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OZONE FORMED BY HIGH-VOLTAGE TRANSMISSION LINE CORONAS

W. Davis, Jr.

ABSTRACT

This memo summarizes a brief state-of-the-art survey concerning ozone formation due to coronas on high-voltage transmission lines. It includes reference to older studies with lines carrying up to 500 kv and to experiments now in progress with lines carrying 765 to 1500 kv. The contribution of weathered lines, at least up to 345 kv, to the atmospheric ozone inventory is probably within the 2 ppb (by volume) sensitivity of analytical instruments.

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1. INTRODUCTION

The Environmental Protection Agency, on page 18 of its comments concerning the Draft Environmental Statement relating to Indian Point Unit 2, suggested that we discuss the production of ozone by the high-voltage transmission lines and that we estimate the concentrations of ozone along these lines under various atmospheric conditions. The request also suggested that we relate these concentrations to potential effects on man and wildlife.

Ozone was not mentioned in connection with Other Wastes, section III.E.4 of the Indian Point Impact Statement. Since we can expect to be questioned about ozone by EPA, or other agency or person, in connection with future impact statements, I am summarizing what I learned from contacts I developed via numerous telephone calls and from a reference[1] brought to my attention by W. G. Stockdale.

2. TITLE 42 - PUBLIC HEALTH

On April 30, 1971, Chapter IV - Environmental Protection Agency, Part 410 - National Primary and Secondary Ambient Air Quality Standard, was published in the Federal Register. In addition to sulfur oxides, nitrogen oxides, and particulate matter, which we have discussed under Other Wastes of the Impact Statement, there are included carbon monoxide, photochemical oxidants, and hydrocarbons. Ozone is discussed as part of photochemical oxidants under 42 CFR 410.9 and in Appendix D of 42 CFR 410. Paragraph 410.9 states:

> "The national primary and secondary ambient air quality standard for photochemical oxidants, measured and corrected for interferences due to nitrogen oxides and sulfur dioxide by the reference method described in Appendix D to this part, or by an equivalent method, is: 160 micrograms per cubic meter (0.08 ppm) -

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maximum 1-hour concentration not to be exceeded more than once per year."

3. STATE OF THE ART

Ozone and other gaseous pollutants, such as nitrogen oxides, are formed as a result of ionization of air molecules that surround the cylindrical conductors used for transmitting electrical energy at high voltages. The ionization is accompanied by a glow phenomenon that is called corona. This topic is discussed in considerable detail by Zaborszky and Rittenhouse in Chapter 4 of ref. 1. The degree of ionization, hence of ozone formation, is dependent upon several variables including voltage, humidity, conductor diameter, surface roughness, and spacing between the conductors.

Transmission lines at Indian Point Unit 2 are at 345, 138, and 13 kv potential; all of these are below the 500 kv involved in the Tidd project.[1] However, several factors, particularly the sensitivity of instruments to ozone concentration, to be mentioned later, and changing conductor roughness (the weathering effect) introduce complications in any attempt to provide a detailed description of the rate of ozone formation and decay around high-voltage and extra-high-voltage (EHV) transmission lines. Zaborszky and Rittenhouse have discussed the effects of conductor surface roughness; in particular, they present data that show a gradual reduction in corona over a half-year's time before loss stability is achieved.

According to the data in ref. 1, the ozone concentration increase due to corona around weathered 13 and 138 kv lines at Indian Point Unit 2, or other reactors, must be negligible in comparison with the limits of detection of 1972 analytical instruments, namely about 2 ppb (by volume). The same statement probably applies to the 345 kv lines since the electric utilities and EPA are now trying to assess the nature of the ozone problem around conductors carrying 765 and 1500 kv. As will be noted below, ozone concentration increase due to 765 kv lines over the ambient value is probably within the instrument uncertainties

of 0.002 ppm, which should be compared with the once-per-year maximum of 0.08 ppm given in 42 CFR 410.

To obtain a 1972 state-of-the-art summary concerning ozone formation, primarily in the EHV range of 765 to 1500 kv, I made numerous telephone calls, which are summarized as follows.

General Electric Co. - James Stevenson and John Anderson of G.E., Schenectady, advised me that they are performing experiments concerning ozone formation around 1500-kv lines as part of an Ultra High Voltage (UHV) Project. This work has been reported to all members of Edison Electric Institute (EEI) and to some of the public utilities. More experiments are being performed and these will be reported in the open literature in the near future (perhaps during the next year). Stevenson and Anderson summarized the work as indicating that any contribution of 1500 kv-transmission lines to the ambient ozone concentration is within the uncertainties of the analytical equipment.

Westinghouse Electric Corp. - Westinghouse personnel performed experiments at their High Voltage Laboratory at Trafford concerning ozone formation for American Electric Power Service Corp. (AEP). The results of these experiments are summarized in a paper recently presented by Sherer, Ware, and Shih[2] of AEP. Frank Roach has stated that additional studies are being performed by Westinghouse people.

Edison Electric Institute. - I contacted C. K. Poarch, Director of Engineering at EEI. He referred me to Howard C. Barnes of AEP.

American Electric Power. - AEP personnel presented (on July 10, 1972) two papers[2,3] at the IEEE Power Engineering Society Meeting in San Francisco summarizing results of very recent tests to measure ozone formation around 765 kv transmission lines. The results of this study indicate that the increase in ozone concentration above ambient values is within the approximately 0.002 ppm sensitivity of the measuring equipment. (Compare with the maximum allowed by 42 CFR 410 of 0.08 ppm.) These two papers are based on work performed for AEP by Westinghouse, Battelle Memorial Institute, Ion Physics Corp., Smith-Singer Meteorologists, Inc., and personnel of The City College of the City University of New York, as well as by AEP personnel.

Environmental Protection Agency. National Environmental Research Center. - Elbert Tabor, of EPA-NERC at the Research Triangle Park, is actively following the question of ozone formation around high-tension lines and is concerned with two subcontracts[4,5] concerning this topic. One is with Versar, Inc., of Springfield, Va., that involves theoretical and laboratory studies.[4] The other is with the Research Triangle Institute (RTI) that involves field measurements.[5] These field measurements will be made in the mountains of West Virginia and Maryland where previous measurements – where there are no high-voltage lines – have shown ozone at levels up to 0.16 ppm, namely constantly at up to twice the national once-per-year maximum defined by 42 CFR 410.

4. PRESENT STATUS OF THE OZONE QUESTION

The status of the ozone question is not completely settled at the present time. Dr. Peyton Young[6] has certainly been active in advocating studies of ozone formation around 765-kv lines and has expressed his view to appropriate people that such high voltages may lead to the formation of significant amounts of oxidants. In any event, he is urging that the degree of air pollution caused by EHV lines be determined before the electric utilities commit themselves to using this new technology. To support his case he presented calculations based on an energy requirement of 9 kWhr per pound of ozone formed and a half-life for ozone decomposition of three days. His calculations are primarily concerned with periods of temperature inversions or still weather conditions, in which cases he considers that the ozone would collect under the lines. He states, "In one hour of still weather the concentration of ozone would build up to 0.4 parts per million – a concentration four to ten times greater than the amount known to cause damage to plants and animals."

Studies performed by and for AEP[2,3] lead to numbers quite different from those used by Young. Sherer, Ware, and Shih[2] conclude that power lines carrying 765 kv will not create a significant problem in terms of ozone formation. This conclusion is based on measured energy requirements in the order of 100 to 400 kWhr per pound of ozone and a half-life for ozone decomposition of less than 1 hr. (Compare with Young's values.)

However, AEP, GE, and EPA-NERC are performing or sponsoring more work concerning ozone formation. A major justification for the EPA work is very high ambient ozone concentrations in certain locations where there are no high-tension lines. One such area is at Mt. Storm, as indicated in an EPA Procurement Plan[4] under title "Investigation of Source of High Ozone Concentration – Mt. Storm, West Virginia." The Procurement Plan entitled "Determination of Coronal Ozone Production by High-Voltage Electrical Transmission Lines" contains the statement, "Concentrations higher than 5 ppm have been observed for extended periods – both day and night." This refers to areas devoid of activities commonly associated with ozone formation. Note that 5 ppm exceeds the once-per-year maximum of 0.08 ppm listed in 42 CFR 410 by a factor of 60. This 5 ppm should also be compared with a value of 0.02 ppm at which damage to vegetation has been observed.[7]

At the present time it seems inappropriate to attempt to answer the question of ozone formation around high-tension lines in detail. It is my opinion that we should briefly mention in section III.E.4 the state of knowledge concerning this question, that research is now being performed under contracts from the electrical power industries and EPA to answer this question in more detail, and that presently available information indicates the increase in ozone concentration due to coronas to be within the uncertainties of the measuring instruments. The response may have to be modified as data become available during the next couple of years.

REFERENCES

1. J. Zaborszky and J. W. Rittenhouse, Electric Power Transmission, The Ronald Press, New York, 1954.

2. H. N. Scherer, Jr., B. J. Ware, and C. H. Shih, "Gaseous Effluents Due to EHV Transmission Line Corona," presented at the IEEE Power Engineering Society Summer Meeting, San Francisco, Cal., July 9-14, 1972.

3. M. Frydman, A. Levy, and S. E. Miller, "Oxidant Measurements in the Vicinity of Energized 765 KV Lines," presented at the IEEE Power Engineering Society Summer Meeting, San Francisco, Cal., July 9-14, 1972.

4. "Determination of Coronal Ozone Production by High-Voltage Electrical Transmission Lines," Procurement Plan, Environmental Protection Agency, Research Triangle Park. The suggested contractor is Versar, Inc., of Springfield, Va. Award date is Dec. 1, 1971, or as soon thereafter as practicable.

5. "Investigation of Source of High Ozone Concentrations – Mt. Storm, West Virginia," Procurement Plan, Environmental Protection Agency, Research Triangle Park. The suggested contractor is Research Triangle Institute. Award date is no later than May 1, 1972.

6. Letter, dated September 19, 1970, from Peyton Young, Ph.D., 755 Sheridan Rd., Winnetka, Ill. 60093, to Frank McElroy, Colonial Center Building, Rm. 103, 5725 Dragon Way, Cincinnati, Ohio 45227. A copy of this letter was transmitted to Mr. Elbert Tabor, National Air Pollution Control Administration, 1033 Wade Ave., Raleigh, N. C. 27605, by Dr. Young's attorneys, Isaac, Postlewaite, O'Brien, and Oman, Eighty-Eight East Broad St., Columbus, Ohio 43215 on October 27, 1970.

7. U.S. Department of Health, Education, and Welfare, Air Quality Criteria for Photochemical Oxidants, Washington, D.C., National Air Pollution Control Administration, 1970. See, particularly, Chapter 6.