

Key Elements of Staff Review of the Department of Energy's Total System Performance Assessment Computer Program and Files

The U.S. Department of Energy's (DOE) total system performance assessment (TSPA) comprises many parameters, models and assumptions that are represented mathematically in 'computer files' using the GOLDSIM computer software package, which is referred to collectively as the TSPA. The TSPA fulfills two primary functions. The first is to integrate many process-level models (e.g., infiltration, radionuclide transport, corrosion) in order to simulate overall system performance and produce estimates of expected dose. The second function is to iterate these performance simulations many times varying certain input parameters within ranges that capture natural variability and uncertainty; this is the stochastic¹ component. DOE uses this computer program to run hundreds of simulations, or "runs," to depict the different ways a potential repository could perform. The program saves these estimates of overall repository performance, expressed as dose estimates, in separate computer files. Still other files are created to preserve intermediate results (such as infiltration rates, degradation rates of waste packages, timing and release rate of radionuclides from the waste package, timing and release rate of radionuclides from the saturated zone). Careful review of the computer program itself, as well as review of the many files created when it runs, will allow the U.S. Nuclear Regulatory Commission (NRC) to follow and confirm the many calculations within the TSPA and to examine the component parameters, models and assumptions relied on in the license application. DOE must include all the information necessary to complete this examination in the license application, and make the application available to all parties. Examination, as used here, means that the input data, calculations, and linkages between processes can be followed in the DOE TSPA. The only requirement for an array of multiple computers of the scale DOE has developed is for running the hundreds or more individual simulations that capture the full range of uncertainty and variability in a relatively short time frame.

To gain insights into how the TSPA for the license application may be used, NRC has obtained published versions of the TSPA used for the Final Environmental Impact Statement (FEIS) and for the Site Recommendation (SR). NRC staff members are able to use commercially available, desktop computers to examine the computer program and files of the TSPA for the FEIS and SR. Specifically, the staff is able to examine the calculations, results, parameters, models and assumptions within the TSPA for the FEIS and SR.

Key elements of NRC's review of DOE's TSPA computer program and files include:

1) Adequacy of scenarios evaluated in the TSPA

NRC staff will examine the models, parameters, and assumptions in the computer program to verify that scenarios in the TSPA appropriately represent the potential evolution of the repository. For example, the TSPA must account properly for the timing and occurrence of disruptive events.

¹ Stochastic means developed in accordance with a probabilistic model.

2) Credibility of TSPA representation of performance

NRC staff will review the computer program and files of the TSPA to determine if the TSPA is properly verified. The goals of this review are to establish: (1) whether the code models the physical processes in the repository system in the manner that was intended; (2) that assumptions made within the TSPA are internally consistent; (3) that estimates of uncertainty in the results are consistent with the model and parameter uncertainty included in the TSPA; and (4) that repository performance and the performance of individual barriers, as represented by DOE, in the TSPA, are consistent and reasonable.

3) Statistical stability and consistency of resulting dose estimates

NRC staff will examine the overall dose estimates, and the intermediate results of the TSPA, to ensure that: (1) the results are statistically stable; (2) the estimated annual dose curves reflect contributions from all the scenarios evaluated; and (3) repository performance and the performance of individual components or subsystems are consistent and reasonable.

The NRC is prepared to perform single simulations of DOE's TSPA. The NRC experience with DOE's TSPA for the FEIS and SR is that single simulations can be performed on a high-performance desktop computer - DOE's computer cluster allows DOE to perform a large number of stochastic simulations in a short period of time that are not possible to perform on a desktop computer. The information required to perform this examination is expected to be in the license application, which will be available to all parties. The NRC staff is exploring the potential for linking several computers to improve efficiency of the licensing review by shortening the time required to perform simulations. However, if additional analyses are necessary, the NRC staff will require DOE to perform additional analyses and submit them for staff review. The staff does not intend to perform its own runs of the TSPA. Simple execution of the computer model is no substitute for the understanding developed through the comprehensive review described in items 1 through 3, above.

The NRC is also prepared to perform independent confirmatory calculations to assist its review of DOE's TSPA at a variety of levels. NRC has developed its own, independent performance assessment model, as well as its own, detailed hydrologic models that NRC will use to support its critique of DOE's TSPA. The NRC's independent total-system performance assessment model (TPA) is publicly available. Over the past 20 years, the NRC staff has published a number of reports documenting the development of TPA and the insights gained from its use. If these independent confirmatory calculations indicate the need for additional information, the staff will request the additional information from DOE. As appropriate, NRC independent confirmatory calculations would be documented in the NRC's Safety Evaluation Report.