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THE ROLE OF THE MATERIALS REVIEW BOARD AND THE NUCLEAR WASTE MATERIALS HANDBOOK

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SUMMARY

The U.S. Department of Energy has established an organizational structure that assures the quality of key data identified as being important to the licensing of a nuclear waste repository by the U.S. Nuclear Regulatory Commission. The Materials Characterization Center collects and/or develops the test methods needed to obtain the data, and acts as a clearinghouse for all data obtained by the methods, regardless of source. The Materials Review Board reviews both test methods and test data submitted to it, and approves them if they meet the rigorous criteria and standards that have been established. The appearance of test methods and test data in the Nuclear Waste Materials Handbook is evidence that the material has undergone intensive review and can be used with confidence within the bounds of the application specified. The principal use of the Handbook is in the repository licensing process.

INTRODUCTION

The Materials Review Board (MRB) is an entity created and authorized by the U.S. Department of Energy (DOE) to certify key data (and underlying test methods) needed in the application for a license for a nuclear waste repository. In this context, the MRB is not unlike a voluntary-consensus standards organization, such as the American Society for Testing and Materials, but the MRB operates within the confines of DOE. The Nuclear Waste Materials Handbook[1] is a loose-leaf document in which are collected the key data and underlying test methods certified by the MRB.

In this paper, we review the evolution and role of the MRB and its associated organizations, the role of the Nuclear Waste Materials Handbook, and the mechanisms by which test methods and test data become part of that document.

REGULATORY BACKGROUND

The disposal system for high-level radioactive wastes from commercial nuclear activities, and perhaps also for such waste from defense-related activities, is to be designed and operated by DOE under a license granted by the U.S. Nuclear Regulatory Commission (NRC). The legal framework within which these activities will occur is provided, in part, by the Nuclear Waste Policy Act.[2] The basic environmental criteria are provided by the Environmental Protection Agency (EPA), which has issued some preliminary drafts of regulations concerning the disposal of high-level waste (HLW).[3] The NRC has provided further details of its requirements in NRC regulations[4] that must be compatible with the broader EPA umbrella requirements. Although the details of the regulations are still evolving, some of the characteristics are already evident.

Two important, materials-related NRC regulations concern the release of radioactive elements from the engineered waste package. During the first 300-1000 years following closure of the repository, the NRC regulations require that containment of HLW within the waste package will be substantially complete. Also, the release of radionuclides from the engineered-barrier system following the containment period is limited to less than 1 part in 100,000 per year of the majority of the inventory calculated to be present after 1000 years of radioactive decay.

MATERIALS DATA AND THE LICENSING PROCESS

The NRC regulations, in turn, are translated into more specific performance requirements of the components of the waste package, i.e., the metallic waste containment (e.g., the canister), the waste form (glass, ceramic, spent fuel), backfill, and host rock. These requirements are based on the state of knowledge of the various repository environments in which the waste package is expected to perform, e.g., temperature, radiation fields, lithostatic and hydraulic pressures, groundwater compositions, etc. The repository projects of DOE consist of the studying of a variety of geologic formations and have described, as well as they are able, the repository environments that the waste packages are expected to encounter and how the environments are expected to vary with time.[5,6,7] This information is used to formulate testing programs to obtain key data needed for licensing purposes.

Because of the extended time over which performance of materials needs to be assured, additional tools in the form of accelerated testing and mathematical models are needed. Well-formulated models based on fundamental understanding of the pertinent physical and chemical principles can be used to perform sensitivity analyses that define the precision and accuracy requirements for input data. Alternatively, the reliability of the output of the model can be defined as a function of the quality of the input data. It follows that the precision and accuracy of input data must be known in a quantitative sense for proper assessment and interpretation of the output of even the best models. Note that this does not require per se highly precise or accurate data, but does require the quantified knowledge of those characteristics. The NRC regulations make explicit reference to the fact that "...it is not expected

that complete assurance that they [performance objectives and criteria stated in unqualified terms] will be met, can be presented. A reasonable assurance...that the objectives and criteria will be met is the general standard that is required...."[8]

It is reasonable to expect that the NRC, in reviewing the documentation associated with a license application, will consider with great care the key data submitted, including the defined boundaries within which the data are known to be valid, their quality, and the quality of the associated models used to predict performance. As the licensing proceedings are carried out in the public domain, submittals will not only be subjected to the scrutiny of the NRC, but also to the scrutiny of the scientific community and the public, including those who have developed, with practiced skills, an uncanny ability to detect flaws in submitted evidence. It is evident that the customer for key data is not the DOE waste management community, but the NRC and the general public. Thus, the public nature of the licensing process, coupled with broad scientific scrutiny, impinges directly on those groups within DOE that are charged with developing the data base for licensing.

The importance of high quality, credible, and defensible information for licensing was recognized by DOE, and led to the establishment of the Materials Characterization Organization (MCO).

MATERIALS CHARACTERIZATION ORGANIZATION

The MCO's two principal components are the Materials Characterization Center (MCC) and the MRB. The former, located at Pacific Northwest Laboratories, is charged with the collection, development, and codification of those test methods needed to obtain the key data for licensing purposes. Inherent in this charge is extensive interaction, principally with repository projects, but also with waste developers and others, for identification of key data and for applicable test methods that may exist. The MCC's second function is that of a clearing house for key materials data, also regardless of source. Both test methods and test data are submitted by the MCC to the MRB for approval actions. Approved test-method and data submissions, along with other pertinent material, are then incorporated into the Nuclear Waste Materials Handbook.

THE FUNCTION OF THE MATERIALS REVIEW BOARD

The function of the MRB is to provide assurance that essential waste package materials test methods and related data are objectively developed and are technically valid. Of prime importance to the successful operation of the MRB is its independence and its makeup of prestigious and technically qualified experts who are respected by their colleagues. The DOE, together with the Chairman of the MRB, has sought to assemble such a group of experts drawn from a broad spectrum of technical disciplines, and has gone to great lengths to assure that the usual tests of credibility and independence have been met. The Chairman and the secretariat of the MRB are located at Argonne National Laboratory.

The data and test methods are subjected by the MRB to a thorough and structured scientific review process that results in rejection, provisional approval, or full approval. It is clear that the MRB functions in an adversary capacity, similar to that of a referee for a journal. Its ultimate efficacy will be determined by the users of the Handbook and the technical community at large. Preliminary and informal indications are that the functions of the MRB, as currently carried out, are in accord with the expectations of the appropriate licensing office of the NRC.

MRB MEMBERSHIP

The members of the MRB are drawn from a variety of scientific and organizational groups that provide a balance of technical disciplines and provide the background and experience of several interest groups. Five members are from the academic community; three from industry; nine from DOE laboratories; one each from the National Bureau of Standards, the NRC, and the MCC; and the Chairman. The following scientific disciplines are represented on the Board: metallurgy (4), ceramics/glass science (3), chemistry of waste management (7), geochemistry (3), corrosion and materials science (3), and solid state physics (1).

The MRB is divided into two panels: the Test Procedures Panel and the Data Release Panel. Their roles are described below.

MRB REVIEW PROCEDURE

All submissions to the MRB come through the MCC, including those having a non-MCC origin. The MCC, which is most knowledgeable of MRB requirements, is responsible for the contents and format of the submission package. The normal progression of a submission is first to the Office of the Chairman (OTC), then to the appropriate Panel (Test Procedures or Data Release), and finally to the full MRB. At all three levels, a submission is reviewed according to existing codified standards. At each level, a submission may be returned with cause to the MCC for changes, additional information, or clarification. The review by the OTC seeks to rectify significant omissions and deviations from the codified standards of review. At the Panel level, a positive vote of three-fourths of the membership is required for approval. At the full Board level, a two-thirds positive vote is required. At both levels, dissenting members are required to state in writing their technical reasons for casting a negative vote. The complete record of a ballot, including all written dissensions, is forwarded to the MCC and to all members of the Panel/Board. This information is of special significance to the resolution of negative votes in subsequent ballots.

CRITERIA FOR REVIEW AND APPROVAL OF TEST METHODS OR DATA

Several codified documents have been prepared to guide the MCC in preparing its submissions to the MRB, and to guide the members of the MRB and its Panels in reviewing the submissions. These documents follow the normal and expected methods of scientific scrutiny, and represent disciplined and controlled approaches to the critique of test methods and test data.

In submissions of test methods, the MCC is required to provide indications of the underlying science of the method, the relevance to repository conditions and waste acceptance criteria, the precision and accuracy of the method, the specific procedural steps that must be followed, the general analytical requirements, etc. Of particular importance is the requirement to define the uses and limitations of the data to be obtained by application of the test method. These requirements are very important to the establishment of the utility of the test data and serve to provide guidance (and warnings) concerning the range of applicability of the data obtained.

In submissions of materials data, the data package must contain the expected details of the procedure, the original data, and the appropriate calculated results. In addition, the MRB reviews comparisons between the new data and results reported in the literature on the same or similar systems. Differences between expected results and actual results require explanations. Of major importance in data packages are detailed evaluations of the statistics of data, and comparisons between results on approved reference materials (and other standards) and those expected on such materials. The latter comparisons have been provided in the MCC/MRB system to give assurance that the data were obtained by reliable experimenters under appropriately controlled conditions.

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Although the details--and, in most cases, even the broad outline--of NRC requirements for a license application have not been promulgated, some indications are available.

By way of example, we cite Ref. 9, which states:

> To demonstrate compliance with the performance criteria, the quality and quantity of evidence, the test methods used to obtain the evidence, the statistical analysis of the data, the predictive models, and the rationale for the conclusions must be judged acceptable.
>
> When designs become available... guidance to the applicant can be provided by listing the tests, test procedures, and ranges of acceptable and unacceptable results that might be used....

Thus, the principal value of the Handbook is its source of high quality and very well circumscribed data intended for use in the deliberations of the NRC concerning the licensing of a nuclear waste repository. All approved data contained in the Handbook, regardless of the source, can be used with confidence within the framework of stated limitations of application and of stated precision and accuracy. The user can be assured that the procedures used to obtain the data have been followed, that control of critical parameters have been exercised in a specified manner, and that measurements were taken with appropriately standardized references. Where deviations from specified procedures have occurred, there is assurance that the effects of ddviations are known and have been taken into account.

COMPARISON OF THE MRB PROCESS WITH THOSE OF THE VOLUNTARY-CONSENSUS SYSTEM

The methods of operation of the MCC/MRB system can be compared with those of the voluntary-consensus system culminating in American National Standards Institute (ANSI) approval on four principal bases: levels of approval, the method of handling dissenting votes, demonstration of consensus, and the formal approval of test data.

In the voluntary-consensus system, final approval is given by the ANSI Board of Standards Review, which considers principally the demonstration of consensus. Technical content is judged at subsidiary levels within an ANSI-approved National Standards Committee or a committee operating under an ANSI-accredited organization, such as the American Society of Testing and Materials (ASTM), American Nuclear Society (ANS), American Society of Mechanical Engineers (ASME), etc. Considerable effort is devoted to the resolution of dissenting votes. The full voting record at each level, including dissensions and their resolutions, moves from one level to the next. Approval requirements at a level vary from a simple majority to 90% of all votes.

In general, test data obtained from approved test methods and procedures are not considered in the voluntary-consensus system. However, data of specific types are critiqued and approved by other specialized peer review groups, then published and updated. Examples in the DOE programs are the Nuclear Systems Materials Handbook and the Materials Handbook for Fusion Energy Systems.

In the case of the MRB, there is only one approval organization, but three levels of approval within it: the OTC, the concerned Panel, and the full Board. Like the voluntary-consensus system, explanations are required for dissenting votes. Complete documentation (including dissensions and explanations) of all ballots is submitted to the next approval level. Thus, members are informed in detail of past actions and may be persuaded by the arguments of dissenters.

In the MCC/MRB system, the burden of demonstration of consensus is assigned to the MCC, which uses several methods: conducting workshops with a broad spectrum of attendees from interested organizations, conducting round-robin tests using candidate test methods, and conducting informal surveys of scientists in the field. The evidence is included in MCC submissions to the MRB.

Unlike the voluntary-consensus system, the MRB also approves test data. As a basis for judging test data, experimenters may be required to perform tests using specified reference materials, usually prepared, characterized, and available from the MCC. An experimenter's data are considered suspect if data using such reference materials deviate excessively from accepted values.

The method of operation of the MCC/MRB system usually results in approval times that are considerably less than those of the voluntary-consensus system.

CONCLUSIONS

The DOE has established an organizational structure that assures the quality of key data identified as being important to the licensing of a nuclear waste repository by the NRC. The MCC collects and/or develops the test methods needed to obtain the data, and acts as a clearinghouse for the data obtained. The MRB reviews both test methods and test data submitted to it by the MCC, and approves them if they meet the criteria and standards of high quality that have been established. The methods used in the review are sufficiently rigorous and in accord with the provisions of the NRC licensing approach; thus, the resulting Handbook can be used by DOE with assurance that scientific scrutiny by others will affirm the conclusions reached.

The appearance of test methods and test data in the Nuclear Waste Materials Handbook is evidence that the material has undergone intensive review and can be used with confidence within the bounds of applications specified. Its principal use is for licensing of the DOE repository.

REFERENCES

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