within a plume. Tr. 6316 (Smith). As recognized by the intervenor, when the surrounding air is cold, heat dissipates very rapidly. Tr. 6837 (Romano). Conversely, when the temperature of the surrounding air more closely resembles that of the plume, dissipation takes place at a slower rate. Tr. 6296 (Smith). Heat dissipation during warmer periods is normally controlled largely by evaporation since the air is typically dry at such temperatures and has a tremendous capacity to absorb moisture. Tr. 6296 (Smith).

16. AWPP contended that the addition of the maximum 35 million gallons a day ("mgd") release from the Limerick cooling towers would inevitably increase the amount of water vapor available to form carburetor icing. It presented no evidence in support of its conclusion, however. Romano, ff. Tr. 6725, at 2; Tr. 6782-84 (Romano). On the other hand,

Applicant's witnesses testified that compared to the amount of water vapor naturally present in the air with which the plume will mix, a maximum release of 35 mgd will not constitute a significant addition to the atmosphere. Smith and Seymour, ff. Tr. 6234, at 5; Tr. 6249 (Smith). As an example, they stated that if the 1.3 million gallons per hour of water vapor typically released from the tower under maximum operating conditions were mixed with 10,000 million cubic meters of air (a section 10 km long, 1 km deep and 1 km wide) containing about 2½ thousandths of a gallon of water vapor per each cubic meter, it would be added to 25 million gallons of naturally occurring water vapor and would not constitute a significant increase. Smith and Seymour, ff. Tr. 6234, at 5.

17. Intervenor postulated, but again presented no evidence or foundation for its proposition, that when the ambient air is saturated, the additional water vapor contained within the plume could not evaporate, thus significantly increasing the amount of localized moisture and the carburetor icing hazard. Tr. 6838-41 (Romano). The Applicant's evidence, based upon its witnesses' experience with cooling tower plumes and study of the literature, showed that when the ambient air is completely saturated, the plume will rise into the atmosphere, merge with the cloud deck, continue to mix with the ambient air, and be transported away, usually over the course of an hour or so. Tr. 6408-10 (Smith).

18. Intervenor also hypothesized that stagnant conditions could concentrate tower emissions in the Limerick area for several days and thus radically increase the amount of moisture available to form carburetor ice. It presented no probative evidence, however, that this event, as postulated, could occur. Tr. 6409, 6710-11, 6838-41 (Romano). To the contrary, the Applicant's witnesses concluded that plumes issuing from cooling towers during stagnant conditions tend to rise to much greater heights than normal and would not markedly increase the amount of moisture in the localized air. Smith and Seymour, ff. Tr. 6234, at 14; Tr. 6407, 6713 (Smith). The Staff's witnesses testified that there is no such thing as completely stagnant air; air always moves, albeit at a slower rate than other times. They also concluded that an accumulation of moisture in a localized area resulting from a plume whose movement might be affected by inversive conditions would be next to impossible. Tr. 7050-51 (Markee).

19. Intervenor conceded that the Limerick plumes will rise and dissipate far above stagnant conditions during hot, humid weather, but alleged that colder ambient air would reduce their temperature such that they would remain earthbound during inversive conditions. Tr. 6838-39 (Romano). The evidence established that while colder weather reduces the temperature within plumes at a faster rate than normal, the presence of warm water vapor adds extra rise and compensates for this effect. Tr. 6296, 6711

(Smith); Tr. 7051, 7105-06 (Markee). The evidence also established that plumes routinely ascend several thousand feet under such conditions. This degree of rise divorces plumes from low level conditions and allows them to be carried off at the speed of the stronger winds aloft where zero wind flow is an extremely transitory and infrequent event that occurs at most only a few tenths of 1% of the time. Markee, ff. Tr. 6883, at 2; Tr. 7054 (Markee); Smith and Seymour, ff. Tr. 6234, at 14; Tr. 6302, 6713 (Smith).

20. Based on their review of the applicable literature, personal studies of cooling tower plumes and knowledge as professional meteorologists, Applicant's witnesses concluded that as a result of the mixing process the area in which in-plume temperatures and humidity could possibly vary enough from the ambient air to affect carburetor icing will not exceed one-fourth mile from the plume's point source, regardless of whether it rises vertically or extends horizontally. Smith and Seymour, ff. Tr. 6234, at 4, 5-6, Figures 1 and 2; Tr. 6267, 6286, 6312-13 (Smith); Tr. 6270, 6286, 6350-51 (Seymour). The Staff agreed with this conclusion and likewise concluded that the visible plume is in every way comparable to a cloud of natural formation insofar as carburetor icing is concerned. Krug, ff. Tr. 6883, at 2; Tr. 7033, 7106-07 (Markee).

21. The Applicant's conclusion was based on the conservative premise that if conditions within the plume do not exceed 1° C., or a quarter to a half-gram of water per

kilogram of the entire atmosphere, it could not have any effect on carburetor icing. Tr. 6249 (Smith). In actuality, their testimony indicated that an in-plume temperature variation of 2 or 3° C. and a humidity differential of 10-20% from that of the ambient atmosphere would not be of any consequence. Smith and Seymour, ff. Tr. 6234, Figures 1 and 2; Tr. 6267 (Smith).

22. While AWPP did not agree with Applicant's conclusion that plumes would have no significant effect on carburetor icing beyond one-quarter mile from the tower orifice, it presented no specific evidence rebutting Applicant's witnesses' testimony and documentary evidence. Instead, it relied solely on opinion and basic textbook physics propositions which were not shown to be applicable to the instant subject. Romano, ff. Tr. 6725, at 2-3; Tr. 6780-83 (Romano). As noted previously, such opinions have no probative value and cannot be given credence by this Board.

Cooling Tower Studies

23. Applicant's witnesses relied upon two cooling tower plume studies as part of the basis for their testimony that plumes will not affect carburetor icing or aircraft operation in the Limerick area. Smith and Seymour, ff. Tr. 6234, at 5-7; Tr. 6423 (Smith). One of these studies, the Thomson (Pennsylvania State University) study of the Keystone cooling towers in Western Pennsylvania (Applicant's Ex. 13), was conducted expressly to determine conditions inside and

outside visible and invisible plumes. Tr. 6259, 6279, 6405, 6418 (Smith). The visible plume was tested by making right-angle cross-sections at various altitudes from top to bottom and at various distances along the length of the plume. Tr. 6259-60, 6419, 6458 (Smith). When the visible plume terminated, those procedures were employed downwind at the same altitudes and at increasing distances out to ten miles to test the invisible plume. Tr. 6419, 6458, 6460 (Smith). This technique enabled the researchers to intersect the so-called invisible portion of the plume with great regularity. Tr. 6262, 6279, 6419-20, 6459 (Smith).

24. The Thomson study results indicate that in-plume temperature and humidity conditions vary sharply within one quarter-mile of the tower, with both quantities significantly exceeding ambient levels for very short periods. Smith and Seymour, ff. Tr. 6234, at 5-6. Beyond a quarter-mile, however, in-plume temperatures were found to be almost indistinguishable from those of the external air, and the humidity difference dropped to 0.25 gm/kg. This is a very small excess; the natural atmosphere, when saturated, contains about 3.5 gm/kg of water vapor at 30° F. This figure increases to 22 gm/kg at 80° F. Smith and Seymour, ff. Tr. 6234, at 5; Tr. 7094, 7106 (Markee).

25. AWPP attempted to discredit the Thomson study by contending that climatic conditions in Western Pennsylvania are radically different from those in Eastern Pennsylvania where Limerick is located, that a nearby hill range skewed

the Keystone results and that the difference in tower height at the two facilities rendered the Keystone results inapplicable to Limerick. Tr. 6423, 6425, 6430-32 (Romano).

26. To the contrary, the Applicant's witnesses testified that the key climatic conditions at the Keystone and Limerick sites are almost identical in terms of their applicability to carburetor icing. Smith and Seymour, ff. Tr. 6234, at 6; Tr. 6423 (Smith). The mean annual temperature at Limerick is approximately 52° F., at Keystone it is approximately 48.5° F. The relative humidity at the two locations are identical in the afternoon and only a few percent different in the early morning. Tr. 6423-24 (Smith). The uncontroverted evidence additionally established that the ridge area of Western Pennsylvania referred to by the intervenor is 40 miles from Keystone and of insufficient height to affect weather conditions or plume patterns at that facility. Tr. 6444-45 (Smith). It also established that once cooling towers reach a certain size and capacity, their plumes share the same characteristics and that the relative height difference between Keystone (325 feet) and Limerick (507 feet) is therefore of no importance in comparing the effects plumes might have on carburetor icing. Tr. 6424-25 (Smith). The Staff agreed that the Thomson study is applicable to Limerick and that it supports the Applicant's conclusions. Tr. 7033-34, 7087 (Markee).

27. Applicant's witnesses also relied on their studies of the Amos cooling towers located near Charleston, West Virginia to determine the dimensions and incidence of plumes potentially long enough to permit the formation of carburetor ice and affect airport traffic patterns, assuming that such potential exists in the first place. Tr. 6404-05, 6518 (Smith). They testified that the Amos plant is comparable to Limerick in every detail and was, therefore, an ideal plant to study in terms of this contention. Tr. 6473 (Smith).

28. The Applicant's witnesses had conducted the Amos studies during the mid-1970's to determine the physical characteristics of visible cooling tower plumes and whether they had any significant environmental effects. Smith and Seymour, ff. Tr. 6234, at 6; Tr. 6519 (Seymour); 6277, 6401, 6519, (Smith). Typically, plume characteristics were defined by measuring their altitude, range and direction from light airplanes. Tr. 6277 (Smith). Attempts were made to measure the invisible plume as well, but no differences were found between it and the ambient air. Tr. 6263, 6277-78, 6632 (Seymour); Tr. 6277 (Smith).

29. The Amos tests were primarily conducted during the colder months and early morning hours because those were the only times plumes long enough to study could be found. The conditions found at those times are the least favorable in terms of plume dispersion. Tr. 6682 (Smith).

30. Intervenor also contended that the results of the Amos studies were invalid because of a sentence contained in a publication discussing those results in which it was stated that the earlier (1973-74) tests did not have an accurate moisture measurement system. This statement was explained by its author to mean that the measurements in question were made with a system which was determined not to respond as quickly as desired and subsequently replaced with a faster reacting instrument in later tests. It was further indicated that the earlier measurements are accurate to within plus or minus 3° F. and therefore quite valid, and that the textbook reflected accuracy of the replacement instrument when measuring temperature is 0.3° F. and plus or minus 1° F. for dew point. Tr. 6478-79, 6635-37 (Smith). In any event, Mr. Smith testified that he and Mr. Seymour relied specifically on the later Amos tests in reaching their conclusions concerning carcuretor icing. Tr. 6677 (Smith).

31. The Board finds that the studies relied upon by the Applicant and Staff in support of their conclusion that conditions within and without plumes will be virtually indistinguishable beyond a quarter-mile are pertinent and authoritative and it concurs with this conclusion.

Requirements and Training
Regarding Carburetor Icing

32. Intervenor's assertion that the Limerick cooling tower plumes will lead to increased carburetor icing ignores the fact that the conditions causing carburetor ice formation are well understood and that steps have been taken to assure that it does not present a significant problem to pilots who are reasonably attentive. Smith and Seymour, ff. Tr. 6234, at 8; Geier, ff. Tr. 6883, at 2-4; Krug, ff Tr. 6883, at 2-3. Carburetor icing occurs as follows: The vaporization of fuel, combined with the rapid expansion of air as it passes through the carburetor, causes that mixture to cool; the water vapor content of the intake air may then condense, and if the temperature in the carburetor reaches 32° F. or below, the moisture can be deposited in the fuel intake system as frost or ice which may reduce or block the passage of the fuel/air mixture to the engine and cause engine failure. Smith and Seymour, ff. Tr. 6234, at 8. Aircraft with fuel injection or turbine engines do not experience carburetor icing. Smith and Seymour, ff. Tr. 6234, at 12.

33. A Staff witness, Mr. Geier, testified that regulations have been enacted requiring carburetor-equipped aircraft to be designed to prevent and eliminate carburetor ice under any conditions. For example, section 33.35(b) of the Federal Air Regulations, which prescribes the

airworthiness standards for the certification of aircraft engines, decrees that:

> The intake passages of the engine through which air or fuel in combination with air passes for combustion purposes must be designed and constructed to minimize the danger of ice accretion in those passages. The engine must be designed and constructed to permit the use of a means for ice prevention.

Section 23.1093(a), which relates to airworthiness standards for small airplanes, mandates that "[e]ach reciprocating engine air induction system must have means to prevent and eliminate icing." Geier, ff. Tr. 6883, at 3; Tr. 6911 (Geier); Smith and Seymour, ff. Tr. 6234, at 4.

34. As recognized by the intervenor, all carburetor-equipped aircraft are required to have carburetor heat systems, and indeed, all aircraft manufactured since World War II have been so equipped Tr. 6834 (Romano); Tr. 6651 (Seymour). Therefore, essentially all of the carburetor-equipped aircraft flown in the Limerick area are outfitted to eliminate carburetor ice. Tr. 6834 (Romano).

35. Intervenor attempted to discredit the effectiveness of carburetor heat controls, however, by arguing that they could malfunction. It presented no evidence as to the frequency of this event or the conditions causing it. Mr. Geier, on the other hand, testified that it is highly unusual for carburetor heat controls to malfunction and that such occurrences generally only result from a defect in the particular control operating the heater. He further

testified that if a carburetor ice control failure were discovered to be the result of a design defect, an airworthiness directive would be issued requiring its replacement on all aircraft of that particular type. Tr. 7104-05 (Geier). In any event, good practice indicates that pilots will test their controls, including the carburetor heater, during the preflight check to ensure that they are functioning properly. Smith and Seymour, ff. Tr. 6234, at 12.

36. As recognized by Mr. Romano, if carburetor heat is applied, carburetor ice will not form. Tr. 6852 (Romano). The evidence is also clear that, if formed, carburetor ice can be removed almost instantaneously by the application of carburetor heat. Tr. 6367, 6384 (Seymour). Only if ice were allowed to buildup over a long period of time could it reduce engine performance sufficiently that the application of heat might not be able to melt all of it. Tr. 6377-78 (Seymour).

37. AWPP theorized that ice crystals resulting from condensed water vapor in the plume could enter the carburetor and cause almost instantaneous freezing. Tr. 7036 (Romano). The evidence indicated, however, that when the air temperature is below freezing it can hold very little moisture and carburetor ice can only form in reduced amounts, if at all. Tr. 6517 (Seymour). When it is very cold, <u>i.e.</u>, as low as 6° F., water is present in the

atmosphere only in crystalized form and freezing cannot be induced in a carburetor. Tr. 6360-61, 6518 (Seymour).

38. Intervenor then contended, but again presented no evidence, that student pilots do not receive adequate training to enable them to deal with carburetor icing. This assertion was entirely unfounded inasmuch as the evidence indicated that the engine controls on the most basic aircraft include only an ignition switch, a fuel control and a carburetor heat control, and that student pilots are taught the use of carburetor heat from the very first lesson. The evidence was also clear that students are taught the signs of ice accumulation. Geier, ff. Tr. 6883, at 4; Krug, ff. Tr. 6883, at 2; 7097-98 (Krug); Tr. 6366 (Seymour). Moreover, student pilots are not allowed to solo unless they are fully versed in the use of aircraft controls. Tr. 6366 (Seymour). FAA circulars specify the procedures that must be examined to determine if applicants meet the necessary level of competence to solo; the ability to properly apply carburetor heat is one factor that is tested. Tr. 7092-93 (Geier). Additionally, carburetor icing is addressed during the periodic training that pilots must take at least once every two years. Tr. 7098 (Krug, Geier).

39. AWPP further argued that flight instructors would direct student pilots to ignore the threat of carburetor icing on their first solo flight and concentrate merely on taking off and landing. Tr. 6956 (Romano). This argument

was conclusively rebutted by testimony to the contrary from a certified flight instructor. Tr. 6956, 6958 (Geier).

40. Most significantly, the testimony given by experienced pilots presented by the Staff and Applicant established that pilots must deal with temperature and moisture changes of a much larger magnitude than those found between the ambient air and cooling tower plumes as part of the daily routine of flying an airplane. The ambient temperature and humidity varies greatly with relatively small changes in altitude. Tr. 6997-98 (Krug). For example, an altitude change of a few hundred feet may result in temperature changes of 5 to 10° F. and a change of 50-60% in relative humidity. Tr. 6356-57, 6646-47 (Smith); Tr. 6367, 6644-46 (Seymour). The intervenor recognized that there may be large temperature and humidity variations with changes in altitude and that pilots could not only accommodate such changes, but, by and large, would be unaware of them. Tr. 6772-75 (Romano).

Formation and Elimination of Carburetor Icing

41. Intervenor's assertion that conditions within cooling tower plumes could cause the increased formation and accumulation of carburetor icing over that of the ambient air, even if correct, ignores the fact that carburetor ice capable of reducing engine performance takes a relatively substantial time to form. As reflected by the evidence adduced at the hearing, it has been determined that under conditions most conducive to the formation of carburetor

ice, i.e., 68° F. and 100% relative humidity, it would take eight minutes from the formation of frost on the throttle plate to accumulate icing sufficient to cause a 25 rpm drop in engine speed. Tr. 6374, 6376-77, 6527-28 (Seymour). Such a drop would not affect engine performance and would not likely attract a pilot's attention. Tr. 6377, 6528 (Seymour).

42. It would then take an additional six to eight minutes to cause a further 200 rpm loss. A loss of 200 rpm in a small plane would result in a reduction in speed of approximately 12 knots (15mph). Tr. 6376-77 (Seymour). If a pilot were maintaining a constant air speed while experiencing a 200 rpm drop, his aircraft would start descending at 200 to 250 feet per minute. A descent of this magnitude would attract a pilot's attention. Tr. 6528 (Seymour). Also, the engine would begin to run progressively rougher at this time, a factor which should also capture the pilot's attention. Tr. 6669 (Seymour). Having lost 200 rpm, it would then take an additional several minutes for icing to form sufficient to cause a further drop of 300 rpm in engine output to a level that might seriously affect engine performance. Tr. 6378, 6669 (Seymour).

43. Carburetor icing in planes with adjustable pitch propellers is indicated by the manifold pressure gauge. Geier, ff. Tr. 6883, at 5. A 2-inch drop in manifold pressure would represent a seven or eight knot loss of speed and would constitute a significant, observable change. Tr.

6380-81, 6384-85 (Seymour). Further testimony established that it is impossible for carburetor ice to cause instantaneous engine failure without a significant preliminary change in manifold pressure or rpm. Tr. 6628-29 (Seymour). Although a number of other problems may be reflected by those instruments, a pilot would not confuse the indications of other engine problems with the formation of carburetor ice. Geier, ff. Tr. 6883, at 5.

44. Intervenor's only evidence that carburetor icing might result in instantaneous engine failure was his experience while approaching Cape May Airport on October 12, 1981. By his own admission, intervenor rarely, if ever, reviews his instruments while flying. Moreover, there is no competent evidence that his engine failure was caused by carburetor icing. Tr. 7095 (Geier). Mr. Romano did not examine his rpm indicator at that time. Tr. 6811 (Romano). Likewise, out of an unsupported belief that he might cause a fire, he did not attempt to restart his engine before landing. Once on the ground, the mechanics found no evidence of a problem. Tr. 6814, 6830-32 (Romano); Tr. 7114 (Geier). The Board thus finds that this testimony has no probative value.

Length of Visible Plumes

45. Intervenor's assertion that cooling tower plumes can increase and aggravate the incidence of carburetor icing is also contradicted by the evidence regarding plume length as combined with the testimony regarding the length of time

necessary for ice buildup. While it is recognized that moisture from cooling towers can exist in visible plume form for many miles on occasion, this is not a common event. Tr. 6363 (Smith); Tr. 6610 (Smith, Seymour). For example, of the 340 individual tests conducted as part of the Amos studies, which were designed to document long plumes, visible plumes ten miles and longer were observed only six times, or less than 1% of the time. Of those six instances, three were at temperatures well below 20° F. and thus too cold to lend themselves to carburetor icing. A state-of-the-art computerized modeling study ("SACTI") designed to predict plume behavior found that the plumes that will issue from the Limerick cooling towers can be expected to reach or exceed ten miles in length less than 4% of the time. Smith and Seymour, ff. Tr. 6234, at 7-8. The vast majority of these plumes will be short, i.e., less than a mile long. Tr. 6610 (Smith, Seymour); Tr. 6628 (Seymour).

46. Even if a pilot were successful in finding a long plume and flew along its axis, descending with a nearly closed throttle at a rate which matched the slope of the plume, and did not utilize carburetor heat, he would have to remain within the plume for over eight minutes to encounter serious icing. A typical single-engine light aircraft cruising or descending at 100 mph would travel 13.3 miles in eight minutes. A pilot cruising or descending at 130 mph would travel 17 miles in eight minutes. Smith and Seymour, ff. Tr. 6234, at 10-11. A pilot could climb along a similar

path in the opposite direction when he would be moving more slowly; however, the aircraft throttle would be open and the risk of icing would therefore be much smaller. Moreover, a pilot climbing at 70 mph would travel 9.3 miles in eight minutes. A pilot climbing at 80 mph would travel 10.7 miles in eight minutes. Smith and Seymour, ff. Tr. 6234, at 10-11. In any event, such action would be contrary to proper procedures and dangerous. Tr. 7002 (Krug).

47. The evidence also indicates that cooling tower plumes are rarely more than one mile wide. Therefore, even flying at an oblique angle, an aircraft could remain within a visible plume approximately only two minutes. Smith and Seymour, ff. Tr. 6234, at 10. As indicated by the testimony, the chances are therefore almost nonexistent that a pilot could encounter a plume having the right temperature and moisture conditions for icing, and of sufficient length that he could inadvertently fly in its core long enough to form serious levels of carburetor icing, even without applying carburetor heat. Smith and Seymour, ff. Tr. 6234, at 11.

48. Based on the evidence of record, if conditions conducive to carburetor icing are present in clouds, they are also present outside of clouds. Also, as discussed below, the vast majority of pilots in the Limerick area operate under visual flight rules and thus must avoid clouds. Ultimately, however, regardless of the time required to form carburetor ice under such conditions, if it

is possible at all, there is sufficient time as a result of the way planes are designed for properly trained, alert pilots to take corrective action once ice becomes a problem. Tr. 7003-05 (Geier, Krug).

Application of Carburetor Heat
in Specific Situations

49. Intervenor also contended that aircraft would be especially susceptible to carburetor icing while landing, taking off and circling Limerick area airports. This assertion was entirely unproved. On the contrary, it was proven that aircraft have specific procedures recommended for the application of carburetor heat for each of those maneuvers, which is described in the manual accompanying that model and which pilots are responsible for knowing. Krug, ff. Tr. 6883, at 2-3; Tr. 6889 (Geier).

50. For example, as part of the pre-flight check, a prudent pilot will ensure that his carburetor heater is properly functioning by applying heat while keeping engine speed at a constant rpm value. Smith and Seymour, ff. Tr. 6234, at 12; Tr. 6674 (Seymour). If the application of heat causes an abnormal decrease in rpm and engine roughness, one would suspect that melting ice had passed through the engine. In that case, a pilot would again apply carburetor heat immediately before take-off to assure that ice had not reformed. Tr. 6674-76 (Seymour).

51. Carburetor heat is normally applied during the landing approach even if there is no indication of an icing

problem. In fact, Mr. Geier knew of no landing procedures for which it was recommended that carburetor heat not be applied unless there was some initial indication of carburetor ice. Tr. 7007 (Geier). If the flight manual instructs the use of carburetor heat "as required," the control should be left on throughout the approach. The evidence further established that this procedure should be followed even if the flight manual does not expressly call for it. Tr. 6890, 7008 (Geier). Carburetor heat is rarely applied during takeoff since the throttle is fully engaged at that time and the potential for carburetor icing is therefore very small. Tr. 6673 (Seymour); Tr. 7042 (Krug).

52. In the case of a go-around, a situation in which a pilot must reapproach the runway after beginning his pre-landing descent, carburetor heat would have been applied during the pre-landing descent. Once a pilot realized that a go-around had become necessary, carburetor heat would be eliminated and full power applied, thus dissipating any ice that might have formed. Carburetor heat would again be applied upon reentering the base leg. Tr. 6676 (Seymour); Tr. 6835-36 (Romano).

53. Intervenor's only evidence challenging these procedures was Mr. Romano's testimony that he did not personally utilize those techniques. The evidence presented by experienced pilots, who have also served or currently serve as flight instructors, was clear that carburetor heat would be applied at some point during each of those

procedures. This evidence is highly competent and entitled to great weight. The Board thus concludes that plumes will not present a problem to pilots landing, taking off or circling Limerick area airports.

Cloud Separation Rule

54. Intervenor next contended that plumes emitted from Limerick would pose a hazard to pilots flying through them to land. This assertion was specifically rebutted by testimony establishing that visual flight rule ("VFR") pilots are required to remain clear of any restrictions to visibility. Tr. 6921 (Geier). Specifically, they must maintain a distance of 1,000 feet above, 500 feet below and 2,000 feet horizontally from clouds. Tr. 6610 (Seymour). A cloud is generally defined as an aggregation of small water droplets or ice particles constituting a visible entity. Tr. 6608, 6707 (Smith); 6893 (Geier). The Staff testified that visible cooling tower plumes have essentially the same visibility as clouds. Markee, ff. Tr. 6883, at 3. Moreover, Mr. Romano recognized that pilots are capable of determining clouds when they see them. Tr. 6819 (Romano).

55. Instrument Flight Rule ("IFR") pilots are not required to remain clear of clouds located in their approach clearance since they are trained and their planes are equipped to fly through such conditions. Smith and Seymour, ff. Tr. 6234, at 13; Tr. 6999 (Krug).

56. The purpose of the cloud separation rule is to prevent the loss of control through loss of visual horizon

and ensure that adequate vision of other aircraft can be maintained. Tr. 6893, 6923 (Geier). Essentially, this rule prohibits pilots from flying through any body of condensed moisture that is not readily transparent. Tr. 6708 (Smith). The testimony was clear that it is bad practice, against regulations and indicative of inattentiveness for a VFR pilot to inadvertently find himself in a cloud mass. Moreover, such incidents are quite unusual. Tr. 6893-94, 6908 (Geier). It was likewise clear that although weather changes can come on quite rapidly, there is no such phenomenon as "sudden weather," that should force a VFR pilot to land through clouds. Tr. 6906 (Geier).

57. In conclusion, it is improper for VFR pilots to fly through clouds to reach an airfield. Such action is prohibited under §98.9 of the FAA's regulations and would otherwise be considered careless. If a pilot penetrated such clouds in an emergency situation, he would be required to prove that the emergency was not his own making. Tr. 6906-8, 7100 (Geier).

Pottstown-Limerick Airport

58. Intervenor's postulation that plumes would interfere with the landing process at airports in the vicinity of the Limerick Station as exemplified by the closest one, Pottstown-Limerick Airport, were also rebutted by testimony presented by the Applicant. Pottstown-Limerick Airport is approximately two miles East North East of the

site boundary. Tr. 6614 (Seymour). The next closest airfields, Pottstown Municipal and Sunset Landing Strip, are approximately four and one-half and five miles from the site, respectively. Tr. 6967-68 (Krug).

59. The runway at Pottstown-Limerick Airport is known as Runway 28 in its east-west orientation and Runway 10 in its west-east orientation. Geier, ff. Tr. 6883, at 6; Tr. 6892 (Krug). The landing pattern at Pottstown-Limerick Airport has been recently changed so that Runway 28 now has right handed traffic. Tr. 6892 (Krug); Tr. 6903 (Geier); Tr. 6691 (Seymour). Runway 10, on the other hand, has a left handed pattern. Geier, ff. Tr. 6883, at 6; Tr. 6904 (Geier).

60. These patterns were changed to their present configuration to take aircraft away from the Limerick cooling towers. Indeed, when members of the FAA's General Aviation Division recently, flew the pattern, landing to the west on Runway 28, they did not come near the towers. Geier, ff. Tr. 6883, at 6; Tr. 7018 (Krug); Moreover, the SACTI study of the Limerick plumes indicated that the maximum frequency of long plumes would be toward the west, away from Pottstown-Limerick Airport. Markee, ff. Tr. 6883, at D-15; (See Finding 45). This code also indicated that the Limerick plumes will always ascend to at least 1,000 feet if they have not otherwise dissipated before reaching that height. Smith and Seymour, ff. Tr. 6234, at 8; Tr. 6617-18 (Seymour).

61. The standard airport traffic altitude is 800 feet for light aircraft and 1,000 feet for heavy aircraft. Tr. 6617, 6686, 6888-89 (Seymour). The specified traffic pattern altitude at Pottstown-Limerick Airport is 1,200 feet mean sea level. Since the airport is 311 feet above sea level, the actual airport altitude pattern is 889 feet and thus well below the lowest height plumes will reach. Tr. 7101-02 (Geier).

62. Pilots at Pottstown-Limerick Airport will be prevented from landing, taking off, or circling near the towers by the presence of a segmented circle indicating the correct landing pattern direction. Although the location of segmented circles is not limited to a designated area, their size is specified in airport advisory circulars, they must be placed in plain view and they are meant to be visible from the typical approach height. Tr. 6887-89, 6899, 6902 (Geier). Intervenor's statement that he had not seen the segmented circle at Pottstown-Limerick Airport was rebutted by evidence establishing that it is clearly visible from the pattern altitude. Tr. 6893 (Krug). The evidence also established that it is bad practice not to check the segmented circle before landing at an uncontrolled airport. Tr. 6887, 6889, 6900 (Geier).

63. Additionally, there are a number of other ways in which a pilot can ascertain the correct landing pattern at an airport. Most small, public-use airports have a Unicom which can be contacted for landing directions. A pilot can

also observe from the air the visible markings indicating the traffic pattern, which all airports even private ones have, and the patterns utilized by other aircraft. Tr. 7091, 7109-10 (Geier).

Conclusions of Law

Based upon the foregoing Findings of Fact which are supported by reliable, probative and substantial evidence as required by the Administrative Procedure Act and the Commission's Rules of Practice, and upon consideration of the entire evidentiary record in this proceeding, the Board reaches the following conclusion pursuant to 10 C.F.R. §2.760a:

Plumes from the Limerick cooling towers have been adequately considered and it has been found they will have no impact on carburetor icing in aircraft flying in the airspace that may be affected by emissions from those towers. Likewise, it has been found that these plumes will not pose a hazard for pilots landing at Limerick area airports.

Order

WHEREFORE IT IS ORDERED in accordance with 10 C.F.R. §§2.760, 2.762, 2.764, 2.785 and 2.786 of the Commission's Rules of Practice, that this Partial Initial Decision shall become effective immediately and shall constitute with respect to the matters decided therein the final action of the Commission forty-five (45) days after the date of

issuance hereof, subject to any review pursuant to the Commission's Rules of Practice.

Exceptions to this Partial Initial Decision may be filed by any party within seven (7) days after service of this Partial Initial Decision. Within fifteen (15) days thereafter (twenty (20) days in the case of the Staff), any party filing such exceptions shall file a brief in support thereof. Within fifteen (15) days of the filing of the brief of the appellant (twenty (20) days in the case of the Staff), any other party may file a brief in support of, or in opposition to, the exceptions.

IT IS SO ORDERED.

THE ATOMIC SAFETY AND LICENSING BOARD

Judge Lawrence J. Brenner, Chairman

Judge Peter A. Morris, Member

Judge Richard F. Cole, Member

Dated at Bethesda, Maryland,
this ________ day of __________

APPENDIX A

Exhibit List

Applicant

Exhibit Description	Transcript Page	Identified at Transcript Page	Admitted at Transcript Page
PECO Ex. 8	Color Photograph of Cooling Tower Plumes Coming from the John Amos Plant.	6236	6236
PECO Exh. 9	Cooling Towers and the Environment. Major Contributors: Maynard Smith, Mark Kramer and David Seymour. October 1974.	6413	6413
PECO Exh. 10	Amos Cooling Tower Flight Program, Test No. 48A. March 11, 1975.	6649	6649
PECO Exh. 11	Douglas Point Power Plant Site Evaluation Final Report. Vol. 1, Part 2. L.C. Kohlenstein, Project Engineer. Published by the Johns Hopkins University Applied Physics Laboratory. January 1976.	6650	

Exhibit Number	Description	Identified at Transcript Page	Admitted at Transcript Page
PECO Ex. 12	John E. Am' s Cooling Tower Flight Program Data. Conducted for the American Electric Power Service Corporation by Smith-Singer Meteorologists, Inc. December 1975-March 1976.	6765	
PECO Ex. 13	Environmental Measurements of Power Plant Cooling Tower and Stack Plumes. Final Report for AEC, ERDA and DOE. Conducted by the Department of Meteorology, Pennsylvania State University. Edited by D.W. Thomson, R.G. de Pena, J.A. Pena. Updated.	6868	
PECO Ex. 14	Table 2.2-3 of the Limerick Generating Station Final Safety Analysis Report, entitled "Airports Within Ten Miles of the Site." Rev. 4, 05/82.	6972	

STAFF

Staff Ex. 8	VFR Terminal Area Chart for the Philadelphia Area. 18th Edition. September 2, 1983.	7104	

Exhibit Number	Description	Identified at Transcript Page	Admitted at Transcript Page
	AWPP		
AWPP Ex. 1	Cover Page and pages 53-54 of *The New Private Pilot*. Published by Pan American Navigation Service. 8th Edition.	6949	
AWPP Ex. 2	*Those Icy Fingers in Your Carburetor*. Excerpt from Aviation Consumer Magazine. January 1, 1982.	7046	

APPENDIX B

WITNESSES IN ALPHABETICAL ORDER

Witness	Following Transcript Page
Boyer, Vincent S.	
"Testimony of Vincent S. Boyer, Senior Vice President, Nuclear Power, Philadelphia Electric Company Regarding Contention V-4."	5237
Statement of Professional Qualifications.	933
Geier, Bernard A.	
"Testimony of Bernard Geier Concerning the Impact of Cooling Tower Plumes on Instruction (Carburetor) Icing of Aircraft."	6883
"Professional Qualifications of Bernard Geier."	6883
Krug, Harry E.P.	
"Testimony of Harry E.P. Krug Concerning the Impact of Cooling Tower Plumes on Induction (Carburetor) Icing of Aircraft."	6883
"Professional Qualifications of Harry E.P. Krug"	6883
Markee, Earl H.	
"Testimony of Earl H. Markee Concerning the Cooling Tower Plumes."	6883
"Earl H. Markee, Jr. Professional Qualifications"	6883

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

In the Matter of	)	
	)	
Philadelphia Electric Company	)	Docket Nos. 50-352
	)	50-353
(Limerick Generating Station,	)	
Units 1 and 2)	)	

CERTIFICATE OF SERVICE

I hereby certify that copies of "Applicant's Proposed Findings of Fact and Conclusions of Law in the Form of a Partial Initial Decision," dated February 16, 1984, in the captioned matter have been served upon the following by deposit in the United States mail this 16th day of February, 1984:

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