UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

NOV 28 1980

MEMORANDUM FOR: Harold R. Denton, Director
Office of Nuclear Reactor Regulation

Ray G. Smith, Acting Director
Office of Standards Development

FROM: Robert B. Minogue, Director
Office of Nuclear Regulatory Research

SUBJECT: RESEARCH INFORMATION LETTER NO. 106
RANCHO SECO BUILDING WAKE EFFECTS ON ATMOSPHERIC DISPERSION

INTRODUCTION AND SUMMARY

This memorandum transmits the results of completed research on characterizing the effects on atmospheric dispersion from building wakes around a large reactor complex located in flat terrain. Wake is defined to be the region of turbulence induced downstream of a solid body in a fluid flow. This research is part of our overall atmospheric transport and diffusion research program endorsed by you in your memoranda dated April 6, 1979, and September 28, 1979 (R. B. Minogue) and April 19, 1979 (H. R. Denton). The objective of this research program is to verify current and proposed methods used to predict the transport and diffusion of airborne radioactive effluents for emergency response and for site evaluation purposes. The results transmitted herewith improve and expand the current data base used to develop appropriate standards and regulatory guides in atmospheric dispersion. The results of this effort have been referenced in the Regulatory Guide 1.145 entitled "Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants;" this guide was issued "for comment" in August 1979.

The research was performed by G. E. Start and colleagues at the Air Resources Laboratory Field Research Office, National Oceanic and Atmospheric Administration, Idaho Falls, Idaho, under the direction of the Site Safety Research Branch, RES. The contractor achieved the objectives as described in the work scope for this project. The tests were planned, conducted, and analyzed with high quality and thoroughness. Measured concentrations were two orders of magnitude lower than values calculated using the current NRC methodology. A reassessment of these calculational procedures appears warranted.

METHODOLOGY

A test series of 23 paired gaseous tracer releases was performed at the Rancho Seco Nuclear Power Station, California, in 1975. The sampling program was designed to (1) study atmospheric dispersion under a variety of thermal lapse rates and wind conditions, and (2) evaluate the effects of flow around buildings on dilution of pollutants. Cross sectional area of the Rancho Seco nuclear complex is 2050 m^2.

The sampling grid consisted of four circular arcs centered on the reactor containment building with radii of 100, 200, 400, and 800 m. Sampler positions were spaced every 6 degrees. Nineteen samplers were placed around the base of the containment vessel and auxiliary building complex and three samplers were placed on the auxiliary building roof. Meteorological data were collected at heights of 4 m, 16 m, and 46 m.

Sulfurhexafluoride (SF_6) and dichlorodifluoromethane (F12) were released simultaneously as tracer gases from two locations chosen from the top of the containment building, the roof of the auxiliary building, and two ground-level locations at the base of the containment building. Both of these tracers are inert and nontoxic in the concentrations used; the background concentrations of these tracers are negligible in the free atmosphere. The tracer release and sampling times lasted 1 hour. The gas collected by the samplers was analyzed with an electron-capture gas chromatograph developed by Lovelock.

The NRC criterion for determining stability, Regulatory Guide 1.23, entitled "Onsite Meteorological Programs," was used to categorize each test utilizing the temperature difference between the 46 m and 10 m heights. Of the 23 tests, 2 were conducted during A (extremely unstable) conditions, 4 during D (neutral), 5 during E (slightly stable), 3 during F (moderately stable), and 9 during type G (extremely stable) conditions. No tests were performed under classes B or C (moderately or slightly unstable).

RESULTS

For each test, the wind and temperature data and the concentration measured at each sampler location are presented in the report. For comparison of the observed data with the expected values, three ratios were computed. The first, RY, represents the ratio between the measured sigma-y value (for a given test and downwind distance) and the Pasquill-Gifford value. Similarly, RZ is the ratio of the sigma-z from the effective cross-wind integrated concentration equation divided by the expected Pasquill-Gifford value. The third ratio, RC, is the computed Pasquill-Gifford concentration divided by the measured peak axial concentration. Sigma-y estimates the crosswind spread of the plume; sigma-z estimates the vertical spread.

Table 1
Comparison of Diffusion as a Function of Stability Class.

DATA CONSIDERED	RY	RZ	RC
All data	5.7	48.9	353.4
Stable (E, F, G)	6.9	58.2	474.3
Unstable (A, D)	2.7	15.9	48.9

Table 2
Comparison of Diffusion as a Function of Distance.

DISTANCE (m)	RY	RZ	RC
100	6.4	91.2	848.9
200	6.0	44.8	289.4
400	5.3	23.3	135.7
800	4.8	18.4	68.4

For 52 comparisons of ground-level tracer releases, nearly two-thirds of the variance in observed sigma-y values can be explained by use of the wind fluctuation statistics; the correlation coefficient was 0.82. Thus, plume meander contributed almost 70 percent to the lateral spread of the plume.

For ground-level releases, gaseous tracers were laterally dispersed about 6 times more than the expected amounts from the Pasquill-Gifford curves of sigma-y. The effective sigma-z values were 16 times greater than the corresponding values from the Pasquill-Gifford curves of sigma-z. The measured ground-level axial concentrations were about 75 times smaller than predicted by the Gaussian diffusion equation for a ground-level release when Pasquill-Gifford values of sigma-y and sigma-z were used.

Beyond the 100 and 200 m arcs, the Gaussian diffusion equation with the traditional building wake correction factor, cA, added to the denominator failed to account for building observed tracer dilutions downwind of the building complex. The systematic growth of the differences between observed and calculated concentrations at greater distances suggests that the use of the add-on cA term is functionally incorrect.

Systematic building wake cavity circulations distributed surface-released tracers vertically throughout the zone in the lee of the containment and auxiliary buildings. The result is the vertical redistribution of material so that the center of the plume mass occurred at a height different from that expected; i.e., the actual heights of release for tracers released from ground-level were significantly elevated; as a result, better predictions were obtained by considering the ground-level releases as being slightly elevated releases.

RECOMMENDATIONS

The results of this research should be incorporated into the current regulatory guides as appropriate. These results should be representative of the dispersion expected around large reactor complexes located in reasonably flat terrain. Additionally, the results indicate a significant conservatism in the calculational approach utilized to assess the dispersion characteristics at a given reactor site. As the results of the complementary studies to this one become available, they will be transmitted in separate research information letters. Specifically, these will include the results from the small building, flat terrain field study and the two wind tunnel simulations of the field prototypes. A reassessment of the basis for justifying the current procedures is needed.

For further information on this study, please contact Robert F. Abbey, Jr., (427-4373), the technical monitor for this work.

Robert B Minogue

Robert B. Minogue, Director
Office of Nuclear Regulatory Research

Enclosure: NUREG/CR-0456

cc: F. Schroeder, NRR
G. Knighton, NRR

Harold R. Denton
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Thomas E. Murley, Acting Director
Office of Nuclear Regulatory Research

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