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USNRC
OCT 8 1975
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SUPPLEMENT NO. 2

RESPONSE TO NUCLEAR REGULATORY COMMISSION QUESTIONS

This Supplement to the Indian Point Unit No. 2 cooling tower report consists of responses by Consolidated Edison Company of New York, Inc., to questions posed by the Environmental Projects Branch No. 1, Division of Reactor Licensing, United States Nuclear Regulatory Commission in the letter of September 5, 1975 from Mr. George W. Knighton, to Mr. William J. Cahill, Jr., Vice President, Consolidated Edison Company of New York Inc.

October, 1975

Question 1.1	On Page 3-3, you mention limited information on design conditions for a wet/dry cooling tower. Provide a detailed description of design considerations of a wet/dry cooling tower, including the ratio of dry to wet cooling for a given air temperature.
Response:	The design considerations for wet/dry cooling towers for Indian Point Unit No. 2 were analyzed in the Cooling Tower Report on the basis of a given continuous thermal requirement and the need to abate tower induced visible plume during critical winter conditions. The wet section of the tower would be capable of dissipating the total condenser heat load (7,350 x 10^6 BTU/Hr) during critical summer conditions represented by a 74°F wet bulb temperature and 55% relative humidity.

The dry section of the wet-dry cooling tower would be designed to dissipate half of the condenser heat load (3,675 x 10^6 BTU/Hr) at critical winter conditions of 20°F dry bulb temperature and 80% relative humidity. The critical winter conditions selected as the basis for dry section design are those that approximate the local minimum dry-bulb temperature coincidental with high relative humidity for the winter months (December, January and February) and are not exceeded more than 5 percent of the time during a normal winter. Under these conditions, the cooling tower would have a cooling capacity of 7,350 x 10^6 BTU/Hr and the tower plume would not be predicted to be visible.

Question II.1

In Section 6.1.4.3 Ambient Salt Monitoring you describe the use of high volume of air concentrations of salt. However, most of the salt drift will remain airborne due to evaporation of the drift droplets. How do those measured values of salt loadings in the air compare with those predicted by your cooling tower plume models as, for example, the magnitude of ambient salt levels due to drift?

Response:

Ambient salt monitoring conducted in the vicinity of Indian Point included measurements of the airborne concentration of salt and the salt deposition rate on the ground.

High volume air samplers were used to measure the airborne concentrations and deposition rate measurements were made with standard dustfall buckets.

Airborne concentrations of salt averaged 1.0 ug/m^3, and deposition rates averaged 160 Kg/Km^2/Mo for the eleven month sampling period.

The cooling tower plume model which accounts for evaporation, predicts an annual average salt concentration of 5.6 ug/m^3 and an average peak deposition of 896 Kg/Km^2/Mo due to drift from the natural draft cooling tower operation.

Mechanical draft cooling tower operation would produce salt concentration and deposition rate values approximately fives times greater than the estimates for the natural draft tower.

Hourly deposition rates are calculated to be as high as 36 $Kg/Km^2/Hr$ for the natural wet cooling tower and 100 to 1000 $Kg/Km^2/Hr$ for the mechanical draft wet cooling towers.

Question II.2

In Section 6.15 Plume Interaction, you provide a brief summary of the interaction of sulfur dioxide with the cooling tower plume. However, the brief summary is not sufficient to support the conclusions drawn. Provide calculations to support your conclusions regarding the interaction of the sulfur dioxide plume from the superheater at Unit No. 1, with a mechanical or natural draft cooling tower plume. Indicate what windspeed is meant in the phrase "excessively high windspeed."

Response:

Possible interaction between the fossil plume, containing sulfur dioxide, emitted from the 390 foot MSL superheater stack, and a plume from either a mechanical draft cooling tower (68 feet AGL or 113 feet MSL) or natural draft cooling tower (565 feet AGL or 618 feet MSL) was determined by comparing nominal effective stack height differentials under predominant meteorological conditions.

Calculations of plume rise for each cooling tower and the superheater plume was based on the Briggs plume rise formula:

$$\Delta H = 1.6 F^{\frac{1}{3}} (10 H_S)^{\frac{2}{3}} / U$$

using a nominal wind speed of 4 m/s. Effective plume heights (H) for the superheater and each of the two types of cooling towers, together with the respective buoyancy factors (F) and physical height (H_s) are tabulated as follows:

Type of Structure	$F(\frac{m^4}{sec^3})$	Physical Height (MSL), m	Effective Plume Height (MSL), m
Superheater stack	334	119.0	426
Natural Draft Cooling tower	6600	185.7	1320
Mechanical Draft Cooling tower	630	34.5	203

The results indicate that the centerline of the superheater plume is separated by more than 700 feet vertically from the mechanical draft cooling tower plume and nearly 3000 feet below the natural draft cooling tower plume. It is therefore, concluded that only the mechanical draft cooling tower plume may potentially interact with the superheater plume.

"Excessively high wind speeds" were defined as winds which could cause aerodynamic downwash conditions to prevail. The effect of the aerodynamic wake of the natural draft cooling tower is considered when wind speeds exceed 11 m/s. This wake effect is based upon wind tunnel studies. Observations of natural draft cooling tower plumes revealed no plumes descended to less than 1/2 of the tower height.

Question 11.3

On pages 12-13 of Appendix B, Vol. 2, Section 3.1, Salt Deposition Due to Drift, describe how the tower exit speed varies with the wet-bulb temperature. How does this variation alter the drift rate? Describe the change in the drop-size distribution with the exit velocity.

Response:

Tower exit speed is not uniquely dependent on wet-bulb temperature. For example, a wet-bulb temperature of 75°F could correspond to a dry-bulb temperature of 100°F and 30% humidity. In that case the exit speed would be about 10.5 ft/sec. A wet-bulb temperature of 75°F could also occur with a dry-bulb temperature of 75°F and 100% humidity, in which case the exit speed would be about 15.7 ft/sec. As illustrated in Figure 1b on page 14 of Appendix C to Appendix B, the variation of the exit velocity is from approximately 10 ft/sec to 18 ft/sec over the extreme operating range. Sensitivity studies indicated the variation of the exit velocity, as incorporated in the buoyancy flux term, alters the drift rate in a minimal manner and does not affect the results presented.

Manufacturer specifications on the drop size distribution, documented in Table 4 of Appendix C to Appendix B, are based on the design conditions of the tower,

Question II.4

On page 24 of Appendix B, Vol. 2, Table 3-1 shows the predicted monthly average salt deposition rate and near ground airborne concentration of salt for each month. Are the estimated peak deposition rates and airborne air concentrations both always at 1.24 miles for all months? If so, provide the basis for selecting this distance of 1.24 miles and describe whether this coincidence is a result of your plume model or due to basic assumptions.

Response:

The estimated peak monthly average salt deposition and near ground airborne concentrations occur at a distance of 1.24 miles downwin of the natural draft cooling tower for all months are predicted on the mathematical plume model using the hourly onsite meteorological data and the tower design data.

The distance of 1.24 miles results from calculations using the salt drift model for both deposition and air concentration.

Question II.5

On pp. 34-35 of Appendix B, Vol. 2, explain why Figures 3-1 and 3-2 do not agree over comparable distances from the plant. This is especially so for the 100 isopleth N and E of the cooling tower. Also explain why Figures 3-5 and 3-6 do not agree for comparable distances from the plant.

Response:

Figures 3-1 and 3-2 (similarly Figure 3-5 and Figure 3-6) present the same calculated concentrations, drawn on charts of two different scales. The slight differences between the charts are primarily due to the inability of the Calcomp plotter routine to construct isopleths for strong gradients. Therefore, the isopleths shown for the range 0-3 miles are more precisely drawn in Figure 3-1 than in Figure 3-2. Figure 3-2, however, is more precisely drawn for predictions for distances over 3 miles, and differs only slightly for the closer distances.

Question II.6. On pp. 10-12 of Appendix C, Vol. 2, you refer to modeling techniques of the plume from mechanical draft cooling towers. However, the sensible heat control of a mechanical draft cooling tower plume is very large compared with that of stack effluents from a fossil plant due to a large volume of air flow with a small temperature rise. How is this heat included in the term F (buoyancy factor) on page 12? What are the units of F and of the value of 630 on page 12?

Response: The buoyancy factor, F, as used in Appendix C, Vol. 2, included both sensible and latent heat. By definition, (Briggs, 1969) the buoyancy factor F of a hot source is:

$$F = g\,Q_H/(\pi C_p \rho T)$$

where T is the average ambient temperature. The quantity Q_H, which is defined as heat emission due to efflux stack gases is considered to be the sum of both the sensible and latent heats:

$$Q_H = \pi R^2 W \rho_e \left[C_p(T_e - T) + \lambda(m_e - m_a) \right]$$

where R is the stack exit radius, W is the exit velocity, T_e and T are exit and average ambient temperatures, ρ is ambient air density, and p_e and C_{pe} are gas density and specific heat at the exit temperature respectively. The quantity λ is the heat of condensation, m_e and m_a are the mixing ratios of the plume at exit and that of ambient air respectively (in units of grams H_2O per gram of dry air).

Combining the above two equations and replacing ρ = MTo/V_oT and ρ_e = MTo/V_oT_e (T_o = 273°K), the buoyancy factor F is simplified as:

$$F = gR^2W\left[(T_e - T)/T_e + \lambda(m_e - m_a)/(C_p \cdot T_e)\right]$$

This final formulation is included in the plume model.

The units of F are (m^4/sec^3) when metric units are used. The units of the average F value, 630, are also (m^4/sec^3).

Question 11.7

On page 12, Equation (7), and on page 4, Equation (2) are valid for point sources only. How did you account for the line source character of the plume discharged from the mechanical-draft cooling towers in your formulae?

Response:

Both Equations (2) and (7) were used to calculate contributions from each of the individual 26 unit cells of a mechanical draft cooling tower at a downwind receptor. The diameter of the unit cell is small compared to the downwind distance and a point source assumption is valid. The line source character of the mechanical draft cooling towers is taken into account by summing up the contributions of moisture and heat from each unit cell at a downwind receptor. The downwind and crosswind distances between the source and a receptor are different for each unit cell. The accumulated contributions at the receptor from all 26 unit cells are considered to be the total contribution from the cooling tower operations.

Question 11.8	In Figures 5.4.1 through 5.4.12 of Appendix C, these figures show no fog near the tower where it is quite common and much fog miles from the plant. Has fog caused the mechanisms proposed in your model ever been observed? Also in Figure 5.5.1 through 5.5.5 explain why you expect icing to occur some distance away from the site rather than within 1000 feet of the mechanical draft cooling towers.
Response:	The mechanical cooling tower fog model was based on established theoretical and empirical formulations but no direct comparison with field data has been made. Photographs of mechanical cooling tower plumes have indicated that the plumes reached ground level at distances of about one mile from the tower, rather than alongside of the tower within 1000 feet. Fog and ice were both predicted using the same model and the same criteria. The separation into two different categories is based on whether the condition occurred above or below freezing condition. Therefore, Figures 5.4.3 and 5.5.1 would indicate for December that the nearest fog formation is approximately 200 meters (650 feet) from the center of the two mechanical cooling towers. Combining fogging and icing in other corresponding figures for other months would show similar close proximity between the cooling towers and fog. The distance from the cooling towers where fog and ice occurs depends on operational, topographic and ambient conditions. In the case of

Indian Point Unit No. 2, the near occurrence of fog or ice is closer than 1000 feet. For example, in December (Figure 5.5.1) the icing occurs approximately 650 feet from the center of the two mechanical draft cooling towers. In February (Figure 5.5.3) and March (Figure 5.5.4) the occurrences are approximately 1600 to 2000 feet from the towers.

The vast majority of modeled icing occurrences at "some distance away from the site" are due to impaction of the moist plume on elevated terrain.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

In the Matter of)
)
CONSOLIDATED EDISON COMPANY) Docket No. 50-247
OF NEW YORK, INC.)
(Indian Point Station,)
Unit No. 2))

CERTIFICATE OF SERVICE

I hereby certify that I have this 6th day of October, 1975, served the foregoing Supplement No. 2 to the "Economic and Environmental Impacts of Alternative Closed-Cycle Cooling Systems for Indian Point Unit No. 2" in response to the letter dated September 5, 1975 from Mr. George W. Knighton to Con Edison by mailing copies thereof, first class postage prepaid and properly addressed to the following persons:

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