OCT 3 1 1985

MEMORANDUM FOR: Those on Attached List

FROM: Robert A. Kornasiewicz, Leader
Hydrology Section
Earth Sciences Branch
Division of Radiation Programs
and Earth Sciences, RES

SUBJECT: TRANSMITTAL OF NUREG/CR-4158, "A COMPILATION OF INFORMATION ON UNCERTAINTIES INVOLVED IN DEPOSITION MODELING"

The enclosed subject report is provided under FIN B0446, Dispersion Model Evaluation. A copy of the Research Summary of this report is enclosed.

Robert A. Kornasiewicz, Leader
Hydrology Section
Division of Radiation Programs
and Earth Sciences, RES

Enclosures:
1. NUREG/CR-4158
2. Research Summary

DIST/R-2811:
Circ/Chron
ESB/Subj/Rdg

dist w/encl: RES Summary

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LBeratan	RKornasiewicz
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Addressees-Memorandum dated OCT 3 1 1985

Subject: Transmittal of NUREG/CR-4158 and Research Summary

F. Congel, NRE, P-712

W. Gammill, NRR, P-730

L. Hulman, NRR, P-822

D. Matthews, IE, EWW-359

P. McKee, IE, EWS-346

K. Perkins, IE, 3320

A. Thadani, NRR, 216

I. Spickler, NRR, P-730

J. Martin, RES 1130-SS

M. Solberg, IE, EWS-346

D. Rohrer, IE, EWW-359

B. Zalcman, IE, 3320

RESEARCH SUMMARY

REPORT TITLE: A Compilation of Information on Uncertainties Involved in Deposition Modeling

AUTHORS: W. S. Lewellen, A. K. Varma and Y. P. Sheng

PROJECT TITLE: Dispersion Model Evaluation

FIN: B0446

NRC PROJECT MANAGER: Robert A. Kornasiewicz

CONTRACTOR: Oak Ridge National Laboratory

PRINCIPLE INVESTIGATOR: F. C. Kornegay

REGULATORY CONTEXT: Section 50.47 of 10 CFR Part 50 establishes standards that must be met by the onsite and offsite emergency response plans in order for the staff to make a positive finding that there is reasonable assurance that adequate protective measures can and will be taken in the event of a radiological emergency. Included in these standards is paragraph 50.47(b)(9) which specifies that "Adequate methods, systems and equipment for assessing and monitoring actual or potential offsite consequences of a radiological emergency condition are in use." Appendix E of 10 CFR Part 50 further cites in this context specific criteria in NUREG-0654; FEMA-REP-1 which include a dose projection capability, utilizing atmospheric dispersion models, for the plume exposure pathway within the EPZ.

RESEARCH OBJECTIVES: The objective of this study was to evaluate existing methods of modeling the deposition processes (both wet and dry) in the atmosphere, to determine the magnitude of the uncertainties in estimating the amount of material that might be deposited from an airborne effluent plume and to identify the sources of these uncertainties and the potential for improving these estimates.

RESEARCH FINDINGS OR RESULTS: The study investigated the physical mechanisms governing the wet and dry deposition processes, including interactions with a forest vegetation canopy, to determine the levels of uncertainty associated with commonly used simple parameterizations of the deposition process as well as more complex parameterizations. An attempt was also made to identify the most valid parameterizations.

For dry depositon velocities of effluents appropriate for accidental releases from nuclear power plants, the range of uncertainty is about three orders of magnitude. Although some of this uncertainty may be attributable to modeling deficiencies, particularly in relation to mechanisms other than turbulent

inertia or Brownian motion for transporting micron size particles across the viscous sublayer, much of the uncertainty can be attributed directly to uncertainties in key independent variables. These include canopy structure, surface-layer atmospheric stability, particle size and surface chemical reactivity. A substantial part of the uncertainty is associated with the various possible atmospheric stability conditions. Another substantial contributor to uncertainty is the particle size distribution in the effluent plume. The analyses showed a maximum range of uncertainty of six orders of magnitude for the dry deposition velocity between that associated with an Iodine plume moving through an unstable atmosphere in a wet forest canopy and a plume of 0.2 micron dry particles moving in a stable atmosphere with light winds over a smooth grassland.

For wet deposition and atmospheric precipitation scavenging, the major uncertainties are attributable to the natural variability of the atmospheric precipitation process and to an incomplete understanding of the underlying process. Variables associated with the atmospheric process include humidity variation, cloud formation, storm frequency and distribution and the patchiness of rainfall. Uncertainty in the determination of collision efficiency is the primary cause of uncertainty in the value of the scavenging coefficient. There are at least six basic mechanisms that lead to collisions between particles in the atmosphere: (1) Brownian motion, (2) turbulent shearing, (3) turbulent accelerations, (4) gravitational sedimentation, (5) electrostatic attraction and (6) thermophoresis and diffusiophoresis. The relative importance of these parameters is dependent on meteorological conditions (primarily atmospheric turbulence which is a function of stability) and the characteristics of the colliding pair.

For particles, the physical properties (i.e., size, density, hygroscopicity, wettability) are more important than the chemical composition in determining scavenging rates. However, for gas scavenging by precipitation the chemical reactivity can be a very important factor in determining scavenging rates.

For below-cloud scavenging (washout) for particulates, there is a reasonable degree of consistency between the values of the scavenging rate (Λ) estimated from the simple model and experimental values for washout of pollutant particles. It appears that washout scavenging rates for particulates have an uncertainty of less than an order of magnitude. A number of atmospheric dispersion codes, for example, ATM, DMSTRAM, and MIDAS use Λ values given by Slade (1968). For the particle and rain parameters discussed here, the value of Λ is recommended to be 1.5×10^{-4} sec^{-1} which is quite reasonable for the washout process. The CRAC2 dose for the wet scavenging of radioactive effluents does not distinguish between washout and rainout and for a rain rate of 5 mm/hr uses a value of $\Lambda = 5 \times 10^{-4}$ sec^{-1} for stable weather and $\Lambda = 5 \times 10^{-3}$ sec^{-1} for neutral and unstable weather. Although the variation in Λ from neutral to unstable conditions is not unreasonable, this range of values appears to be high compared to the data for the washout scenario of precipitation scavenging.

Dingle and Lee (1973) have developed a particularly promising simplified methodology to determine scavenging rates. This model examines the basic physics of the precipitation scavenging process, yet avoids getting buried in the large number of associated individual physical and chemical subprocesses.

Although the large variabilities in wet-removal rates as a function of time can be accounted for by <u>qualitative</u> explanations, it is not at this time possible to predict the variability quantitatively for specific instances such as would be desired for applications to models used in assessing dispersion of

plumes from reactor releases. In some special circumstances, existing modeling techniques may be capable of order-of-magnitude estimates, but an enhanced understanding of the detailed microphysical and dynamic processes will be needed before reliable parameterizations of wet deposition can become available. In addition the temporal variability of the atmospheric turbulence in storm systems will impose limits on the accuracy of predictions of wet deposition for single events.

REGULATORY IMPLICATIONS: This study indicates that the interaction between the fluctuations of the rainfall and the variations of the effluent concentrations within the plume may be responsible for the greatest degree of uncertainty in local estimates of the wet scavenging of the effluent plume. The development of models to adequately account for these effects requires additional work.

The full range of stability conditions need to be considered when assessing the consequences of an accidental airborne release. However, the stability input used to determine the deposition velocity should be compatible with the stability conditions selected for use in the associated dispersion calculation.

The "conditionality" of the deposition processes in the atmosphere makes the determination of "worst case" scenarios, for assessing accident consequences involving the impact of plumes affected by deposition, very difficult. A wide range of meteorological conditions as well as land use and population patterns around the site would need to be evaluated if the model is to identify the worst case. Conditions that may result in reduced deposition close to the release point could very likely produce increased deposition at greater distances and vice versa.

The information developed by this study can be used in support of NRC reviews of licensee/applicant emergency response accident assessment capabilities, as well as in the selection or use of models that may be installed at the NRC Operations Center.

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OFC: ESB	:ESB	:	:	:	:	:
RAK	LB					
NAME:RKornasiewicz	:LBeratan	:	:	:	:	:
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