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A Division of Southwest Research Institute™
6220 Culebra Road • San Antonio, Texas, U.S.A. 78228-5166
(210) 522-5160 • Fax (210) 522-5155

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U.S. Nuclear Regulatory Commission
ATTN: Mrs. Deborah A. DeMarco
Two White Flint North
11545 Rockville Pike
Mail Stop T8A23
Washington, DC 20555

Subject: Programmatic Review of Paper

Dear Mrs. DeMarco:

The enclosed paper is being submitted for programmatic review. This paper will be submitted for presentation at the "Geological Evidence and Theoretical Bases for Radionuclide-Retention Processes in Heterogeneous Media, organised in the framework of GEOTRAP, the OECD/NEA Project on the Transport of Radionuclides in Geologic, Heterogeneous Media and hosted by the Swedish Nuclear Fuel and Waste Management Company (Sweden) in Äspö, Sweden. The workshop will be held May 6 through 9 and a visit to the Äspö underground laboratory will be on May 10, 2001. The title of this paper is:

> "The Consideration and Representation of Retention Processes in Performance Assessment—a Regulatory Perspective"

This paper is a product of the CNWRA and does not necessarily reflect the view(s) or regulatory position of the NRC.

Please advise me of the results of your programmatic review. Your cooperation in this matter is appreciated.

Sincerely,

Budhi Sagar
Technical Director

Enclosure

cc:

W. Reamer	D. Brooks	CNWRA Directors
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J. Linehan	S. Wastler	P. Maldonado
J. Greeves	J. Firth	T. Nagy, Contracts
E. Whitt	K. McConnell	S. Mohanty
J. Bradbury		P. Bertetti

Washington Office • Twinbrook Metro Plaza #210
12300 Twinbrook Parkway • Rockville, Maryland 20852-1606

THE CONSIDERATION AND REPRESENTATION OF RETENTION PROCESSES IN PERFORMANCE ASSESSMENT—A REGULATORY PERSPECTIVE

Budhi Sagar
Center for Nuclear Waste Regulatory Analyses, Southwest Research Institute
San Antonio, TX, USA 78250

Richard Codell
U.S. Nuclear Regulatory Commission
Washington, D.C., USA

Bjorn Dverstrop and Bo Stromberg
Swedish Nuclear Power Inspectorate
Stockholm, Sweden

ABSTRACT

Processes that prevent or delay the migration of radionuclides in the geosphere relative to ambient water velocity are called retention processes. These processes can be chemical (e.g., ion exchange, sorption, and mineral precipitation) or physical (e.g., matrix diffusion from fractures into rock matrix or filtration of colloidal particles). Such retention processes can significantly delay and reduce the rate at which radionuclides are released to the biosphere and hence reduce the dose to biota, including humans. Retention processes are considered important components of the safety case (e.g., radionuclide delay in the unsaturated and the saturated zones) and are listed as principal factors in the U.S. Department of Energy Repository Safety Strategy (M&O, 2000) for the proposed Yucca Mountain site.

The regulatory perspective on any topic related to safety, including retention processes, is formed in response to the primary regulatory mission of gaining reasonable assurance (or determining that the same cannot be gained) that public health, safety, and the environment will be protected. While the implementor alone is responsible for the design, construction, operation, and closure of a repository, once such a facility is approved (or licensed) by the regulator, in the public's mind the regulator is as much responsible for the integrity of the facility as the implementor. The public can easily lose confidence in the regulator's competence and effectiveness if the safety of an approved facility comes into question. Therefore, it is the regulator's job to evaluate potential vulnerabilities in the implementor's safety case. The intensity of regulatory scrutiny of the retention processes will depend on the importance of these processes to the implementor's safety case. Specifically, the depth of examination of these processes during regulatory reviews will depend on the contribution they make to meeting the performance objectives (e.g., see Eisenberg and Sagar, 2000 for a discussion of importance analysis).

Since repository safety is to be assessed for thousands of years after closure, simulation of repository behavior through mathematical modeling is an essential element of a safety case. The conceptual model of the engineered and natural barriers, mathematical formulation of the retention processes including coupling with thermal and hydrologic processes, estimation of model parameters, and numerical implementation of the model including consideration of both the model and parameter uncertainties are components that must be examined to determine whether the incorporation of the retention processes in the safety case is acceptable. The regulatory approach envisions an adequate description of the retention processes consistent with their

contribution to the safety case (see Davis et al., 1991 and Wingfore et al., 1999). In a regulatory review, greater uncertainties may be acceptable if the retention processes have a small effect on the overall safety of the repository.

While, it is preferable to have as realistic a description of the various processes in performance assessment as possible, a wholly realistic description is not absolutely necessary to support regulatory decisions. For example, from a regulator's perspective, it will be acceptable to entirely neglect (not take credit for) retention processes in a safety case even though this may not be a realistic assumption. In such a situation, so long as it is assured that neglecting retention processes does not negatively effect repository performance, and so long as other regulatory requirements (e.g., defense-in-depth and/or multiple barriers) are satisfied, it should be acceptable to the regulator even though the overall system performance estimated using this assumption will itself not be realistic (i.e., it will tend to over-estimate radionuclide releases to the biosphere). Such assumptions can contribute to a safety margin—the difference between the unknown realistic value and the estimated conservative value of the performance measure such as radiation dose. Multiple barriers and defense-in-depth measures also contribute to safety margins. It is a good idea for the implementor to provide qualitative arguments whether an assumption in the safety case adds to or detracts from the safety margin, if quantitative estimation of the safety margin is not feasible.

In this paper, we discuss the various questions posed by the workshop organizers with respect to two of the retention processes—ion exchange (or sorption) and matrix diffusion.

This paper documents work performed in part for the U.S. Nuclear Regulatory Commission (NRC) by the Center for Nuclear Waste Regulatory Analyses under contract NRC-02-97-009. This work was conducted on behalf of the NRC Office of Nuclear Material Safety and Safeguards, Division of Waste Management. The paper is an independent product and does not necessarily reflect the views or regulatory position of the NRC.

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