2.4.13 ACCIDENTAL RELEASES OF LIQUID EFFLUENTS IN GROUND AND SURFACE WATERS

REVIEW RESPONSIBILITIES

Primary - Mechanical and Civil Engineering Branch (EMEB)

Secondary - Plant Systems Branch (SPLB)
Equipment and Human Performance Branch (IEHB)

I. AREAS OF REVIEW

The ability of the ground and surface water environment to delay, disperse, dilute, or concentrate accidental radioactive liquid effluent releases is reviewed with emphasis on relating the effects of such releases to existing and known future uses of ground and surface water resources. (Note that effects of normal releases and of the more likely accidents are discussed in the applicant's environmental report.)

II. ACCEPTANCE CRITERIA

Acceptance criteria for this section of this review standard relate to 10 CFR Parts 52 and 100 as they require that hydrologic characteristics of the site be evaluated with respect to the consequences of the escape of radioactive material from the facility.

Compliance with 10 CFR Parts 52 and 100 requires that local geological and hydrological characteristics be considered when determining the acceptability of a nuclear power plant site. The geological and hydrological characteristics of the site may have a bearing on the potential consequences of radioactive materials escaping from a nuclear power plant or plants of specified type that might be constructed on the proposed site. Special precautions should be planned if a reactor or reactors would be located at a site where a significant quantity of radioactive effluent could accidentally flow into nearby streams or rivers or find ready access to underground water tables.

These criteria apply to Section 2.4.13 of this review standard because the reviewer evaluates site hydrologic characteristics with respect to the potential consequences of radioactive materials escaping from a nuclear power plant or plants of specified type that might be constructed on the proposed site. Radionuclide transport characteristics of ground and surface water environments are reviewed with respect to accidental releases in order to ensure that current and future users of ground and surface water are not adversely affected by an accidental release from a nuclear power plant or plants of specified type that might be constructed on the proposed site. Regulatory Guide 1.113 provides guidance in selecting and using surface water models for analyzing the flow field and dispersion of contaminants in surface waters.

Meeting the requirements of 10 CFR Parts 52 and 100 provides assurance that accidental releases of liquid effluents to ground and surface waters, and their adverse impact on public health and safety, will be minimized.

To meet the requirements of 10 CFR Parts 52 and 100 with respect to accidental releases of liquid effluents, the following specific criteria are used:

1. Radionuclide transport characteristics of the groundwater environment with respect to existing and future users must be described. Estimates and bases for coefficients of dispersion, adsorption, groundwater velocities, travel times, gradients, permeabilities, porosities, and groundwater or piezometric levels between the site and existing or known future surface and groundwater users must be described and be consistent with site characteristics. Potential pathways of contamination to groundwater users must also be identified. Sources of data must be described and referenced.

2. Transport characteristics of the surface water environment with respect to existing and known future users must be described for conditions which reflect worst-case release mechanisms and source terms so as to postulate the most pessimistic contamination from accidentally released liquid effluents. Estimates of physical parameters necessary to calculate the transport of liquid effluent from the points of release to the site of existing or known future users must be described. Potential pathways of contamination to surface water users must be identified. Sources of information and data must be described and referenced. Acceptance is based on the staff's evaluation of the applicant's computational methods and the apparent completeness of the set of parameters necessary to perform the analysis.

3. Mathematical models are acceptable to analyze the flow field and dispersion of contaminants in ground and surface waters, providing that the models have been verified by field data and that conservative site-specific hydrologic parameters are used. Furthermore, conservatism must be the guide in selecting the proper model to represent a specific physical situation. Radioactive decay and sediment adsorption may be considered, if applicable, providing that the adsorption factors are conservative and site specific. Regulatory Guide 1.113 provides guidance in selecting and using surface water models.

III. <u>REVIEW PROCEDURES</u>

Section 2.4.13 of the applicant's safety assessment is reviewed to identify any missing data, information, or analysis necessary for the staff's evaluation. Applicant responses to the requested information will be evaluated using the methods outlined below, and staff positions will be developed. Resolution, if possible, of differences between the staff's and the applicant's estimation of liquid effluent dispersion will be coordinated through the NRR project manager; and the safety evaluation report (SER) will be written accordingly.

The staff will make independent calculations of the transport capabilities and potential contamination pathways of the groundwater environment under accidental conditions with respect to existing and future users. Special attention should be directed to planned use of permanent dewatering systems to ensure that pathways created by those systems have been identified. The staff will, in consultation with IEHB and SPLB, choose the accident scenarios leading to the most adverse contamination of the groundwater or the surface water via the groundwater pathways. Analysis of the contamination will commence with the simplest models, such as those presented in References 8 and 21, using demonstrably conservative assumptions and coefficients. Dilutions and travel times (or alternatively, concentrations directly) resulting from the preliminary analyses will then be checked by IEHB to determine acceptability. If the indicated concentrations of radionuclides identified by IEHB are less than the values identified in 10 CFR Part 20, Appendix B, Table 2, Column 2, no further computational efforts will be warranted. Further analyses using progressively more realistic and less conservative modeling techniques, such as those of References 13 and 24, will be undertaken if the preliminary results are not acceptable.

Independent calculations will be made of liquid effluent transport for the surface pathways identified. For preliminary analysis, the staff will employ simplified calculational procedures or models, such as those contained in References 3 and 9. The analysis will be performed using demonstrably conservative coefficients and assumptions, and the physical conditions (such as lowest recorded river flow) likely to give the most adverse dispersion of the liquid effluent. The applicant's model assumption and results will be compared with the staff's results to ensure that the results are comparably conservative. The estimation of liquid effluent dispersion will reflect potential future changes that might result from variations in use by known future surface and groundwater users.

Concentrations of radionuclides in the body of water under consideration will be calculated based on the staff's dispersion computations and with initial concentrations provided by the IEHB for the most critical event. Acceptability of the resultant concentrations of radioactive effluent at the points of interest will be determined by consultation with IEHB. If the concentrations of the diluted liquid effluents computed by the staff are within acceptable limits of Appendix B, Table 2, Column 2, of 10 CFR Part 20, no further computation effort is indicated. If the concentrations computed by conservative simplified methods exceed the limits of 10 CFR Part 20, more precise and less conservative models, such as those used for hydrothermal prediction (Reference 10), and coefficients will be employed by the staff.

IV. EVALUATION FINDINGS

For early site permit reviews, the findings will summarize the applicant's and the staff's estimates of dilution factors, dispersion coefficients, flow velocities, travel times, and potential contamination pathways between the site and the nearest water user in conformance with 10 CFR Parts 52 and 100. If the estimates are comparable, or if no potential problem exists, staff concurrence with the applicant's estimates will be stated. If the staff predicts substantially more conservative conditions, a statement of the staff basis will be made.

Sample statements for early site permit reviews follow:

> As set forth above, a postulated failure of the miscellaneous waste collection tank (for the plant type specified by the applicant, the tank outside of containment with the highest radioactive inventory) was analyzed to estimate the concentration of radioactive contaminants in nearby wells. The contents of the tank were conservatively assumed to enter the groundwater instantaneously, and the nuclides were assumed to travel with the water with no credit taken for ion exchange processes. The nearest downgradient potable water well is located 880 meters (2900 feet) northeast of the plant site. Assuming a very high permeability of 15 micrometers (590 microinches) per second, the travel time to the nearest down gradient potable well was 9.5 years. The calculated concentrations of all nuclides were well below the maximum permissible concentrations listed in 10 CFR Part 20, Appendix B, Table 2. In this analysis, it was also assumed that

the contents of the tank traveled with the groundwater to A Creek. It was then assumed to mix with creek water, flow into Lake B, and then to the water supply intake for the city of C. Concentrations at the water supply intake for the city of C were also small fractions of 10 CFR Part 20 limits for all nuclides.

A postulated failure of the distillate storage tank for a plant of type specified by the applicant that might be constructed on the proposed site, which would be located in the plant yard, was also analyzed. It was conservatively assumed that the entire contents of the tank are introduced, as a slug release, into Lake B at the mouth of A Creek. (In reality, a failure of this tank would result in effluent flowing through the site drainage to A Creek, where it would be diluted before entering the lake.) Our analysis showed that the concentration of all nuclides would be small fractions of the 10 CFR Part 20 limits at the water supply intake for the city of C.

Based on these considerations, the staff concludes that a nuclear power plant of type specified by the applicant that might be constructed on the proposed site would be capable of meeting the requirements of 10 CFR Parts 52 and 100 with respect to potential accidental releases of radioactive liquid effluents.

V. IMPLEMENTATION

The following is intended to provide guidance to applicants and licensees regarding the NRC staff's plans for using this section of this review standard.

This section will be used by the staff when performing safety evaluations of early site permit applications submitted by applicants pursuant to 10 CFR Part 52. Except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein will be used by the staff in its evaluation of conformance with Commission regulations.

Implementation schedules for conformance to parts of the method discussed herein are contained in the referenced regulatory guides.

VI. REFERENCES

In addition to the following references describing methods and techniques of evaluation, data published by Federal, State, and other agencies and organizations will be used as available.

1. 10 CFR Part 100, "Reactor Site Criteria."

2. N. H. Brooks, "Diffusion of Sewage Effluent in an Ocean Current," in "Waste Disposal in the Marine Environment," Pergamon Press, New York (1960).

3. H. B. Fisher, "The Mechanics of Dispersion in Natural Streams," Jour. Sanitary Engineering Division, Proc. Am. Soc. Civil Engineers, Vol. 93, No. HY6, pp. 187-216 (1968).

4. H. B. Fischer, "Dispersion Predictions in Natural Streams," Jour. Sanitary Engineering Division, Proc. Am. Soc. Civil Engineers, Vol. 94, No. SA5, pp. 927-943 (1968).

5. E. Gasper and M. Oncescu, "Radioactive Tracers in Hydrology," Elsevier Publishing Co., New York (1972).

6. S. N. Davis and R. J. M. DeWiest, "Hydrogeology," John Wiley & Sons, Inc., New York (1966).

7. Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants."

8. NUREG-0868, "A Collection of Mathematical Models for Dispersion in Surface Water and Groundwater" (June 1982).

9. Regulatory Guide 1.113, "Estimating Aquatic Dispersion of Effluents from Accidental and Routine Reactor Releases for the Purpose of Implementing Appendix I."

10. G. H. Jirka, G. Abraham, D. R. F. Harleman, "An Assessment of Techniques for Hydrothermal Pr E. Gasper and M. Oncescu, "Radioactive Tracers in Hydrology, ediction," USNRC, NUREG-0044, 1976.

11. Regulatory Guide 4.4, "Reporting Procedure for Mathematical Models Selected to Predict Heated Effluent Dispersion in Natural Bodies of Water."

12. S. W. Ahlstrom, R. J. Serne, R. C. Routson, and O. B. Cearlock, "Methods for Estimating Transport Model Parameters for Regional Groundwater Systems," BNWL-1717, Battelle Pacific Northwest Laboratories, Richland, Washington (1972).

13. R. C. Routson and R. J. Serne, "One-Dimensional Model of the Movement of Trace Radioactive Solutes Through Soil Columns: The PERCOL Model," BNWL-1718, Battelle Pacific Northwest Laboratories, Richland, Washington (1972).

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15. K. L. Kipp, D. B. Cearlock, and A. E. Reisenauer, "Mathematical Modeling of a Large, Transient, Unconfined Aquifer with a Heterogeneous Permeability Distribution," paper presented at the 54th Annual Meeting of the American Geophysical Union, Washington, DC, April 1973.

16. W. H. Li and F. H. Lai, "Experiments on Lateral Dispersion in Porous Media," Jour. Hydraulics Division, Proc. Am. Soc. Civil Engineers, Vol. 92, No. HY6 (1966).

17. W. H. Li and G. T. Yeh, "Dispersion of Miscible Liquids in a Soil," Water Resources Research, Vol. 4, pp. 369-377 (1968).

18. D. R. F. Harleman, P. F. Mehlhorn, and R. R. Rumer, "Dispersion Permeability Correlation in Porous Media," Jour. Hydraulics Division, Proc. Am. Soc. Civil Engineers, Vol. 89, No. HY2, pp. 67-85 (1963).

19. L. E. Addison, D. R. Freidrichs, and K. L. Kipp, "The Transmissivity Iterative Programs on the PDP-9 Computer--A Man-Machine Interactive System," BNWL-1707, Battelle Pacific Northwest Laboratories, Richland, Washington (1972).

20. "Fundamentals of Transport Phenomena in Porous Media," International Association for Hydraulic Research, Elsevier Publishing Company, New York (1972).

21. C. A. Appel and J. D. Bredehoeft, "Status of Groundwater Modeling in the U.S. Geological Survey," USGS Circular 737 (1976).

22. American Nuclear Society, "Standards for Evaluating Radionuclide Transport in Groundwater, Draft 2."

23. J. O. Duguid and M. Reeves, "Material Transport Through Porous Media: A Finite Element Galerkin Model," ORNL-4928, Oak Ridge National Laboratory, Environmental Science Division, Publication 733, March 1976.

24. R. L. Taylor and C. B. Brown, "Darcy's Flow Solutions with a Free Surface," Journal of the Hydraulics Division, ASCE, Vol. 93, No. HY2, pp. 25-33, March 1967.

25. S. P. Neuman and P. A. Witherspoon, "Finite Element Method of Analyzing Steady Seepage with a Free Surface," Water Resources Research, Vol. 6, No. 3, pp. 889-897, June 1970.

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27. G. F. Pinder and E. O. Frind, "Application of Galerkin's Procedure to Aquifer Analysis," Water Resources Research, Vol. 8, No. 1, pp. 108-120, February 1972.

28. J. Rubin and R. V. James, "Dispersion-Affected Transport of Reacting Solutes in Saturated Porous Media: Galerkin Method Applied to Equilibrium Controlled Exchange in Unidirectional Steady Water Flow," Water Resources Research, Vol. 9, No. 5, pp. 1332-1356, October 1973.

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31. M. Reeves and J. O. Duguid, "Water Movement Through Saturated-Unsaturated Porous Media: A Finite Element-Galerkin Model," ORNL-4927, Oak Ridge National Laboratory, Oak Ridge, Tennessee, February 1975.

32. 10 CFR Part 20, "Standards for Protection Against Radiation."

33. 10 CFR Part 52, "Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants."