QUALITY ASSURANCE FOR GEOLOGIC INVESTIGATIONS

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ABSTRACT

A quality assurance handbook was written to provide guidance in the application of quality assurance to geologic work activities associated with the National Waste Terminal Storage (NWTS) Program. It is intended to help geoscientists and NWTS program managers in applying quality assurance to their work activities and projects by showing how technical and quality assurance practices are integrated to provide control within those activities and projects. The use of the guidance found in this handbook should help provide consistency in the interpretation of quality assurance requirements across the various geologic activities within the NWTS Program. This handbook also can assist quality assurance personnel in understanding the relationships between technical and quality assurance practices. This paper describes the handbook.

INTRODUCTION

The U.S. Department of Energy (DOE) has established the National Waste Terminal Storage (NWTS) Program to develop necessary technology and to qualify sites for disposal of commercially generated high-level radioactive wastes. Establishing the geochemical, geophysical, and hydrological properties of potential geologic repository sites for that waste is the principal task of the scientific investigations associated with site characterization. Much of the data and information obtained from those investigations will become the technical bases upon which site selections will be made. Thus, the quality and uniformity of the data are extremely important. Because faulty or inadequate data can result from many causes, control must be established over all potential sources of loss and failure throughout the lifetime of each investigation. Quality assurance helps to provide the necessary controls.

The DOE, as it carries out its responsibility to administer the NWTS Program, requires that quality assurance be applied in an effective manner across the program. The Nuclear Regulatory Commission (NRC), as it carries out its responsibility to license repositories, assesses the safety of the repository design and compliance with regulatory requirements. The effectiveness of NWTS quality assurance programs is a major factor in NRC's assessment.

With today's intensive national attention to nuclear activities, there is great public concern about nuclear waste. There must be, therefore, well understood and accepted quality assurance programs established within the NWTS Program to provide necessary control over NWTS activities and consistency across all activities. Practices must be so defined and established that both the technical participants and other affected or interested observers (state and federal agencies, intervenors, and the public) are assured of adequate protection against the adverse effects of loss and failure. In particular, the public must be assured that its health and safety are protected. It is important, therefore, that geoscientists involved in the NWTS Program not only use sound geotechnical practices in their work activities, but that they also augment those practices with suitable quality assurance practices. This paper describes a new approach for applying quality assurance to geologic investigations.

COMMUNICATING CONCEPTS OF QUALITY ASSURANCE

A significant problem with applying quality assurance to geologic investigations has been the difficulty in communicating between the geotechnical and quality assurance communities on technical and quality assurance concepts. A key factor influencing the difficulty is the quality assurance standards used within the nuclear industry. They were written for activities such as the design, construction, and operation of nuclear facilities, particularly nuclear power plants. The specific standard preferred by DOE for use in waste programs is ANSI/ASME NQA-1, "Quality Assurance Program Requirements for Nuclear Power Plants." The geoscientists generally reject the relevancy of this standard to geotechnical activities.

The NQA-1 standard is considered relevant, however, because the logic applied to controlling the design, construction, and operation of nuclear power plants to avoid losses and failures is applicable to all types of work activities. Attempts to assist geoscientists in understanding quality assurance by interpreting the requirements of NQA-1 have helped, but they have not been entirely satisfactory because the format and language of NQA-1 have been retained. Another approach has been devised in which nine principles of quality assurance that are readily associated with geotechnical activities have been developed based on the requirements of NQA-1.

A handbook was written based on the new approach. The handbook is intended to help geoscientists and NWTS program managers in applying quality assurance to their work activities and projects by showing how technical and quality assurance practices are integrated to provide control within those activities and projects. The use of the guidance found in the handbook will help provide consistency in the interpretation and use of quality assurance across the various geologic activities within the NWTS Program. The handbook also can assist quality assurance personnel in understanding the relationships between geotechnical and quality assurance practices.

HANDBOOK ON QUALITY ASSURANCE

The handbook has three chapters and three appendices, as shown in Table I. Basic guidance is provided by the three chapters. In Chapter 1, the role of quality assurance in obtaining quality data and the importance of such data are discussed. Chapter 2 presents the principles of quality assurance in terms of practices that can be used in controlling work activities to assure the acquisition of quality data. Chapter 3 describes a process for applying quality assurance to geologic work activities. The appendices provide supplemental information to give the users a better understanding of the following: why quality assurance is required; where quality assurance requirements come from; how those requirements are interpreted for application to geologic investigations; and how the principles of quality assurance relate to various geologic work activities. The supplemental information in Appendix A is a review of the DOE and NRC policy and governing documents that require the use of quality assurance in the NWTS Program. Appendix B presents the 18 Basic Requirements of the ANSI/ASME NQA-1 Standard and provides interpretations of NQA-1 requirements for application to geologic investigations. Appendix C provides examples of selected principles for typical geotechnical activities.

TABLE I. TABLE OF CONTENTS FOR HANDBOOK

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The key parts to this handbook are Chapters 2 and 3, which contain the nine principles of quality assurance developed for geotechnical work and a method for selecting appropriate principles for a specific project or work activity. The principles and the method are described in this paper by using excerpts taken from the handbook. Excerpts are used also to briefly describe the supplemental information found in the appendices.

PRINCIPLES OF QUALITY ASSURANCE

Quality assurance provides a planned and systematic approach for developing and applying actions necessary to assure the quality of output from work activities. Its use can help avoid omissions and oversights that could adversely affect quality. All scientific and engineering disciplines have established practices that provide control over various sources of loss and failure that can occur when carrying out experiments and studies. Such practices help to assure scientists that their activities are properly planned and executed so that useful (quality) data are obtained. Comparison of control practices used by scientists with quality assurance practices often shows that both types are clearly related. Thus, quality assurance is used by scientists to some degree whether or not they are consciously doing so. When a quality assurance program is implemented, established work practices are not replaced; rather they are supplemented as necessary to provide a complete quality program.

The quality assurance standard governing the NWTS Program is ANSI/ASME NQA-1, which is discussed in Appendices A and B. Based on NQA-1 requirements, nine principles of quality assurance have been identified for geologic investigations. The principles are presented in Chapter 2 and each is defined by describing practices that provide the control functions associated with the NQA-1 requirements upon which the principle is based. Table II is a list of these principles. The relationship between each principle and NQA-1 requirements is shown in Appendix B. Quality assurance programs developed for geologic investigations and based on these nine principles should provide a program that is in compliance with NQA-1. Each principle is summarized below.

TABLE II. QUALITY ASSURANCE PRINCIPLES FOR GEOLOGIC INVESTIGATIONS

PLANNING AND ORGANIZATION OF ACTIVITIES
PREPARATION AND CONTROL OF PROCEDURES
TRAINING AND QUALIFICATION OF PERSONNEL
CONTROL AND HANDLING OF SAMPLES
ACQUISITION AND PROTECTION OF DATA
PEER REVIEW
IDENTIFICATION AND CORRECTION OF DEFICIENCIES
USE AND CONTROL OF RECORDS
CONTROL OF PURCHASED ITEMS AND SERVICES

Planning and Organization of Activities

Planning and organizing work activities is identified as a principle because it is essential that there be a conscious and deliberate planning and organizing effort for each important work activity. Although this principle emphasizes a function that usually precedes the actual conduct of work, there is need to maintain a continuing planning effort until completion of a work activity. This need unfortunately can be too easily de-emphasized or overlooked, particularly during the work performance stages where cost and schedule priorities may dominate.

The primary purpose of planning and organizing is the clear and specific identification of work requirements and objectives. Planning and organizing should clearly identify objectives, participants, organizational interfaces, responsibilities, restraints or limitations, and the expected result of the work.

Preparation and Control of Procedures

Most work activities are carried out in a planned, systematic, and controlled manner so that the products or end results will conform to expected outcomes. The process used to produce such an outcome often involves discrete actions taken in a specific order. Any change in an action or in the order without a valid reason most likely will result in an unsatisfactory outcome. To control the processes and avoid errors leading to unsatisfactory results, procedures are written that provide guides for those doing the work. The significance of having a procedure for a specific activity depends on several factors such as the importance of the results to the overall success of the activity or larger project/ program, the degree to which an error has an adverse effect on the end result, the state of the training and knowledge of those doing the work, the need to document the process used, and the need to substantiate the technical basis of the process used. To be effective and to help provide credibility to the activity being performed, procedures should be well-written, complete, and correct. When procedures are required, their preparation and control should be based on the following concepts.

A formalized process for preparing procedures helps to promote well-written, complete, and correct procedures. The following elements should be included in the preparation process: format, criteria for writing and editing, review, and approval. Practices should be established to provide assurance that the adequancy of procedures is not adversely affected with time and use. This includes assuring that procedures are applied correctly when used. Criteria for the following elements should be included in the control process: distribution of procedures, application or use of procedures, revision of procedures, and qualification of procedures.

Training and Qualification of Personnel

An important factor affecting all work activities is the training and qualification of those doing the work. There are very few, if any, organizations engaged in work activities that do not provide some type of training. Training can vary from direct, on-the-job training by a more experienced worker to a formal program involving both classroom and on-the-job training. The extent of training required depends on the complexity of the work, education and previous experience requirements, the economics involved, and the overall importance of the work to meeting the goals of the organization.

Closely associated with training is the concept of qualifying people for a job before beginning work. Qualification includes not only specific training, but also the review and verification of applicable education and experience. Using adequately trained and qualified people should be a requirement for all geologic investigations. The extent of training required for a specific activity will depend on the factors mentioned above as well as on the importance of that activity to the licensing of a repository. Qualification of each person performing work activities should be certified by management.

Control and Handling of Samples

A source of data important to site characterization is the analysis and testing of geologic materials associated with a repository site. The reliability of the physical and chemical characteristics determined for each type of material depends on the validity of the processes used to analyze those materials and to make experimental tests. As important, or even more important, is the integrity[a] of the samples used. A widely recognized axiom states that results from analyses and tests are no better than the samples from which those results were obtained. Loss of sample integrity can occur from inadequate sampling procedures and from improper control and handling practices once the samples have been taken.

Practices for controlling and handling samples are divided normally into those associated with the sampling process, with the laboratory, and with in-field analysis and testing. Practices associated with the sampling process are those control and handling activities followed from the time a sample is obtained until those doing the sampling complete their final task, which can be putting the sample in storage, sending it to a laboratory, making in-field analyses, or some combination of these tasks. Criteria for the following practices should be established for the sampling process: identification, handling, storage, shipping, and records. Practices involved in controlling and handling samples in a laboratory begin with the receipt of a sample and continue until final disposition is made. Criteria for the following practices should be established in the laboratory: inspection, identification, records, handling, and disposition. Sample control and handling practices for in-field analysis and testing are very similar to those for sampling and the laboratory. An appropriate combination of practices from the two operations should be used, keeping in mind the precautions needed to avoid losing a sample, using a wrong sample, and destroying the integrity of a sample.

Acquisition and Protection of Data

The practices used to assure proper acquisition and protection of data are of importance to essentially all facets of geologic investigations. Data are interpreted to include any site-related measurements or recordable observations acquired as a part of geophysical, geochemical, or hydrological studies, plus the results of any associated laboratory analyses. In the broadest sense, data include any information generated for use in the technical assessment of site-related evaluations or experiments. The success of site explorations, experiments, or any of the R&D oriented site studies required to determine site suitability depends on obtaining data that are applicable, sufficiently accurate, readily identifiable, retrievable, and suitably preserved. To obtain quality data, control practices should be established that provide for the following: validity of technical concepts used, use of instructions and procedures, document control, identification of data, control of measuring and test equipment, control of inadequate or erroneous data, and records.

Peer Review

A way to validate practices is through independent peer reviews. Peer reviews can help validate technical adequacy and, perhaps more importantly, can validate the application of established practices. For those situations when practices are new or beyond the state-of-the-art, independent peer review is essential. Practices should be established that do the following: designate responsibility for planning and conducting peer reviews, define informal and formal peer reviews, determine when peer reviews are used, establish criteria for planning and conducting peer reviews, and provide for documenting peer reviews.

Identification and Correction of Deficiencies

Deficiencies include failures, defects, errors, deviations from specified requirements, and other conditions considered adverse to quality. Uniform and well-defined practices are required to assure proper control and disposition of deficiencies. These practices should emphasize the timely or prompt identification and correction of all deficiencies or conditions that might adversely affect the quality of continuing geologic investigations. It is important to evaluate deficiencies thoroughly so that actual causes can be determined and proper corrections can be made to avoid, or at least minimize, recurrences. There should be follow-up to verify that corrective actions have been taken.

[a]Sample integrity refers to the state of being reliable or suitable for the sample's intended use.

Use and Control of Records

The use and control of records are key in providing documentary evidence of technical adequacy and quality for all geologic investigations. Records provide the direct evidence and support for the necessary technical interpretations, judgments, and decisions for site selection. Records preparation and use must be an integral part of ongoing work activities. These records must directly support current or ongoing technical studies and activities and must provide the historical evidence needed for later reviews or analyses, particularly those which might be anticipated as a part of repository licensing.

There can be many acceptable methods for the use and control or management of records. The selected method or system should, however, include certain generally accepted features or practices. An effective system of records management must provide records that are legible, identifiable and retrievable. Also, the system must be well understood and accepted by those responsible for the activities being recorded. Practices that establish an effective records system include the following: records system definition and documentation, record validation, records identification and classification, and records distribution and storage.

Control of Purchased Items and Services

When needed items and services are not available on-site, purchase of those items and services is necessary. To obtain the necessary quality, procurement actions should follow uniform written procurement instructions that provide a systematic approach to the procurement process. It is essential that technical and quality requirements be properly evaluated and control practices be established according to quality needs. Evaluation should consider various factors, including cost and schedule effects, failure consequences, methods of acceptance, programmatic importance, and applicable codes or standards.

APPLICATION OF QUALITY ASSURANCE

Geologic investigations associated with site characterization, leading to site selection and NRC licensing of repositories, include a variety of work activities from which data are obtained and analyzed. The quality of data and the validity of the analyses will have a significant influence on the site selection and licensing processes. Attaining acceptable quality will depend, of course, on how well those work activities are performed. The application of appropriate principles of quality assurance will assist in achieving adequate performance, particularly if those principles are effectively integrated into the work activities.

As described in Chapter 2, nine principles of quality assurance have been identified for geologic investigations. Chapter 3 illustrates a process for applying the principles to individual work activities. Application requires a knowledge of the activity's objective(s), work tasks, constraints, potential sources of loss and failure, and the consequences of loss and failure. Also required is an understanding of the principles and how they are used.

The process has four steps. The first is to define the technical and programmatic objectives and requirements of the work activity. The second is to identify sources of risk within the work activity and then to evaluate those risks in terms of probability and consequences. The third step is to select the principles of quality assurance that will provide the control needed for successful completion of the activity. These steps should be carried out early so that quality assurance can be more effectively integrated into the work. The fourth step is implementing the selected principles. Examples of principles selected for various geologic activities are given in Appendix C. The examples are presented on a generic basis and they are not intended to be applicable to specific NWTS projects.

A hypothetical example is included in Chapter 3 to illustrate how each step in the selection process can be used. The example is based on laboratory work done to characterize core samples. No research activities are involved. The laboratory is functioning as a service or support laboratory using established procedures.

SUPPLEMENTAL INFORMATION

The purpose of Appendix A is to provide information about the DOE's QA policy and governing documents, to discuss their impact and relevance to the NWTS Program, and to present and discuss briefly the NRC's documents applicable to the NWTS Program. Within DOE, there is a hierarchy of QA documents that begins at the Headquarters level and progresses down through the field offices to DOE contractor organizations. The top-level document includes QA policy and general requirements, which are extended in more specific terms to lower levels by guidance letters and field office orders. Guidance includes indicating the preferred national QA standard or standards that should be used when planning and implementing quality assurance. The NRC will license nuclear waste repositories associated with the NWTS Program. Various documents issued by the NRC provide NRC's QA requirements for licensing. The principal document is 10 CFR 60, "Disposal of High Level Radioactive Wastes in Geologic Repositories." It has several subparts covering the various aspects of licensing. Subpart G prescribes quality assurance requirements and designates where quality assurance will be applied, which includes those activities associated with site exploration and selection. Other NRC regulatory guides and branch technical positions may become applicable to the licensing of repositories. Branch technical positions are internal NRC criteria used to evaluate the adequacy of documents submitted during the licensing process.

To assist individuals in understanding the relationship between the principles of quality assurance presented in Chapter 2 and the NQA-1 standard, the eighteen basic and supplementary quality assurance requirements from NQA-1 are reviewed in Appendix B. The basic requirements are quoted verbatim from the standard and the key elements of each are given. In addition, a brief discussion regarding application to NWTS geologic investigations is given for each. DOE has established that NWTS QA programs will be in conformance with all basic and supplementary requirements of NQA-1 with certain additions and modifications. Specific NWTS additions and modifications are identified in the discussions. A table at the end of Appendix B provides a summary of the relationships between the basic requirements of NQA-1 and the principles of quality assurance identified in Chapter 2.

Chapter 3 uses a hypothetical geologic work activity to illustrate the selection process for determining the quality assurance principles applicable to a typical geologic work activity. The output from that selection process provides a matchup of work tasks and applicable quality assurance principles. Appendix C provides selected QA principles for nine other generic geologic activities. Although each NWTS geologic investigation will have individual and unique characteristics, one or more of the examples in the appendix should be reasonably representative of many project or site activities.