THE DOE WASTE ACCEPTANCE PROCESS AND PRELIMINARY SPECIFICATIONS FOR THE DEFENSE WASTE PROCESSING FACILITY AND THE WEST VALLEY DEMONSTRATION PROJECT

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ABSTRACT

The Office of Civilian Radioactive Waste Management (OCRWM) has established a process to identify the minimum acceptable requirements for disposal of high-level wastes in a deep geologic repository. The overall process has been designed to establish generic requirements for any reprocessing facility; however, the first application of the process specifically addresses those facilities which are on schedules for waste form production prior to repository license application. There are currently two facilities which are scheduled to start production prior to submittal of the license application for the first repository. The West Valley Demonstration Project (WVDP) will start hot operations in 1st Qtr, FY 90 and the Defense Waste Processing Facility (DWPF) is scheduled to start hot operations in the 3rd Qtr, FY 90.

This paper describes the Waste Acceptance Process used by the Department of Energy (DOE) to establish the required documentation which is used to support the license application, and addresses the rationale for the repository acceptance requirements for the DWPF and WVDP waste forms. The key specifications on the canister and waste form are described. Additionally, information on the radionuclide release property requirements and the role of OCRWM in assessing the waste producers' quality assurance programs is discussed.

INTRODUCTION

The Nuclear Waste Policy Act (NWPA) of 1982 charges the Department of Energy (DOE) with responsibility for siting, designing, licensing, constructing, operating, and permanently closing a mined geologic disposal system (MGDS) for high-level nuclear waste and spent nuclear fuel. The Office of Geologic Repositories (OGR) within the DOE's Office of Civilian Radioactive Waste Management (OCRWM) has the primary responsibility for the MGDS. The MGDS consists of the waste package, the engineered features within the repository and the geological environment.

As a component part of the waste package the waste form may be required to play a role in meeting the overall performance objectives of the repository. The two types of wastes currently planned for disposal in the first geologic repository are spent nuclear fuel and vitrified high-level wastes (HLW). Both wastes are characterized by large amounts of concentrated fission products with resulting heat loads. For the purposes of this document, the discussion will focus on the vitrified HLW produced from reprocessing of spent fuel.

There are two facilities which are scheduled to vitrify HLW in the near future for permanent geologic disposal: the Defense Waste Processing Facility (DWPF) located in Aiken, S.C., and the West Valley Demonstration Project (WVDP) located in West Valley, NY. Both facilities will use borosilicate glass as the waste form matrix. The waste which will be processed at the DWPF has been generated from weapons materials production at the Savannah River Plant over the past 40 years. The DWPF is under construction and is scheduled to start processing operations in third quarter fiscal year 1990. The plant will produce approximately 410 canisters per year for the first fifteen years with a total of 8,000 canisters. Each canister will be .6 meters in diameter and 3 meters long. Each canister contains about 1480 kgs of glass. The WVDP will solidify the liquid HLW remaining at the former commercial nuclear fuel reprocessing plant at West Valley, New York. The WVDP will be a two year campaign, scheduled to start in first quarter fiscal year 1990, producing about 300 canisters of waste glass. The canisters are approximately the same size and weight as the DWPF canisters. The waste at both facilities is stored onsite and exists as sludge, supernatant, and in the case of DWPF a saltcake. The majority of the radioactivity is in the sludge except for cesium isotopes which are in the supernatant. The DWPF and WVDP have different process steps: for example, the cesium is removed from the supernatant through a precipitation process at DWPF and by ion-exchange at the WVDP, but the final products have very similar characteristics. Consequently, the requirements for waste acceptance are essentially the same for both facilities.

The production schedules of the first two HLW processing facilities, however, do not coincide with the formal process for licensing the first repository by the Nuclear Regulatory Commission (NRC). Therefore, it was necessary for the DOE to develop a process for identifying the minimum requirements for acceptance of wastes produced by facilities which start production prior to repository license application. The Waste Acceptance Process outlines the documentation which will be required to provide the confidence that waste forms produced prior to repository licensing will be acceptable for disposal, and is also the basis for

establishing the generic requirements for future waste producers. The purpose of this paper is to describe the DOE Waste Acceptance Process and the Waste Acceptance Preliminary Specifications for the first two HLW production facilities.

WASTE ACCEPTANCE PROCESS

The Waste Acceptance Process (WAP) has been designed to identify the required documentation and activities to establish the minimum acceptable requirements for disposal of wastes, other than spent fuel, in any of the candidate repository media. The basis for the specifications are regulatory requirements and other repository system design criteria. Geologic repositories for disposal of HLW are required to be licensed by the Nuclear Regulatory Commission (NRC) and must meet the appropriate regulatory requirements. Specific performance objectives on waste packages and the engineered barrier system are contained in Title 10, Code of Federal Regulations, Part 60, "Disposal of High-Level Radioactive Wastes in Geologic Repositories" (10 CFR 60.113 and 60.135), and the requirements for cumulative releases of radionuclides to the accessible environment are provided in Title 40, Code of Federal Regulations, Part 191, "Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes" (40 CFR 191). System requirements for the waste package and engineered barrier systems are contained in "Generic Requirements for a Mined Geologic Disposal System" OGR/B-2 dated September 1984, and site-specific repository system design requirements prepared by each of the three candidate first repository sites. The regulatory requirements and system requirements on the waste package and engineered barrier system result in derivative requirements on the waste form which establishes the need for waste form specifications and tests.

The time line diagram for the HLW production facilities, Fig. 1, shows that the first two HLW production facilities are scheduled to begin production in the early part of fiscal year 1990 (WVDP) and mid-fiscal year 1990 (DWPF). The WVDP schedule is based on agreements with the state of New York for processing the waste and a desire to avoid costs of about 15 million dollars per year for maintaining of the site for each year that decommissioning is delayed. The decision to fund the DWPF was based on avoidance of the need for additional waste tanks, and the need to deal with potential environmental problems on a timely basis. The other two defense HLW production facilities, Hanford, Washington and at the Idaho National Engineering Laboratory facility, are scheduled for start-up in fiscal year 1995 and fiscal year 2008, respectively. The repository siting and licensing schedule is to select the repository site and submit a license application to the NRC in fiscal year 1995. Therefore, two HLW producers will start production prior to the application for the repository license. To avoid having waste forms produced which could cause problems with repository design and waste acceptance, the DOE has developed the Waste Acceptance Process (WAP) to provide guidance to waste producers and to identify the steps which will be required for demonstrating the acceptability of a waste form for disposal in a repository.

There are three DOE organizations involved in the Waste Acceptance Process: the repository projects, the OGR Headquarter's repository program, and the waste producers. The first step in the process is the development of repository site-specific waste acceptance requirements documents which describe minimum requirements for acceptance of generic waste forms. The repository site specific requirements are to be used by OGR to develop a generic repository requirements document for generic waste forms. This document would represent the minimum acceptable

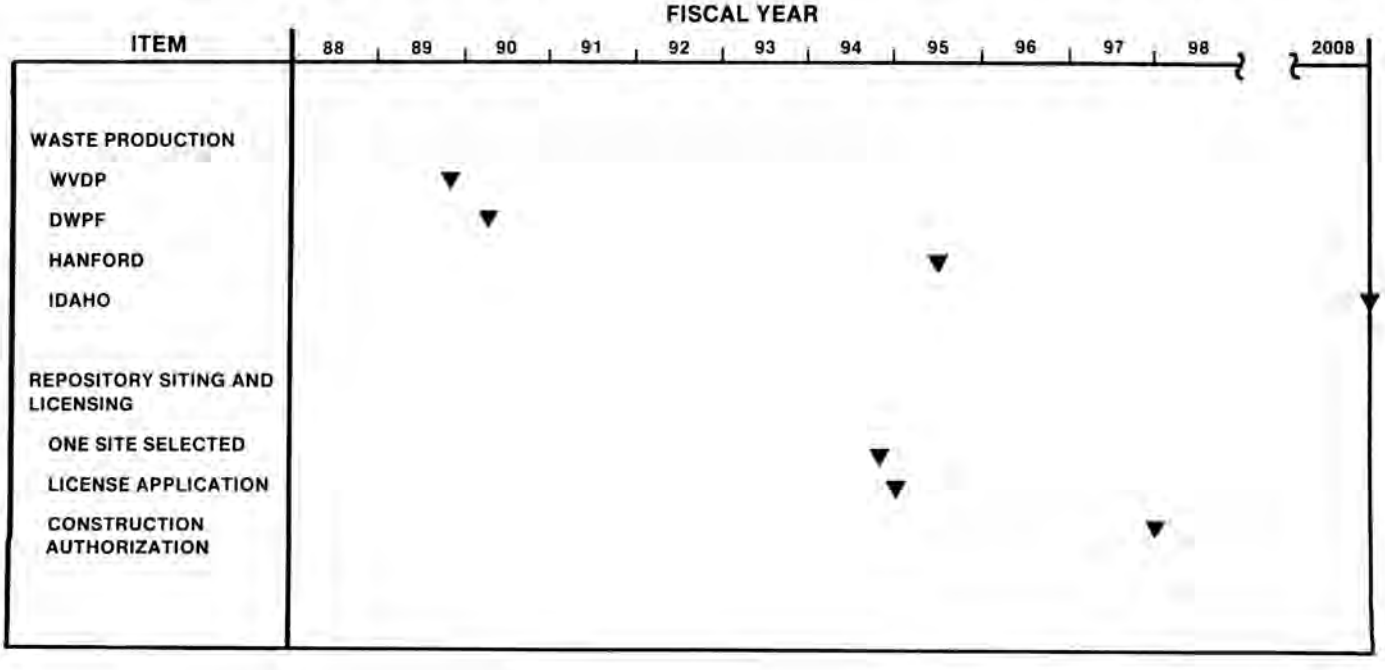

Fig. 1. Waste Production and Repository Schedule.

requirements for a generic waste form for disposal in any of the candidate repository media. A future waste producer could use this document as guidance for development of a waste form, and submit a waste form description document as a proposal for meeting the generic repository requirements. The waste form characteristics are added to the OGR Generic Requirements Document (OGR/B-2) which is the basis for repository design. The repository projects develop testing programs, (described in Site Characterization Plans) which provide the repository site specific waste form performance data for licensing. As part of the development of the Site Characterization Plans (SCP's) the repository projects assign performance allocations to the waste form and other parts of the MGDS.

The repository site specific Waste Acceptance Specifications provide a greater level of detail than the generic waste acceptance requirements and addresses a specified waste form (e.g., borosilicate glass) and a specific waste producer (e.g., DWPF). The individual repository site requirements for a specific waste form and specific waste producer are combined into an OGR baselined document called the Waste Acceptance Preliminary Specifications (WAPS). The WAPS identify the minimum requirements which ensure that a specific producer's waste form will be acceptable for disposal and include constraints which will require that the performance expectations from the test programs are applicable to the actual product. The WAPS for DWPF and WVDP are the first produced by the waste acceptance process and are discussed in greater detail below.

Continuing with the Waste Acceptance Process, the waste producer develops a Waste Compliance Plan, which provides a detailed description of the test methods and process controls planned to achieve compliance with the WAPS. Compliance will be demonstrated in the waste producer testing programs, which are documented in a Waste Qualification Report, that is reviewed and concurred on by the repository projects. The Waste Qualification Report is used with information from site characterization and becomes part of the licensing data base. This data base will be used to provide information for site selection and repository licensing and, in the case of DWPF and WVDP, will assist in providing DOE with the confidence in waste form acceptability as part of the decision making process for facility start-up. After repository site selection the WAPS will be updated and will become part of the repository license application. Following the completion of the repository licensing, the specifications will be finalized to incorporate any requirements which may evolve through the licensing process. The final specifications, and the waste form production records, will be the basis for acceptance of the product for disposal in the repository.

The above process for waste acceptance is intended to provide a broad approach for a wide variety of waste producers. At the time the process was finalized the activities associated with the development of documentation to support the activities of DWPF and WVDP had progressed significantly. The primary difference, however, is that the generic waste acceptance requirements have not been completed. Thus, the repository testing programs and the site specific waste acceptance specifications for DWPF and WVDP have been based directly on the regulatory and disposal system requirements and not formally on a generic requirements document as envisioned by the Waste Acceptance Process. After the WAPS for DWPF and WVDP have been issued, DOE plans to use the experience gained while developing the preliminary specifications to develop generic requirements to guide all future waste producers in strict accordance with the process.

The vehicle used to implement the WAP is the Materials Steering Committee which is composed of DOE representatives from the repository projects and the waste producers. The Materials Steering Committee is responsible for reviewing the draft OGR documents generated by the Waste Acceptance Committee, and coordinating comments among the DOE Field Offices. The Waste Acceptance Committee is a technical working group of contractor representatives of the various repository projects and waste producer activities responsible for generating the detailed waste acceptance documentation. A schematic of the waste acceptance organization is shown in Fig. 2.

The NRC has the responsibility for repository licensing and is in a position to provide valuable input with regard to waste acceptance at appropriate points prior to licensing. The early involvement of the NRC has been initiated and comments on the WAPS have been incorporated into the specifications for DWPF and WVDP. The NRC also will have the opportunity to review the waste producers' waste compliance plans and qualification reports, in addition to their reviews of the repository site characterization plans and testing programs.

WASTE ACCEPTANCE PRELIMINARY SPECIFICATIONS

Background

The Waste Acceptance Preliminary Specifications (WAPS) for DWPF and WVDP, as discussed above, are the first to outline the minimum acceptable requirements for disposal of HLW in any of the three candidate first repository media. Where possible, the WAPS are the generic requirements for all three first repository projects. However, in one case, the radionuclide release specification, a generic specification was not adequate to address the compliance requirements due to the fundamental differences in the repository media. In this case, repository site-specific requirements for radionuclide release performance are being prepared.

The specifications in the WAPS are based on the regulatory requirements placed on the disposal system and additional requirements which are needed for the design of the repository to ensure safe handling and disposal. In this regard, the requirements which are currently represented in the specifications, in most cases, apply to the waste at the time of receipt at the repository. And, due to the similarity of the DWPF and WVDP waste forms, the specifications will be discussed as if the requirements were the same for both facilities, while in reality there are minor differences.

The WAPS are based on the best currently available information and will be revised as the site characterization and repository design programs proceed to provide additional information for the license application. As described previously, the WAPS will evolve into the updated Waste Acceptance Specifications which will be used for the license application and will not become final until the license is approved and applicable NRC licensing technical requirements are incorporated into the specifications.

The specifications have been organized into four sections: the waste form, the canister, the canistered waste form, and the quality assurance requirements. The waste form is the radioactive waste materials and

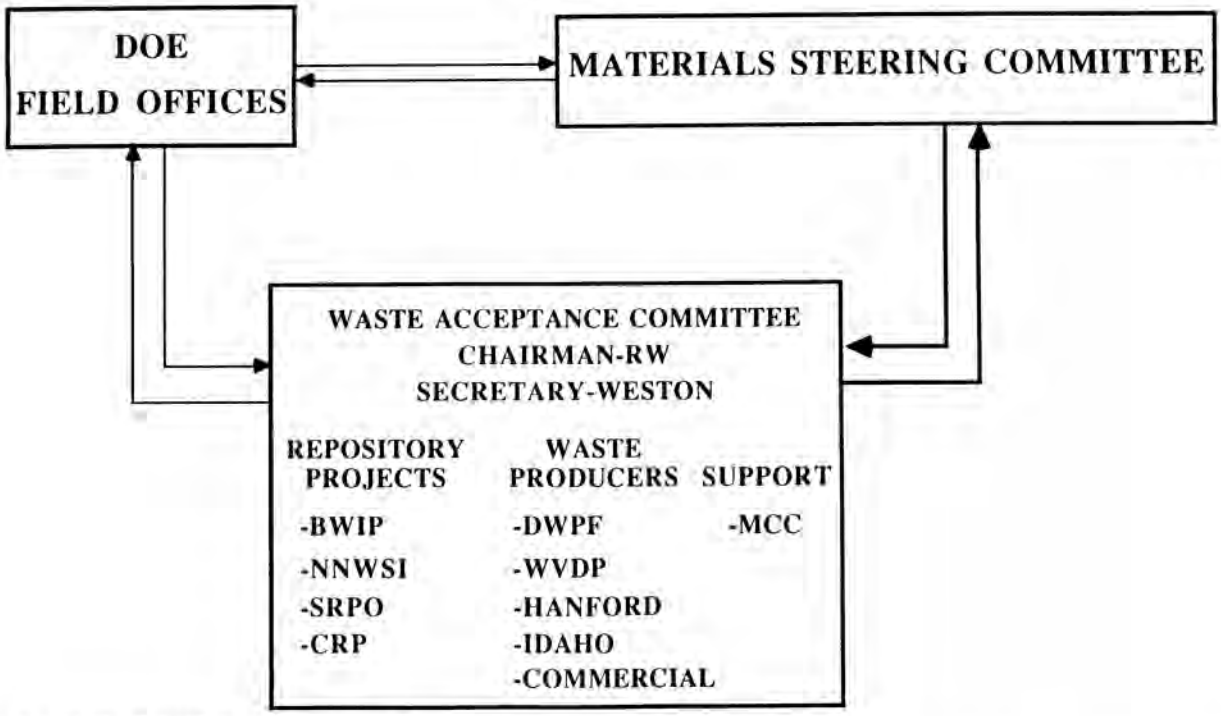

Fig. 2. Waste Acceptance Organization.

any encapsulating or stablizing matrix. In the cases of DWPF and WVDP, the waste form is borosilicate waste glass. The canister is the metal vessel into which the borosilicate waste glass is poured during waste form fabrication. The canistered waste form is then the waste form and the surrounding canister. The quality assurance requirements were separated into one section for applicability to all parts of the specification.

Waste Form Specifications

The waste form specifications identify the requirements for information on the composition and performance of the waste form. The chemical composition of the waste form is needed to characterize the elemental and crystalline phases of the product. Chemical elements present in concentrations greater than .5% by weight are required to be identified and quantified. The total radionuclide inventories of the producers' wastes are needed to establish the waste producers' contributions to the repository source term for compliance with cumulative release standards. The radioisotopes of concern have concentrations of .05% or greater of the total curies present at any time up to 1100 years and half lives greater than 10 years. The minimum concentration of .05% is needed to ensure that all isotopes of possible consequence to safety and isolation analysis are included. This value is currently held in reserve pending the development of the repository site characterization plans; however, the current limit provides a factor of 2 reduction with respect to the .1% limit of isotopes which must be considered in meeting the 10 CFR 60.113 release rate criterion. The half-life limits of 10 years allows pre-closure exposure and accident concerns to be addressed. The 1100 years is based on a 1000 year containment period plus 100 years for the repository operating period. This specification requires the waste producer to provide estimates of the total quantity of radionuclides to be shipped to the repository, estimates of the average inventory in each canistered waste form, and the expected variations in the inventories to ensure that the full range of isolation assessments and unanticipated process events can be adequately addressed. To provide consistency, the total radionuclide inventories are required to be indexed to the year 2025, which was chosen as a reasonable date for completion of emplacement operations at the first repository. The key elements of the composition specification requirements are provided below:

- Chemical Specification
  1. Characterization of the elemental composition and crystalline phases
  2. Elemental composition for elements with concentrations | .5%
  3. Expected variations
  4. Method of compliance in the WCP
  5. Characterization data in the WQR
  6. Documentation concerning actual canistered waste form to be provided in production records

- Radionuclide Inventory Specification
  1. Radioisotopes with half-lives greater than 10 years
  2. Concentrations | .05% of inventory up to 1100 years
  3. Inventory projections on total quantities and individual canistered waste forms indexed to year 2025
  4. Method of compliance in the WCP
  5. Characterization data in the WQR
  6. Documentation on actual canistered waste forms to be provided in production records

As discussed in the previous section, steps 4, 5, and 6 above are integral parts of the waste acceptance process. In general, a similar approach is used to

qualify the data from the waste producers on all the specifications. For the purposes of this report, these steps will be referred to in the future as the "waste acceptance process activities".

The data on the chemical and radionuclde composition also provide the information on the planned production to allow performance testing of representative material. The strategy for compliance would be developed by the waste producer providing an envelope which might represent the bounding and normal operating conditions under which the waste would be produced. The repository release performance testing could then cover the full range of products from expected operating conditions.

The heart of the regulatory compliance requirements deals with the release of radionuclides to the environment. Both the NRC and EPA have defined long-term radionuclide release in terms of the engineered barrier system and the mined geologic disposal system. The site characterization plans, as described previously, will specify the allocation of performance requirements among the various components of the engineered barrier system of which the waste form is one. A generic test which would be able to provide performance information on release of a waste form in each of the candidate repositories would be ideal; however, due to the fundamental differences in the site conditions, tests which are representative of actual repository conditions must be site specific. These tests are being developed along with the preparation of site characterization plans and will be made part of the specifications upon completion.

It is of equal importance to know that the radionuclide release properties of the waste form can be controlled during production and that there are no process functions which will have a negative effect on long-term performance. The specification places the responsibility of control of the process on the waste producer and the correlation of the site specific test results with the waste form performance requirements on the repository projects. The tests which are currently being considered by the repository projects have durations of 28 days to 6 months and are not considered suitable by the waste producer to evaluate process control. Therefore, the waste producers, while controlling the variables that are determined to be important in affecting the glass durability have an option to develop a correlation between those parameters and the repository site specific tests. If the waste producer can not make a suitable correlation, then data will be collected to show compliance with the repository specified test.

The other aspect of radionuclide release deals with the establishment of repository design limits to ensure adequate post-closure performance. Available data indicate that the borosilicate glass waste form will perform acceptably and predictably under repository conditions as long as the phase structures and compositions of the glass are unchanged. Additionally, the data indicate that neither energy input nor radioactive decay significantly affect radionuclide release from the waste glass as long as the temperature of the glass does not exceed the transition temperature. The waste producer is required to provide data on the transition temperature of the waste form, and time-temperature-transition (TTT) diagrams which identify the conditions that cause changes in the phase structure of phase composition of the waste form. The waste form samples representing the bounding conditions of temperature, duration of exposure, and waste form composition are subjected to the release properties test discussed above to ensure compliance.

The specifications which relate to waste form durability are summarized below:

- Specification for radionuclide release properties
  1. Control of radionuclide release properties during production
  2. Relate method of control to repository site-specific tests
  3. Compliance at time of production
  4. Verification of radionuclide release properties as required by waste acceptance process activities

- Specification for chemical and phase stability
  1. Provide data on the transition temperature of the waste form
  2. Construct time-temperature-transition curve for the waste form
  3. Radionuclide release properties to be provided over the same range of temperature and exposures
  4. Certification that the waste form during storage and transportation does not exceed the transition temperature
  5. Verification as required by waste acceptance process activities

Canister Specifications

The canister specifications focus on the metal vessel into which the borosilicate glass is poured during waste form fabrication. These specifications are intended to provide the repository information on the canister material, the fabrication methods, the canister identification, and the methods which will be used for canister closure. The repository must be able to evaluate long term performance of the canistered waste form in the repository environment, and the amount of information required to make the evaluation is proportional to the function of the canister as part of the engineered barrier system. The current role does not require the canister to act as a post-closure engineered barrier; therefore, the primary purpose of specifying a material is to ensure that the presence of the material in the waste package system is properly accounted for. By specifying austenitic stainless steel manufactured to an ASTM specification, this requirement is met. The rationale for a specification to address fabrication and closure is to evaluate the use of the canister to provide safe containment of the waste during handling and packaging in the repository container. The canister is also expected to act as a mechanism to prevent externally derived liquids from contacting the waste until it is sealed in the repository container. Regulatory requirements in 10 CFR 60 require that the waste package be identifiable. The canistered waste form is required to be labeled to ensure identifiability until the waste is enclosed in the repository waste package. Once the waste is enclosed in the repository disposal package, the burden of maintaining identity shifts to the waste package. The key elements of the canister specifications are provided below:

- Material Specification
  1. Fabricated from austenitic stainless steel
  2. ASTM alloy specification and composition
  3. Verification as required by waste acceptance process activities

- Fabrication and Closure
  1. Fabrication methods identified
  2. Closure to be leaktight (ANSI N14.5-1977)
  3. Verification as required by waste acceptance process activities

- Identification and Labeling
  1. Assign alphanumeric code
  2. Label of canister to be visible from top and side
  3. Verification as required by waste acceptance process activities

Canistered Waste Form Specifications

These specifications have been developed to provide information on the combined waste form and canister as units which will be shipped to the repository. Appropriate specifications cover questions on criticality, explosiveness, heat generation, dose rate, and criteria which address conditions which may compromise the ability of the waste package to achieve performance objectives. For example, the current specification requires that the waste producer show that the canistered waste form contains no free liquid that could be drained from the canister either initially or after having been subjected to temperatures up to the transition temperature. The purpose is to eliminate chemical interactions which could degrade the repository container from the inside, and to avoid potential spillage of contamination in the event of a canister-handling mishap. Additionally, there is a requirement for the waste producer to show that the maximum internal pressure does not exceed 7 psig to ensure that gas will not build up inside the container and contribute to the dispersion of radionuclides. A specification on organic materials has been added to ensure that organics which tend to mobilize radionuclides are not present. The free volume has also been limited for repository design considerations, to economize the repository space, and limit the amount of volume available for water to come in contact with the waste form after breach of containment.

There are requirements on the canistered waste form which limit the overall dimensions so that the repositories can design the handling devices and waste package requirements. The specification reflects the requirement to provide information about the lifting and handling devices of the canister to achieve compatibility with the repository handling systems. The canistered waste form is also tested to determine that a fall from a credible height during repository handling will not cause a breach after the drop. The repositories can then be designed to ensure that larger drops are not possible or that appropriate mitigating measures are included in the designs. The key elements of the canistered waste form specifications can be summarized below:

- Free Liquid Specification
  1. The canister shall not contain free liquid that can be drained from the canister
  2. The canister shall not contain free liquid after being subjected to temperatures up to the transition temperature
  3. Verification as required by waste acceptance process activities

- Gas Specification
  1. The canistered waste form shall not contain free gas other than cover and radiogenic gases
  2. The maximum internal gas pressure shall not exceed 7 psig
  3. The composition of any gases which are generated as a result of the waste being subjected to the transition temperature shall be reported
  4. Verification as required by waste acceptance process activities

- Explosiveness, Pyrophoricity, and Combustibility
  1. The canistered waste form shall not contain combustible material
  2. Data to show compliance after the waste form is subjected to the transition temperature is required
  3. Verification as required by waste acceptance process activities

- Organic Materials Specification
  1. The canistered waste form shall not contain organic material
  2. Verification as required by waste acceptance process activities

- Free Volume Specification
  1. The free volume shall not exceed 20% of the total void volume
  2. The nominal free volume and expected range of variation shall be reported
  3. Verification as required by waste acceptance process activities

- Removal of Radioactive Contamination on External Surfaces
  1. Alpha contamination limit: 2200 dpm/100 cm^2
  2. Beta and gamma contamination: 2200 dpm/100 cm^2
  3. All visible glass on the exterior is removed
  4. Verification as required by waste acceptance process activities

- Heat Generation Specification
  1. The canistered waste form shall not exceed a total heat generation of 800 watts at time of shipment
  2. The average heat generation rate and range of variation shall be estimated for the life of the production facility
  3. Verification as required by waste acceptance process activities

- Specification on Maximum Dose Rates
  1. Maximum gamma dose rate: 10^5 rem/hr
  2. Maximum neutron dose rate: 10^3 rem/hr
  3. Actual dose rates provided at shipment
  4. Verification as required by waste acceptance process activities

- Chemical Compatibility Specifications
  1. The extent of corrosiveness and reactivity among the waste form, canister, and any filler material shall be documented
  2. The canister corrosion from the interior shall be evaluated up to the transition temperature
  3. Verification as required by waste acceptance process activities

- Subcriticality Specification
  1. The waste producer shall show that the waste form shall remain subcritical under all credible conditions

2. The neutron multiplication factor shall be sufficiently below unity to show a 5% margin
3. Verification as required by waste acceptance process activities

- Weight, Length, Diameter, and Overall Dimensions
  1. Weight not to exceed 3000 kg
  2. Length not to exceed 3 meters
  3. Diameter not to exceed 61 cm
  4. Overall dimensional requirements must be met at time of shipment
  5. Verification as required by waste acceptance process activities

- Drop Test
  1. The canistered waste form shall be capable of withstanding a 7 meter drop
  2. Verification as required by waste acceptance process activities

- Handling Features Specification
  1. The canistered waste form shall have a neck, lifting flange, and appropriate grapple
  2. Verification as required by waste acceptance process activities

Quality Assurance

The quality assurance (QA) section has been separated as an individual specification to ensure that all activities relevant to licensing of a repository are conducted with appropriate QA controls. In general, all items which are considered part of the waste acceptance process and will generate information which will become part of the waste compliance plan, waste qualification report, or the production records must be performed under an approved QA program.

Quality assurance programs for the HLW production facilities will be evaluated to ensure that they meet the applicable requirements outlined in the Office of Geologic Repositories Quality Assurance Plan for High-Level Radioactive Waste Repositories (OGR/B-3). Several areas, however, require additional definition to implement the unique requirements inherent in repository activities.

The following areas have been given additional consideration in OGR/B-3:

- Selection, Indoctrination and Training of Personnel
- Overview of Quality Assurance Activities
- Q-List Methodology
- Quality Assurance Records
- Document Requirements for Experiments and Research
- Peer Review

CONCLUSION

The waste acceptance process has been designed to identify the required documentation and activities to establish the minimum acceptable requirements for disposal of HLW in any of the candidate repositories. This approach has been used to generate the acceptance specifications for the first two HLW production facilities and provides the basis for evaluating information that will be submitted as part of the waste compliance plan, waste qualification report, or production records to ensure that repository performance objectives can be met.

There are several important efforts that the DOE will initiate in the near future which will allow the development of generic waste acceptance requirements to be used by any future HLW production facility as a basis for waste acceptance. Additionally, the completion of the repository site characterization plans and waste form performance allocation will allow the development of site-specific tests which can be included in the specifications.

The procedures established by the DOE have provided the direction needed to move forward with the waste acceptance activities and facilitate a unified approach to generate qualified data which can be used as part of the license application.