IMPLEMENTATION GUIDE

for use with DOE M 435.1-1

Chapter IV

Low-Level Waste Requirements

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IV. A. Definition of Low-Level Waste.

Low-level radioactive waste is radioactive waste that is not high-level radioactive waste, spent nuclear fuel, transuranic waste, byproduct material (as defined in section 11e.(2) of the *Atomic Energy Act of 1954*, as amended), or naturally occurring radioactive material.

Objective:

The objective of this requirement is to provide the criteria for determining which DOE radioactive wastes are to be managed as low-level waste in accordance with DOE M 435.1-1, Chapter IV, *Low-Level Waste Requirements*.

Discussion:

DOE M 435.1-1, Section I.1.C., Radioactive Waste Management, requires that all DOE radioactive waste shall be managed as either high-level waste, transuranic waste, or low-level waste within one of the existing Office of Environmental Management radioactive waste management programs. To assist in determining whether a particular waste stream is low-level waste, see Figure I.1, Logic Diagram for Determining Radioactive Waste Type, which accompanies the guidance for the requirement.

Management of wastes containing radioactivity that do not meet or are excluded from the definition of low-level waste above, (i.e., 11e.(2) byproduct material, residual radioactive material as defined in the *Uranium Mill Tailings Radiation Control Act* (UMTRCA), or naturally occurring radioactive material) should continue to be managed under the provisions of the UMTRCA or DOE 5400.5, *Radiation Protection of the Public and the Environment.* However, DOE M 435.1-1 allows for small quantities of these wastes to be managed in accordance with this chapter. See the guidance on DOE M 435.1-1, Section IV.B.(4).

Basis. The definition of low-level waste is based on, and is essentially equivalent to, the definition used in the *Nuclear Waste Policy Act of 1982*, as amended. The requirements analysis (see methodology discussion of Technical Basis and Considerations, Appendix A) conducted in development of DOE O 435.1 and DOE M 435.1-1 indicated the *Nuclear Waste Policy Act of 1982*, as amended, definition should form the basis for the Department's definition to be consistent with the full set of legal drivers for radioactive waste management that are now in public law. This definition also is consistent with the definition in 10 CFR 61.3, NRC's requirements for low-level waste disposal.

Section 161 of the *Atomic Energy Act of 1954*, as amended [Section 161(b)] authorizes the Department to promulgate rules "to govern the possession and use of special nuclear material,

source material, and byproduct material" and Section 161(i) authorizes the Department to prescribe such regulations as it deems necessary to govern any activity authorized pursuant to the *Atomic Energy Act of 1954*, as amended, specifically including standards for the protection of health and minimization of danger to life or property. Although most sources of ionizing radiation are encompassed by the terms "byproduct material," "source material" and "special nuclear material," some sources, such as machine-produced radioactive material, are not. Because all ionizing radiation has the potential to cause harm, the Department does not limit its radioactive waste management requirements to situations involving byproduct, source and special nuclear material.

Low-level radioactive waste is defined by what it is not. The definition provides the framework for this concept by listing the basic radioactive waste types that are not low-level waste, thereby limiting the wastes that are to be managed as low-level waste. Thus, an understanding of the definitions of high-level radioactive waste, spent nuclear fuel, transuranic waste, byproduct material, and naturally occurring radioactive material is necessary to determine whether a subject waste is to be managed as low-level waste in accordance with DOE M 435.1-1, Chapter IV. The definitions of and relevant guidance on high-level waste (see Chapter II.A) and transuranic waste (see Chapter III.A) are contained in the guidance on Chapters II and III of the Manual, respectively. The guidance on definitions in Chapters II and III should be consulted first for making a determination on how to properly manage a suspect waste stream. Specific waste determination cases discussed in that guidance may provide assistance on deciding which radioactive wastes are to be managed as low-level waste. Many of these specific waste stream decisions are referenced and/or discussed again in the following guidance on the definition of low-level waste.

High-Level Waste Exclusion. High-level waste is the first type of radioactive waste excluded from the definition of low-level waste. Guidance on the definition of High-Level Waste in Chapter II clarifies the meaning of that term for applicability to certain DOE waste streams. That guidance should be consulted first for determining if a waste stream should be managed as high-level waste. Those waste streams that should be managed as low-level waste must meet the requirements of DOE M 435.1-1, Chapter IV.

Radioactive waste that meets the requirements of waste incidental to reprocessing, either by citation or evaluation, is excluded from the scope of high-level waste. It is the intent of the requirements of DOE O 435.1 and DOE M 435.1-1 that wastes which are excluded from the high-level waste management requirements because they have been determined to be not high-level waste through the waste incidental to reprocessing determination process and contain transuranics less than 100 nCi/g are low-level waste to be managed in accordance with Chapter IV of DOE M 435.1-1. (See guidance on Waste Incidental to Reprocessing, DOE M 435.1-1, Section II.B).

Example: At the Hanford Site the high-level waste program used the evaluation process to gain NRC support for on-site disposal of the low-activity waste stream removed from the high-level waste tanks as waste incidental to reprocessing. The on-site disposal facility shall meet the low-level waste requirements for disposal in accordance with DOE M 435.1-1.

Spent Nuclear Fuel Exclusion. Spent nuclear fuel is excluded from the definition of low-level waste. Spent nuclear fuel is defined in the *Nuclear Waste Policy Act of 1982*, as amended, as "*...fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated by reprocessing.*" The term refers to the spent fuel rods and assemblies as they are managed upon removal from a reactor, especially in terms of the applicability of provisions for management of spent fuel in the *Nuclear Waste Policy Act of 1982*, as amended. Guidance on the definition of high-level waste for Chapter II, DOE M 435.1-1 clarifies the meaning of spent nuclear fuel for applicability to certain Department waste streams that could fit the description of spent nuclear fuel. That guidance should be consulted first for determining whether one of these waste streams is to be managed as high-level waste. Those waste streams that are determined should be managed as low-level waste must meet the requirements of DOE M 435.1-1, Chapter IV.

Example: Site Q has irradiated target elements in long-term storage that must be disposed. The targets contain neither fissile material, nor do they meet the definition of transuranic waste. The targets are managed for disposal as low-level waste.

Transuranic Waste Exclusion. Transuranic waste is excluded from the definition of low-level waste. As mentioned, the definition of transuranic waste is further explained in the guidance on Requirement III.A. That guidance clarifies the applicability of the term transuranic waste for certain DOE radioactive waste streams. The guidance should be consulted first for determining if a waste stream should be managed as transuranic waste. Those streams that should be managed as low-level waste must meet the requirements of Chapter IV, DOE M 435.1-1.

Three exceptions to the definition of transuranic waste are discussed in the guidance for transuranic waste requirements (DOE M 435.1-1, Section III.A). The first exception is high-level waste which, as discussed previously, is also excluded from the definition of low-level waste. The second exception is waste that DOE, with the concurrence of the EPA Administrator, has determined does not need the degree of isolation that is provided by implementation of the disposal requirements of 40 CFR Part 191. This waste is to be managed as low-level waste in accordance with Chapter IV of DOE M 435.1-1. The third exception applies to waste generated by commercial activities that have concentrations of radionuclides that would result in categorization as transuranic waste. As long as the waste is not high-level waste, it could be accepted (with NRC approval not to invoke 40 CFR Part 191) as Greater-than-Class-C (GTCC) low-level waste per the classification system in 10 CFR 61.55. This waste is to be managed as

low-level waste in accordance with Chapter IV of DOE M 435.1-1. However, GTCC waste is to be disposed of in a facility licensed by the U.S. Nuclear Regulatory Commission (See the guidance on Complex-Wide Low-Level Waste Management Program concerning management of commercial (NRC licensed) GTCC, DOE M 435.1-1, Section IV.C.).

Also, consistent with the guidance on transuranic waste (DOE M 435.1-1, Section III.A), radioactive waste that does not meet the definition of transuranic waste in accordance with the measurement, error, and uncertainty guidance described in *Transuranic Waste Characterization Quality Assurance Program Plan, Waste Acceptance Criteria for the Waste Isolation Pilot Plant*, and/or other controlling documents is also to be managed as low-level waste in accordance with Chapter IV of DOE M 435.1-1.

Dilution of a transuranic waste stream to reclassify the waste as low-level waste (i.e., reducing the concentration to less than or equal to 100 nCi (3700 Bq) per gram) is not permitted by the Department. While it is recognized that in the course of stabilizing a waste stream some changes in waste concentration may occur, actions to dilute a waste stream below the concentration limits for transuranic waste are prohibited. It is also recognized that actions taken to process a waste stream for safety or technological reasons that are justified, may result in the waste being reclassified after processing as low-level waste.

> *Example: Due to the moisture content of a transuranic waste sludge, the waste does not meet the WIPP WAC. The site evaluates several treatment options taking into consideration factors such as worker exposure, waste minimization, cost and complexity of the treatment process and disposal facility waste acceptance requirements. The treatment process selected involves adding grout to the transuranic waste sludge to eliminate free liquids resulting in a solidified waste form that contains transuranic radionuclides in concentrations less than 100 nCi (3700 Bq) per gram and meets the waste acceptance criteria for a low-level waste disposal facility.*

Byproduct Material Exclusion. Byproduct material as defined in Section 11e.(2) of the *Atomic Energy Act of 1954*, as amended, is also excluded from the definition of low-level waste. Byproduct material is defined as: "*. . . (2) The tailings or wastes produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content.*" Section 11e.(2) byproduct material is included in the waste types not managed as low-level waste because Congress determined that this waste stream had unique qualities, particularly the generation of radon gas, and needed to be managed in accordance with its own set of environmental standards and technical requirements. The *Uranium Mill Tailings Radiation Control Act* (UMTRCA) provides the legal framework under which 40 CFR Part 192 and the Department's program for remediation of old uranium mill tailings sites was developed and implemented.

Naturally Occurring Radioactive Material Exclusion. Waste with naturally occurring radioactive material is also excluded from the definition of low-level waste. Naturally occurring radioactive material, or NORM, is material that contains natural radioactivity and is not regulated by NRC under the *Atomic Energy Act of 1954*, as amended. In some cases, changes in the composition, radionuclide concentrations, availability, or proximity to man of such material as a result of human practices cause a potential for increased exposure to the public. The *Atomic Energy Act of 1954*, as amended and the *Energy Reorganization Act of 1974* charge DOE with protecting the public from exposure to radiation caused by its research, development, or production activities. Therefore, DOE regulates such exposures under its radiation protection directives. For non-DOE activities, the Congress provided NRC authority for only source, byproduct, and special nuclear material and not for the generation of consumer products or other products from natural material. However, DOE does have responsibilities for NORM that has been technologically enhanced by DOE activity.

The policy of the Department is that small quantities of naturally occurring and/or 11e.(2) byproduct materials or wastes containing such materials may be disposed in DOE low-level waste disposal facilities provided that the requirements for disposal of low-level waste are met.

> *Example: A small amount (100 cubic meters) of 11e.(2) materials that are similar to mill tailings, but from an apparently different process, are discovered at the remedial action site near Garden City. These materials are removed from their current location and are packaged and stored. An evaluation of the performance assessment at Site X indicates that these materials are acceptable for disposal there. The wastes are certified and shipped to Site X for disposal.*

Chapter IV of DOE 5820.2A addresses this matter and provides the requirements for management of small quantities of 11e.(2) and naturally occurring radioactive material as low-level waste. This practice may continue under DOE M 435.1-1, IV.B.(4). Guidance for this requirement should be consulted for discussions on management of small quantities of 11e.(2) byproduct and naturally occurring radioactive material as low-level waste.

Supplemental References:

1. *Nuclear Waste Policy Act of 1982,* as amended, January 7, 1983.

2. NRC. *Licensing Requirements for Land Disposal of Radioactive Waste,* 10 CFR Part 61, U.S. Nuclear Regulatory Commission, Washington, D.C..

3. CAO, 1998. *U.S. Department of Energy, Transuranic Waste Characterization Quality Assurance Program Plan,* Revision 1, CAO-94-1010, U.S. Department of Energy, Carlsbad Area Office, Carlsbad, NM, December 18, 1998.

4. CAO, 1996. *Waste Acceptance Criteria for the Waste Isolation Pilot Plant*, Revision 5, DOE/WIPP-069, U.S. Department of Energy, Carlsbad Area Office, Carlsbad, NM, April 1996.

5. DOE, 1988. *Radioactive Waste Management*, DOE 5820.2A, U.S. Department of Energy, Washington, D.C., September 26, 1988.

IV. B. Management of Specific Wastes.

The following provide for management of specific wastes as low-level waste in accordance with the requirements in this Chapter:

(1) Mixed Low-Level Waste. Low-level waste determined to contain both source, special nuclear, or byproduct material subject to the *Atomic Energy Act of 1954,* as amended, and a hazardous component subject to the *Resource Conservation and Recovery Act* (RCRA), as amended, shall be managed in accordance with the requirements of RCRA and DOE O 435.1, *Radioactive Waste Management,* and this Manual.

(2) TSCA-Regulated Waste. Low-level waste containing polychlorinated biphenyls, asbestos, or other such regulated toxic components shall be managed in accordance with requirements derived from the *Toxic Substances Control Act,* as amended, DOE O 435.1, *Radioactive Waste Management,* and this Manual.

(3) Accelerator-Produced Waste. Radioactive waste produced as a result of operations of DOE accelerators is low-level waste and shall be managed in accordance with DOE O 435.1, *Radioactive Waste Management,* and this Manual, and all applicable Federal or State requirements.

(4) 11e.(2) and Naturally Occurring Radioactive Material. Small quantities of 11e.(2) byproduct material and naturally occurring radioactive material may be managed as low-level waste provided they can be managed to meet the requirements for low-level waste disposal in Section IV.P of this Manual.

Objective:

The purpose of this requirement is to (1) ensure that DOE low-level waste is managed in accordance with the applicable requirements of external regulations, specifically those of the *Resource Conservation and Recovery Act* (RCRA) and *Toxic Substances Control Act* (TSCA), that address non-radiological hazards, in addition to being managed in accordance with the requirements of DOE O 435.1 and the *Radioactive Waste Management Manual,* DOE M 435.1-1, and (2) allow for the management of certain other radioactive wastes as low-level waste that are the responsibility of the Department under the *Atomic Energy Act of 1954,* as amended.

Discussion:

The *Radioactive Waste Management Manual*, DOE M 435.1-1, contains requirements for managing the radioactive character of low-level waste. Through the safety and hazards analysis process used in developing the Manual, non-radiological hazards associated with managing certain wastes were identified. During the development of the requirements necessary to control the identified hazards, it was concluded that sufficient external regulations, promulgated pursuant to RCRA and TSCA, exist for controlling the non-radiological hazards.

Section 161 of the *Atomic Energy Act of 1954*, as amended [Section 161(b)] authorizes the Department to promulgate rules "to govern the possession and use of special nuclear material, source material, and byproduct material" and Section 161(i) authorizes the Department to prescribe such regulations as it deems necessary to govern any activity authorized pursuant to the *Atomic Energy Act of 1954*, as amended, specifically including standards for the protection of health and minimization of danger to life or property. Although most sources of ionizing radiation are encompassed by the terms "byproduct material," "source material" and "special nuclear material," some sources, such as machine-produced radioactive material, are not. Because all ionizing radiation has the potential to cause harm, the Department does not limit its radioactive waste management requirements to situations involving byproduct, source and special nuclear material.

Through the safety and hazards analysis, it was also recognized that the Department has management responsibility over some other radioactive waste, namely accelerator-produced, naturally occurring, and 11e.(2) byproduct material, which is specifically excluded from the definition of low-level waste, but for which the Department is responsible for protecting the public, workers, and the environment from the radioactivity from the waste under the *Atomic Energy Act of 1954*, as amended, and therefore needed to be considered to cover the full inventory of radioactive waste that must be managed under DOE O 435.1 and DOE M 435.1-1. The analysis to develop requirements concluded that the Department's policies, requirements, and guidance currently in place under DOE 5820.A should be continued and improved where needed. Guidance below under Accelerator-Produced Waste and 11e.(2) and Naturally Occurring Radioactive Material discusses the continuation of the 5820.2A policies and practices and provides discussion for meeting requirements of DOE O 435.1 and DOE M 435.1-1 for these wastes.

Mixed Low-Level Waste. In managing low-level wastes which are subject to RCRA and TSCA requirements, personnel need to be cognizant of the requirements for storage and disposal of the waste. The ability to dispose of RCRA or TSCA waste that has a radioactive component is very limited. Therefore, waste generators should avoid creating a mixed or TSCA-regulated low-level waste, and generators and waste managers should avoid actions that result in generating low-level waste with no path to disposal (see guidance for DOE M 435.1-1, Section I.2.F.(19)).

Example: It is typical for personnel within a radiological control area at Laboratory A to always declare all waste to be radioactive. It is recognized that all the waste is not low-level waste; however, by managing it as such, the facility saves time and money in surveying and performing radioactive/clean determinations. However, RCRA or TSCA waste is not automatically declared radioactive out of convenience, because such designation would greatly limit the management and disposal options for the waste and increase the overall waste management costs at Laboratory A. Instead, personnel specifically survey any waste that has been identified as RCRA- or TSCA- regulated in order to make a radioactive/clean determination and thus minimize the amount of waste that will be designated as mixed or TSCA regulated.

RCRA and State Hazardous Waste Regulations. The *Resource Conservation and Recovery Act* required the Environmental Protection Agency to promulgate regulations for management of hazardous waste. The legislation also provides for states to promulgate and implement hazardous waste regulatory programs that are at least as protective as the Federal program. The hazardous waste requirements that personnel must follow in managing (i.e., generating, transporting, treating, storing or disposing) mixed low-level waste and in closing affected facilities are primarily in 40 CFR Parts 260 through 270, or authorized state regulations. A variety of guidance manuals and information relevant to the management of the hazardous component of mixed low-level waste has been prepared both by the state regulatory agencies and the Environmental Protection Agency (see for example *U.S. Environmental Protection Agency, Catalog of Hazardous and Solid Waste Publications, EPA530-B-96-007, September, 1996)*. These guidance documents should be consulted when developing management programs for mixed low-level waste.

Hazardous waste regulations promulgated by states with RCRA authority may be more restrictive than the Federal regulations. The more restrictive requirements may include a broader definition of hazardous waste than the Federal requirements or may impose another state's definition of hazardous waste when waste is received from that state. Waste management personnel therefore need to be aware of the requirements of the regulations in their own state as well as the implications of the regulations in states to which they intend to transfer waste.

Example 1: In a state that invokes regulations equivalent to the EPA hazardous waste regulations, waste oil that meets the criteria for low-level waste would not be managed as mixed low-level waste. However, if the oil was to be shipped to another state in which the state regulations defined hazardous waste to include waste oil, the waste would have to be packaged, manifested, transported, and stored as a mixed waste.

Example 2: If the direction of waste transfer in the above example were reversed, a different situation could arise. The waste would be declared a mixed waste in the state of origin because the state regulations had a broader definition of hazardous waste. The state to which it was to be shipped does not specifically regulate waste oil as a hazardous

waste. However, the state regulations of the receiving site require that waste be considered to be as it was categorized in the state of origin. In this case, the waste would still be considered to be and need to be managed as mixed waste even after it was shipped to the state that did not explicitly regulate waste oils.

The RCRA requirements prohibit storage of hazardous (including mixed) waste that are restricted from land disposal except for purposes of accumulating sufficient quantities to facilitate recovery, treatment, or disposal. The *Federal Facility Compliance Act of 1992* required the Department to prepare site-specific treatment plans to address treatment of mixed waste to meet the land disposal restrictions at each facility at which DOE generates or stores mixed waste. To meet the requirement, site-specific treatment plans were developed, and through agreements or consent orders, commitments to schedules to treat or otherwise meet the land disposal restrictions were made. These site-specific treatment plans and agreements or consent orders need to be part of the life-cycle planning performed in accordance with Waste Generation Planning (DOE M 435.1-1, Section IV.H).

PCB, Asbestos, and Other TSCA Wastes. Low-level wastes contaminated with PCBs or asbestos do not meet the definition of mixed waste. However, the situation is similar because external regulations promulgated under the authority of the *Toxic Substances Control Act* (TSCA) must be complied with in addition to the requirements of DOE O 435.1 and the Manual. Waste managers responsible for managing PCB-containing products should consult the EPA requirements at 40 CFR Part 761. The regulations impose requirements for the destruction, storage awaiting destruction, and disposal of PCBs. Waste managers responsible for managing materials containing asbestos should consult the EPA requirements at 40 CFR Part 61, subpart M. These regulations impose requirements for the removal of asbestos during demolition and renovation and disposal of asbestos-containing waste. This regulation includes cross-references to several other regulations governing management of asbestos that may also apply. Planning for management of these wastes and any low-level waste that includes a component which is regulated under TSCA needs to be addressed in the Complex-Wide Low-Level Waste Management Program and the Site-Wide Waste Management Programs (DOE M 435.1-1, Sections I.2.B.(1), I.2.F.(1), and IV.C).

Example: A site has determined that contaminated transformer oil from an on-site electrical source contains PCBs. The site makes arrangements for treatment at another facility which is permitted under TSCA for PCB treatment (PCB destruction) and return of the low-level waste (grouted ash) for disposal at the generating site.

The DOE M 435.1-1 requirements imposed on the radioactive component of RCRA or TSCA waste should not create a duplication of management activities that can be satisfied by compliance with either a RCRA or TSCA requirement. Also, documentation required by RCRA or TSCA

requirements which provide the same or similar documentation as required by DOE M 435.1 can be used to satisfy the DOE M 435.1-1 requirement.

> *Example: Mixed low-level waste is being transferred from one site to another for treatment. The Uniform Hazardous Waste Manifest is prepared as required by 40 CFR Part 262. The manifest is determined to satisfy the need to document the transfer of ownership of the waste, the transfer date, the physical location of the waste, and other information specified in DOE M 435.1-1. If the waste acceptance requirements of the facility receiving the waste allow it, the manifest may also provide the necessary information on the chemical and physical characteristics of the waste.*

Accelerator-Produced Waste. Commercially generated accelerator-produced waste is not source, special nuclear, or byproduct material that must be licensed by the NRC under the *Atomic Energy Act of 1954*, as amended. However, the Department retains the responsibility under the *Atomic Energy Act of 1954*, as amended, for protection of the public, workers, and the environment from the radioactivity produced from Department of Energy accelerators. Such waste may include shielding and structures which are activated by operation of an accelerator, or the targets that are bombarded by the accelerator beam. Radioactive waste produced from Department of Energy accelerator activities is to be managed as low-level waste. Accelerator-produced wastes have been managed as low-level waste by the Department in the past, and this provision in DOE M 435.1-1 maintains this practice.

Accelerator-produced waste may be mixed with hazardous constituents that are regulated under RCRA or state-equivalent legislation. In this case, Department Field Elements need to interact with state authorities concerning the appropriate management of these wastes. These wastes are not mixed waste to the extent that the accelerator-produced materials are not source, byproduct, or special nuclear material. However, they should still be managed appropriately for the dangers posed by both the radioactivity and the hazardous component, as if they were mixed waste. Some states may have agreed with Department Field Elements already on the appropriate set of requirements that these wastes should be managed under. The Department is fully responsible for ensuring that the requirements associated with the hazardous components are complied with, as well as managing the waste for its radioactivity in accordance with Chapter IV of the Manual.

> *Example 1: Lead (Pb) bricks are used as shielding in a new tritium production accelerator in State S. When the shielding is discarded, the resultant waste is a RCRA-regulated hazardous waste (and is not a "mixed waste" because the radioactive component is not source, special nuclear, or byproduct material). The lead brick shielding waste is managed in accordance with State S hazardous waste requirements. The shielding waste is managed as mixed waste, however, because all DOE Manual Chapter IV requirements are also met. The tritium production accelerator includes management requirements for this waste in a RCRA-based agreement with State S.*

Example 2: A Department of Energy research accelerator uses a variety of target materials. None of the targets contain hazardous constituents, however, once a research activity is completed, the discarded targets have been activated. The discarded targets are handled to protect against exposure to radiation and are managed as low-level waste including disposal at a DOE low-level waste disposal facility.

11e.(2) and Naturally Occurring Radioactive Material. This section of DOE M 435.1-1 was provided to continue the policies, requirements, and guidance in place under DOE 5820.2A concerning disposal of small quantities of 11e.(2) and naturally occurring radioactive material. Under the *Nuclear Waste Policy Act of 1982*, as amended, and the *Low-Level Radioactive Waste Policy Act*, low-level waste is defined to exclude 11e.(2) byproduct material. However, DOE O 435.1 continues the Department's existing policy that small quantities of these materials may be managed as low-level waste in accordance with the low-level waste requirements of DOE M 435.1-1. This requirement is not intended to allow large volumes of 11e.(2) material from sites subject to 40 CFR Part 192 would be routinely disposed in a low-level waste disposal facility. These wastes, waste quantities too large for acceptance at DOE low-level waste disposal sites, and other 11e.(2) byproduct and naturally occurring radioactive materials that are inappropriate for management as a low-level waste are to be managed under the provisions of UMTRCA, 40 CFR Part 192, or DOE 5400.5, *Radiation Protection of the Public and the Environment*, as applicable. Recognizing DOE's responsibility for properly managing these materials when generated or encountered during cleanups, DOE 5400.5 contains requirements that are applicable for the management of naturally occurring radioactive material waste streams. [Although the Department is unlikely to manage any of these, examples of such wastes are rare earth processing facility wastes, mineral extraction byproducts, such as phosphogypsum and copper tailings, coal ash, and oil and gas extraction byproducts.]

The Department manages other radioactive waste streams that contain naturally occurring radioactive material that are excluded from the definition of low-level waste. These waste streams are those in which the naturally occurring radioactive material has been technologically-enhanced and intentionally altered for the purpose of utilizing the radioactive properties of the material. Examples of these are sealed sources containing radium and compounds of uranium which no longer are considered source material, but which have not been converted to a form that could be used productively. These waste streams are appropriately managed as low-level waste to provide adequate protection of workers, the public, and the environment.

To understand what is meant by the term "small quantities," the legislative intent of the UMTRCA as implemented in the policies of the Department provide the needed guidance. In enacting the UMTRCA, Congress addressed a problem of large volumes of diffuse material in several locations that required proper controls. These residual radioactive materials regulated under UMTRCA are managed by the Department according to the requirements of 40 CFR Part 192 and disposed at specially designated tailings disposal sites established under the UMTRCA.

It is the policy of the Department that small quantities of naturally occurring and/or 11e.(2) byproduct materials or wastes containing such materials may be disposed in DOE low-level waste disposal facilities provided that the requirements for disposal of low-level waste are met.

The requirement, in stating that the disposal requirements in DOE M 435.1-1, Section IV.P must be met, means the naturally occurring or 11e.(2) byproduct material must be included in the performance assessment and composite analysis for the facility, that adequate controls are established for the waste stream based on the evaluations, and the minimum disposal requirements of Chapter IV are to be met. The inclusion of a significant quantity of naturally occurring or 11e.(2) byproduct material in a low-level waste disposal facility is expected to result in additional controls for that waste stream due to the risk posed by radon emanation from the waste, where "significant" in this context is to be determined through the performance assessment and composite analysis evaluations and other considerations included in the radioactive waste management basis for the disposal facility.

Example 1: A significant amount (100,000 cubic meters) of new mill tailings are discovered in a location not previously determined to be contaminated at the UMTRCA site at Slick Rock, CO. These mill tailings will be removed from their location and either be disposed of at the Cheney disposal cell or DOE will pay a UMTRCA Title II site to dispose of the tailings, consistent with UMTRCA, as amended.

Example 2: A small amount (100 cubic meters) of 11e.(2) materials that are similar to mill tailings, but from an apparently different process, are also discovered at this contaminated site near Slick Rock. These materials will also be removed from their current location and managed in the same manner as discussed in Example 1.

Example 3: Some uranium bearing waste from processes undertaken at the Fernald facility is proposed for disposal at the Site Y disposal facility. Sufficient capacity is available to dispose of the amount of the waste to be generated. The waste is included in the performance assessment and composite analysis, and controls are established. These include provisions for stabilizing the waste and placing it in specially designed boxes, for additional analysis of the cover that will eventually be placed on the disposal unit used, and for additional information in the records for the disposal facility concerning the nature of the waste in this specific disposal unit.

Example 4: Small quantities (a few vials) of paints and other items containing radium are discovered among the radioactive materials that DOE has agreed to take possession of from a university professor who retired. DOE has no use for the materials, and is not aware of any needs outside of the Department. The material is considered waste, and is disposed by the laboratory personnel who took possession of the materials as low-level

waste, after consultation with the disposal facility who will receive the waste that the amount is not significant and no additional controls for its disposal are needed.

In addition, naturally occurring or 11e.(2) byproduct material determined to be manageable as low-level waste that is also mixed with constituents covered under RCRA or TSCA must also meet all of the requirements in those laws and be managed as mixed low-level waste in accordance with DOE O 435.1 and DOE M 435.1-1.

Supplemental References:

1. *Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act*, 42 U.S.C. 6901 et seq., 1984.

2. *Federal Facility Compliance Act of 1992*, as amended, October 6, 1992.

3. *Toxic Substances Control Act*, as amended, October 11, 1976.

4. *Uranium Mill Tailings Radiation Control Act*, as amended, 42 U.S.C. 7901 et seq., 1978.

5. EPA, 1993. "Final Rule; Environmental Radiation Protection Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes," *Federal Register*, Vol. 58, No. 242, U.S. Environmental Protection Agency, Washington, D.C., December 20, 1993.

6. EPA. 40 CFR Parts 260-270, U.S. Environmental Protection Agency, Washington, D.C.

7. EPA. *Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions*, 40 CFR Part 761, U.S. Environmental Protection Agency, Washington, D.C.

8. EPA, 1996. *U.S. Environmental Protection Agency Catalog of Hazardous and Solid Waste Publications*, EPA530-B-96-007, U.S. Environmental Protection Agency, Washington, D.C., September 1996.

9. EPA, 1973. *National Emissions Standards for Hazardous Air Pollutants – National Emission Standard for Asbestos*, 40 CFR Part 61, Subpart M, U.S. Environmental Protection Agency, Washington, D.C., April 6, 1973.

10. DOE, 1990. *Radiation Protection of the Public and Environment*, DOE 5400.5, U.S. Department of Energy, Washington, D.C., February 8, 1990.

IV. C. Complex-Wide Low-Level Waste Management Program.

A complex-wide program and plan shall be developed as described under *Responsibilities,* 2.B and 2.D, in Chapter I of this Manual.

Objective:

The objective of this requirement is to ensure the development, documentation, and implementation of a complex-wide low-level waste management program to provide for cost-efficient and integrated management of low-level waste throughout the complex and within individual site radioactive waste management programs. Mixed low-level waste is, as appropriate, reflected in low-level waste plans and through its own program plan.

Discussion:

The Department's management of low-level waste occurs at numerous sites that generate, stage, and store waste, and at several sites that treat and dispose of the waste. A complex-wide program and plan establish the overall mission for the Department's management of low-level waste and to provide a framework within which the individual site programs operate. The *Radioactive Waste Management Manual*, DOE M 435.1-1, General Requirements (Section I.2.B) assigns the Assistant Secretary for Environmental Management the responsibility for developing and maintaining complex-wide, waste-type programs. The *Manual* General Requirements (Section I.2.D) also assigns the Deputy Assistant Secretary for Waste Management the responsibility for developing and implementing complex-wide, waste-type program plans. The complex-wide low-level waste management program and plan are developed following the guidance provided for DOE M 435.1-1, Section I.2.B and I.2.D requirements.

Mixed Low-Level Waste Program. Mixed low-level waste is managed within the Department through an existing Mixed Low-Level Waste Management Program. Appropriate management interfaces and exchanges of technical information need to be identified in the low-level waste management program wherever necessary to affect safe and effective management of both mixed and non-mixed low-level waste. The systematic planning of mixed low-level waste can either be integrated with low-level waste planning or as a subset of low-level waste as appropriate. Mixed low-level waste interfaces, exchanges, inputs, and subsets discussions need to be included in the documentation of the complex-wide low-level waste management program and in the site radioactive waste management programs, as appropriate. The low-level and mixed low-level waste management programs should utilize existing data wherever possible.

Example: A laboratory facility is providing information to be included in the Complex-Wide Low-Level Waste Management Program Plan. Existing mixed low-level waste data and plans from the lab's Site Treatment Plan prepared under the Federal

Facilities Compliance Act are provided and are included in the appropriate sections of the Complex-Wide Program Plan or in a separate Mixed Low-Level Waste Management Program Plan, as needed.

Greater-Than-Class C Program. Commercial Greater-than-Class C (GTCC) radioactive waste (generated by an NRC licensee) is also managed within an existing GTCC Program in the Department. Appropriate management interfaces and exchanges of technical information also need to be identified in the low-level waste management program wherever necessary to ensure safe and effective management of both DOE low-level waste and commercial GTCC low-level waste. The systematic planning of commercial GTCC waste management can either be integrated with the low-level waste planning or as a subset of low-level waste, as appropriate. Commercial GTCC low-level waste interfaces, exchanges, inputs, and subsets discussions need to be included in the documentation of the complex-wide low-level waste management program and in the site radioactive waste management programs, as appropriate. The low-level waste management and the GTCC programs should utilize existing data wherever possible.

As specified in the *Low-Level Radioactive Waste Policy Act*, the facility that will be used to dispose of commercially generated GTCC from NRC licensees must be licensed by the NRC, in accordance with 10 CFR Part 61. Therefore, the Complex-Wide Low-Level Waste Management Program, and the site-wide programs where commercial GTCC will be managed until disposal, needs to include inventory control, waste tracking, and recordkeeping that will lead to the successful licensing of the commercial GTCC disposal facility.

Performance Assessment and Composite Analysis Maintenance. Performance assessments of DOE low-level waste disposal facilities have been developed over a number of years. Composite analyses for low-level waste disposal facilities have recently been developed. Maintenance of these analyses is required to ensure that performance assessments and composite analyses adequately represent the current and expected future state of the low-level waste disposal facilities for which they are required. Such maintenance is properly the responsibility of the individual DOE sites conducting performance assessments and composite analyses. However, to promote efficient use of resources and foster an appropriate degree of consistency among the site programs, a complex-wide performance assessment and composite analysis maintenance program should be developed and implemented as part of the Complex-Wide Low-Level Waste Management Program as described in the *Complex-Wide Strategy for Maintenance of Department of Energy Low-Level Waste Disposal Facility Performance Assessment and Composite Analysis*.

Compliance with this requirement is demonstrated by the presence of the performance assessment and composite analysis maintenance element in the Complex-Wide Low-Level Waste Management Program, and the appropriate inclusion of interfaces, technical information, data,

inputs, and subsets of the DOE mixed low-level waste program and the commercial GTCC programs into the Complex-Wide Low-Level Waste Management Program.

Supplemental References:

1. DOE, 1998. *Complex-Wide Strategy for Maintenance of Department of Energy Low-Level Waste Disposal Facility Performance Assessments and Composite Analyses,* U.S. Department of Energy, Washington, D.C., October 1998.

IV. D. Radioactive Waste Management Basis.

Low-level waste facilities, operations, and activities shall have a radioactive waste management basis consisting of physical and administrative controls to ensure the protection of workers, the public, and the environment. The following specific waste management controls shall be part of the radioactive waste management basis:

(1) Generators. The waste certification program.

(2) Treatment Facilities. The waste acceptance requirements and the waste certification program.

(3) Storage Facilities. The waste acceptance requirements and the waste certification program.

(4) Disposal Facilities. The performance assessment, composite analysis, disposal authorization statement, closure plan, waste acceptance requirements, and monitoring plan.

Objective:

The objective of this requirement is to ensure that the hazards associated with low-level waste management facilities, operations, and activities have been identified, their potential impacts analyzed, and appropriate controls documented, implemented, and maintained for the protection of workers, the public, and the environment.

Discussion:

As described in the guidance on DOE M 435.1-1, Section I.2.F.(2) requires the radioactive waste management basis to provide for development and documentation of controls to ensure the safe and efficient management of radioactive waste. Requiring an approved radioactive waste management basis for the initiation of new, or continuation of existing, radioactive waste management activities should prevent the operation of facilities without the appropriate controls. The term “controls” used here and elsewhere in the discussion of a radioactive waste management basis refers to processes, procedures, equipment, instruments, and other items that are intended to curb the likelihood of, or the consequences from, a problem that could arise from managing radioactive waste. Controls includes such things as placards, alarms, tools, shielding, training checklists, duplication of critical steps, redundant monitoring, analysis, sampling and testing, etc. As discussed in Section I.2.F.(2), the radioactive waste management basis for low-level radioactive waste management facilities, operations, and activities must be documented.

The required elements of the radioactive waste management basis vary with the type of waste management operation or facility and the types of hazards associated with the facility. As stated in the introductory statement of this requirement, the items required for a radioactive waste management basis listed in the requirement for the four types of low-level waste management facilities, operations, and activities is not a complete list of those items which should be included in a radioactive waste management basis. Several processes, procedures, and documents that are required by other directives and requirements provide for radioactive waste management controls that should be considered part of the radioactive waste management basis. The guidance on DOE M 435.1-1, Section I.2.F.(2) discusses this aspect of the radioactive waste management basis in detail.

> *Example: Site Q operates a low-level waste storage facility. The Field Element staff is required to ensure that it operates under a radioactive waste management basis. The staff reviews the items in the requirement cited above, plus the facility-specific procedures for implementing the site's radiological control program, health and safety plan, training program, quality assurance program, and record-keeping plan, and determines an adequate radioactive waste management basis exists.*

Also, as discussed in the DOE M 435.1-1, Section I.2.F.(2) guidance, if a low-level waste management facility already operates under an approved Authorization Basis, it may not need any additional controls to demonstrate that it has a radioactive waste management basis. In this case, the Authorization Basis documentation is reviewed and evaluated to determine whether it sufficiently covers the requirements needed for a radioactive waste management basis. The Field Element Manager has the responsibility to ensure the low-level waste management facilities under his or her authority have a radioactive waste management basis.

> *Example: The Authorization Basis documentation for a Liquid Radioactive Waste Handling Facilities at Site T, which includes a Liquid Treatment Facility (a low-level waste treatment facility), is reviewed. Based on the review, it is determined that the following Authorization Basis documents and associated programs include significant descriptions of the controls for the management of low-level waste at the Effluent Treatment Facility:*
>
> - *Safety Analysis Reports (SARs)*
> - *Technical Justification for Continued Operation/Basis for Interim Operation/Design Basis Accident Analysis Report*
> - *Operational Safety Requirements/Technical Safety Requirements (includes waste acceptance requirements of the Effluent Treatment Facility)*
> - *Technical Standards*
> - *SAR Update Request Packages*

- *Other Documents Identified by DOE and the contractor as Authorization Basis Documents (Safety Evaluations, Exemptions, Unreviewed Safety Questions Evaluation)*
- *DOE Safety Evaluation Reports*
- *Listing of Documents that are to be Configuration Managed but are not AB Documents (includes Liquid Treatment Facility Waste Certification Program Plan for certifying waste to the Solid Waste Disposal Area)*

Following analysis of the information, the DOE field office concludes the complete set of operational requirements relied upon by the site to ensure that the public, workers, and the environment are protected from the hazards associated with the management of the radioactive waste at the Liquid Treatment Facility are in place. A radioactive waste management basis statement is prepared that concludes the basis is covered in the Authorization Basis documents.

For a facility that generates low-level waste, the radioactive waste management basis is to include the program for certifying that waste meets the waste acceptance requirements of the facility(ies) to which the waste will be sent. The waste certification program is reviewed against the applicable requirements of DOE M 435.1-1 and approved in accordance with the manual before becoming part of the radioactive waste management basis. As discussed in guidance on DOE M 435.1-1, Section I.2.F.(2), several other processes and procedures will contribute to a complete radioactive waste management basis at a generating facility.

Example: A small laboratory facility on DOE's Site R generates low-level waste. The radioactive waste management basis for the facility is established through the review and approval of the lab's waste certification procedure and a review of the following for adequacy: the site Health and Safety Plan, the site Training Program, and the site Waste Transfer Procedure. This is documented in a radioactive waste management basis statement covering the laboratory.

Facilities that store or treat low-level waste are to have approved waste acceptance requirements (see DOE M 435.1-1, Section IV.G) prior to the issuance of a radioactive waste management basis. The waste acceptance requirements will usually suffice as the documentation of the radiological, physical, and chemical limitations on waste that can be safely received at the facility, provided they are developed correctly considering the hazards of the waste to be managed, and are kept up-to-date. A facility that stores or treats waste also is generally expected to have a waste certification program. Waste from these facilities will have to be certified as meeting the waste acceptance requirements of the facility to which it will be transferred, and the facilities have the potential for generating radioactive waste (e.g., secondary processing streams from treatment, monitoring and sampling, radioactive release cleanup). Consequently, storage and treatment

facilities should also have an approved waste certification program as part of their radioactive waste management basis.

The radioactive waste management basis for low-level waste disposal facilities is to be based on documented controls similar to those discussed for treatment or storage facilities, but with additional conditions imposed by the performance assessment and composite analysis required in DOE M 435.1-1, Section IV.P and by the disposal authorization statement issued following Headquarters review and approval of the performance assessment and composite analysis. As described in DOE M 435.1-1, Sections IV.Q and IV.R, the preliminary closure plan and preliminary monitoring plan are also to be reviewed as part of the evaluation of the performance assessment and composite analysis leading to the issuance of the disposal authorization statement. The results of the performance assessment and composite analysis, along with the controls based on the safety analyses required by DOE 5480.23, provide the basis by which the quantities and concentrations of radionuclides that can be accepted for disposal will be identified and documented in the waste acceptance requirements.

The responsibility for the radioactive waste management basis for low-level waste disposal facilities resides with the Field Element Manager. However, Headquarters review and approval of the performance assessment and composite analysis and issuance of the disposal authorization statement is necessary prior to issuance and documentation of the radioactive waste management basis, in accordance with the requirements in the Manual. Also, the documents required for the radioactive waste management basis for disposal facilities are related to one another and depend on information contained in or as a result of information or analysis in one or another of the other documents.

> *Example: The radioactive waste management basis for a low-level waste disposal facility, includes (among many controls, including safety and health plans, training programs, etc.) limits on tritium that can be accepted in a disposal unit, as calculated by the performance assessment. This limitation is included in the waste acceptance requirements of the facility as a limit per package. The disposal authorization statement also includes a condition that the closure plan is to be updated within 18 months of the issuance of the disposal authorization statement to include consistent monitoring locations with the preliminary monitoring plan submitted separately. The radioactive waste management basis statement references the disposal authorization statement to include these conditions for continued operations.*

The Headquarters review and approval of the performance assessment and composite analysis will lead to the issuance of the disposal authorization statement to the Field Element Manager, who should combine this with his/her own findings on the waste acceptance criteria and preliminary closure and monitoring plans to document the radioactive waste management basis for the disposal facility. Guidance on DOE M 435.1-1, Sections IV.P.(2) [performance assessment],

IV.P.(3)[composite analysis], IV.P(5)[disposal authorization statement], IV.Q.(1)[preliminary closure plan], and IV.R.(3)[preliminary monitoring plan] provide details on what information needs to be addressed in these documents for review and approval for a radioactive waste management basis to be issued.

As part of the radioactive waste management basis, site personnel needs to implement a system or process for tracking the waste inventory at a storage, treatment, or disposal facility. Tracking the waste inventory is a means of ensuring that radionuclide limits established in accordance with a safety analysis or performance assessment will not be exceeded. In addition, a system or process for accurately tracking waste received at a facility can facilitate providing information to the complex-wide waste management data system (see guidance Section I.2.D.(2)).

Compliance with this requirement is demonstrated by a demonstrated radioactive waste management basis that is signed by the Field Element manager or a designee for each low-level waste management facility, operation, or activity. Using a graded approach, it may be possible to include multiple activities under a single radioactive waste management basis, but it should be possible to objectively identify which activities are covered. Further, the documented radioactive waste management basis includes or references the controls that are established on a facility-specific basis to address the unique waste management requirements and circumstances for each facility, operation, and/or activity.

> *Example: A storage facility that stores mixed and non-mixed low-level waste has approved waste acceptance requirements and a waste certification process that enables low-level waste to be stored for 9 months and then shipped to a specific facility for disposal. The mixed low-level waste is stored indefinitely. The radioactive waste management basis statement references the waste certification process and the waste acceptance requirement documentation, which in turn invokes the waste acceptance requirements of the disposal facility. In addition to other site-wide programs and plans (e.g., radiological control, health and safety, training), the radioactive waste management basis statement also cites the RCRA permit issued for storage of mixed low-level waste, and the facility operating procedure for segregating mixed and non-mixed waste within the facility.*

Supplemental References:

1. DOE, 1992. *Nuclear Safety Analysis Reports*, DOE 5480.23, U.S. Department of Energy, Washington, D.C., April 10, 1992.

IV. E. Contingency Actions.

The following requirements are in addition to those in Chapter I of this Manual.

(1) Contingency Storage. For off-normal or emergency situations involving high activity or high hazard liquid low-level waste storage or treatment, spare capacity with adequate capabilities shall be maintained to receive the largest volume of liquid contained in any one storage tank or treatment facility. Tanks or other facilities that are designated low-level waste contingency storage shall be maintained in an operational condition when waste is present and shall meet the requirements of DOE O 435.1, *Radioactive Waste Management,* and this Manual.

(2) Transfer Equipment. Pipelines and auxiliary facilities necessary for the transfer of high activity or high hazard liquid low-level waste to contingency storage shall be maintained in an operational condition when waste is present and shall meet the requirements of DOE O 435.1, *Radioactive Waste Management,* and this Manual.

Objective:

The objective of this requirement is to mitigate the impacts on the public, workers, or environment in the event that a leak develops in a tank storing high activity or high hazard liquid low-level waste or in a facility processing such waste. The mitigation is provided by ensuring spare waste storage capacity is a required part of a site's emergency management program. To meet this objective, there needs to be both capacity to handle the largest volume of any single storage tank or liquid waste in process, and the capability to transfer the waste.

Discussion:

This requirement shall be implemented through and included in site emergency management programs that are required by DOE O 151.1, *Comprehensive Emergency Management System.* The directive DOE O 151.1 is referenced in DOE M 435.1-1, Chapter I and considered necessary for the safe management of radioactive waste. The Comprehensive Emergency Management System requires the development of a complex-wide system for preparing for and managing emergencies. At the site level, personnel are to establish an Operational Emergency Base Program that provides the framework for responding to events involving, among other subjects, health and safety, and the environment. The program requires a qualitative hazards survey to identify the emergency conditions, describe the potential impacts, and summarize the planning and preparedness requirements that apply.

During the development of the requirements of DOE M 435.1-1, *Radioactive Waste Management Manual*, a waste management hazard and safety analysis identified the loss of containment of a storage tank or waste processing facility containing radioactive liquids as a hazard requiring mitigation. In addition to requiring facility designs to maintain waste confinement (see DOE M 435.1, Section IV.M.(2)), the ability to respond to leaks or other off-normal conditions if they occur was also considered necessary. Consequently, the requirements to have adequate spare capacity and the ability to transfer waste to the spare capacity were established.

Liquid low-level waste is considered high activity if procedural or physical controls are required to protect workers from radiation exposure. Liquid low-level waste is considered a hazard if it presents a situation that has the potential to adversely impact the health and safety of personnel, the public, or the environment. High hazards are those with the potential for onsite and offsite impacts to large numbers of persons or with the potential for major impacts to the environment or national security.

Operating procedures are developed and utilized for transfer of high activity or high hazard liquid low-level waste to contingency storage. The procedures should address maximum operational capacities and limits for components of the operational system (e.g., spare storage capacity available in tanks). The procedures should define and address all possible emergency transfer scenarios needed to comply with this requirement.

Contingency Storage. Contingency storage is to be provided for both stored liquid low-level waste and for liquid low-level waste treatment facilities. In the case of storage tanks, adequate volumetric capacity must be available to receive the largest volume of waste stored in any single tank. In the case of a treatment facility, adequate capacity must be available to allow all in-process liquids in the facility to be moved into storage in the event of emergency or off-normal conditions.

A number of factors are considered in maintaining spare capacity. First, the requirement includes a provision that the spare capacity has “adequate capabilities.” Therefore, the spare capacity must have the necessary features and functionality as dictated by the design and safety analysis for the facility and wastes of concern. Features to be taken into account include appropriate materials of construction, shielding, ventilation and filtration, heat dissipation, liquid level monitoring, and mixing. Similarly, if the waste that may need to be transferred is regulated by some external regulation (e.g., RCRA), the tank(s) that would be used for spare capacity should be properly permitted. Likewise, the design bases events for the facility must be considered in determining the design of contingency storage, and whether some events may be severe enough that additional considerations must be included in the siting design, or operation of contingency storage to ensure its availability if there were a leak in an existing storage tank.

The requirement specifies that the contingency storage provided is to meet the requirements of DOE O 435.1 and DOE M 435.1-1. Of prime interest is the ability of existing contingency tanks or other facilities to meet the requirements for confinement in Low-Level Waste Treatment and Storage Facility Design DOE M 435.1-1, Section IV.M.(2). Additionally, compliance with the requirements for ventilation, instrumentation and control systems, and monitoring systems for storage facilities is also very important for tanks or facilities that will be used for contingency storage. Meeting these requirements, in combination, ensures that the use of existing tanks or other facilities for contingency storage minimize the potential impacts of off-normal or emergency situations involving high activity or high hazard liquid low-level waste.

Spare capacity may be provided by a single tank or by the combined available volume in multiple tanks. In cases where radiation fields are sufficiently low, spare short-term capacity may be able to be provided by portable tanks, tankers (i.e,. railroad cars), or tank trucks, provided that all applicable requirements can be met. Due to the potential of airborne radioactive material, impoundments or bermed areas open to the air generally should not be used for spare storage capacity, unless a safety analysis shows that the risk to workers and the public is low.

> *Example: Liquid radioactive waste is stored in six underground storage tanks with a design capacity of 250,000 gallons each. The waste in the all tanks has the same chemical and radiological characteristics. One tank contains 200,000 gallons and each of the others contain about 100,000 gallons. Capabilities exist to retrieve waste and transfer it among the six tanks. This system meets the requirement because the largest volume of 200,000 gallons can be distributed between any two of the other tanks.*

Transfer Equipment. The ability to perform waste transfer is just as important as having the capacity. Equipment necessary to transfer each tank or treatment facility volume of high activity or high hazard liquid low-level waste in the event of a leak or other off-normal condition is to be identified and documented.

> *Example: Liquid radioactive waste is stored in six underground tanks with the volumes and characteristics described in the previous example. Although there are transfer lines to any of the tanks from a central diversion box, the tanks were constructed without the capability to retrieve the waste. This situation does not comply with the requirement. Although there is adequate capacity, the ability to transfer the waste does not exist.*

Equipment necessary to transfer the contents of each tank is tested and inspected as part of a routine maintenance program (see DOE M 435.1-1, I.1.E.(9)). Special attention should be given to including in the maintenance program equipment and transfer lines that are not routinely used in managing liquid wastes. Inspection and testing includes the following items:

- leak testing of transfer pipelines;
- ensuring the availability of any jumpers necessary for completing waste transfer;
- confirming that instrument panels, control panels, valves, pumps and any necessary ventilation equipment is supplied with the necessary electrical power, air (for pneumatically-controlled items), steam, and water; and
- performing functional tests of instruments, controls, valves, pumps, and ventilation equipment.

The capability to perform an emergency transfer of high activity or high hazard liquid low-level waste is to be maintained at all times. Therefore, every shift must include or have immediate access to qualified individuals and the equipment necessary to perform transfers in a timely manner, unless analysis of the hazards associated with the waste concludes that an immediate transfer is unnecessary.

> *Example: A large shielding block is in place over a jumper pit that needs to be accessed during an emergency transfer of liquid waste. The block can only be moved by a crane. Therefore, implementation of this requirement entails making sure that the crane is always operationally available (in a matter of hours rather than days) and every shift has access to an individual qualified to operate the crane and remove the block.*

Spare capacity may also be shared by different waste types, however mixing radioactive wastes of different types should be evaluated and is generally not acceptable.

> *Example: A tank farm contains both high activity liquid low-level waste and liquid transuranic waste in separate tanks and a third empty tank for contingency. An empty mobile tank is maintained and available for emergency transfers of either waste in the event that the contingency tank must be used by either the low-level transuranic waste. Mixing waste types is prohibited in this case.*

Compliance with these requirements are demonstrated if adequate spare capacity and transfer equipment exists for emergency transfers of all high activity and high hazard liquid low-level waste. In addition, the capability to perform emergency transfers is demonstrated by having waste transfer routings identified, operational procedures to direct transfers, staff trained to the procedures, and records showing that the spare capacity and transfer capability are kept in operating condition.

Supplemental References:

1. DOE, 1995. *Comprehensive Emergency Management System*, DOE O 151.1, U.S. Department of Energy, Washington, D.C., September 25, 1995.

IV. F. Corrective Actions.

The following requirements are in addition to those in Chapter I of this Manual.

(1) Order Compliance. Corrective actions shall be implemented whenever necessary to ensure the requirements of DOE O 435.1, *Radioactive Waste Management*, and this Manual are met.

Objective:

The objective of this requirement is to ensure that actions will be taken to preclude, minimize, or mitigate hazards whenever a situation arises at a low-level waste management facility that could threaten worker or public safety, or the environment.

Discussions:

DOE M 435.1-1, Section I.2.G states that all personnel have a responsibility to identify conditions that require corrective actions to achieve compliance with the Order and Manual requirements or to address health and safety conditions that pose an imminent or possible danger. The Manual states that this responsibility includes considering shutdown or curtailment of facilities and activities, if warranted by the seriousness of the circumstances. This requirement ensures that this responsibility is implemented for all low-level waste management facilities and activities.

Corrective actions are activities which, when implemented, will address and correct noncompliant or hazardous conditions. Corrective actions can include improvements to documentation (e.g., procedures, plans, authorization basis documents), training and qualification programs or procedures, physical and process design changes, changes to operating conditions, or a combination of these activities.

Corrective Action System. A corrective action system exists for addressing noncompliant or hazardous conditions for low-level waste management facilities, operations, and activities. Corrective actions in response to quality assurance program assessments are addressed in the *Implementation Guide for Use with Independent and Management Assessment Requirements of 10 CFR 830.120 and DOE O 414.1 Quality Assurance*. The corrective action system provides for documenting noncompliant or hazardous conditions, identifying the organizations or individuals responsible for developing and implementing corrective actions, providing corrective action status, and tracking progress through final implementation of the actions. The corrective action system is instituted as a fundamental part of the systematic evaluation of radioactive waste activities that is implemented by the site-wide radioactive waste management program (see guidance for DOE M 435.1-1, Section I.2.F.(1)).

A problem requiring corrective action could range from a minor deviation from a procedure, to a situation that poses an immediate threat to health and safety from an uncontrolled release of large quantities of radioactive material. For situations where a problem could pose an immediate risk to a worker, member of the public, or damage to the environment, immediate shutdown of the process or facility may be appropriate as the first step in addressing the problem (see guidance for DOE M 435.1-1, Section IV.F.(2)).

> *Example: An employee of the Site Q laboratory facility noticed that a drum of mixed low-level waste which was supposed to be closed and ready for shipment did not have a rim lock and was not correctly labeled. He alerted the lab manager, who alerted central waste management. The laboratory corrective action system resulted in a corrective action plan that identified the lab manager as the responsible individual for producing a revised procedure on locking and labeling waste drums, and providing training to the lab staff. A reminder memo was sent to affected staff and a follow-up review was scheduled for 45 days after the occurrence .*

If a facility or activity can be allowed to operate while a noncompliant or hazardous condition exists, the allowance and any associated limitations must be defined as part of the facility or activity's radioactive waste management basis, identified as a configuration controlled item in a configuration management plan or included in a revision or modification to an operating procedure or similar controlled documentation. If a noncompliance impacts safety associated with use of a procedure, system, or facility, the corrective action system must provide for preventing the use (e.g., locking out) of the affected procedure, system, or facility.

> *Example: In the example above, waste generation was temporarily curtailed so that no new waste drums would be filled until the revised procedure was in place. Waste generation was allowed to resume as the training took place. No new drums were ready for locking and labeling until training had been completed.*

Corrective Actions for Low-Level Waste Disposal Facilities. Situations could be present at low-level waste disposal facilities that may require corrective measures even though there is no immediate or obvious safety or environmental concern. This is because some situations, left unchecked, could result in performance degradation to an extent that the ability of the disposal facility to continue to meet performance objectives could be compromised at some time in the future. Monitoring to detect degrading performance factors must be incorporated in the performance monitoring plan required by DOE M 435.1-1, Section IV.R (see guidance on DOE M 435.1-1, Section IV.R.(3)(c)). Some factors that should be considered include:

- Routine and special inspection of site conditions;
- Detection of events or conditions that could degrade performance of the disposal site;
- Periodic studies and surveys to determine the extent of migration of radionuclides, projection of potential future public doses, and their significance relative to the performance objectives;
- Specification of graded levels of response for each pathway; and
- Identification of corrective measures.

Conditions that have resulted in, or may lead to, site performance failure from ponding or flooding need to be corrected or mitigated as necessary. Ponding and flooding at the site provide opportunity for increased infiltration of water into the waste disposal units. Corrective measures to be considered include filling and regrading of the ponded area, construction of adequate surface water control systems such as dikes or diversion dams, and contouring of surfaces to control surface runoff.

Conditions at the disposal facility that may lead to site performance failure because of water accumulation in excavations also need to be corrected. Hydrologic conditions to be considered include:

- Infiltration through the excavation cover;
- Lateral intrusion; and
- Elevation of the water table.

Other site conditions to be considered include subsidence or cracking of the excavation cover and inadequate or damaged surface water diversion system. Corrective measures to be considered include:

- Reduction of the permeability of the excavation cover by compaction;
- Contouring of the cover material for controlled removal of surface water;
- Installation of subsurface drainage;
- Installation of barriers of low-permeability materials;

- Modification of nearby topography and surface material to reduce infiltration into the surrounding soils;

- Excavation of cover subsidence zone (add fill material, compact, contour, and stabilize, if subsidence is due to voids between packages, grout can be injected into void space);

- Pothole subsidence (fill, compact, and recontour);

- Cracking (excavate zone around crack, fill, compact, and recontour);

- Design and installation of diversion system to prevent offsite surface water from entering the site; and

- Repair or installation of onsite drainage system to remove onsite runoff.

Conditions at the site that may lead to exposure of the waste need to be corrected, since such exposure is a danger to workers and provides the opportunity for radionuclide transport by surface water and air pathways or by vectors (insects, rodents, etc.). These conditions include wind and water erosion of the excavation cover, subsidence or cracking of the excavation cover, burrowing by animals into the waste, and growth of deep-rooted plants. Corrective measures to be considered include:

- Filling and regrading the surface;

- Establishing erosion resistant cover;

- Filling of burrow holes;

- Installing physical, chemical, and/or biological barriers;

- Removal of deep-rooted plants; and

- Vector control.

Compliance with this requirement is demonstrated if a corrective action system addresses noncompliant or hazardous situations involving low-level waste management facilities in a systematic fashion, and allows identification of problems by all personnel.

Supplemental References:

1. DOE, 1996. *Implementation Guide for Use with Independent and Management Assessment Requirements of 10 CFR 830.120 and DOE O 414.1 Quality Assurance*, DOE G 414.1-1, U.S. Department of Energy, Washington, D.C., August 1996.

2. DOE, 1990. *Environmental Monitoring for Low-level Waste Disposal Sites: Low-level Management Handbook Series*, Revision 2, DOE/LLW-13Tg, National LLW Management Program, Idaho Falls, ID, 1990.

3. DOE, 1986. *Exposure and Improved Techniques in Radiological Environmental Monitoring at Major DOE Low-level Waste Disposal Sites*, DOE/LLW-54T, National LLW Management Program, Idaho Falls, ID, 1986.

IV. F.(2) Operations Curtailment. Operations shall be curtailed or facilities shut down for failure to establish, maintain, or operate consistent with an approved radioactive waste management basis.

Objective:

The objective of this requirement is to limit the operation of waste management activities and facilities as necessary to avoid creation of near- or long-term safety or environmental hazards.

Discussion:

DOE M 435.1-1 requires that a radioactive waste management basis be established for each low-level waste management facility, operation, or activity. The radioactive waste management basis documents the conclusion that the potential hazards from management of radioactive waste have been sufficiently evaluated and that adequate controls are in place to provide assurance that the public, workers, and the environment are being protected. Field Element Managers are responsible for ensuring a radioactive waste management basis is developed, reviewed, approved, and maintained for each DOE radioactive waste management facility, operation, or activity (DOE M 435.1-1, Section I.2.F.(2)). The guidance for that requirement should be consulted for additional details on the development, review, and approval of a radioactive waste management basis. Also, additional discussion concerning the radioactive waste management basis for low-level waste generator, treatment, storage, and disposal facilities is discussed under guidance for DOE M 435.1-1, Section IV.D.

As part of the Field Element Manager's responsibilities for maintaining the radioactive waste management basis for low-level waste management facilities, operations, and activities under

his/her authority, the Field Element Manager evaluates the compliance of the facilities, operations, and activities with the constraints and controls documented in the radioactive waste management basis by ensuring that routine assessments are conducted. If the Field Element Manager determines, either through routine assessment or by virtue of an occurrence or off normal event, that an operation, activity, or facility is not operating in compliance with an approved radioactive waste management basis, it must be curtailed or shut down. The action taken is commensurate with the hazards associated with the noncompliance and with the continued operation of the facility.

This requirement is to be implemented in a graded manner. Actions to be taken are based on assessments of adherence to radioactive waste management bases, and can range from shutdown of an operation or facility to placing limits or constraints on what activities can be performed or how the activities are to be performed. Shutdown of a facility involves stopping all operations in the facility except surveillance or monitoring activities necessary to maintain the facility in a safe standby condition. Shutdown is considered appropriate when there is either a potential imminent threat to safety or environmental protection that cannot be mitigated, or a blatant failure to establish or comply with a radioactive waste management basis.

Alternatively, there may be cases where the facility, operation, or activity assessment determines that the radioactive waste management basis is no longer current or has been violated, but there is no imminent threat to public, worker, or environmental protection. In such a case, the Field Element Manager may decide that shutdown of the facility is not necessary. It may be sufficient to impose certain limits until the radioactive waste management basis is made current. The limits imposed may prohibit the generation, receipt, or processing of certain waste streams, or may involve constraints on the processes that may be performed.

> *Example: Site Q conducts bi-annual assessments of the Building B low-level and mixed low-level storage facilities for compliance with the radioactive waste management basis. The 1996 biannual assessment found two non-compliance findings and five observations. The corrective action system implemented at Site Q requires the non-compliance findings to be entered and formally responded to with corrective action plans, but not the observations. The non-compliances were in document control and training, so the storage activities were not curtailed in any way while the document control and training procedures were improved. The facility was assessed again in 1997 to determine if the corrections were in place, which was an accelerated assessment schedule from the normal bi-annual assessments.*

The action taken in response to the failure to establish a radioactive waste management basis is to be clearly documented in a formal communication (e.g., letter, memorandum). Such communication needs to identify the reason for the shutdown or curtailment, and identify what is necessary to initiate restart. Generally, development of a corrective action that is implemented

through the corrective action system discussed in the preceding section would be appropriate for responding to a shutdown or curtailment of activities at a low-level waste management facility.

In concert with Core Requirement #6 of the Integrated Safety Management System, "Feedback and Improvement," the Field Element Manager should use the audits and assessments to identify opportunities for improvement in the implementation of an activity or facility's radioactive waste management basis. Identified improvement actions should be shared with like organizations and tracked by management to determine whether they are yielding the anticipated improvements. Communicating the results of assessment upward in the DOE and contractor organization will allow the findings to reach the management level with authority necessary to effect improvements.

Compliance with this requirement is demonstrated with a documented system of routine assessments to determine whether waste management activities and facilities are operating in accordance with an approved radioactive waste management basis that provides for graded limitations that can be placed on activities and operations that do not have, or are operating outside of, an approved radioactive waste management basis, including shutdown of the facility.

Supplemental References:

1. DOE, 1997. *Safety Management Functions, Responsibilities, and Authorities Policy*, DOE P 411.1, U.S. Department of Energy, Washington, D.C., January 28, 1997.

2. DOE, 1996. *Safety Management System Policy*, DOE P 450.4, U.S. Department of Energy, Washington, D.C., October 15, 1996.

3. DOE, 1997. *Line Environment, Safety and Health Oversight*, DOE P 450.5, U.S. Department of Energy, Washington, D.C., June 26, 1997.

4. DOE, 1997. *Manual of Safety Management Functions, Responsibilities, and Authorities Manual*, DOE M 411.1-1, U.S. Department of Energy, Washington, D.C., October 8, 1997.

IV. G. <u>Waste Acceptance</u>.

The following requirements are in addition to those in Chapter I of this Manual.

(1) Technical and Administrative. Waste acceptance requirements for all low-level waste storage, treatment, or disposal facilities, operations, and activities shall specify, at a minimum, the following:

(a) Allowable activities and/or concentrations of specific radionuclides.

(b) Acceptable waste form and/or container requirements that ensure the chemical and physical stability of waste under conditions that might be encountered during transportation, storage, treatment, or disposal.

(c) Restrictions or prohibitions on waste, materials, or containers that may adversely affect waste handlers or compromise facility or waste container performance.

Objective:

The objectives of the waste acceptance requirements are to ensure that low-level waste which is received at a facility contains only the radionuclides that the facility can safely manage, and only in concentrations and/or total activities which are compatible with the work to be undertaken in the facility; ensure that low-level waste which is to be received at a facility is in a form or container that will maintain its integrity and retain acceptable configuration under the conditions that are expected to be encountered during the management steps the waste will undergo; and ensure that no low-level waste received at a facility contains materials that will compromise the safety or integrity of the facility under the expected operating conditions.

Discussion:

As discussed in Section I.2.F.(6) of the guidance for Chapter I, General Requirements, the waste acceptance requirements establish the conditions for waste that facilities can safely receive. Therefore, the acceptance requirements for a low-level waste storage, treatment, or disposal facility include all requirements that low-level waste must meet to be acceptable for receipt, and for the subsequent storage, treatment, or disposal, as appropriate.

In conducting the analyses for development of the DOE M 435.1-1 requirements, minimum acceptance requirements that must be specified in the waste acceptance documentation for storage, treatment, and disposal facilities in order for low-level waste to be safely handled were identified. DOE M 435.1-1, Sections IV.G.(1) (a) through (c), and (e) provide minimum

acceptance requirements that must be in all low-level waste storage, treatment, and disposal facility waste acceptance requirements. DOE M 435.1-1, Section IV.G.(1)(d) provides additional minimum acceptance criteria that must be in all low-level waste disposal facility requirements. Guidance on subrequirement (a) is provided below under Radionuclide Content or Concentration. Guidance on subrequirements (b) and (c) is provided under Waste Form and Package Criteria and Prohibitions. Guidance on subrequirements (d) and (e) is provided under the citations of those requirements following the guidance on subrequirements (a) through (c).

Development of Waste Acceptance Requirements. A facility receiving waste for storage, treatment, or disposal is required to document the waste acceptance requirements for the facility. These requirements have their foundation in facility design capabilities such as volume, handling weight, allowable contents, and radiological limits (i.e., criticality, radiation, contamination). Other requirements may include any number of regulations promulgated by the EPA, NRC, DOT, the host state, and DOE itself. The designer and operator of the facility receiving waste are likely to be most knowledgeable and understanding of the requirements and limitations of the facility and, therefore, are in the best position to establish the waste acceptance requirements or criteria that must be met for waste sent to the facility.

A low-level waste management facility at a site may have its own specific stand-alone waste acceptance requirements. Or a site may have general waste acceptance requirements applicable to all low-level waste management facilities at the site, with separate facilities, adding facility-specific acceptance requirements to the site waste acceptance requirements as necessary. This practice may be particularly effective at sites with many facilities which manage small quantities of waste with multiple locations for staging, storage, and/or central management of waste. At such facilities, most of the process and procedural waste acceptance requirements could be in one document applicable to the whole site, which would be supplemented with specific technical requirements for acceptance at each of the separate management locations. If activities across various facilities are similar, they could share the same supplemental waste acceptance requirements documents. Likewise, if several activities are carried out at locations that are close to one another, or are managed by the same entity, then one supplemental technical document may be prepared to cover those activities.

The waste acceptance requirements and documentation for a facility receiving waste for storage, treatment, or disposal is prepared using a graded approach commensurate with the hazards associated with the management of the waste in the facility and the complexity of the activities to be conducted in the facility and upon the waste. The waste acceptance requirements document for a facility which receives major transfers of large quantities of low-level waste from many generators, or with high specific activities or highly variable contents may need to address many hazards and consequently be more detailed. By contrast, a storage facility which will only pass-through properly packaged waste directly to a disposal facility without any additional processing or packaging may only need a minimum set of requirements. Perhaps only a few administrative

requirements would be necessary for proper receipt of waste at such a storage facility, along with assurance that waste received at the storage facility meets the disposal facility technical waste acceptance requirements.

> *Example 1: A large DOE low-level waste disposal facility accepts waste from many offsite generators, from a variety of processes, including a variety of types and concentrations of radionuclides. Waste acceptance requirements for receipt and disposal of low-level and mixed low-level waste are prepared as a stand-alone set of requirements due to the complexity and diversity of the wastes received. The processes for acceptance, and technical and administrative requirements for the waste are unique to this disposal facility.*

> *Example 2: At a large DOE site, several facilities are used for storage of low-level waste. One waste acceptance requirements document is prepared containing all of the necessary administrative requirements for all storage buildings. Each storage facility has a technical procedure which contains the specific technical criteria for the facility, and which implements the administrative waste acceptance requirements document for the processes and forms, etc. that are needed for storage of low-level waste.*

The performance assessment, composite analysis, disposal authorization statement, safety analysis report, criticality analysis, and any other appropriate safety and/or authorization basis documents are to be used to establish the waste acceptance criteria for receiving facilities low-level waste for storage, treatment or disposal. These documents and analyses provide the basis for radioactivity (concentration and inventory) limits, waste classes or categories, waste form and/or packaging stability requirements, allowable chemical content, allowable free liquid content, and any other necessary waste package or form requirements to ensure that the facilities' design bases, performance, and operating bases are protected.

DOE M 435.1-1, Chapter IV requires the conduct of a performance assessment maintenance program. Under this program the performance assessment must be revised if changes occur in radionuclide inventories beyond expected limits, facility design, or the understanding of the site or any other features that change the conclusions of the existing performance assessment. Thus, when the performance assessment is changed, the waste acceptance requirements need to be reviewed to determine if the performance assessment changes affect any acceptance criteria. If so, then the acceptance requirements are modified as appropriate.

> *Example: Monitoring wells located on the boundary of a low-level waste disposal facility indicate the presence of migrating radionuclides sooner than estimated by performance assessment calculations. The data affecting release rates for these radionuclides in the performance assessment are analyzed following this discovery. The analysis indicates the presence of a significant chemical catalyst which results in higher*

release rates. The calculations in the performance assessment are updated and waste acceptance requirements and radionuclide inventory limits are revised based on the new performance assessment modeling results.

Radionuclide Content or Concentration. Radiological limits for storage, treatment, and disposal facilities may be derived from a number of technical as well as administrative sources. In developing radionuclide limits, personnel need to consider legislative and/or regulatory limitations, the disposal facility performance assessment and composite analysis, safety analysis reports, and criticality analyses. In addition to establishing general radiological limits (e.g., a contact dose rate), these sources identify specific radionuclides whose concentration or total activity must be limited in the waste acceptance criteria in order to remain within the bounds for safe and legal facility operation.

The results of the performance assessment and composite analysis will provide information on certain critical radionuclides that are most important for assuring that the long-term performance of the low-level waste disposal facility will be maintained. In some cases, the critical radionuclides need to be specifically identified in the waste acceptance criteria, and additional technical or administrative requirements specified for them. A critical radionuclide may require specific information on the characterization documentation that must be input into the disposal facility records. The waste acceptance requirement documentation specifies what this information is and how it is to be provided to the facility receiving waste for storage, treatment or disposal.

Example: The results of the performance assessment for a specific low-level waste disposal facility indicates that control of several specific radionuclides is important to the protection of ground water resources. The waste acceptance requirements for the facility state the limits on each of these radionuclides and that the amount of each of these nuclides must be specifically reported on the characterization documents for packages of low-level waste received at the facility. The waste acceptance requirements indicates that the lower limit of detection of equipment used to characterize waste must be included in the characterization information where a 0 (zero) is reported for any of these radionuclides.

The performance assessment analysis may also indicate that some waste streams or forms to be disposed at the disposal facility being evaluated need to be packaged or otherwise disposed in a structurally stable form. These wastes may be identified specifically and identified in the waste acceptance requirements as needing to be structurally stable prior to acceptance at the disposal facility. Alternatively, the waste acceptance requirements may include a site-specific classification or categorization system which requires stability, or some other additional management steps, for wastes containing certain concentrations of specific radionuclides. The waste acceptance requirements may also allow for acceptance of certain wastes in a bulk, non-containerized fashion.

Example: The results of an intruder analysis in the performance assessment for a specific low-level waste disposal facility indicate that wastes containing concentrations of three radionuclides greater than calculated values may not be acceptable for near-surface disposal unless measures are taken to provide intruder protection from the wastes. A supplementary intruder analysis is conducted using new assumptions of a more stable waste form. The supplementary intruder analysis indicates that a higher concentration of the radionuclides can be accepted using the more stable waste form assumed in the analysis. Therefore the waste acceptance criteria are developed to allow for wastes to be received containing the lower concentration of the radionuclide in untreated waste, and allows for wastes to be received containing the higher concentration of the radionuclides, if the waste is treated to the more structurally stable waste form.

The safety analysis report prepared for a low-level radioactive waste management facility may also identify specific radionuclides that warrant specific attention from a worker safety standpoint, and may require special handling if received and managed at the facility.

Example: A storage facility that manages low-level mixed waste is subject to RCRA Part B permit requirements for routine inspection of the waste. An analysis of worker radiation exposure associated with inspection of the storage configuration indicates that several radionuclides need to be controlled below certain concentrations to maintain doses to workers as low as reasonably achievable. The waste acceptance requirements for the facility reflect the allowable concentrations from the safety analyses as maxima for waste that can be accepted for storage in the facility.

Any criticality analysis that will be conducted to derive the criticality safety program in conformance with DOE M 435.1-1, Section I.1.E.(4) may also result in some limitations on acceptance of fissile radionuclides. These limitations need to be included in the waste acceptance requirements, as appropriate.

Waste Form and Package Criteria and Prohibitions. Waste acceptance requirements should specify that wastes received at the facility are in a physically/chemically stable form. As used in this requirement, stability refers to the physical and chemical properties of waste that are necessary for it to be handled safely at a facility and to undergo the management steps normally performed at that facility. Such stability is dependent on the waste management steps to be performed with the waste (e.g., treat, store, or dispose) and the time to complete the management step (e.g., time until treatment or length of expected storage period). Therefore, waste acceptance requirements must specify the necessary physical and chemical stability for the specific operations and activities for a given facility. Waste acceptance requirements for a low-level waste treatment facility need to specify the physical and chemical precautions and conditions under which untreated waste can be received at the facility so that facility safety and effective operations will not be compromised. Any physical or chemical stabilization of waste prior to transfer to a

receiving facility need to be done according to a systematic process that may include consideration of bench scale testing and verification that the process is producing satisfactory results.

The waste acceptance requirements need to specify waste streams, classes, or categories of waste requiring application of specific physical, chemical, or structural stabilization methods, as determined by the results of site-specific analysis of site conditions, the waste that needs physical or chemical stabilization, and the desired performance of the facility. For treatment and storage facilities, the results of safety analysis or other safety documentation may indicate certain waste streams require specific physical or chemical stabilization to be safely handled by workers. The waste acceptance requirements should specify limitations or technical criteria for these waste streams, classes, or categories to meet. For disposal facilities, the performance assessment and composite analysis may conclude that certain waste streams require stabilization in order to contribute to a reasonable expectation that the disposal performance objectives will be met. Again the waste acceptance requirements should specify the structural stability limitations or criteria for these waste streams to meet.

> *Example: The results of the performance assessment for a specific low-level waste disposal facility indicate that wastes containing three long-lived radionuclides are acceptable for near-surface disposal provided some measures are taken to provide additional protection to water resources. The waste acceptance requirements identify low-level wastes containing these radionuclides as Category G low-level wastes (G for groundwater). These category G low-level wastes will only be accepted in high integrity containers and then be disposed in trenches containing special groundwater protection barriers.*

Acceptable waste forms, containers, and packages providing structural stability or inadvertent intrusion protection are specified by the waste acceptance requirements. Structural stability refers to the property of the waste to provide for stability of the disposal site during and after operations to reduce the amount of subsidence and prevent or minimize radionuclide migration from the disposal unit. Any structural stabilization that is conducted to meet waste acceptance requirements needs to also be done according to a systematic process that includes consideration of bench scale testing and verification that the process is producing satisfactory results, as appropriate. The waste acceptance requirements indicate the testing and verification processes that are acceptable. Consideration should be given to incorporating the technical positions and tests discussed in the US Nuclear Regulatory Commission's Technical Positions on Waste Form (Refs. 1 and 2) into the low-level waste disposal site waste acceptance requirements for acceptable verification tests for structurally stable waste.

The waste acceptance requirements need to list any specific packages and containers pre-approved as acceptable for the low-level waste management facilities, as well as acceptable

overpacks. Consideration should be given to the policy on use of standardized low-level waste disposal containers (Ref. 3) and its attendant guidance on recycling of radioactively contaminated carbon steel.

The waste acceptance requirements need to identify any of the following specific technical requirements that must be included to ensure that waste received at any storage, treatment, or disposal facility is consistent with the operating basis of the facility:

- the acceptable limits for waste package external surface dose rate for both contact and remote handled packages, and heat generation;
- the acceptable limits for free liquid content, specified on a per package basis;
- the acceptable limits for maximum void space, specified on a per package basis;
- the necessary labeling and marking to be applied to low-level waste packages;
- the necessary information about any bar coding or other tracking system used at the facility receiving the waste and the application of the system by generators;
- any specific requirements associated with acceptance of bulk waste, including any additional restricted materials or limitations on materials and any specific technical requirements bulk waste must meet for compatibility with disposal operations and the conditions or specifications for handling bulk waste containers that will not be disposed;
- any specific radionuclides or chemical or hazardous materials that are prohibited from acceptance at the facility;
- any specific requirements associated with acceptance of mixed low-level waste, including any additional restrictions or limitations on the waste or specifications for handling mixed waste containers;
- any specific packages or types of packages or containers that are prohibited from or restricted in acceptance at the facility;
- any specific requirements associated with acceptance of special low-level waste streams needing out of the ordinary attention for receipt, handling, storage treatment, or disposal, (e.g., sealed sources), including any additional restrictions or limitations on the waste or specifications for handling the waste containers;

- any package protection requirements needed for transport and receipt to provide needed physical protection to the packages to prevent breaching and so that the certified status of the waste is preserved;

- the necessary shipping arrangements for transport to the facility receiving the waste, including any electronic traffic data bases or scheduling system used.

Example 1: The Site B mixed waste incinerator waste acceptance criteria contains a list of acceptable radionuclides and their acceptable concentrations, states the acceptable limits for waste package external dose rate, contains a list of acceptable RCRA hazardous constituents that can be destroyed by the incinerator, states that all waste must be received in specially designed fiberboard boxes (expedites waste feed), prohibits acceptance of Polychlorinated Biphenyls (PCBs) (it does not have a Toxic Substances Control Act approval), and prohibits acceptance of gaseous, reactive, and explosive waste.

Example 2: The Central Waste Management Unit Storage and Transfer Facility at Site B provides centralized collection, staging, and transfer for all Site B low-level, mixed low-level, and transuranic wastes. Site B waste is transferred/shipped to a variety of storage, treatment, and disposal facilities, some on- and some off-site. The waste acceptance requirements for the Central Waste Management Unit Facility specifies that all waste must be certified to the waste acceptance criteria of the downstream facility to which it goes next. The requirements also contain instructions on obtaining specific site-specific labels containing barcoding from the Central Waste Unit, and instructions for attaching specifically colored waste drum ring bands corresponding to a code that correlates with the wastes' next destination established by Central Waste that facilitates sorting and segregating of the waste at the Transfer Facility.

Compliance with these waste acceptance requirements is demonstrated if they are documented, contain clear and precise criteria specifying the radionuclide limits in the form of contents or concentrations that can be accepted, the limitations and prohibitions on waste forms and packages that can be received, and the limits, prohibitions, or instructions concerning any other technical information so that the waste is compatible with the safety basis of the facility, and which will result in acceptable waste at subsequent steps in managing the low-level waste.

Supplemental References:

1. NRC, 1983. *Final Waste Classification and Waste Form Technical Position Papers*, U.S. Nuclear Regulatory Commission, Washington, D.C., May 1983.

2. NRC, 1991. *Technical Position on Waste Form*, Revision 1, U.S. Nuclear Regulatory Commission, Washington, D.C., January 1991.

3. Cowan and Owendoff, 1996. Steven Cowan and James Owendoff to Distribution, memorandum, *Use of Standardized Low-Level Waste Disposal Containers*, U.S. Department of Energy, Washington, D.C., April 17, 1996.

IV. G.(1) Technical and Administrative.

(d) The following are additional waste acceptance requirements that shall be specified in low-level waste disposal facility waste acceptance requirements:

1. Low-level waste must contribute to and not detract from achieving long-term stability of the facility, minimizing the need for long-term active maintenance, minimizing subsidence, and minimizing contact of water with waste. Void spaces within the waste and, if containers are used, between the waste and its container shall be reduced to the extent practical.

2. Liquid low-level waste or low-level waste containing free liquid must be converted into a form that contains as little freestanding liquid as is reasonably achievable, but in no case shall the liquid exceed 1 percent of the waste volume when the low-level waste is in a disposal container, or 0.5 percent of the waste volume after it is processed to a stable form.

3. Low-level waste must not be readily capable of detonation or of explosive decomposition or reaction at anticipated pressures and temperatures, or of explosive reaction with water. Pyrophoric materials contained in waste shall be treated, prepared, and packaged to be nonflammable.

4. Low-level waste must not contain, or be capable of generating by radiolysis or biodegradation, quantities of toxic gases, vapors, or fumes harmful to the public or

workers or disposal facility personnel, or harmful to the long-term structural stability of the disposal site.

5. Low-level waste in a gaseous form must be packaged such that the pressure does not exceed 1.5 atmospheres absolute at 20 C.

Objective:

The objective of the technical and administrative requirements for low-level waste disposal is to ensure that low-level waste disposed in DOE waste disposal facilities are in a form and/or packaged so that the waste contributes to the facility meeting the performance objectives for disposal of low-level waste.

Discussion:

The analyses performed in developing the DOE M 435.1-1 requirements indicated that minimum waste form requirements were needed for disposed low-level wastes to be able to continue to have reasonable assurance that the long-term hazards from the waste would not adversely impact the public, workers, or the environment. These minimum waste form requirements are designed to achieve the performance objectives of the disposal facility over the long term. In order to effectively contribute to meeting the performance objectives, the waste form and/or packages should contribute to the goals of minimizing: (1) the need for long-term active maintenance of the facility following closure; (2) subsidence during and after waste emplacement; and (3) the contact of water with disposed waste. To assist in achieving these goals, the requirement includes reducing void spaces within the packages of waste and within the waste itself, minimizing the amounts of liquid that could be released through leaching or if a waste container were breached, ensuring that waste packages do not contain any materials which would be potentially harmful to the public or workers if a container was breached during operations or which would create an unstable condition in the disposal unit following disposal.

Facility Stability. Subrequirement (DOE M 435.1-1, Section IV.G.(1)(d)1.) is intended to provide a set of minimum requirements for waste forms and containers to contribute to the long-term stability of the disposal site and thus contribute to a reasonable expectation that the performance objectives for the disposal facility will be met for a long time into the future. Waste acceptance requirements are to specify site-specific limits or criteria for acceptable structural stability of waste forms and containers based on site conditions, the waste that requires stability, and the desired performance of the facility. (Long-term stability of a low-level waste disposal facility is discussed and described further in guidance on Section IV.M.(3), Low-level Waste Disposal Facility Design.)

Waste forms and containers should maintain their basic shape and form for a period of time corresponding to the period of time necessary to achieve performance objectives. For most low-level waste, standard 55-gallon drums and boxes such as B-25 boxes are adequate. Containers should be designed to withstand the loads that are likely to be present in the disposal unit, including waste disposed above and any overburden and closure cover materials. Consideration needs to also be given as to whether live loads (i.e., vehicles) will be present at the disposal units.

Disposal units disposing of bulk wastes like contaminated dirt and construction rubble need to compact the disposal units to minimize subsidence. The practice of compaction as a regular part of disposal unit operations may also be considered for the disposal of waste in cardboard boxes, which could degrade in an uncontrolled fashion and contribute to subsidence problems unless they are dynamically compacted at the time of disposal unit covering.

The subrequirement also includes the minimization of void spaces to contribute to the stability of the site. This applies to both the amount of void spaces within the waste, as well as between the waste and its packaging if containers are used. The control of void spaces is achieved visually for containers containing job control waste, for example, as well as being an integral parameter for wastes prepared using a process control. The use of encapsulation methods, such as grout, may need to be considered for wastes containing highly-activated components that are likely to remain hazardous well beyond any foreseeable period of time a waste container is likely to last.

Liquid Wastes. The intention of the free liquid subrequirement (DOE M 435.1-1, Section IV.G.(1)(d)2.) is for liquid wastes or wastes that contain free liquid to be treated or packaged so that there is as little liquid remaining as is reasonably achievable. The requirement is also intended to address liquids that could become free liquids during transportation or which could be released due to thermal cycling or vibration that occurs during shipment. This can be accomplished through solidification or stabilization methods, by a dewatering process, or by packaging the waste with absorbent material. (It is, in fact, good practice to add a small quantity of absorbent (e.g., a quarter inch) in the bottom of most containers of waste. “Dry” waste is often not completely dry. Condensation also often occurs. The use of absorbent helps to reduce incidence of surface contamination and needless problems of appearance should small drops of condensation leak from a container.) For waste placed into a disposal container, the process or design for removing or reducing the liquid shall result in free liquid that is no more than 1 percent of the container volume. For wastes that are processed to a stable form, that is, where the waste form itself acts as a monolithic form and will be placed into the disposal unit without a container, the process or method shall result in free liquid that is no more than 0.5 percent of the volume of the waste form. The volume of the waste form in this case is the final volume following treatment to the stable form. If a waste is treated through a process that results in a processed, stable form, but it is also inside a container, then the free liquid requirement for the stable form shall be followed, that is, there should be no more volume of free liquid than 0.5 percent of the volume of the stabilized waste inside the container of stable waste.

A challenge is presented in determining compliance with the free liquid requirement because of the need to minimize or prevent exposures to workers. This would be a concern because one way to determine compliance would be to randomly examine waste forms and containers to determine the volume of free liquid. This has been done in the past at some older disposal operations by puncturing a hole in a container as it is received and measuring the amount of liquid that is obtained from the package. A better approach is to utilize processes, procedures, or methods whose results can be assumed appropriate as long as written protocol is followed, or which can be tested without damaging the waste package, for example, through test runs with surrogate materials. ANS Standard 55.1 (Ref. 1) is recommended for performing measurements of free liquids in solidified low-level waste forms and containers.

When using a container with absorbent materials, the process and procedure for loading the container with waste needs to call for introduction of more absorbent by volume than is needed for the amount of free liquid calculated in the waste, both for a safety factor, and because it is difficult to calculate exactly how much liquid will be freed during transportation and handling. Another measure in using absorbents to be considered would be redundancy, such as using two different kinds of absorbents, or using layering, such as double bagging. For processing waste to a stable form, or for a dewatering process, the use of test runs to produce samples that could undergo analysis using non-radioactive surrogate materials to determine optimum processing parameters that will result in meeting the liquid requirement is recommended. Likewise, the results of test or actual runs could be used to establish parameters for a subsequent treatment process when the waste material and feed are the same as a previous successful treatment process, and the correlation can be justified and verified.

Particular attention needs to be placed on the treatment and packaging of low-level waste to minimize free liquids for waste streams having a high initial moisture content. Additional measures could be considered for inclusion in waste acceptance criteria that call for specific calculations of how much of the interstitial liquid could become free liquid during handling and transportation, specific testing of absorbent to be used for such waste streams, consideration of the addition of a certain minimum amount or specification of absorbent, or the required solidification, stabilization, or additional packaging of waste streams that may be of particular concern (e.g., high-activity liquids present).

Soils present a particular challenge in regards to the free liquid requirement since many soils have a high initial moisture content, yet, in many cases the soil will not yield a significant amount of free liquid. Modifications to the measures discussed need to be considered to provide the needed information without the expenditure of resources that may be necessary for certain operations waste that may yield free liquids. For example, the evaluation for determining how much of the interstitial liquid could become free liquid during handling and transportation could be done on a set of standard soils from the site, with the results being provided on a generic basis rather than on a container-by-container basis.

Nuclear power plants employ a "process control program" to consistently produce products which are acceptable for disposal and which will meet waste acceptance requirements of receiving facilities. General guidance and requirements for process control programs can be found in NRC's standard review plan for nuclear power plants (NUREG-800) (Ref. 2).

Explosive, Reactive, Pyrophoric, and Degrading Low-Level Waste. The intention of the explosive, reactive, and pyrophoric subrequirement (DOE M 435.1-1, Section IV.G.(1)(d)3.) is that wastes containing a material that could react with water or spontaneously detonate or ignite be treated or packaged so that the chance for this to occur is significantly reduced. This is accomplished through solidification or stabilization or by packaging methods. The requirement is not intended to prohibit waste from containing potentially explosive or pyrophoric materials, only that they be appropriately treated, prepared, and packaged so the chance of ignition or explosion is significantly reduced.

Similarly, the intention of the radiolysis, biodegradation, and toxic subrequirement (DOE M 435.1-1, Section IV.G.(1)(d)4.) is that wastes must not be capable of generating toxins that will be harmful to workers during operations if a container were to be breached, or which could contribute to a slow degradation of the stability of the disposal site. The requirement in this case explicitly states that the waste must not contain any of the gases or vapors to begin with, but it also states that the waste shall not be capable of generating any from the materials present in the waste. In this case, just like above, a treatment or packaging method is used to render the waste incapable of generating the gases or vapors.

Gaseous Low-Level Waste. The gaseous low-level waste subrequirement (DOE M 435.1-1, Section IV.G.(1)(d)5.) is intended to protect workers and the long-term stability of the site by specifying the maximum pressure at which gaseous radioactive waste is to be packaged. The requirement is also intended to apply to the situation where gases are generated within the waste packages following closure of the package. An analysis may need to be conducted on any waste materials that could potentially generate gases due to conditions of storage or treatment to ensure that the pressure stated in the requirement will not be exceeded. The analysis needs to also include the potential for any conditions inherent in the waste and/or waste form that could cause gas generation. For example, spent ion exchange resins could generate hydrogen gas while in storage due to radiolysis.

Compliance with the waste acceptance requirements for low-level waste disposal facilities is demonstrated if they contain these minimum disposal facility requirements, or equivalent.

Supplemental References:

1. ANS, 1979. *American National Standard for Solid Radioactive Waste Processing System for Light Water Cooled Reactor Plants*, ANS 55.1, American Nuclear Society, La Grange Park, IL, 1979.

2. NRC, 1981. *Standard Review Plan for Nuclear Power Reactors*, NUREG-0800, U.S. Nuclear Regulatory Commission, Washington D.C., 1981.

IV. G.(1) Technical and Administrative.

(e) The basis, procedures, and levels of authority required for granting exceptions to the waste acceptance requirements, which shall be contained in each facility's waste acceptance documentation. Each exception request shall be documented, including its disposition as approved or not approved.

Objective:

The objective of this requirement is to ensure that formal procedures exist and a decision process is clear concerning the granting of exceptions to waste acceptance requirements.

Discussion:

Waste acceptance requirements are established to ensure that facilities can safely manage waste received for storage, treatment, or disposal, and is particularly critical for disposal facilities in assuring the long-term performance will be maintained. Thus, exceptions or deviations to acceptance criteria cannot be routine and must be carefully reviewed and documented, especially to provide for the permanent record of waste disposed. The procedures for granting exceptions needs to clearly state the entire process for requesting an exception, describe acceptable bases for granting exceptions, and identify any additional information that is needed to supplement the documentation normally provided for waste transfers. The approval process needs to be clearly spelled out so the generator can conduct the request appropriately.

Example: The waste acceptance requirements for a low-level waste storage facility specifies three acceptable containers that can be received at the facility. It also includes a procedure for obtaining an exception to the waste acceptance criteria concerning containers only. (The requirements specifically state that no other exceptions will be granted). The procedure for the container exceptions includes minimum information about any containers other than the three pre-approved that must be submitted, who it is

to be submitted to, and the criteria that will be used to determine if the container may be found acceptable as an exception.

Waste acceptance requirements are acceptable if they are documented and contain a clear description of the procedure and bases obtaining for an exception or deviation to the acceptance criteria for low-level waste to be received at the facility.

Supplemental References: None.

IV. G.(2) Evaluation and Acceptance. The receiving facility shall evaluate waste for acceptance, including confirmation that the technical and administrative requirements have been met. A process for the disposition of non-conforming wastes shall be established.

Objective:

The objective of this requirement is to establish a process by which personnel at a facility receiving low-level waste for storage, treatment, or disposal determine that the waste being transferred is acceptable in accordance with the waste acceptance requirements and for that process to specifically address the management of waste that does not conform with all of the requirements when it is received at the facility.

Discussion:

This requirement makes it the responsibility of officials at a facility to which waste is transferred to confirm that waste is in compliance with the established waste acceptance requirements and also provides a mechanism by which the officials confirm that waste can be accepted and safely managed.

Evaluation and Acceptance. The methodology for implementation of this requirement needs to be flexible and defined on a facility-specific basis. The complete process and procedures, including the responsibilities of the generating facility, need to be clearly documented so that both the generator and the facility receiving the waste understand the process that will be used. As with implementation of other parts of DOE M 435.1-1, this requirement is implemented using the graded approach process. Facilities receiving low-level wastes from many generators, offsite generators, or high activity low-level wastes, may need to implement more detailed waste evaluation and acceptance processes than a facility receiving waste from a small number of onsite generators.

The evaluation and confirmation process consists of one or more of the following approaches, and is designed to demonstrate that the waste presented meets the waste acceptance requirements of the facility receiving waste for storage, treatment, or disposal:

- Testing, sampling, and analysis of the contents of a representative sample of waste packages as they are received at the facility;
- Testing and analysis of a number of samples taken by the generator facility;
- Detailed review of sampling and analysis data generated by the sending facility or an independent laboratory employed by the generating facility;
- Audit, surveillance, or observation of the sender's waste characterization activities and processes and waste certification programs.

Testing, sampling, and analysis of the contents of a representative sample of waste packages upon receipt is complicated by the fact that additional risk is posed if a technique such as opening of drums and obtaining grab samples is used. Therefore, consideration needs to be given to implementing non-destructive examination technologies if receipt sampling and analysis is the preferred approach. Likewise, analysis of samples taken at the generator's site may involve additional risk, and also may be expensive to implement. If this method is employed, samples which are representative, either statistically or correlated with generator profiles, need to be obtained for analysis to ensure this method is effective. This sampling would include packages from the generators sending the largest volumes of waste to the facility or packages containing the critical radionuclides as identified in the waste acceptance requirements.

The use of a detailed review of the sampling and analysis data gathered by others would include an evaluation of the methodologies used for collecting the sample, maintaining the integrity of the sample and data (e.g., through a chain of custody), and performing the radioanalyses. As above, the samples collected would need to be representative of the waste, either statistically or with a bias towards large generators or generators of significant radionuclides (i.e., those that are most limiting for the storage, treatment, or disposal facility).

The use of assessments audits, reviews or surveillances to verify compliance of the waste generators certification programs with acceptance requirements would need to be conducted on a schedule commensurate with the frequency of waste generation and shipments. The documentation of the verification process would include organization and authorities; frequency of assessments; methods to be employed; the information that will be documented as a result; and the qualifications of personnel.

Example: The waste acceptance process for Storage Building B on the Western Site, which receives waste from multiple generators involves assay to confirm transuranic waste and to segregate transuranic and low-level waste, and sample collection and analysis to confirm the RCRA status of waste. The process calls for assaying and sampling one waste package of every 25 from established waste streams and one of every 5 for new waste streams of for waste from generators who have a history of poor compliance with the waste acceptance criteria.

Discussions contained in *Methods for Verifying Compliance with Low-Level Radioactive Waste Acceptance Criteria* (Reference 2), provide additional guidance for evaluation and acceptance of waste at receiving facilities.

Non-Conforming Low-Level Waste. Facilities receiving low-level waste for storage, treatment or disposal need to have a documented process to be used in the event a non-conforming waste is received. A non-conforming waste is a waste container or shipment which is certified by the generator as meeting the waste acceptance requirements of the receiving facility but which is found to be in violation of the acceptance requirements during the receiving facility's waste receipt and acceptance process. Facility procedures need to address how non-conforming waste will be segregated from acceptable waste, the process for notifying the sender of the non-conformance, and the acceptable methods for dispositioning the non-conforming waste. The process includes prior notice to the sender of the actions to be taken by the facility receiving the waste and the sender's obligations, particularly regarding the cost of the actions, to support the disposition of the non-conforming waste.

Example: A low-level waste storage facility's waste acceptance process includes returning non-conforming waste to the generator under all circumstances, billed to the generator. The paperwork/certifications for waste return is included in the paperwork accompanying all packages to facilitate return of packages.

Compliance with the waste acceptance requirements for a low-level waste management facility is demonstrated if they include a process for evaluation and acceptance of incoming waste to ensure the acceptance criteria of the facility receiving the waste are met that includes one of or a combination of: (1) testing, sampling, and analysis of representative samples of waste upon receipt; (2) testing, sampling, and analysis of split samples of waste taken at the generator site; (3) evaluation of testing, sampling, and analysis of data provided by the generator, or (4) audits, reviews, surveillance, or observations of generator waste certification programs and characterization activities. Additionally, acceptable waste acceptance requirements for a storage, treatment or disposal facility will have documented procedures and actions to be taken if a waste that does not conform to the waste acceptance criteria is received at the facility.

Supplemental References:

1. DOE, 1997. *Nevada Test Site Waste Acceptance Criteria* (NTSWAC), Revision 1, U.S. Department of Energy, Nevada Operations Office, Las Vegas, NV, August 1997.

2. DOE, 1993. *Methods for Verifying Compliance with Low-Level Radioactive Waste Acceptance Criteria*, DOE-LLW-185, U.S. Department of Energy, National Low-level Waste Management Program, Idaho Falls, ID, September 1993.

IV. H. Waste Generation Planning.

The following requirements are in addition to those in Chapter I of this Manual.

(1) Life-Cycle Planning. Prior to waste generation, planning shall be performed to address the entire life cycle for all low-level waste streams.

Objective:

The objective of this requirement is to provide for the disposal of all low-level waste that is generated in the future by ensuring that prior to generating a new low-level waste stream, the specific waste management facilities necessary for safe management of the waste from the time it is generated up to and including its disposal are identified and sites are discouraged from generating low-level waste that does not have an identified path to disposal.

Discussion:

The *Complex-Wide Review of DOE Low-Level Waste ES&H Vulnerabilities* conducted in response to Defense Nuclear Facilities Safety Board Recommendation 94-2 identified storage of low-level waste with no identified path forward to disposal as a major complex-wide vulnerability. The safety and hazards analysis conducted as part of the preparation of DOE O 435.1 also identified significant weaknesses and risks associated with low-level wastes being generated without a path to disposal, particularly weaknesses associated with long-term storage of waste and potential loss of characterization data from generators and the subsequent need for recharacterization. Therefore, as part of the generator planning requirements in General Requirement I.2.F.(7), specific requirements are identified for planning for management of waste prior to its generation, and for approval to generate low-level waste streams with no path forward to disposal.

Life cycle planning for all low-level waste. The Site-Wide Waste Management Program required in Chapter I of DOE M 435.1-1, Section I.2.F.(1), calls for systematic planning of the management of all radioactive waste at DOE sites. Guidance on the Site-Wide Waste Management Program discusses information to be included in life-cycle planning documentation for all low-level waste streams at the site.

However, additional information is required of certain low-level wastes to ensure full life cycle planning is being done for all waste. The additional information needed for certain waste streams is influenced by the fact that, on the implementation date of the Order, the low-level waste will be in one of three stages of its life-cycle: (1) waste generated in the past (in storage), (2) waste being generated at present; and (3) wastes not yet generated (future wastes); and will either have an identified path to disposal, or will not.

Therefore, from a waste generation planning perspective, there are six different "states" of low-level waste, depending on when the waste was or is generated and whether it has or will have a path to disposal. The following paragraphs explain the recommended life cycle information for these different low-level wastes.

Low-Level Waste With a Path to Disposal

Generated currently - The life-cycle information for low-level waste that is currently generated with an identified path to disposal includes a description of the management steps for the waste as discussed in guidance for the Site-Wide Radioactive Waste Management Program.

Generated in the future (from a new process) - The life-cycle information for low-level waste with an identified path to disposal that is generated from a new process includes a description of the management steps for the waste as discussed in guidance for the Site-Wide Radioactive Waste Management Program.

Generated in the past (in storage) - In addition to the basic information on management steps, life cycle information for low-level waste with a path to disposal that is in storage (due to budget constraints, delays due to regulatory matters or management decisions, or for other reasons) includes a schedule for achieving disposal.

Low-Level Waste Without a Path to Disposal

Generated in the past (in storage) - The life-cycle information for low-level waste in storage as of the issuance of DOE O 435.1 for which there is not an identified path to disposal includes the basic information on the management steps for the waste which can be identified, a discussion of the issues that hinder disposal of the waste, and the plans and schedule for achieving resolution of the issues.

Generated in the future (from a new process) - The life-cycle information for low-level waste without an identified path generated from a new process to disposal includes the basic information on the management steps for the waste which can be identified, a discussion of the issues that hinder disposal of the waste, and the plans and schedule for achieving resolution of the issues. This information will be assembled in the course of getting the generation of this waste approved in accordance with the process required in DOE M 435.1-1, Section I.2.F.(19), and which is discussed in the next section of this guidance.

Generated currently - The life-cycle information for low-level waste without an identified path to disposal includes the basic information on the management steps for the

waste which can be identified, and a discussion of the issues that hinder disposal of the waste and the plans and schedule for achieving resolution of the issues. These waste streams are not expected to receive approval for generation in accordance with General Requirement I.2.F.(19). However, the life-cycle planning information needs to address the continued generation of this waste. The life-cycle planning information for continuing to generate a no path forward waste needs to include consideration of the necessity to generate the waste, an understanding of what prevents the disposal of the waste, the needed capacity and capabilities for continued storage of the waste, and the plans for future disposal of the waste. Discussions would also be included on any alternatives to the process that generates the no path forward waste that have been considered.

Providing the life cycle information discussed above for waste streams already being generated is relatively straightforward. Essentially for most low-level waste, the information already exists and has been utilized for other planning documents such as the Programmatic Environmental Impact Statement. [Low-Level Waste Baseline Disposition Maps contain much of the information necessary to satisfy the planning requirements discussed here. An example Disposition Map is included as Figure IV.H.1 at the back of this section of guidance.]

Example 1: A low-level waste generating facility operating at Site A continues to operate with no alterations. The facility generates the same low-level waste streams it has been generating for years, and none of them are waste streams without a path forward to disposal. The life-cycle information about low-level waste generated at this facility is included in the current waste inventories and capacities section of the Site A Radioactive Waste Management Plan, and no technical or programmatic issues are included in the Plan concerning these waste streams.

Example 2: The same Site A as Example 1 has three waste streams with a path to disposal that have been in Storage Building 200 for two years. These wastes are also included in the current waste inventories and capacities section of the documentation of the Site A Radioactive Waste Management Plan. Also, the issues (one waste contains PCBs but is not approved for shipment to the TSCA incinerator, the other two wastes require special shipping casks which have not been approved) that prevent their disposal are explained in the issues for path forward waste in storage section of the Site A Radioactive Waste Management Plan, along with discussions of steps toward their resolution (e.g., the special shipping cask approval is expected January 2000).

Example 3: The disposal facility planned to receive the three wastes discussed in Example 2 is suddenly closed. The three wastes are now without a path to disposal. The next time the Site A Plan is updated, they are still included in the current waste inventories and capacities section, and a determination to move the three wastes from Building 200 to Building 400 in 2003 is described. A new section of the Plan is written

for issues for no path forward waste in storage, which describes the issues of PCBs and special casks, but also includes the loss of disposal capacity. Also discussed is the use of the special cask, once it is approved, to act as a high integrity storage container. Plans are also described for determining alternate disposal locations, to be completed in July 2002.

To provide waste management steps for waste streams that have not been generated yet, it would likely be inappropriate to assume that the same management steps will be taken as some already generated waste. Instead, some investigations of appropriate management steps may be necessary to provide adequate life cycle planning information. The bulk of these generator planning requirements and the rest of this guidance address planning for new waste streams.

Waste generator planning prior to generation. Planning, prior to generating low-level waste (subrequirement H.(1)), is intended to address low-level waste streams that do not already exist. Low-level waste streams that are first generated after issuance of the Order are subject to this requirement. Waste generator planning is a component of the waste generator program required in I.2.F.(7) of the General Requirements Chapter of DOE M 435.1-1. Waste generator planning activities need to be integrated in the generator program with waste characterization, certification, and transfer activities.

Generator planning prior to generation addresses the life-cycle of the waste to disposal, including the interim steps of waste management. This can be accomplished by preparing a waste stream profile and reviewing it with the facility(ies) that will need to manage the waste. The waste stream profile format used needs to be consistent with the needs of the storage, treatment, and/or disposal facility that will be involved in managing the waste stream. An example of a waste stream profile form derived from the *Nevada Test Site Waste Acceptance Criteria* (NTSWAC) is included at the back of this guidance as Figure IV.H.2. The waste generator confirms with potential storage, treatment, and disposal facilities that the waste stream can be managed appropriately based on the facility's current waste stream characteristics and the planned facility capacity. So conceivably, a generator may need to contact multiple facilities (e.g., a storage and/or treatment facility in addition to the disposal facility) to ensure proper waste management.

Example 1: A previously operating high-level waste treatment facility that generates a low-level waste stream has been shut down for eighteen months and is scheduled to restart operations six months after DOE O 435.1 is issued. Low-level waste generation planning is performed. The planning determines that the previous disposal option for the low-level waste is not available, but an alternative disposal location is easily arranged. Therefore, the planning provides early warning of a potential problem which is resolved prior to the generation of the waste.

Example 2: Waste stream ARL-111 is a new mixed low-level waste stream to be generated from a process at Laboratory X. The waste stream is similar to another waste stream that has been generated for some time, and which receives treatment at the mixed waste incinerator facility Y, and the residues are disposed at the Low-Level Waste Disposal Facility. A Laboratory X waste profile is prepared and transmitted to both the Y incinerator and the disposal facility. After discussions, it is verified that the new waste stream can be managed at the two facilities.

The determination of whether a low-level waste stream has an identified path to disposal is based on the availability of existing or planned facilities and operations and on the technical capability of managing the waste at the facility. A planned facility is considered to be available if it has been authorized (e.g., a line item in a Congressional appropriation or equivalent approval for design and construction). A facility is not considered available if it is not authorized to accept or manage a particular waste type or concentration. If a planned facility is designated in the planning information, then the planning information also needs to address the schedule for when the facility will be operational, and the appropriate management steps that will be taken for waste designated for that facility until it becomes operational.

For purposes of planning for disposal of a low-level waste stream, a facility or capabilities that are part of a program or strategic plan, but have not been authorized are not considered available. If an available planned facility is canceled, the generator site needs to revise the planning for the life-cycle of the low-level waste, an alternate path to disposal needs to be identified and documented, and approval to generate the low-level waste needs to be obtained from the cognizant Field Element Manager as required in the General Requirements at I.2.F(19).

Example 1: Site X generates a low-level waste with concentrations of uranium that are too high to be suitable for on-site disposal. A new disposal cell for high-activity long-lived radionuclides will be developed at another site. The new facility has been authorized by Congress as a line item and will be operational by 2006. Since this is the only facility that may be able to dispose of this waste, Site X reflects the assumption to use the new facility by 2007, subject to operation and certification, since they have no other path forward for disposal.

Example 2: As in the above example, Site X generates a high-activity long-lived waste stream that cannot be disposed on site. An existing disposal operation at another site is technically capable of disposing this waste. The facility, however, has not completed the necessary analyses under NEPA to be able to accept waste from off site. Until the necessary NEPA analyses have been completed, the disposal facility is not available to Site X.

Whether a path to disposal can be identified is also based on the acceptability of the waste at the facilities at which it must be managed. For existing facilities, this involves no more than an evaluation of the waste stream properties against the waste acceptance requirements of the facility and determining there are no impediments for its management. For planned facilities, this determination is more involved. For some waste streams, the acceptability at a planned facility could be determined based on similar circumstances already known to exist in the Complex. This may be a common situation for wastes that do not have a full path to disposal because of issues that are not entirely technical (e.g., commercially generated [NRC licensed] Greater-than-Class-C low-level waste). For other waste streams, particularly those with a technical impediment to disposal, the acceptability may need to be evaluated and a judgement made that a planned facility will be able to accept the waste provided some necessary treatment is performed (e.g., low-level waste approved to go to a disposal facility but which is waiting for a final PEIS decision), or some administrative step is successfully accomplished (e.g., a RCRA permit is obtained so that mixed waste can be accepted).

The generator is responsible for ensuring that low-level waste is not generated unless there is due consideration for the ultimate disposal of the waste. The objective of this requirement is not to prohibit, under all conditions, the generation of low-level waste that does not have an identified, achievable path to disposal. In meeting the DOE O 435.1 planning requirements, it is appropriate for waste management organizations to provide assistance to the generator in determining the waste management path, particularly in cases where the waste management organization may utilize offsite treatment, storage, or disposal facilities.

Compliance with this planning requirement is demonstrated by the individual sites establishing a process for evaluating the life-cycle of low-level waste prior to its generation, including the identification of low-level wastes with no path to disposal and appropriate records justifying the newly generated low-level waste stream(s), and site personnel possessing planning information showing the location(s) where low-level waste will be stored, treated, and/or disposed along with a confirmation that the personnel managing the facilities agree that the low-level waste may be managed at those facilities.

Supplemental References:

1. DOE, 1997. *Nevada Test Site Waste Acceptance Criteria* (NTSWAC), Revision 1, U.S. Department of Energy, Nevada Operations Office, Las Vegas, NV, August 1997.

IV. H.(2) Waste With No Identified Path to Disposal. Low-level waste streams with no identified path to disposal shall be generated only in accordance with approved conditions which, at a minimum, shall address:

(a) Programmatic need to generate the waste;

(b) Characteristics and issues preventing the disposal of the waste;

(c) Safe storage of the waste until disposal can be achieved; and

(d) Activities and plans for achieving final disposal of the waste.

Objective:

The objective of this requirement is to ensure that prior to generation of a new low-level waste stream with no path to disposal, the need to generate the waste is carefully considered, and plans for safe long-term storage and for resolving issues that prevent disposal of the wastes are developed.

Discussion: There are instances where programmatic needs may necessitate the generation of low-level waste without an identified path to disposal. In these instances, the Field Element Manager must ensure development of a process for identifying generation of low-level waste with no path to disposal and approving the conditions under which such low-level waste can be generated (see Section I.2.F.(19)). The process of identifying waste with no path to disposal and establishing conditions for its generation is intended to raise to the attention of DOE management that a commitment is being made with the generation of such a waste, including prolonged storage of this waste and resolving those issues that prevent the waste from being disposed.

> *Example: Through generation planning it is discovered that a proposed project to remediate an old glove box facility would generate some low-level waste streams that would most likely not have a path to disposal using existing facilities. The Field Element Manager determines that generating low-level waste streams with no path to disposal is not worth the benefit of proceeding as planned with the project. Cleanup strategies and schedules are changed that allow the project to commence and avoids generating the no path forward waste while determinations are made on disposal options.*

The minimum conditions for generating a waste without an identified path to disposal are identified in this requirement. They include evaluations and considerations that involve both the waste generating and waste management organizations. The decision to proceed with the activity generating the waste is made considering the total situation based on these minimum considerations.

Programmatic need to generate the waste. There must be a clear identification of the programmatic mission being served that results in the generation of low-level waste with no

identified path to disposal. Alternate means of accomplishing the mission without generating the waste should be discussed. These could include use of alternative materials to achieve the mission, use of different processes, or substitution of chemicals other than the ones originally to be used.

Characteristics and issues preventing the disposal of the waste. The reasons that the low-level waste cannot be disposed of must be identified. These may be technical or programmatic reasons. For example, if a waste needs to be treated in order to meet a disposal facility waste acceptance criteria and an appropriate treatment facility is not available, the lack of treatment would be identified as the reason the waste does not have a path to disposal. Identifying the characteristics and issues preventing disposal is necessary to support the development of plans for achieving disposal.

Safe storage of the waste until disposal can be achieved. Since the waste cannot be disposed of pending the resolution of programmatic or technical issues, facilities must be available for safe storage. In order to evaluate the ability to provide for the storage of the waste, there needs to be an estimate of the amount of the waste that will be generated, as well as an estimate of the time necessary to keep the waste in storage. Identification of the requirements for safe storage and acceptable storage facilities is a prerequisite to generating the waste so that unique or risky aspects of storage that may make long-term storage problematic can be identified.

Activities and plans for achieving final disposal of the waste. The decision to generate waste with no identified path to disposal must be based on a plan to eventually achieve disposal. The plan to achieve disposal of the waste needs to identify the activities being pursued to resolve issues preventing disposal and a schedule for their resolution. The activities described may be fairly detailed if the problems are technical and involve only one waste stream at a site. In other cases involving more programmatic issues, or which involve several waste streams at several sites, the activities and schedules to resolve issues may be less certain because they are dependent on other internal or external organizations (for example, approval of another Field Element Manager to ship waste).

Consideration might be given to delaying the generation of a waste stream for which there is no reasonable alternative to generating the no path forward waste if there are difficult problems that must be overcome to achieve safe storage or final disposal.

For many of the wastes that are currently without an identified path to disposal, programmatic and/or complex-wide problems and issues contribute to the lack of final disposal. Thus, all or part of the solution to an individual problem low-level waste stream may be programmatic or complex-wide steps taken as part of the Site-Wide Radioactive and/or Complex-Wide Low-Level Waste Management Programs that will address the vulnerabilities associated with no path forward waste

and lead to resolution of issues and disposal of the waste. This process is also discussed in several places in the General Requirements guidance.

Satisfaction of this planning requirement can be demonstrated by the waste generation organization having documentation concerning the decision to generate a low-level waste stream that does not have an identified path to disposal. This documentation needs to include the cognizant Field Element Manager or designee approval to generate the waste, an explanation of the need for the process that generates the low-level waste, a discussion of the reason it cannot be disposed of, the proposed management plan for the waste, and an up-to-date schedule of activities being pursued to resolve constraints to the disposal of the subject waste.

Supplemental References:

1. DOE, 1997. *Nevada Test Site Waste Acceptance Criteria* (NTSWAC), Revision 1, U.S. Department of Energy, Nevada Operations Office, Las Vegas, NV, August 1997.

Figure IV.H.1. Example Low-Level Waste Disposition Map

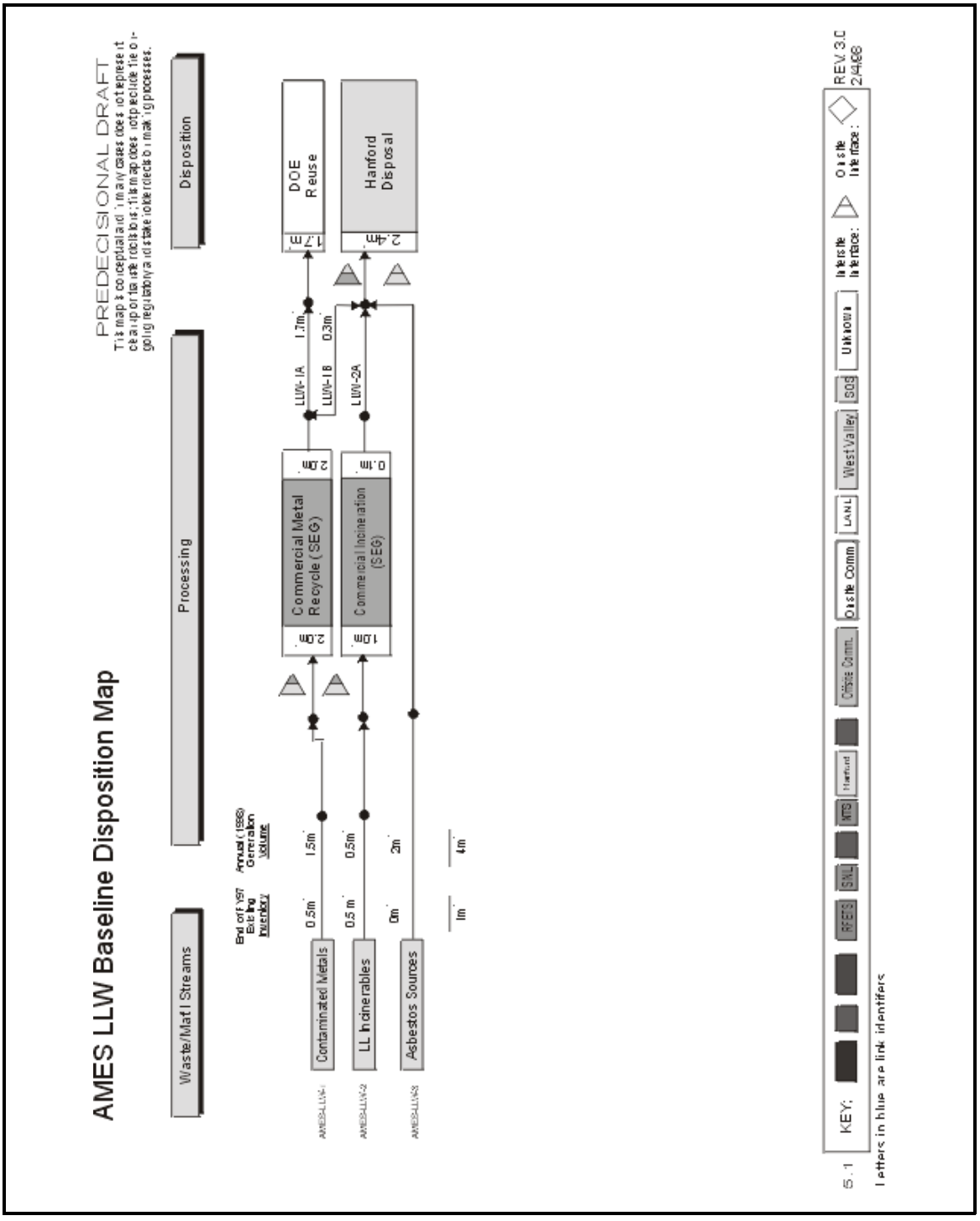

Figure IV.H.2. EXAMPLE WASTE PROFILE FORM (FOR GENERATION PLANNING)

A. Generator Information

1. Waste Certification Official _____ Phone _____ FAX _____

2. Technical _____ Phone _____ FAX _____

3. DOE Contact _____ Phone _____ FAX _____

4. Facility Name _____

Address _____

City _____ State _____ ZIP _____

5. EPA Identification Number _____

B. General Waste Stream Information

1. Waste Stream Identification Number _____

Profile Revisions Number _____ Profile Revision Date _____

2. Waste Description _____

3. Waste Category ☐ Low-Level ☐ Mixed Low-Level

4. Generating Process Description _____
_____
_____

Process Description continuation Page Attached ☐ Yes ☐ No
Flow Diagram Attached ☐ Yes ☐ No

5. Estimated Rate of Generation ☐ One Time Only _____ m^3
☐ Ongoing _____ m^3/yr

C. Physical Properties

1. Waste Form Description
☐ Solid ☐ Solidified ☐ Encapsulated ☐ Sludge ☐ Powder/Dust
☐ Sealed Sources ☐ Absorbed Liquid ☐ Other _____

2. List waste stream components Estimated Percent by ☐ Volume ☐ Weight

		Estimated Density (kg/m^3)
_____	_____ to _____	_____
_____	_____ to _____	_____
_____	_____ to _____	_____
_____	_____ to _____	_____
_____	_____ to _____	_____
_____	_____ to _____	_____

Component Continuation Page Attached ☐ Yes ☐ No

3. Does the waste contain the following?

☐	Yes	☐	No	Free Liquids
☐	Yes	☐	No	Particulates
☐	Yes	☐	No	Gases
☐	Yes	☐	No	Etiologic Agents
☐	Yes	☐	No	Chelating Agents
☐	Yes	☐	No	Polychlorinated Biphenyls
☐	Yes	☐	No	Explosives
☐	Yes	☐	No	Pyrophorics
☐	Yes	☐	No	Regulated Asbestos-Containing Material
☐	Yes	☐	No	Radioactive Animal Carcasses
☐	Yes	☐	No	DOE Equivalent Greater-Than-Class C Packages
☐	Yes	☐	No	Other

D. RCRA Characterization

1. RCRA Characterization by ☐ Process Knowledge ☐ Sampling and Analysis ☐ Both

2. Does the waste exhibit any characteristic of hazardous waste as defined in 40 CFR Part 261?

☐ Yes	☐ No	Ignitability
☐ Yes	☐ No	Corrosivity
☐ Yes	☐ No	Reactivity
☐ Yes	☐ No	Toxicity

3. ☐ Yes ☐ No Is the waste listed as defined in 40 CFR Part 261?

4. ☐ Yes ☐ No Is the waste hazardous per state-of-generation regulations?

_____
State of generation

5. ☐ Yes ☐ No Has the waste been treated?

6. If sampling and analysis was used for RCRA characterization, complete applicable portions of summary table below. If analytical results are available for additional hazardous constituents, attach an equivalent summary table.

	Known or Expected? Yes	Known or Expected? No	Analysis Sample (mg/L) (Statistical Mean)	Confidence Interval	Detection Limit (mg/L)	Exceeds Regulatory Level? Yes	Exceeds Regulatory Level? No
TCLP Metals:							
Arsenic	☐	☐	_____	_____ to _____	_____	☐	☐
Barium	☐	☐	_____	_____ to _____	_____	☐	☐
Cadmium ☐	☐		_____	_____ to _____	_____	☐	☐
Chromium	☐	☐	_____	_____ to _____	_____	☐	☐
Lead	☐	☐	_____	_____ to _____	_____	☐	☐
Mercury	☐	☐	_____	_____ to _____	_____	☐	☐
Selenium	☐	☐	_____	_____ to _____	_____	☐	☐
Silver	☐	☐	_____	_____ to _____	_____	☐	☐

	Sample Known or Expected? Yes	Analysis No	(mg/L) (Statistical Mean)	Confidence Interval	Detection Limit (mg/L)	Exceeds Regulatory Level? Yes	No
TCLP Volatiles: Benzene	☐	☐	_____	_____ to _____	_____	☐	☐
Carbon Tetrachloride	☐	☐	_____	_____ to _____	_____	☐	☐
Chlorobenzene	☐	☐	_____	_____ to _____	_____	☐	☐
Chloroform	☐	☐	_____	_____ to _____	_____	☐	☐
1,4-Dichloro-benzene	☐	☐	_____	_____ to _____	_____	☐	☐
1,2-Dichloro-ethane	☐	☐	_____	_____ to _____	_____	☐	☐
1,1-Dichloro-ethylene	☐	☐	_____	_____ to _____	_____	☐	☐
Methyl ethyl ketone	☐	☐	_____	_____ to _____	_____	☐	☐
Pyridine	☐	☐	_____	_____ to _____	_____	☐	☐
Tetrachloroethylene	☐	☐	_____	_____ to _____	_____	☐	☐
Trichloroethylene	☐	☐	_____	_____ to _____	_____	☐	☐
Vinyl chloride	☐	☐	_____	_____ to _____	_____	☐	☐
TCLP Semivolatiles:							
0-Cresol	☐	☐	_____	_____ to _____	_____	☐	☐
M-Cresol	☐	☐	_____	_____ to _____	_____	☐	☐
p-Cresol	☐	☐	_____	_____ to _____	_____	☐	☐
Cresol	☐	☐	_____	_____ to _____	_____	☐	☐
2,4-Dinitrotoluene	☐	☐	_____	_____ to _____	_____	☐	☐
Hexachlorobenzene	☐	☐	_____	_____ to _____	_____	☐	☐
Hexachlorobutadiene	☐	☐	_____	_____ to _____	_____	☐	☐

	Sample Known or Expected? Yes	Analysis No	(mg/L) (Statistical Mean)	Confidence Interval	Detection Limit (mg/L)	Exceeds Regulatory Level? Yes	No
Hexachloroethane	☐	☐	_____	_____ to _____	_____	☐	☐
Nitrobenzene	☐	☐	_____	_____ to _____	_____	☐	☐
Pentachlorophenol	☐	☐	_____	_____ to _____	_____	☐	☐
2,4,5-Trichloro-phenol	☐	☐	_____	_____ to _____	_____	☐	☐
2,4,6-Trichloro-phenol	☐	☐	_____	_____ to _____	_____	☐	☐
TCLP Pesticides and Herbicides:							
Chlordante	☐	☐	_____	_____ to _____	_____	☐	☐
2,4-D	☐	☐	_____	_____ to _____	_____	☐	☐
Endrin	☐	☐	_____	_____ to _____	_____	☐	☐
Heptachlor (And its hydroxide)	☐	☐	_____	_____ to _____	_____	☐	☐
Lindane	☐	☐	_____	_____ to _____	_____	☐	☐
Methoxychlor	☐	☐	_____	_____ to _____	_____	☐	☐
Toxaphene	☐	☐	_____	_____ to _____	_____	☐	☐
2,4,5-TP(Silver)	☐	☐	_____	_____ to _____	_____	☐	☐

E. Radiological Properties

1. Radiological Characterization by (Check all that apply)
   ☐ Process Knowledge ☐ Sampling & Analysis ☐ Materials Control & Accountability
   ☐ Direct Measurement ☐ Gross Radiation Measurement ☐ Other _____

2. Were the following used in radiological characterization ? ☐ Scaling Factors ☐ Ratios

3. List reportable radionuclides.

Radionuclide	Activity Range (BQ/m^3)			Activity Representative of Final Waste Form (Bq/m^3)
_____	_____	to	_____	_____
_____	_____	to	_____	_____
_____	_____	to	_____	_____
_____	_____	to	_____	_____
_____	_____	to	_____	_____
_____	_____	to	_____	_____
_____	_____	to	_____	_____
_____	_____	to	_____	_____
_____	_____	to	_____	_____
_____	_____	to	_____	_____
_____	_____	to	_____	_____

4. ☐ Yes ☐ No Does the waste contain transuranic waste creating nuclides?

Transuranic Nuclides	Activity Range (nCi/g)			Activity Representative of Final Waste Form (nCi/g)
_____	_____	to	_____	_____
_____	_____	to	_____	_____
_____	_____	to	_____	_____
_____	_____	to	_____	_____
_____	_____	to	_____	_____

5. ☐ Yes ☐ No Is enriched uranium present? If yes, provide enrichment of U-253 by weight percent _____. Provide Maximum mass U-235 per package _____ g/package. Reference controlling documents.

_____

_____

_____ _____

_____

6. ☐ Yes ☐ No are other fissionable nuclides present? If yes, list below.

Nuclide	Maximum Activity Concentration (Bq/m^3)
_____	_____
_____	_____
_____	_____

F. Packaging Description

1. Container type(s) _____

___

DOT Specification(s) _____

☐ Yes ☐ No ☐ N/A Does container meet 3,375 lb/ft^2 strength test?

2. Standard container external dimensions _____
Packaged bulk external dimensions _____

3. Weight Range _____ kg to _____

4. ☐ Yes ☐ No Waste stream includes unclassified material.

5. ☐ Yes ☐ No Waste stream includes classified material.

6. ☐ Yes ☐ No Estimated radiation dose rate at disposal package surface.
_____ to _____ mSv/h, at 1 mwrwe _____ to _____ mSv/h.

G. Generator Signature

To the best of my knowledge, the information in this document and attachments is true and accurate.

_____	_____	_____
Preparer's Printed Name	Signature	Date
_____	_____	_____
Waste Certification Official's Printed Name	Signature	Date
_____	_____	_____
U.S. Department of Energy	Signature	Date

IV. I. Waste Characterization.

Low-level waste shall be characterized using direct or indirect methods, and the characterization documented in sufficient detail to ensure safe management and compliance with the waste acceptance requirements of the facility receiving the waste.

Objective:

The objective of this requirement is to ensure that sufficient knowledge of low-level waste's characteristics (e.g., chemical, physical, radiological) is available to protect workers handling the waste and to support effective decision-making for its management. This information is to be maintained from generation, through storage and treatment in sufficient detail to ensure that the requirements of subsequent treatment and storage facilities, transportation regulations, and the disposal requirements for low-level waste will be met.

Discussion:

The *Radioactive Waste Management Manual* assigns the Field Element Manager the responsibility of ensuring development, approval, and implementation of a program that addresses the responsibilities of waste generators, including waste characterization (DOE M 435.1-1, Section I.2.F.(7)). The characterization data acquired during generation, storage, and after treatment of low-level waste need to be reliable and in sufficient detail to ensure subsequent management can be conducted safely and to meet the waste acceptance requirements of all subsequent receiving facilities. Accurate characterization of low-level waste is essential to: 1) waste planning by generators, as required by DOE M 435.1-1, Section IV.H; 2) waste certification by generators and other senders of waste, as required by DOE M 435.1-1, Section IV.J; 3) waste transfers by generators and other senders of waste, as required by DOE M 435.1 Section IV.K; and; 4) waste evaluation and acceptance by receivers of waste, as required by DOE M 435.1-1, Section IV.G.

In conducting the analyses for development of the DOE M 435.1-1, characterization was identified as necessary to ensuring the safe management of waste from generation through disposal. Waste characterization is defined (DOE M 435.1-1, Attachment 2) as:

> "The identification of waste composition and properties, such as by review of acceptable knowledge (which includes process knowledge), or by nondestructive examination, nondestructive assay, or sampling and analysis, to comply with applicable storage, treatment, handling, transportation, and disposal requirements."

Accurate waste characterization is necessary so that the waste and waste containers are compatible and worker handling of waste containers can be performed safely. All information necessary for personnel to safely handle a container of low-level waste needs to be known at all times during the life-cycle of the waste.

Waste characterization is a tool for gathering information that supports defensible decisions regarding safety, process, environmental and compliance matters in the management of low-level waste. The significance of the waste management decision will guide the graded application of this requirement, as well as the more detailed characterization requirements addressed in subsequent sections of this guidance. These subsequent sections address application of a data quality objectives process to guide characterization (Section IV.I.(1)) and minimum characterization requirements (Section IV.I.(2)).

Use of Direct and Indirect Methods. Waste managers are to characterize low-level waste using an appropriate combination of direct and indirect methods. The appropriate method for characterizing waste depends on the parameter being measured, the hazards associated with acquiring the information, and the amount and quality of the data needed as determined through a data quality objectives or similar process.

Direct methods of characterizing waste can be used to established certain physical and chemical attributes as well as radiological characteristics. The most common direct methods for characterizing the chemical and/or radiological characteristics are sampling and laboratory analyses and certain nondestructive evaluation techniques (e.g., real-time radiography). Direct characterization methods are conducted in accordance with the quality assurance program and plan governing the site and laboratory facilities.

Indirect methods of characterization use non-destructive examination techniques and acceptable knowledge to replace, supplement, and/or initially provide data that might otherwise be collected by direct, intrusive characterization of the waste. In the safety and hazard analysis performed in support of development of DOE M 435.1-1, the use of indirect methods was identified as an appropriate means of characterizing waste and at the same time complying with the as low as reasonably achievable (ALARA) principle for keeping radiation exposures to a minimum. An additional benefit of characterizing low-level waste by the use of indirect methods is the avoidance of the generation of waste associated with sample materials, and laboratory equipment and expendables.

In order for indirect methods of low-level waste characterization to serve their purpose of providing information necessary for the safe management of waste, the data need to be sufficiently accurate. The level of accuracy is determined through application of data quality objectives, or comparable process. Consistent with the data quality objectives, correlations demonstrating that data provided by indirect methods are representative of the actual waste may need to be

supported through the application of direct methods. The methodology could employ a number of techniques, some of which involve some direct sampling and analysis of the waste stream. The following guidance paragraphs discuss different indirect methods.

Similar to the EPA and NRC guidance on characterizing mixed waste, DOE endorses the use of indirect methods such as the use of acceptable or waste knowledge for characterizing physical, chemical, RCRA-regulated and radioactive components of waste. The term acceptable knowledge (or waste knowledge) includes process knowledge; records of analyses performed prior to the effective date of a requirement; or a combination of process knowledge and previous records, supplemented with chemical analyses (NRC/EPA, 1997). Process knowledge refers to detailed information on processes that generate waste subject to this requirement or information on processes similar to that which generated the waste being characterized.

Acceptable knowledge characterization of low-level waste is based on an understanding of the materials and processes used to generate the waste, or analytical data obtained from the process or waste stream or both. Acceptable knowledge also includes information regarding the source of the waste stream, the physical form and materials comprising the waste, the chemical constituents of the waste, and the nature of the radioactivity present. Acceptable knowledge may be used to describe low-level waste if the source information is consistent, defensible, and auditable. In practice, acceptable knowledge can be effectively used where low-level waste is generated in well known and tightly controlled processes for which the product is highly predictable.

While the development of a process for identifying and documenting low-level waste acceptable knowledge is not dictated by this requirement, the following guidance provides an overview of elements of an acceptable process for assembling acceptable knowledge documentation:

- Acceptable knowledge is compiled in an auditable record.
- Correlations within waste streams in terms of time of generation, waste generating processes, analytical data, and site-specific facilities are clearly described.
- A reference list of applicable documents, databases, quality control protocols, and other sources of information that support the acceptable knowledge information is prepared.
- Procedures which outline the methodology that is to be used to identify and assemble auditable acceptable knowledge records, including the origin of the documentation, how the assembled information was or will be used, and any limitations associated with the information.

Characterization data gained through acceptable knowledge must be within the acceptable range of certainty and precision identified by the data quality objectives or similar process. Additionally, the effects of time-dependent processes must either be negligible or predictable. If acceptable knowledge is supported by the collection, analysis, and comparison of statistically valid samples with the acceptable knowledge records, periodicity of sampling and analysis should correlate with the nature of any changes in the process creating the waste or with changes that are being documented in characterization data.

Non-destructive examination and assay techniques use methods such as passive-active neutron assay, high resolution gamma ray spectroscopy, and thermal neutron capture to non-destructively collect data relating to the radionuclide constituents in the waste. Acceptable performance of assay techniques is determined through measurement of known standards and comparison to established quality assurance objectives of the applicable characterization program. A process, similar to the one discussed above regarding acceptable knowledge needs to be established and documented in site procedures that outline the exact nature of the acceptable use of non-destructive examination techniques for providing characterization information on waste.

Another indirect method of providing radionuclide characterization data is through the use of a known relationship, or scaling factors, between a measured radionuclide or a dose rate and the radionuclide(s) of interest. As discussed above for acceptable knowledge and non-destructive examination techniques, use of scaling factors must be correlated with actual data.

The use of scaling factors is generally established by an initial characterization that provides a statistical basis for use of the scaling factors. As with any indirect method, the characterization program needs to include confirmatory measurements. The frequency of the confirmatory measurements is based on the consistency of the process generating the waste. Additionally, the history of previous confirmatory measurements may also influence the frequency of future confirmatory measurements with results that are very consistent providing justification for less frequent confirmatory measurements.

> *Example: A low-level waste stream from an actinide processing building is sampled and analyzed and determined to be composed of three primary nuclides: Pu-239, Am-241, and Pu-238. The samples are found to contain the three radionuclides in essentially the same ratio. The process is known to be uniform and is therefore expected to generate similar concentrations in the waste stream as the facility is operated. Therefore, the contents of future waste containers are routinely characterized based on a gamma energy analysis which detects gamma radiation from the Am-241 and Pu-238. The characterization program requires the collection and full analysis of samples once a month to confirm that the ratio of the three radionuclides falls within an acceptable range (based on application of the data quality objectives process).*

Characterization Documentation. The requirement states that characterization data shall be documented in sufficient detail to enable the waste acceptance requirements of the receiving facility to be met. The following elements are essential to this process for acquiring and controlling characterization data:

Organization(s) and Responsibilities - Identification of the organizations involved and responsible for characterization of low-level waste.

Quality Assurance - Characterization data need to be subjected to a quality assurance program and the program that applies need to be identified and documented.

Procedures - The process for obtaining waste characterization data is formalized in procedures which describe to the user the steps that are to be followed and the administrative process for ensuring the data are of the quality needed. Topics that need to be proceduralized include the processes for sampling, packaging, transportation, laboratory analysis, and data control.

Procurement/Purchasing Controls - The procurement and/or purchasing of items or services that are significant to characterizing low-level waste are controlled and documented. Such procurement includes the purchase of sampling equipment and sample transport containers, as well as services such as laboratory analyses (onsite or offsite). As dictated by the type of procurement, the documentation needs to include (or reference) the technical specifications for the item/service being procured, identification of quality assurance requirements including any required inspections, specifications of documentation requirements (e.g., certification of compliance or conformance, laboratory analytical results), and a statement ensuring access to the provider's facilities as necessary to perform audits and inspections. The characterization data need to be traceable through the provider's process of generating it and verifying its accuracy.

Document/Data Change Control - Records that contain characterization data, whether it has been generated through sampling and analysis, nondestructive assay, or acceptable knowledge, need to be controlled. In addition, the waste characterization procedures and quality assurance program documentation are subject to document control. Document and data control need to include review, approval, and distribution to designated recipients (users), and a controlled process for making revisions to documents or data. Existing document and data control programs at a site may be adequate to provide the necessary controls for documents related to low-level waste characterization data, but will need to be reviewed to ensure the objectives of DOE M 435.1-1 requirements are met.

Training - Characterization data are generated and managed only by personnel that are properly trained to recognize the significance of the data. Generally, training of laboratory

personnel will be adequate to support low-level waste characterization, but needs to be reviewed versus the goals of the characterization. Other staff managing and using characterization data need to understand what is to be done with the data (i.e., what decisions are to be made) once data are collected.

Records - Waste characterization records include those that are necessary to meet the waste acceptance requirements of receiving facilities, and as specified by the waste certification program DOE M 435.1-1, Section IV.J.

As noted above, existing programs at a site may provide the framework within which the elements of waste characterization can be addressed (e.g., quality assurance, training, document control).

The waste acceptance requirements of a facility to which the waste is sent also may impose additional requirements on what is to be included in the waste characterization data. The waste acceptance requirements for the receiving facility include specific quality assurance, administrative, or documentation requirements so that waste characterization data are acceptable to the facility.

Example: Requirements have been established for the characterization of low-level waste for the disposal facility at the Nevada Test Site. These characterization requirements are documented in Chapter 4.0 of the Nevada Test Site Waste Acceptance Criteria (NTSWAC), Revision 1. One of the requirements described there is the preparation and submittal of waste profile forms containing characterization information.

Compliance with this requirement is demonstrated by a program for documenting and the existence of records that document the process for acquiring and verifying the validity of low-level waste characterization data acquired through the use of direct or indirect methods.

Supplemental References:

1. CAO, 1996. *Waste Acceptance Criteria for the Waste Isolation Pilot Plant,* DOE/WIPP-069, Revision 5, U.S. Department of Energy, Carlsbad Area Office, Carlsbad, NM, April 1996.

2. EPA, 1994. *Guidance for the Data Quality Objectives Process,* EPA QA/G-4, U.S. Environmental Protection Agency, Washington, D.C., September 1994.

3. NRC/EPA, 1997. "Joint NRC/EPA Guidance on Testing Requirements for Mixed Radioactive and Hazardous Waste," *Federal Register,* Vol. 62, No. 224, U.S.

Environmental Protection Agency and U.S. Nuclear Regulatory Commission, November 20, 1997.

IV. I.(1) Data Quality Objectives. The data quality objectives process, or a comparable process, shall be used for identifying characterization parameters and acceptable uncertainty in characterization data.

Objective:

The objective of this requirement is to invoke a process for determining the type, quantity, and quality of characterization data needed to support the safe management of low-level waste so as to ensure that needed data are acquired, the data meet the objectives they are being collected for, and resources are not wasted on unnecessary, incomplete, or unusable data collection efforts.

Discussion:

The type, quantity, and quality of characterization data obtained for the safe management of low-level waste need to be consistent with the purpose for which the characterization information will be used. The uses of low-level waste characterization data include: complying with storage, treatment, and disposal facilities' waste acceptance requirements; determining radiation shielding and other protective measures; evaluating compliance with processing requirements; and meeting legislative or regulatory commitments. This requirement is included in DOE M 435.1 to ensure that the appropriate characterization data to support the safe management of low-level waste are generated. The requirement is intended to promote a structured process for the collection and use of low-level waste characterization data and to avoid the collection of data that is neither necessary nor defensible.

Input from various waste management organizations and interested groups is necessary to establish a clear understanding of the characterization data needs and the level of data quality that is acceptable for making low-level waste management decisions. The current requirement invokes the use of a structured process for determining the type, quantity, and quality of characterization data needed. Such a process, called a data quality objectives process, has been developed by the Environmental Protection Agency and is documented in *Guidance for the Data Quality Objectives Process* (Reference 1). Application of the EPA process and use of the EPA guidance is an acceptable way of meeting this requirement. However, use of other comparable processes that employ a structured approach to yield similar results is also acceptable.

The objectives of applying a structured process such as the data quality objectives process are to:

- manage and control the risks of making incorrect decisions;

- determine the data required to support making specific decisions;
- determine the type and quality of required data;
- allow stakeholders, decision makers, data users, and relevant technical experts to participate in planning and assessment;
- determine the quantity, location, and type of samples required;
- quantify the uncertainty in data through development of statistical sampling plans; and
- reduce overall costs by identifying resource-efficient sample collection and analytical methods by optimizing the sample and analysis plans.

The data quality objective process is a strategic planning approach based on the scientific method that is used to prepare for a data collection activity. The value of using this process to develop low-level waste characterization parameters is that it: reduces radiation exposure and saves resources by making characterization data collection operations more resource-effective; enables characterization data users and others to participate in characterization data planning; and provides a structured method for defining characterization data performance requirements, i.e., quality.

To foster the development and implementation of an effective data quality objectives or similar process, individuals are assigned responsibility for specific activities for each application of the process. Key activities of the process include:

- preparing the data quality objectives documentation;
- identifying stakeholders;
- identifying technical experts;
- ensuring opportunities for input and coordinating stakeholder and technical experts into the data quality objective process;
- reviewing and commenting on the developed data quality objectives; and
- approving the data quality objectives documents.

A more detailed description of the assignment of specific responsibilities for implementing a data quality objectives or similar process is presented in the Hanford "Data Quality Objectives Procedure" (Reference 2).

The data quality objectives process consists of seven steps. The output from each step influences the choices that will be made later in the process. Even though the data quality objectives process is depicted as a linear sequence of steps, in practice it is iterative; the outputs from one step may lead to a reconsideration of prior steps. This iteration is encouraged since it will ultimately lead to a more efficient data collection design. During the first six steps of the process, a team of process-cognizant personnel should develop decision performance criteria (i.e., data quality objectives) that will be used to develop the data collection design.

The final step of the process involves developing the data collection design based on the data quality objectives developed in the first six steps. The first six steps need to be completed before the team attempts to develop the data collection design because the design is dependent on a clear understanding of the first six steps taken as a whole.

Following is a listing and brief description of each of the seven steps. This is followed by an example of how the data quality objectives process can be applied to low-level waste characterization.

1. *State the Problem* – Concisely describe the problem to be studied. Review prior studies and existing information to gain a sufficient understanding to define the problem.

2. *Identify the Decision* – Identify what questions the study will attempt to resolve, and what actions may result.

3. *Identify the Inputs to the Decision* – Identify the information that needs to be obtained and the measurements that need to be taken to resolve the decision statement.

4. *Define the Study Boundaries* – Specify the time periods and spatial area to which decisions will apply. Determine when and where data should be collected.

5. *Develop a Decision Rule* – Define the statistical parameter of interest, specify the action level, and integrate the previous data quality objective outputs into a single statement that describes the logical basis for choosing among alternative actions.

6. *Specify Tolerable Limits on Decision Errors* – Define the decision maker's tolerable decision error rates based on a consideration of the consequences of making an incorrect decision.

7. Optimize the Design – Evaluate information from the previous steps and generate alternative data collection designs. Choose the most resource-effective design that meets all data quality objectives.

Example: The Blue Disposal Facility at Site X needed to establish the requirements for acceptable waste potentially containing free liquids for disposal. Due to their performance assessment and public concerns, the operating manual for the facility will specify that no free liquids shall be disposed, so the acceptance documentation must specify what specifically must be done to waste before it is shipped to ensure there will be no free liquids upon arrival. They used a data quality objectives-like process to answer some of the questions or issues related to the waste acceptance criterion. The Site X personnel worked with technical experts from several waste generators to address the issues. The question was formulated as, what does a generator have to do with waste that contains liquids that could potentially become free due to vibration and thermal cycling during transport? The answer to this question could make a significant difference in the cost of making waste streams consisting of soils from cleanups acceptable for disposal depending on how much testing and/or treatment was required by the Blue Facility's waste acceptance criteria. The data quality objective that was developed was:

> *The moisture content of low-level waste with high moisture contents (greater than 35%) must be specified on waste profile data sheets, and shall be packaged with approved absorbents (see approved absorbents list at Appendix A). The amount of absorbent added to a waste package shall be equivalent to 2 times the amount necessary to absorb the amount of free liquid which would result if 80% of the contained liquid, based on the moisture content, were to become free. [Approved absorbent must be added in accordance with Recommended Procedure BL-23.]*

The above description of the use of the data quality objectives process, and the example, are provided as an introduction to the process. A more detailed description of the process can be found in the referenced EPA guide. The data quality objectives process is most useful during the planning stages of identifying low-level waste characterization and uncertainty parameters, i.e., before the data are needed and collected. The value of the process is diminished significantly if the characterization data have already been collected because there is a tendency to make the questions that need to be answered fit the available data. The data quality objectives process is applied in a graded manner, i.e., the depth of detail and the magnitude of the resources expended in implementing the process should be commensurate with the relative importance of the characterization data in terms of the decisions to be made and protection of the public, workers and the environment.

The intent of this requirement is not that waste streams with characterization processes already in place and accepted by storage, treatment, and disposal facilities be recharacterized using the Data

Quality Objectives Process, or a comparable process, or that the characterization processes be revised using the Data Quality Objectives Process, or a comparable process. The intent is that, as new waste streams are identified and generated, the Data Quality Objectives Process, or a comparable process, be used for identifying characterization parameters and acceptable uncertainty in characterization data. If the characterization parameters of an existing waste stream characterization data. If the characterization parameters of an existing waste stream characterization process are to be significantly modified, then the Data Quality Objective Process, or a comparable process, should be used.

Compliance with this requirement is demonstrated by the documented use of a data quality objectives or a comparable process for determining the type, quantity, and quality of characterization data needed to safely manage low-level waste.

Supplemental References:

1. EPA, 1994. *Guidance for the Data Quality Objectives Process,* EPA QA/G-4, U.S. Environmental Protection Agency, Washington, D.C., September 1994.

2. WHC, 1996. *Data Quality Objectives Procedure,* Revision 1, WHC-IP-1216, Westinghouse Hanford Company, January 31, 1996, (included as Appendix A in draft Manual HNF-SD-WM-PROC-021, Revision 0, Lockheed Martin Hanford Corporation, January 2, 1997).

IV. I.(2) Minimum Waste Characterization. Characterization data shall, at a minimum, include the following information relevant to the management of the waste:

(a) Physical and chemical characteristics;

(b) Volume, including the waste and any stabilization or absorbent media;

(c) Weight of the container and contents;

(d) Identities, activities, and concentrations of major radionuclides;

(e) Characterization date;

(f) Generating source; and

(g) Any other information which may be needed to prepare and maintain the disposal facility performance assessment, or demonstrate compliance with applicable performance objectives.

Objective:

The objective of this requirement is to establish minimum low-level waste data that have been determined to be necessary for safe and effective management during the life cycle of the waste.

Discussion:

In the process of developing DOE O 435.1 and DOE M 435.1-1, the safety and hazard analysis indicated that certain characterization data were critical because several consequences could be avoided or minimized if certain basic information was accurately known about low-level waste. This requirement identifies those critical characterization data points that must be known for safe handling and proper management. The sections below provide guidance on each of these specific characteristics.

Physical and Chemical Characteristics. Physical characteristics support handling and packaging activities. Parameters should include a description of the material, its density, consistency, and appearance. Chemical characteristics impact handling, storage, containment, and can impact treatment processes. These characteristics determine the compatibility of the waste with other waste and the waste container, as well as its compatibility with proposed treatment processes. Parameters should include pH, reactivity, chemical compounds present, and the presence of hazardous and/or toxic constituents. Physical and chemical characteristics can be determined directly by visual examination and/or sampling and analysis. Physical characteristics can be determined directly, indirectly by use of acceptable knowledge and/or by non-destructive examination techniques such as computed tomography or real-time radiography. Chemical characteristics can also be determined by use of acceptable knowledge.

Volume and Weight. Volume and weight information is necessary for proper control of storage and disposal facility capacities as well as proper payload control for transportation and handling systems. Typical parameters include:

- container volume, measured as the external volume of the waste container which represents the volume that will be occupied in a storage or disposal facility (e.g., 55 gallon drum or 120 cu ft (for a 4 x 5 x 6 box));
- actual waste volume, including stabilization media;

- container weight; i.e., the total weight of the container and all of its contents (waste, shielding, stabilization media) that would have to be handled;

- identification of the stabilization medium, if used; and

- waste container utilization factor, measured as the percentage of the packaging volume that is filled with waste, including stabilization media. This parameter does not require an individual calculation be made of stabilization or absorbent media volume, but that those media be included in the total waste volume calculation.

These characteristics are generally determined by acceptable knowledge (e.g., container size, stabilization medium) or by measurement (e.g., weight).

Radionuclide Data. Radionuclide information allows for proper control of thermal loads for storage and disposal facilities, determination of personnel safety procedures, control of total activity limits for transportation, storage, and disposal, and also determination of the waste type. Parameters which constitute radionuclide information may include the following:

- total activity in the container, in curies;

- identity and activity per unit mass of the major radionuclides. For purposes of this guidance, major radionuclides are those which affect the determination that a waste is low-level waste, that the waste is within a site- or facility-specific category or class of low-level waste (e.g., a category that requires solidification), and any others determined to be of importance to the receiving facility (e.g., by safety analysis, performance assessment, etc.);

- radiation dose levels at the surface of the container; and

- container external surface contamination levels.

These characteristics can be determined directly by smear survey or radiochemical analysis of the waste, or indirectly by waste container non-destructive assay, radiation survey, and/or by documentation of nuclear materials accountability information or individual assays performed on components contained in the container.

Characterization Date and Generating Source. The date of characterization and generating source information help to determine the validity of currently held documentation on the waste, which, in turn, will determine the need for additional sampling or analysis. Parameters include characterization date, packaging date, DOE site, building location of the process which generated the waste and the generating process, if available.

Performance Assessment and Compliance Data. Additional data about waste that are important to performance or evaluating performance of the disposal facility, or to complying with laws, applicable regulations, or authorizing conditions (e.g., of a permit) may also need to be collected. The specific data needed will, by necessity, be identified by the disposal facility operator. Parameters which need to be included with waste characterization data may be identified by the analysts developing the disposal facility performance assessment, specified through conditions imposed on the site through the review and approval of the performance assessment, or derived from internal regulatory compliance evaluations. Examples of the types of data that may be needed are the presence and amounts of chelating agents which can enhance the transport of radionuclides from the disposal facility, or the presence and concentrations of specific chemicals which are not acceptable above specific limits (e.g., reporting polychlorinated biphenyls concentrations versus a limit of 50 ppm).

All of these data may not be required for a particular phase in the management of the waste's life cycle. The specific data needed will be determined by the waste acceptance criteria of a particular receiving facility.

> *Example: Experimental work in a laboratory generates a liquid low-level waste stream that is transferred via a pipeline to a central storage tank. Although the minimum characterization requirements include "weight of the container and contents," this is not relevant to this waste stream and the characterization data in the waste acceptance requirements for the central storage tank do not include packaging weight.*

Compliance with this requirement is demonstrated by the existence of a program or procedure for determining and records that document characterization of low-level waste consistent with the minimum characterization data requirements.

Supplemental References:

1. NRC, 1983. *Final Waste Classification and Waste Form Technical Position Papers*, U.S. Nuclear Regulatory Commission, Washington, D.C., May 1983.

IV. J. Waste Certification.

A waste certification program shall be developed, documented, and implemented to ensure that the waste acceptance requirements of facilities receiving low-level waste for storage, treatment, and disposal are met.

Objective:

The objective of this requirement is to ensure that low-level waste transferred to a facility for storage, treatment, or disposal meets the receiving facility's waste acceptance requirements to reduce the likelihood that transferred wastes contain unacceptable materials or characteristics, and to avoid hazards that would occur from the transportation and handling of waste packages which do not meet acceptance requirements. Certification also ensures that the storage, treatment, or disposal facilities receiving the low-level waste operate within limits established through safety analyses and/or performance assessments.

Discussion:

The *Radioactive Waste Management Manual*, General Requirements, assigns the Field Element Manager the responsibility of ensuring development and approval of a program that addresses the responsibilities of waste generators (DOE M 435.1-1, Section I.2.F.(7)). The generator requirements are to address hazards associated with a waste management facility receiving unexpected volumes or types of waste, or receiving waste that may not meet the waste acceptance requirements of the facility to which it is transferred. The generator requirements address generation planning, waste characterization, waste certification, and waste transfer. As discussed in this guidance, a certification program is to be established by generators of radioactive waste to provide a mechanism for confirming that waste is in compliance with the waste acceptance criteria of the facility to which the waste is being transferred. The certification program is required by any organization or facility that transfers waste to another facility.

Example: The Building Five Storage Facility has low-level waste that it has received for storage over the last year. Facility personnel plan to continue to receive low-level waste and store it until it can be transferred to the Nevada Test Site disposal facility. Building Five operates under a certification program in accordance with the Nevada Test Site Waste Acceptance Criteria (NTSWAC) that certifies the waste meets the Nevada Test Site technical acceptance criteria.

The certification program is part of the waste generator program that is approved by the Field Element Manager or designee. The certification program requires that an authorized official confirms compliance with the waste acceptance requirements of the facility to which waste is

being transferred. Additional guidance correlated to the waste certification requirements of Chapter IV, Low-Level Waste Requirements, is provided below.

Program Development and Documentation. The waste certification program to meet this requirement consists of a documented, structured process that works in concert with the DOE M 435.1-1 requirements for low-level waste acceptance (Section IV.G) and transfer (Section IV.K) to control the transfer of waste to a storage, treatment, or disposal facility. Development of the waste certification program involves defining and documenting controls for those items and activities that affect certifying that a waste and its packaging meets the waste acceptance criteria of the receiving facility. The documentation should include the following:

Organizations and Responsibilities - Certification program documentation needs to identify the organizations and officials involved in the certification process and the responsibilities of each. Officials who are authorized to certify waste are identified in the documentation.

Quality Assurance - The certification program is subject to quality assurance controls. The quality assurance controls that apply to waste certification activities need to identified and documented. The use of existing quality assurance program under which the certification activities will be performed is acceptable and appropriate.

Procedures - The process for certifying waste is to be formalized in procedures. The procedures need to describe to the user the steps that are to be followed and the administrative process for ensuring waste containers are certified. The procedures require a signed statement certifying waste meets the appropriate criteria. The procedures also document the steps necessary for complying with the applicable transportation requirements (e.g., requirements from a safety analysis report for packaging and/or from Title 49, Code of Federal Regulations).

Procurement/Purchasing Controls - The procurement and/or purchase of items or services that are significant to certifying that a waste meets the waste acceptance criteria of a receiving facility need to be documented. Such procurements may include the purchase of materials such as waste containers, or laboratory services (onsite or offsite). As dictated by the type of procurement, the documentation should include (or reference) the technical specifications for the item/service being procured; identification of quality assurance requirements including any required testing or inspections; specification of documentation to be provided on delivery (e.g., fabrication inspection and/or test records; a certificate of compliance or conformance; laboratory analytical results); and a statement ensuring access to the provider's facilities as necessary to perform audits and inspections. The certification program ensures that the procurement documentation is reviewed and approved by an official with knowledge of the need, intent, and requirements for the

procurement. The program also provides for documented verification commensurate with the relative importance and complexity of the items or services being procured.

Document Control - The principal documents that constitute the certification program need to be subject to document control. Program documentation will identify which documents are to be controlled. The waste certification program description, waste certification procedures, and quality assurance program documentation need to all be subject to document control. Document control includes review and approval, distribution to designated recipients (users), and a controlled process for making changes to the documents. Existing document control programs at a site may provide the necessary controls for documents that are part of the waste certification program.

Training - The certification program needs to identify the training requirements for the various individuals who are involved in the program. At a minimum, the program will require training of the official who certifies the waste meets the waste acceptance criteria of the facility(ies) to which the waste is being transferred. In addition, individuals will need to be trained in the procedures that control the part of the certification process with which they are involved.

Records - The certification program documentation needs to describe the management of certification records (see guidance for subparagraph (1) of this Waste Certification requirement).

Example: A site generates a small amount of low-level waste that is sent to a central facility managed by a waste management organization. The generating organizations work with the receiving facility to define the waste certification program for the site. Through a review of the existing site procedures, site personnel determine the waste certification program can operate under the existing site quality assurance program, document control program, procurement process, and records management program. However, they determine that the site training program does not adequately address the certification process. Consequently, the waste managers work with the training department and develop a training module that explains the purpose and process of waste certification. The certification program documentation identifies these other programs are applicable, specifies the facilities from which waste would be transferred, designates the officials responsible for waste certification at those facilities and their training requirements, and specifies a procedure (within the document control program) that ensures compliance with the waste acceptance criteria. Within the existing programs, site personnel identify the records to be maintained and retention times, technical specifications and receipt requirements for obtaining waste packaging materials, and requirements for analytical data.

Operating within the parameters defined by the program, the waste generators are able to certify waste for transfer to the onsite receiving facility.

As noted in the preceding example, existing programs at a site may provide the framework within which elements of the waste certification program can be addressed (e.g., quality assurance, training, document control). The waste acceptance requirements of the facility to which the waste is to be sent may impose additional requirements on what is to be included in the waste certification program. Whether the waste acceptance requirements of the facility to which waste is transferred mandate a waste certification program (e.g., a commercial facility), the organization transferring the waste is responsible for developing and implementing a certification program to provide internal assurance that the waste acceptance requirements will be met.

Implementation. The waste certification program is implemented through the use of the documented controls, processes, and procedures. The key document in a waste certification program is the certification statement or equivalent. The certification statement is the documentation signed by a designated official that certifies that the low-level waste meets the appropriate requirements. The list below is a generic listing of the topics that are recommended for consideration in development of certification statements for waste shipments that go from one DOE site to another.

1. Container and Physical Properties

   - container type or description
   - labeling/markings
   - weight
   - vents
   - liquids

2. Nuclear/Radiological Properties

   - fissile content
   - transuranic activity
   - other radioactivity
   - dose rate
   - surface contamination
   - thermal power

3. Chemical Properties

   - mixed waste
   - polychlorinated biphenyls

- other hazardous constituents
- pyrophorics
- explosives
- corrosives
- compressed gases
- volatile organic compounds

4. Packaging/Shipping Data

- packaging
- shipping information

Graded Approach. A graded approach is used in implementing the waste certification program. As mentioned, the above list is recommended for the intersite transfer of low-level waste. Intersite transfers involve certifying that the waste is in compliance with the requirements for the receiving facility itself and with Department of Transportation requirements. However, even though the above list should be considered, it may be shortened and simplified for onsite transfers where the organizational relationships and knowledge of waste and waste generating activities may reduce the information that needs to be documented and transferred with each individual waste container or shipment. For onsite transfers, much of the information may already be available to the receiving facility. Onsite transportation of waste should be certified as meeting Department of Transportation or site-specific requirements for transportation.

> *Example: For an onsite transfer of waste at Site D, the receiving facility/organization already has a waste stream profile provided by the generator facility/organization. Because of the existence of the waste stream profile, the certification is performed by an individual trained in the waste packaging and certification procedures signing a waste pick-up request that provides the radionuclide inventory of the waste packages being transferred and the waste stream identification number.*

The waste acceptance requirements of the facility receiving the waste (see DOE M 435.1-1, Section IV.G) may dictate additional items which must be part of the certification statement. Even if such information is not dictated by the receiving facility, the waste acceptance criteria should be used to identify key elements to include on the waste certification statement.

Compliance with the development and documentation portion of the certification requirement is demonstrated by a waste certification plan that identifies the organizations involved, assigns responsibilities for implementing the program, and describes or references the quality assurance, training, procurement controls, records management, and procedures to be used by the program. Acceptable performance for implementing the program is demonstrated when appropriate personnel are trained and follow the procedures that govern their part of the waste certification

process. Additionally, acceptable performance is demonstrated if the waste certification plan and procedures are current and controlled in accordance with a document controls program, and records related to certification (e.g., certification statements, training records, procurement records, characterization records, container records) are generated and managed in accordance with the established site program.

Supplemental References:

1. DOE, 1997. *Nevada Test Site Waste Acceptance Criteria* (NTSWAC), Revision 1, U.S. Department of Energy, Nevada Operations Office, Las Vegas, NV, August 1997.

IV. J.(1) Certification Program. The waste certification program shall designate the officials who have the authority to certify and release waste for shipment; and specify what documentation is required for waste generation, characterization, shipment, and certification. The program shall provide requirements for auditability, retrievability, and storage of required documentation and specify the records retention period.

Objective:

The objective of this requirement is to ensure waste certification programs are developed that clearly identify the documentation required for certifying low-level waste, specify personnel with the authority to make the certification, and provide a traceable and verifiable record of and basis for certification.

Discussion:

Officials who have the authority to certify low-level waste meets the waste acceptance requirements of the receiving facility must be designated by a cognizant manager. To avoid having personnel who are not knowledgeable of waste acceptance and transfer requirements authorizing the release of waste, the program needs to identify, by title or name, the officials who are authorized to certify the waste. The official(s) are qualified by virtue of position, responsibilities, and training to make this certification. The official(s) have sufficient familiarity with the waste being generated and have been trained relative to the acceptance criteria of the receiving facility (and applicable transportation requirements) to be able to certify in writing that the waste is acceptable for transfer. The official(s) need to also have authorization from the receiving facility to transfer the waste (see DOE M 435.1-1, Section IV.K, Waste Transfer). Implementation of this element should be tailored to specific site needs and situations.

Example: Onsite transfers of low-level waste at Site E from multiple laboratories or processes to the central waste management facility involves training multiple personnel (e.g., one for each laboratory or process) who have the authority to certify waste as meeting the onsite waste acceptance requirements. However, for the transfer of low-level waste from the central waste management facility at Site E to an offsite facility, there is one designated official at the site who is trained on the acceptance criteria of the offsite storage, treatment, or disposal facility waste acceptance criteria and transportation requirements, and is authorized to certify the waste.

The waste certification program needs to specifically identify the documentation to be produced to support the certification that low-level waste meets the waste acceptance criteria of the receiving facility. The required documentation may include the following:

Waste Stream Profile (or record relating the waste to a previous profile). The waste stream profile is a description of the waste stream, generally identifying the source, physical and chemical description, and upper limits on radionuclides.

Radionuclide Characterization Data. Radionuclide characterization data include the concentration and/or inventory of radionuclides as determined by characterization (see guidance for DOE M 435.1-1, Section IV.I, Waste Characterization).

EPA Uniform Hazardous Waste Manifest. The EPA manifest is required by 40 CFR Part 262 for the transfer of a hazardous or mixed waste.

Waste Container Data and Integrity Maintenance Documentation. Container data includes information about the containers dimensions and physical attributes and procurement information. Integrity documentation includes the records of ownership and "transfer" of waste containers and data. (See guidance for Waste Transfer, DOE M 435.1-1, Section IV.K.)

Radiological Survey Results (or documentation referencing a survey record). Survey results include the determination of the surface contamination of the waste container and the external dose rate.

Bill of Lading. A document indicating the contents of a shipment.

Real-time Radiography Results. The results of radiography performed to detect unallowed material in the waste package (e.g., liquids, compressed gas cylinders).

Certification Statement. The statement required by DOE M 435.1-1 to document that waste is in compliance with the acceptance criteria of the facility to which the waste is being transferred.

Authorization to Transfer. Documentation indicating that an official from the facility to which the waste is to be transferred has authorized transfer of the waste to the facility.

As noted for other elements of this requirement, the organization developing the certification program uses a graded approach in determining which of these documents are needed. Regardless of the extent of the required documentation, the certification statement can serve as a checklist that all of the waste acceptance criteria have been considered and the waste is in compliance.

In order to ensure that information is available if or when it is needed in the future, the low-level waste certification program needs to identify which records are to be maintained and how they are to be maintained. The certification program documentation may include specific records management requirements, or may simply invoke an existing acceptable records management program. Although no minimum record retention times are established in DOE M 435.1-1, certain records may need to be maintained indefinitely. Whereas hazardous waste regulations require only a three-year retention period, DOE low-level waste disposal facilities should plan on maintaining pertinent records at least through the operations, closure, and post-closure monitoring periods, and consider making them part of any local land use records. The pertinent records would be those which identify physical, chemical, and radiological characteristics of the waste and the certification of that information. Generating, storage, or treatment facility waste management records may not be required beyond the life of the facility or operation, provided pertinent information has been supplied to the facility where the waste will be disposed.

Example: Personnel at a storage facility maintain records describing when they received waste, what the waste was (characterization and container data provided by the generator), and to whom the waste was eventually transferred. Once the waste is disposed of and the waste characterization and container information is in the possession of the organization responsible for the disposal facility, the organization responsible for the storage facility disposes of its records.

To meet the requirement for auditability and retrievability, the method of records storage and retention needs to allow a person to trace shipment or waste container information back to the generator certification data (e.g., characterization data, source data, container data). In accordance with the DOE M 435.1-1 Transfer Requirements (Section IV.K), information on the source and characteristics of the waste are to be transferred when waste is transferred. However, it is not the intent of this requirement to mandate that a certification statement be generated for

waste already in storage as of the issuance of DOE O 435.1. Such documents must be created for any subsequent transfers of waste.

> *Example: A site should be able to provide the characterization, container, and certification information for any waste container within a storage, treatment, or disposal facility if that waste container is transferred after issuance of DOE O 435.1.*

Compliance with this requirement is demonstrated by a program or procedure for record keeping and records showing that low-level waste is certified as having met the waste acceptance criteria of the facility to which it was transferred and that the certification statement is supported by additional records regarding the waste source, characterization, and container.

Supplemental References:

1. DOE, 1997. *Nevada Test Site Waste Acceptance Criteria* (NTSWAC), Revision 1, U.S. Department of Energy, Nevada Operations Office, Las Vegas, NV, August 1997.

IV. J.(2) Certification Before Transfer. Low-level waste shall be certified as meeting waste acceptance requirements before it is transferred to the facility receiving the waste.

Objective:

The objective of this requirement is to certify that low-level waste meets the acceptance requirements of the storage, treatment, or disposal facility before it is transferred to prevent transferring waste that could endanger receiving facility personnel, and to avoid the delay and potential hazards associated with corrective actions taken to remedy non-compliant conditions.

Discussion:

The waste certification requirements above address development, implementation, and content of a waste certification program. The requirement that waste be certified before transfer ensures that the program is effective in preventing the transfer of waste that does not meet the waste acceptance criteria of the facility receiving the waste for storage, treatment, or disposal. In accordance with this requirement, waste should be released for transfer to another facility only after there is a certification by an authorized official that the waste acceptance requirements have been met. Ensuring certification occurs prior to allowing the physical transfer of waste prevents potential hazards associated with managing waste rejected by the facility to which it is transferred. Requiring certification before waste is transferred also reduces the likelihood of having to recall a waste shipment due to a discovery by the certification official, after the waste is in transit, that the

waste does not comply with the waste acceptance requirements. Guidance on DOE M 435.1-1, Section IV.K discusses when a transfer occurs, and can be consulted to determine when this requirement needs to be met.

Certification that the waste is ready for transfer and meets the waste acceptance criteria and the applicable transportation requirements is a control point in the transfer process. The procedures controlling waste transfer do not allow the transfer to occur unless the certification statement has been signed. Once signed, the certification statement becomes part of the record for the transfer of the waste (see Waste Transfer, DOE M 435.1-1, Section IV.K). An example of a certification statement for shipment of low-level waste to the Nevada Test Site is included as Figure IV.J.1 (in this case, the certification statement is a label that is affixed to the waste container.) The signature on the certification statement confirms that the waste has been characterized for physical, chemical, and radiological characteristics, properly packaged, and necessary container markings and shipping data have been prepared.

> *Example: Central Waste Management Facility personnel are responsible for receiving waste, providing storage for a short time, and making transfers to an offsite low-level waste storage facility. In order for the workers at the Central Waste Management Facility to place a waste container on a truck for transfer, the operating procedures for the facility require that they have a signed certification statement that correlates to the container(s) (either bar coded or numbered). Once a waste container is loaded, a copy of the certification statement is included in the waste transfer papers and another is included in the Central Waste Management Facility files.*

Compliance with this requirement is demonstrated by the presence of a certification program which includes procedures requiring a signed certification statement prior to the release of waste for transfer, and by dated records showing that waste was certified before being transferred.

Supplemental References:

1. DOE, 1997. *Nevada Test Site Waste Acceptance Criteria* (NTSWAC), Revision 1, U.S. Department of Energy, Nevada Operations Office, Las Vegas, NV, August 1997.

IV. J.(3) Maintaining Certification. Low-level waste that has been certified as meeting the waste acceptance requirements for transfer to a storage, treatment, or disposal facility shall be managed in a manner that maintains its certification status.

Objective:

The objective of this requirement is to ensure that certified low-level waste is managed to maintain the certification status and avoid the unnecessary handling of waste containers that would be necessary for recertifying waste.

Discussion:

There may be instances where low-level waste that is already certified to a disposal facility's waste acceptance requirements must be stored before transferred to the next stage in the waste management process (usually the disposal facility, but it could be another storage facility). If low-level waste is certified as meeting the waste acceptance criteria of another facility in addition to the receiving facility, it needs to be stored and controlled so that the certification for the subsequent management step remains valid until the waste can be transferred.

Waste needs to be stored under conditions and with controls to protect it from physical damage, and to prevent tampering (i.e., placement of unallowed materials into the container) so it can be transferred for disposal without re-certification. Also, certifying officials need to be aware of any limitations on the amount of time a waste can be stored without invalidating the certification. Actions necessary to certify a low-level waste that involve potential radiation exposure to workers are deferred, if possible, until there is a reasonable expectation that the waste can be transferred to the receiving facility within the time that the certification is valid. Routine monitoring required for waste in storage may not allow all activities that could result in worker exposure to be deferred.

This requirement is not to be interpreted in a manner that interferes with a facility performing a normal, acceptable waste management function. Therefore, if a low-level waste is certified as meeting the waste acceptance criteria of a treatment facility, the requirement to maintain the certification is not intended to prevent the treatment facility from treating the waste. Even though treating the waste will not “maintain” the certification, the purpose of the certification is to ensure the waste can be safely accepted for treatment. Maintenance of the certification status is intended to cause the waste to be stored, transported, and staged at the treatment facility in a manner that will allow personnel to treat the waste without concern that it no longer meets the acceptance criteria. In addition, despite the protection provided for the waste, sampling prior to treatment may still be a necessary process control step.

Specific requirements for protecting the certification status of low-level waste are generally negotiated with the receiving facility. Requirements to be considered include protecting the waste container, preventing unauthorized introduction of material into the waste, and protecting the data written or stamped on the waste container. The Waste Transfer requirements (DOE M 435.1, Section IV.K) also address protecting waste packages and data to ensure that characterization and container data remain accurate and useable by waste managers. Waste containers need to be

provided with sufficient protection from the elements (e.g., precipitation, wind, flooding, excessive heat), such that the character of the waste and container, and therefore the certification are not altered. Waste containers need to also be stored in a manner that prevents modifying their contents (e.g, under lock and key or with a tamper indication device) and in a location where the waste container will not be damaged (away from equipment high traffic areas where there is the possibility of damage). In addition, it is necessary to be able to relate each waste container to information about the contents of the container. Container markings must be protected from defacement or removal, and records regarding container identification and contents must be safely stored.

> *Example: Mixed low-level waste is certified to be in compliance with the Site X's waste acceptance requirements, and to the waste acceptance requirements of Storage Building A where it will reside until the disposal can take place. The mixed waste is stored in accordance with a procedure that ensures the certification status to Site X is unaffected. The procedure calls for storage of the mixed low-level waste in accordance with a security plan reviewed and approved by the Site X waste acceptance personnel, storage in a specially designated area within Storage Building A, and record-keeping in a separate database from other waste in storage.*

Compliance with this requirement is demonstrated by a program or procedure reflecting this requirement is present and site personnel are able to show that the storage of low-level waste containers is in a facility or manner where the containers would not be damaged by normal weather events, and cannot be accessed by unauthorized personnel. Further, each container can be traced to its certification and the information supporting that certification.

Supplemental References:

1. DOE, 1997. *Nevada Test Site Waste Acceptance Criteria* (NTSWAC), Revision 1, U.S. Department of Energy, Nevada Operations Office, Las Vegas, NV, August 1997.

2. DOE, 1991. *Hanford Site Solid Waste Acceptance Criteria*, WHC-EP-0063-3, U.S. Department of Energy, Office of Environmental Restoration and Waste Management, September 1991.

Figure IV.J.1 - Example Waste Certification Forms

Low-Level Waste Certification

"I certify that containers:

(Container I.D. number[s])

do not contain hazardous waste as defined in Title 40 CFR Part 261 or _____ (state-of-generation) hazardous waste regulations, and do meet the NTSWAC requirements:

(1) according to the results of tests performed in accordance with the requirements as specified in Subpart C of Title 40 CFR Part 261; and/or

(2) according to the supporting documentation provided to me about the materials and processes that produced this waste.

To the best of my knowledge, I believe the information I have submitted is true, accurate, and complete."

_____ _____
Generator Waste Certification Official (Print Name/Sign) Sign

Mixed Waste Certification for Land Disposal Restrictions:

I certify under penalty of law that I personally have examined and am familiar with the waste through analysis and testing or through knowledge of the waste to support this certification that the waste in containers:

(Container I.D. number[s])

complies with the treatment standards specified in Title 40 CFR Part 268, Subpart D, and all applicable prohibitions set forth in 40 CFR 268.32, RCRA Section 3004(d) or _____ (state-of-generation) hazardous waste regulations.

I believe that the information I submitted is true, accurate, and complete, I am aware that there are significant penalties for submitting a false certification, including the possibility of a fine and imprisonment.

_____ _____
Generator Waste Certification Official (Print Name/Sign) Sign

IV. K. Waste Transfer.

A documented process shall be established and implemented for transferring responsibility for management of low-level waste and for ensuring availability of relevant data. The following requirements are in addition to those in Chapter I of this Manual.

Objective:

The objective of this requirement is to ensure that the responsibility for low-level waste containers is established, maintained, properly transferred, and adequately documented so that ownership, and therefore responsibility for safe management, of waste is clear. This responsibility includes maintaining the waste characterization information, the container information, and information about the treatment, storage, transportation and disposal status of containers of waste. This responsibility also includes an assurance that the container of waste has not been altered in a manner that affects its certification status or the ability of the waste to be properly managed.

Discussion:

As discussed in Section I.2.F.(7) of the guidance for DOE M 435.1-1 Chapter I, the radioactive waste generator program includes consideration of the generation planning, characterization, certification, and transfer of low-level waste. In the generator's program, initial responsibility is assigned for containers of low-level waste and a documented process for transferring the responsibility is established.

In the development of DOE O 435.1 and DOE M 435.1-1, maintaining the integrity of waste containers was identified as necessary for the proper control and safe management of low-level waste. Similarly, maintaining information about containers of low-level waste (characterization and container data) was recognized as vital to making and executing safe management decisions. In order to ensure that it is clear who has the responsibility for protecting the integrity of each container of low-level waste and associated waste and container data, there needs to be one person who is identified as being responsible for the waste at any time. Confusion over who is responsible for specific waste containers is avoided by documenting the transfer of responsibility.

This requirement is similar to the concept of chain of custody used in sample management. As with samples, low-level waste containers may be the responsibility of many different organizations during their management life cycle. At any point during the life cycle management of the waste, the identity of the individual responsible for each container of waste needs to be explicit. By clearly identifying the owner of each container of waste, there is no question regarding who is responsible for protecting the waste container and the waste characterization and container data,

and for moving the waste to the next phase of waste management (i.e., storage, treatment, or disposal).

Maintaining Waste Container and Data Integrity. The individual responsible for a container of waste is responsible for maintaining and protecting both the integrity of the container of waste and the data about the container of waste. Protecting the integrity of the waste container is the same as protecting the certification status of a waste container as discussed in the Waste Certification guidance. Essentially it involves managing the container of waste so that it is not damaged or does not degrade because of the conditions under which it is managed.

Maintaining the data about the container of waste involves ensuring receipt or traceability, or developing (as discussed below) information necessary to support subsequent waste management activities, or clearly documenting and ensuring that the information is stored and updated so that full and accurate information is available to the next individual to whom the waste is transferred.

Transferring Responsibility. The transfer of responsibility for containers of low-level waste and the associated waste and container data is to be done in accordance with procedures at each of the facilities involved. The facility from which the waste is transferred, typically establishes (for newly-generated waste) or possesses (for stored wastes) a record or data package about the waste and its container. The facility operating procedures should require the development of an ownership log sheet similar to a chain-of-custody log. This log becomes the data package that is transferred with the container of waste. Upon transfer, the facility transferring the waste is responsible for ensuring personnel at the facility to which the waste is being transferred have assumed responsibility for the waste. A signed and dated copy of the ownership log sheet can serve this purpose. All subsequent transfers, e.g., from storage or treatment facilities, are to be in accordance with procedures requiring the transfer of the data package and documentation of the transfer of responsibility for the waste.

Procedures at the storage, treatment, or disposal facility should require the receipt of certain information about any low-level waste which is received. To ensure that they have sufficient information to safely manage the waste and to transfer the waste to a subsequent waste management facility (if appropriate), it is important for storage, treatment, and disposal facility personnel to ensure they are provided information about the containers of waste for which they become responsible. The receiving facility requires the following documented information be available for all waste they expect to receive:

- Responsible individual. The name, title, affiliation, and phone number of each person who has held responsibility for the waste, starting with the generator. This listing can serve as the ownership log with each person signing the log upon accepting responsibility for the waste.

- Transfer dates. The date the transfer was accepted by each new "owner" of the waste.

- Waste container information. Information about the container (see guidance for IV.K.(2) in this section).

- Characterization information. Information about the waste (see guidance on Waste Characterization).

- Physical location. The site and name (e.g., unique identifier such as a building number) of each location where the waste was managed.

- Previous transportation. Dates of transportation and names of carriers.

- Certification status. A signed certification statement or equivalent (see guidance on Waste Certification). Only the certification statement for the facility to which the waste is being transferred must be part of the waste package data. Previous certification statements may be included if they serve the purpose of documenting other data that should be part of the data package (e.g.,container or characterization data).

- The planned disposition of the waste. Expected storage, treatment, and disposal (see guidance on Generation Planning and Site-Wide Radioactive Waste Management Program).

For each transfer beginning with the generator, the receiver of the waste is responsible for obtaining the proper information from the sender of the waste. The receiver's responsibility is to ensure receipt or availability of complete and accurate information concerning containers of waste. The information needs to be reviewed prior to actual transfer and is a condition of acceptance by the receiver.

Example: A treatment facility receives low-level waste for processing. Upon signing for receipt of the waste, the facility manager becomes the individual responsible for the waste. Facility procedures require that a copy of the data received from the generator be kept in a file cabinet which is accessible only to one individual on each shift. As the containers of waste are processed in the facility, information is recorded in a log and the data package is updated to reflect the change in status of the waste. Upon completion of the processing, the treated waste is packaged in new waste containers and a certification statement is generated indicating that the treated waste meets the waste acceptance criteria for the storage facility to which it will be shipped. Before the waste is transferred, the treatment facility personnel provide a complete set of data to the storage

facility personnel. The data package reflects the new container numbers for the treated waste, but includes the data on the original containers received at the treatment facility. The treatment facility also keeps a duplicate copy of the data package which includes a copy of a waste log indicating transfer of ownership to the storage facility.

The responsibility for ownership of the waste can be different than that for waste certification. The individual responsible for the waste does not necessarily have to be the same individual that certifies the waste is ready to be transferred (see guidance on Waste Certification). As indicated above, the certification status is one piece of information that is transferred with the waste.

Compliance with this requirement is demonstrated if facilities have procedures for the receipt of waste and the transfer of waste, as appropriate, which address the acquisition of waste and container data and the transfer of ownership, respectively. Further evidence of acceptable performance is facility records showing that data on the waste containers is available and accurate, and that documented transfer of responsibility occurs.

Supplemental References:

1. EPA, 1997. *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, SW-846, Third Edition, U.S. Environmental Protection Agency, Washington, D.C., June 1997.

IV. K.(1) Authorization. Low-level waste shall not be transferred to a storage, treatment, or disposal facility until personnel responsible for the facility receiving the waste authorize the transfer.

Objective:

The objective of this requirement is to ensure that shipments or transfers of low-level waste are made only with the cognizance and approval of personnel at the facility receiving low-level waste so that preparations can be assured for its safe management.

Discussion:

As discussed in the guidance for DOE M 435.1-1, Section I.2.F.(7), the radioactive waste generator program includes consideration of the generation planning, characterization, certification, and transfer of low-level waste. During the development of DOE O 435.1 and DOE M 435.1-1, a review of waste management functions indicated that the receipt of waste without personnel at the facility receiving the waste having knowledge of what was sent presented a potential hazard. If waste is transferred to a facility without prior authorization, the controls necessary for the proper and safe management of the waste may not be in place. As a

consequence, the waste may be rejected and returned to the sender. This requirement represents a control to minimize the potential for exposures and releases during the handling and transfer of low-level waste.

Safe transfer of the waste can only be assured if the facility receiving the waste for storage, treatment, or disposal has considered the acceptability of the waste versus its safety operating constraints. Personnel at a storage, treatment, or disposal facility who authorize the transfer of waste are indicating that they have the capability to receive the waste and manage it in a manner that is protective of workers, the public, and the environment. Therefore for the purposes of safe life-cycle management, the receipt of authorization prior to the transfer of low-level waste to a storage, treatment, or disposal facility is essential. Meeting this requirement is the responsibility of the organization or individual transferring (sending) the waste. The following are considered transfers:

(1) Waste is physically moved from one location to another, even if ownership does not change.

(2) Waste is physically moved from one location to another and ownership changes.

(3) Waste is not physically moved, but ownership changes.

The actions and documentation necessary to obtain authorization will depend on the specific storage, treatment, or disposal facility to which waste is to be transferred. In some cases, the submittal of a waste stream profile which provides a description of the waste and a range of the waste characteristics, augmented by conversations with the generator, may provide enough information for the storage, treatment, or disposal facility staff to be confident that they can safely manage the waste. In other cases, the waste acceptance requirements of the storage, treatment, or disposal facility may dictate that an onsite visit and review of the generator's waste certification program be performed. In order to expedite the transfer of waste, staff responsible for sending the waste need to ensure they understand what information and activities need to be completed in order to receive transfer authorization.

Authorization to transfer waste is received in writing and states the scope of the authorization. The authorization may specify a specific group of waste packages or specific number of shipments of a particular waste type. However, it is acceptable for the written authorization to specify a waste stream(s) which the generator can send on a routine basis. Any additional conditions or notification requirements can be included in the written authorization. Whereas it is the responsibility of the storage, treatment, or disposal facility to prepare the written authorization, the organization sending the waste must not transfer waste until they have authorization and understand which waste is included in the authorization.

Example: An activity at Site X results in the routine generation of low-level waste in the form of contaminated personnel protective equipment, swipes, plastic sheeting, and paper waste. The waste stream is designated by the number X-2156. Consistent with site procedures, the generator prepares a waste stream profile which describes the characteristics, packaging, and projected generation rate of the waste stream and provides it to the waste management organization. The waste management organization reviews the waste stream profile and calls the generator facility representative to clarify the information on the waste stream profile. The waste management organization has previously reviewed the generator's certification program. Based on the certification program and the waste stream profile, the waste management organization prepares a letter authorizing the generator to transfer any waste that meets the X-2156 profile until further notice. The authorization letter also states that the generator must provide the waste management organization notice of the number of waste containers to be transferred 48 hours before a transfer occurs.

When low-level waste is transferred (moved from one location to another), but the ownership of the waste does not change (i.e., the same individual is responsible for both facilities), a separate authorization may not be required. Recognizing that the intent of this requirement is to ensure that the waste is expected and can be safely managed at the facility to which it is being transferred, other documentation can serve as the written authorization.

Example: The manager of the waste management organization is the official responsible for authorizing transfer of waste to either of two separate storage facilities, Building A and Building B. Even though the waste acceptance criteria are the same for the two facilities, waste is accepted and logged into each facility separately. The manager decides to consolidate all of the waste into Building A for more efficient management. The authorization to transfer is provided by the certification statement indicating that the waste meets the Building A waste acceptance requirements, and the documentation of the new storage location on the waste characterization and container data.

Compliance with this requirement is demonstrated by sites having procedures that require a confirmation of authorization before releasing waste for transfer, and records showing that transfers are made in accordance with written authorizations.

Supplemental References:

1. DOE/CAO, 1995. *Generator Site Certification Guide*, DOE/CAO-95-2119, U.S. Department of Energy, Carlsbad Area Office, Carlsbad, NM, 1995.

IV. K.(2) Data. Waste characterization data, container information, and generation, storage, treatment, and transportation information for low-level waste shall be transferred with or be traceable to the waste.

Objective:

The objective of this requirement is to establish and maintain information about the characteristics of low-level waste and the waste containers to ensure that sufficient information to support management of waste in a manner that is protective of workers, the public, and the environment is always available.

Discussion:

The *Radioactive Waste Management Manual*, assigns the Field Element Manager the responsibility of ensuring development and approval of a program that addresses the responsibilities of waste generators (DOE M 435.1-1, Section I.2.F.(7)). The generator requirements are to address hazards associated with a waste management facility receiving unexpected volumes or types of waste, or receiving waste that may not meet the applicable waste acceptance requirements. Generator requirements address generation planning, waste characterization, waste certification, and waste transfer. The requirement for traceability of data addresses the hazards associated with transferring low-level waste without providing or maintaining adequate information about the container and its content. Establishing and maintaining the identity of the waste, as well as maintaining controls based on the waste's hazards, are necessary for its safe transfer and subsequent management. Acquisition of information about the waste is addressed in the guidance on Waste Characterization (DOE M 435.1-1, Section IV.I). Certification that waste is ready for transfer (i.e., meets the waste acceptance requirements and transportation requirements) is discussed in the guidance on Waste Certification (DOE M 435.1-1, Section IV.J). Maintenance of documentation regarding transfer of waste is discussed later in this section of guidance.

In the process of developing DOE O 435.1 and DOE M 435.1-1, transfer was identified as the activity in the life-cycle management of waste with the greatest potential for loss of information about containers of waste, and the associated loss of adequate waste management controls needed to avoid exposure or release of radioactivity. Therefore, when waste is transferred, the waste characterization and container data must be transferred or available to the new "owner" (i.e., responsible waste manager) of the waste.

Example: A liquid low-level waste is being transferred to a treatment facility for solidification. The waste was characterized and the waste characterization information listed on the waste certification statement. Although the waste met the waste acceptance criteria for the treatment facility and an authorization to make the transfer was granted,

the characterization information was not transmitted before or in conjunction with the waste transfer. Due to storage limitations at the treatment facility, the drums of waste were placed in an unheated staging area. After a three days of below freezing weather, it was noted that the drums were bulging and split. Had the characterization information been documented and transferred with the waste, treatment facility personnel would have known it was an aqueous waste and would have imposed controls on the waste to protect it from freezing conditions.

Sufficient information about the container in which waste is packaged needs to be provided to the storage, treatment, or disposal organization to which waste is transferred to ensure that the containers are handled safely.

The information about the container is supported by and traceable to the more detailed container procurement information. The organization that procures the container is responsible for properly documenting the essential information regarding the procurement. The information needs to be maintained so questions about adequacy of the container for its originally intended or alternate uses can be assessed and to answer questions about subsequent procurements. Information documented concerning the procurement of waste containers includes:

- Purpose of the container;
- Container performance requirements;
- Purchase specifications; and
- Manufacturer certifications verifying performance to purchase.

The information concerning the purpose of the container includes the designed service life, the environments for which the container was designed and is compatible with, and other information necessary to allow proper use of the container. The procurement information includes vendor information, product specifications, lot or serial number information, and other procurement information necessary to document the container purchased.

The detailed procurement data about containers can be, but do not have to be, transferred at the time waste is transferred. As long as the records are retrievable and can be correlated to the waste containers, it is acceptable for an organization transferring waste to maintain the records.

The type of container information that should be provided upon transfer of containers of waste will depend on the type of waste and subsequent waste management steps. Typically, the information includes the following:

- container size and type - generally this would be the container that is providing the primary containment of the waste (e.g., DOT 7A 55-gallon drum, standard waste box, or DOT 7A 80-gallon overpack);

- container enhancements - additional items that have been added to the primary container to facilitate container performance (e.g., shielding, liners, plastic bags, absorbents);

- lifting limitations - allowable and/or unallowable lifting points and methods; and

- load limitations - based on the physical characteristics, the maximum number of containers or weight that can be placed on top of the waste container.

When waste is initially placed in the container, the organization packaging the waste documents and manages the information regarding its characteristics (e.g., radioisotopic inventory, total activity, radiation dose, waste form). When the container of waste is physically transferred or the ownership has changed, the information regarding the waste and container must be provided or made available to the organization that acquires responsibility for the waste. A transfer is considered to have occurred if the waste is physically moved from one location to another or if there is a change in responsibility for the waste.

The following waste container characterization data are typically provided with the transfer of low-level waste:

- physical and chemical description of waste (use of item description code or waste stream identifier, if applicable);

- radiological inventory (see guidance on Waste Characterization);

- gross weight;

- volume percent utilized;

- fixed and removable surface contamination (alpha and beta/gamma);

- surface dose rate;

- tamper-indicating device number; and

- thermal power.

Example: Building 2000 is undergoing a facility cleanout that involves the decontamination of building surfaces and the removal of excess processing equipment. The organization responsible for the facility identifies two types of waste containers to be used, 55-gallon drums for small items, personnel-protective clothing, and contamination control waste, and standard waste boxes for larger pieces of equipment. The job is managed such that one operator is responsible for logging each piece of waste put into the containers. Upon filling a waste drum or box, the container is closed, and a tamper-indicating device is installed. Radiological Services personnel perform radiological surveys of each container of waste and record the data. The authorized waste certification official uses the data recorded on the waste log and survey sheets, supplemented with radiological characterization data, weight data, and other information to fill out a waste certification checklist. The checklist requires identification of waste container data as discussed above. In accordance with site procedures, the checklist is a piece of required paperwork that is to be provided to the storage, treatment, or storage facility to which the waste is transferred.

This requirement needs to be implemented with consideration given to documentation requirements imposed by other internal programs or external organizations such as the Environmental Protection Agency or Department of Transportation. These other documentation requirements, such as an EPA Uniform Hazardous Waste Manifest or a transportation bill of lading, may include much of the waste container information that is provided to the storage, treatment or disposal facility to which waste is transferred. Therefore, to the extent these other documents have the appropriate information, they may be used to meet the requirement to convey information about the waste being transferred to a subsequent waste management facility. If documentation prepared to meet requirements of other programs or organizations is used, it may need to be supplemented to provide any additional data on waste characterization and packaging addressed in this guidance.

Example: Mixed low-level waste is being sent from one site to another for storage. Since the waste is regulated under RCRA, a Uniform Hazardous Waste Manifest is prepared as required by 40 CFR Part 262. The manifest includes information about the physical and chemical characteristics of the waste, the container type, and container weight. The site has developed a 'Radiological and Supplemental Characteristics Data Sheet' to provide additional information about the containers of mixed waste. The data sheet provides additional information about the radiological inventory, surface dose rate, surface contamination, fissile material content, number of the tamper-indicating device installed on the waste containers, load limitations, and handling limitations. Between the two documents the storage facility is provided enough information so they can safely manage the waste.

Compliance with this requirement is demonstrated if there are procedures requiring that characterization and container data be provided and maintained for each low-level waste transfer and documented records of transfers show that the information is being provided.

Supplemental References:

1. EPA. *Standards Applicable to Generators of Hazardous Waste*, 40 CFR Part 262, U.S. Environmental Protection Agency, Washington, D.C.

IV. L. <u>Packaging and Transportation</u>.

The following requirements are in addition to those in Chapter I of this Manual.

(1) Packaging. If containers are used:

(a) Low-level waste shall be packaged in a manner that provides containment and protection for the duration of the anticipated storage period and until disposal is achieved or until the waste has been removed from the container.

(b) When waste is packaged, vents or other measures shall be provided if the potential exists for pressurizing or generating flammable or explosive concentrations of gases within the waste container.

(c) Containers of low-level waste shall be marked such that their contents can be identified.

Objective:

The objective of these requirements is to ensure that when low-level waste is packaged, the container selected is adequate to contain the waste and limit radiation exposure for the entire time the waste is in storage, and to ensure that the container can be correlated to necessary information on its contents. The first subrequirement is to ensure the selection of a container for waste based on the life-cycle of the waste so that there will not be unnecessary repackaging of waste. The second subrequirement is to prevent the build up of pressure or concentrations of gases that could cause a loss of waste confinement. The third subrequirement is to ensure that it is possible to identify the contents of the container of waste during storage and when the waste is removed from storage for treatment or disposal without having to open the container.

Discussion:

The need for packaging requirements specific to waste management concerns evolved from the development of DOE O 435.1, and past experience in low-level waste transportation. The safety and hazards analysis conducted in support of the Order and Manual development identified loss of confinement of a waste container as a potential hazard affecting worker safety and releases to the environment. In addition, the inability to associate a container with data on the contents was identified as a situation that would result in unnecessary worker exposure due to the need to re-characterize the waste. Mitigation of each of these concerns can be achieved through proper packaging and compliance with the requirements of this section.

An analysis of existing requirements affecting the packaging of waste identified the Department of Transportation (DOT) regulations (49 CFR) and the DOE Orders, DOE O 460.1A and DOE O 460.2 as sources of packaging requirements (see DOE M 435.1-1, Section I.1.E.(11)) . Generally, the DOT requirements apply to offsite shipments and any other transport on publicly-accessible roads. *Packaging and Transportation Safety* (DOE O 460.1A) invokes the DOT requirements, or documented requirements providing equivalent safety, for onsite shipments. These regulations require the use of DOT Type A or Type B packaging (depending on radionuclide content) for DOE waste shipments. DOE 460.1A also establishes the means and approval authority for qualifying packaging as Type A or Type B. *Departmental Materials Transportation and Packaging Management* (DOE O 460.2) includes DOE policies and requirements that supplement the DOT regulations. Requirements from DOE O 460.2 relevant to waste packaging include the inspection of waste shipments upon receipt, provision of data to the Department's Packaging Management Plan, and performance of routine assessments of transportation and packaging operations.

While the DOT requirements and DOE packaging and transportation requirements were considered adequate for shipping waste, they were not considered sufficient to address the other low-level waste management concerns associated with long-term storage or with selecting and packaging waste based on the entire waste management life cycle.

The life-cycle management of low-level waste may involve the packaging of waste followed by a protracted storage period while awaiting disposal. Selection of a container (i.e., a receptacle and any other components or materials necessary for the receptacle to perform its required containment function) needs to account for all waste management steps expected prior to and including disposal. Therefore, the container needs to meet the requirements for transportation, storage, and eventual disposal (to the extent the disposal requirements are known). Alternatively, if waste treatment is required, the container needs to be adequate to contain the waste during storage and allow the waste to be transferred to the treatment facility where it might be removed from the container prior to treatment. Subsequent to treatment, packaging of the treated residues is based on meeting all of the requirements of the remaining waste management steps. Selection of a container that fulfills the needs of all subsequent waste management actions ensures waste confinement and eliminates the need to repackage the waste, thus avoiding potential exposure to workers.

> Example: The Site X disposal facility will be the recipient of some low-level waste that is being generated at Site Q. The waste will be stored for 3 months at Site Q, transported to another facility where it will be consolidated with other low-level waste, stored for

another 3 months, then transported to Site X for disposal. Containers that will be found acceptable for disposal at Site X were determined to be appropriate for all management steps; therefore, upon generation, the low-level waste can be immediately placed in a Site X acceptable container and will not need to be repackaged during any subsequent management step.

Containment and Protection. Low-level waste must be adequately contained and the container protected from conditions that could cause container degradation. Inadequate containers or container degradation could lead to failure and result in the spread of contaminated materials, worker exposure, or the non-acceptance by a receiving facility. When selecting low-level waste containers, consideration must be given to the conditions to which the container will be subjected. If waste is to be stored outside for an extended period and subjected to the natural environment, the container must be made of materials that have been demonstrated to maintain integrity during these conditions.

Example: Bulk contaminated soil and debris was packaged in wooden boxes and stored outside for up to four years. The boxes degraded to the point that they no longer served as containment and were literally falling apart. Due to the selection of inadequate containers for the time of storage and storage conditions, the waste had to be repackaged prior to transfer and the used wooden boxes also managed as low-level waste.

Low-level waste must not be incompatible with the container in which it is placed. The physical, chemical, and radiological attributes of the waste need to be considered when selecting a container. Container integrity must not be jeopardized due to the size, shape, or weight of objects contained in the waste. Containers need to be compatible with any unusual chemical characteristics, water content, and pH of the waste. If absorbent or other materials are used to bind liquids contained in the waste, the resultant waste matrix must not be capable of spontaneous combustion, decomposition, explosion, liquid desorption, or otherwise have the ability to affect the integrity of the containers in any way (see Storage guidance IV.N).

Shielding may also be required to provide protection to workers who handle the waste containers or who are responsible for monitoring low-level waste in storage. The necessity for shielding is considered at the time of packaging so that the shielding can be integrated into the waste container before waste is present if internal shielding is acceptable to the storage, treatment, or disposal facility. Alternatively, the storage configuration may be designed to provide the necessary shielding. If shielding is required, consideration needs to be given to the use of materials that do not have the possibility to become a mixed waste if contaminated by the radiological constituents. Guidance for DOE M 435.1-1, Section IV.K.(1) discusses the selection and procurement of low-level waste containers and the necessary information that is documented.

Example: A new facility generates high-activity low-level waste sludges with caustic properties and multiple fission products requiring remote-handling. The container selected has been designed to withstand chemical attack from the sludge, includes sufficient absorbent to ensure there are no free liquids, and incorporates shielding. The container provides protection of workers, the public, and the environment during its intended service life.

The anticipated service life needs to be considered when selecting a container for low-level waste. A determination of the anticipated storage time, environment, and location (waste acceptance criteria) is essential to selecting the proper waste container. For low-level waste that does not have an identified path to disposal, the waste container may need to be designed to remain effective for an extended and/or indefinite storage period.

Example: A site needs to repackage a small quantity of low-level waste with no identified path to disposal. A plan has not yet been completed for resolving the disposal issues. The selected container has been designed to withstand the effects of time and last a minimum of 50 years if stored indoors.

When selecting containers for low-level waste, consideration needs to be given to the full life-cycle of the waste, with a goal of packaging the waste only once. The selected waste container needs to be compatible with transportation requirements and the waste acceptance criteria of the facilities expected to manage the waste. Containers can also be designed and utilized in storage and treatment facilities that allow for direct disposal. Prior to packaging, the consideration of the management steps the waste will go through should minimize risks associated with handling and repackaging the waste. The waste container maintains structural integrity and containment until it is disposed of or the waste has been removed from it. DOE low-level disposal sites have generally identified several DOT-certified drums and standard waste boxes in their waste acceptance criteria documentation as containers that are acceptable for handling and disposal at their sites. These drums and boxes may be considered for all management steps to facilitate disposal if they are compatible with the interim management steps the waste will undergo.

Example 1: A site selected a certain 4 x 4 x 8-ft box as the container for high volumes of miscellaneous low-level waste that was to be stored for a few years prior to disposal. However, because consideration was not given to the entire life cycle for management of the waste, site personnel did not take into account that the boxes were not acceptable at the disposal facility which was to dispose of the waste. Consequently, in order to make the waste acceptable for disposal, site personnel will have to repackage the waste and may have to treat the 4 x 4 x 8-ft boxes as low-level waste as well.

Example 2: A requirements analysis was performed on the life-cycle plan for a specific new low-level waste stream that will generate odd-sized solid debris. The analysis

indicated that a standard waste box could be used to meet all the requirements for transportation, as well as satisfy the storage and disposal facilities waste acceptance requirements.

To ensure that the waste container performs as expected, the following need to be considered when placing waste in the packaging:

- Containers free of deformations or imperfections that may cause a loss of container integrity before the designed lifetime.
- Waste placement in a manner that does not adversely affect the integrity of the waste container.
- Containers utilized such that void space within the container is minimized, although care should be taken to avoid exceeding weight or other limitations identified through consideration of the life-cycle management process.
- Waste container labels and markings permanently applied.

The selection of the container is influenced by the storage conditions, storage duration, and the monitoring expected for the waste containers. Ensuring waste containers provide confinement for their expected storage life is therefore dependent on ensuring an appropriate storage environment consistent with the container characteristics. Storage of low-level waste containers is addressed in the guidance for DOE M 435.1-1, Section IV.N.

Vents. The use of vents or another mechanism for controlling the accumulation of gases and/or build up of pressure within the waste container needs to be considered when low-level waste is packaged or repackaged. Based on the characterization of the waste, a determination is made as to whether the waste contains materials which could evolve gases (e.g., through decomposition of organics or radiolysis). The life cycle management of the waste container is also considered from the standpoint of exposure to environmental conditions that could cause atmospheric pressure in the waste container to vary enough from the ambient pressure so as to cause a breach of confinement. Either of these safety-related conditions may result in a decision to use vent clips, permeable gaskets, or other means for controlling the potential hazards.

Example: Steel boxes are being used to store, transport, and dispose of low-level waste. The inherent design of the steel box eliminates any possibility for it to become pressurized or otherwise generate hazardous concentrations of gases.

If vents are warranted, waste managers need to consider installation of vents or other mitigating measures at the time the waste is packaged. By installing the vents at the time waste is packaged, unnecessary waste container handling and the associated radiation exposure can be avoided. For waste containers currently in storage, a waste manager needs to consider the safety hazards associated with the containers and install vents as appropriate to mitigate hazards. What action may be appropriate depends on the immediacy of a hazard associated with the waste containers. If hazardous concentrations of gases could be generated (e.g., based on similarity of waste container contents to waste streams known to be a problem, or physical indications such as bulging drums), action needs to be taken to prevent an accident while the waste is in storage. If there is no perceived imminent threat, the appropriate time to install vents or apply mitigating measures may be when the waste containers are being prepared for transfer to the next step in the waste management cycle.

> *Example: Low-level waste sludge is currently stored in sealed steel drums which are scheduled to be disposed shortly. Analysis of the characterization information for the waste indicates the possibility for the generation of flammable gases. Several representative drums are sampled for the suspect gas and an analysis is performed. Based on the low concentrations found it is determined that the drums do not need to be vented.*

Marking and Labeling. The marking and labeling of low-level waste containers need to be done in a manner that allows traceability to the documentation of the waste characteristics and container information. The marking or labeling needs to be applied in a manner that will be visible if the waste package is on the outside of a storage or transportation array. For a 55-gallon drum, this is generally accomplished by placing the marking or labeling about every 120 degrees around the outside of the drum. For a waste box, acceptable labeling can be accomplished by placing labels on each side of the box. Waste package identification should be in medium to low density Code 39 bar code symbology in accordance with ANSI/AIM-BC1-1995. Bar coding is to be a minimum of 1 inch high and should be accompanied by alphanumeric characters at least ½ inch high. Durability and readability of marking and labeling is one of the items included in the inspection program for waste in storage (see guidance for DOE M 435.1-1, Section IV.N.(1)(d)).

> *Example: A waste generator is packaging waste in accordance with its site certification program that successfully certifies low-level waste for disposal at the Nevada Test Site. In accordance with the NTS certification procedures, labels meeting ANSI/AIM-BC1-1995 that contain the waste stream identifier, shipment identifier, and unique package identifier are placed in two locations in accordance with Appendix C of the NTS WAC, Rev.1. This satisfies the marking and labeling requirement.*

Waste characterization and the container documentation is to be associated with each individual container of waste. Guidance related to documentation is discussed in guidance for Waste

Transfer (DOE M 435.1-1, Section IV.K). The documentation needs to include the aspects relative to container selection including, the designed service life, the environments that the container was designed for and is compatible with, and other information necessary to allow proper use of the container.

Compliance with the packaging requirement is demonstrated by: (1) procedures which document proper packaging protocols; and (2) no trends of routine repackaging of low-level waste that is packaged after issuance of DOE O 435.1. Successful performance of this requirement is also demonstrated by a record of containers for which failure has not routinely occurred under management conditions. It is recognized that there may be failed containers for waste previously placed in storage. For those containers, the goal is to only have to repackage the waste one time after it is retrieved and characterized. Further, acceptable performance is demonstrated by containers of waste having marking and labeling that allows correlation with waste characterization data and container information.

Supplemental References:

1. DOE, 1995. *Departmental Materials Transportation and Packaging Management,* DOE O 460.2, U.S. Department of Energy, Washington, D.C., September 7, 1995.

2. DOE, 1996. *Packaging and Transportation Safety*, DOE O 460.1A , U.S. Department of Energy, Washington, D.C., October 2, 1996.

3. DOT. *Shippers-General Requirements for Shipments and Packagings*, 49 CFR Part 173, U.S. Department of Transportation, Washington, D.C.

4. ANSI/AIM, 1995. *Uniform Symbology Specification Code 39,* ANSI/AIM-BC1-1995, American National Standards Institute, Automatic Identification Manufacturers, Pittsburgh, PA, August 16, 1995.

IV. L.(2) Transportation. To the extent practical, the volume of waste and number of low-level waste shipments shall be minimized.

Objective:

The objective of this requirement is to reduce the risk associated with low-level waste management by reducing the number of miles traveled in transporting waste. This is to be done by the efficient use of waste containers, minimizing the volume of waste which requires shipment, and optimizing shipping plans and schedules.

Discussion:

The need for transportation requirements specific to waste management concerns was evaluated in the development of DOE O 435.1, *Radioactive Waste Management* and the *Radioactive Waste Management Manual* (DOE M 435.1-1). An analysis of existing requirements affecting waste transportation identified the Department of Transportation (DOT) regulations (49 CFR) and the DOE Orders, DOE O 460.1A and DOE O 460.2 (see DOE M 435.1-1, Section I.1.E.(11)), as sources of applicable requirements. Generally, the DOT requirements apply to offsite shipments. *Packaging and Transportation Safety* (DOE O 460.1A) invokes the DOT requirements, or documented requirements providing equivalent safety, for onsite shipments. *Departmental Materials Transportation and Packaging Management* (DOE O 460.2) includes DOE policies and requirements specific to DOE that supplement the DOT regulations. Requirements from DOE O 460.2 relevant to low-level waste transportation address development of a Transportation Plan for high-visibility shipment campaigns, use of the Department's Transportation Tracking and Communications System, and administrative requirements. Additionally, for waste exceeding Type A quantities of radioactive material per DOT requirements, notification of the expected date of arrival is to be given to the site to which the waste is being shipped, and if the waste is not received on the expected day, notification of the shipper is mandated.

The DOT requirements and DOE packaging and transportation requirements were considered adequate for ensuring safe transportation of the waste. However, recognizing that one of the higher risks associated with waste management is from the number of miles traveled in transporting waste, low-level waste shipments should be minimized to reduce worker exposure, risk, and cost. This can be achieved, in part, by ensuring that all containers or primary packagings (e.g., drum or waste box) are used to capacity, and that transportation systems are efficiently utilized. Reaching the capacity (volume or weight) of the waste container should be a goal of every waste packaging operation. Containers should be filled so as to minimize void volume and allow closure, without exceeding its container weight capacity or compromising its integrity, or waste acceptance criteria of the storage, treatment, or disposal facility.

> *Example: Miscellaneous low-level waste such as personnel protective equipment, contaminated tools, and paper and plastic sheeting are being packaged in 55-gallon drums for eventual disposal. Site personnel use a compactor to maximize the amount of waste placed in the drum. Administrative controls ensure that drum weight limits are not exceeded.*

The same goal applies to transport systems, where waste containers should be held and accumulated until a sufficient number of packages is available to make cost-effective use of the transportation system. Additional guidance on accumulation of packages for cost-effective transportation (i.e., staging) is addressed under guidance on storage (DOE M 435.1-1, Section IV.N).

The distance low-level waste is transported, and the number of times waste is physically handled is directly related to the risk of release or exposure. As part of the planning and documentation concerning the life-cycle management of low-level waste, the Site-Wide Radioactive Waste Management Program should seek to reduce the number of times the waste is handled or otherwise transported. Site low-level waste management programs need to ensure that both on-site and off-site transport and handling is minimized.

Example 1: A site that generates small quantities of low-level waste performed an optimization study and determined the nominal volume of waste that needed shipment off-site for the year. Staging the waste prior to transport reduced the number of shipments and allowed the transfer of the waste to occur during the summer when road conditions were best.

Example 2: A waste management operation on a large DOE reservation generates low-level waste that can only be fully characterized by facilities located elsewhere on the reservation. Staging the waste and transferring it during off-peak traffic hours reduced the number of shipments across publicly-traversed roads on the reservation, and helped minimize the risk to the public.

Low-level waste transportation needs will be specific to each site. Availability of treatment, storage, and disposal capabilities, as well as funding profiles, will influence the need to ship low-level waste. In this requirement, the term “to the extent practical” means that site personnel have latitude in making decisions regarding what is practical for their particular situation. This requirement is not intended to force decisions that are contrary to safe waste management, regulatory compliance, or cost-effectiveness. Detailed and documented planning that provides the rationale for a waste shipment regimen is the best way to balance this requirement with site-specific realities.

Example: A site-specific evaluation was performed to support a recommendation on either building low-level waste storage capacity or maintaining the current number of small off-site shipments. The evaluation indicated that concerns over building the storage facility outweighed the potential to minimize shipments and the current shipment regimen was continued. The evaluation was included as part of the Site-Wide Waste Program documentation.

Transportation over the nation's highways and railways results in the most direct contact between the Department’s radioactive waste and the general public, stakeholders, and representatives of States, Tribes, and local government organizations. These groups are primarily concerned with the shipment of these materials through states, cities, and neighborhoods. Efforts to minimize the volume and number of low-level waste shipments will help alleviate their concerns.

Compliance with this requirement can be demonstrated by a combination of site procedures directing the efficient use of waste container capacity and documentation showing that low-level waste shipments are systematically planned and optimized to the extent practical.

Supplemental References:

1. DOE, 1995. *Departmental Materials Transportation and Packaging Management,* DOE O 460.2, U.S. Department of Energy, Washington, D.C., September 7, 1995.

2. DOE, 1996. *Packaging and Transportation Safety*, DOE O 460.1A, U.S. Department of Energy, Washington, D.C., October 2, 1996.

3. DOT. *Shippers-General Requirements for Shipments and Packagings*, 49 CFR Part 173, U.S. Department of Transportation, Washington, D.C.

IV. M. Site Evaluation and Facility Design.

The following requirements are in addition to those in Chapter I of this Manual.

(1) Site Evaluation. Proposed locations for low-level waste facilities shall be evaluated to identify relevant features that should be avoided or must be considered in facility design and analyses.

Objective:

The objective of this requirement is to ensure that a suitable site location is selected and relevant features of the proposed site that should be included in the design of a low-level waste management facility are evaluated so the facility can be appropriately designed to provide protection to the public, workers, and the environment, and to identify features of the site that would be detrimental to this goal so they can be avoided.

Discussion:

DOE M 435.1-1 includes the requirement in Chapter I, *General Requirements and Responsibilities*, to adhere to the requirements contained in DOE O 420.1, *Facility Safety,* and DOE O 430.1A, *Life Cycle Asset Management,* in site evaluation and facility design. In the development of DOE M 435.1-1, additional requirements for site evaluation were considered to be necessary to ensure that full consideration of the beneficial or detrimental aspects of a site are considered to assure that the site location is adequate and to form a sound basis for facility design that is protective of the workers, the public, and the environment. The importance of site evaluation was established by the awareness that the characteristics of the site contribute to a large extent to the ability of the facility to function as planned and in the minimization of the transport of radionuclides to members of the public and the potential contamination of the environment.

The subrequirements included in this section are intended to ensure that sites selected for low-level waste management facilities are properly evaluated, especially sites for low-level waste disposal, and that sites are not used for which detrimental aspects of the site cannot adequately be designed against without still compromising the protection of the public, workers, or the environment. Guidance on subrequirement IV.M.(1)(a) discusses the minimum specific characteristics of sites for low-level waste management facilities that should be evaluated. Specific characteristics of a site for a low-level waste disposal facility are identified in the requirement that must be considered. Guidance on selection of a suitable site for new disposal facilities is also included.

Guidance on subrequirement IV.M.(1)(b) provides information on those aspects of a site for which adequate protection cannot be provided through facility design, and guidance on subrequirement IV.M.(1)(c) provides detailed guidance on evaluation of sites for low-level waste disposal facilities that provide for additional contributions to meeting the goals and objectives contained in this Order and Manual for disposal of low-level waste. Site evaluation includes the selection and characterization of potential sites, which are necessary steps in the development of a new low-level waste management facility. Selection of sites for DOE low-level radioactive waste management facilities is constrained to those federal lands owned and managed by DOE. Within DOE reservations, the process of selecting sites has the purpose of identifying the best location with consideration of those natural features which are desirable for the facility. Characterization of a selected site has the purpose of developing the necessary data to support a site-specific design of the facility.

The site selection process is likely to vary from one DOE site to the next, because of substantial differences in geology, hydrology, meteorology, ecology, and socioeconomics. Similarly, the interests of stakeholders, as they are involved in the process, are likely to influence the issues to be addressed in site selection, and vary from one DOE site to the next. Site characterization is a program of investigations and tests to determine the properties of the site that are important to the design of the facility and the analysis of facility and site performance. While generalized program elements are defined in this guidance, details of the program can only by derived from site-specific and facility-specific considerations.

> *Example: New disposal facilities are being considered at the Hanford Reservation and Savannah River Site. The Savannah River Site evaluation includes the evaluation of surface water, while the Hanford Reservation site evaluation does not. Likewise, the Hanford Reservation site evaluation includes the consideration of wind erosion, while the Savannah River Site evaluation does not.*

Compliance with this requirement is demonstrated by proposed site evaluations that are comprehensive, defensible, and provide sufficient data for facility design, other required analysis, and for avoiding site characteristics that could compromise objectives for safety and protection of the environment, and by the inclusion of the evaluations in the radioactive waste management basis documentation for the facilities.

Supplemental References:

1. DOE, 1995. *Facility Safety*, DOE O 420.1, U.S. Department of Energy, Washington, D.C., October 13, 1995.

2. DOE, 1998. *Life Cycle Asset Management*, DOE O 430.1A, U.S. Department of Energy, October 14, 1998.

IV. M.(1) Site Evaluation. Proposed locations for low-level waste facilities shall be evaluated to identify relevant features that should be avoided or must be considered in facility design and analyses.

(a) Each site proposed for a new low-level waste facility or expansion of an existing low-level waste facility shall be evaluated considering environmental characteristics, geotechnical characteristics, and human activities, including for a low-level waste disposal facility, the capability of the site to demonstrate, at a minimum, whether it is:

1. Located to accommodate the projected volume of waste to be received;

2. Located in a flood plain, a tectonically active area, or in the zone of water table fluctuation; and

3. Located where radionuclide migration pathways are predictable and erosion and surface runoff can be controlled.

Objective:

The objective of this requirement is to ensure that specific evaluations are performed as part of the evaluation of a site for a low-level waste management facility, and that the evaluations are appropriately considered in the final site selection and layout, and the design and construction of the facility. In particular for low-level waste disposal facilities, the objective of this requirement includes ensuring that particularly important site attributes have been evaluated.

Discussion:

This subrequirement identifies the primary site characteristics that must be evaluated in the process of establishing a new low-level waste storage, treatment, or disposal facility, or an expansion of an existing facility, so that the features of the site can be thoroughly understood, that a determination can be made that the site is suitable to support the facility, and so the relevant features of the site can be appropriately factored in the facility design. Each of the items is discussed in the sections that follow.

Some of the site characterization data and evaluations specified in the requirement may already or are going to be included in documents required for authorization of facility construction and operation, or documented separately. These documents include analyses prepared in accordance with the *National Environmental Policy Act*, the Preliminary Safety Analysis Report, the Performance Assessment and Composite Analysis (for disposal facilities), and others. If data already exist or are being prepared for additional documentation or other purposes, then sufficient references to other documents should be used in establishing the suitability of the site and for inclusion in the design of the facility.

Some of the site characteristics and how they affect design are more significant if the proposed facility is a disposal facility. Specific minimum site attributes are listed in the requirement which must be thoroughly evaluated and included in the disposal facility design. These site attributes are also critical in determining the suitability of the site for a disposal facility. Guidance on these site criteria are discussed under Site Selection for a Disposal Facility.

Environmental and Geotechnical Characteristics. The basic environmental and geotechnical characteristics of a proposed site must be established to determine its suitability for the proposed use, and so that basic parameters needed for the design of the facility are identified. Basic elements of this characterization program include meteorology, surface water hydrology, groundwater hydrology for both saturated and unsaturated media, geology, soils, water quality, site stability, air quality, ecology, land and cultural resources, and socioeconomics. Field studies should be performed so as to not compromise the integrity of the land to be dedicated to waste management activities. The extent of investigation in each of these broad topic areas is dependent on the site specific characteristics of the proposed site. Data collected during the site characterization program need to reflect application of the data quality objectives (DQO) process to ensure meaningful and wise use of resources. The characterization of the site is carried out in accordance with the site's quality assurance program, including maintaining records of data collected. Documentation of the results of the site characterization program is not only needed for use in design, but it also may serve a valuable purpose in fulfilling the requirements of the NEPA process.

Design basis events need to be identified and assessed as to their potential impacts on the safe operation of the facility. Design basis events are certain severe natural events that are estimated and assumed to occur in order for their impact (or design loadings) to be imposed on the proposed facility to ensure design of a safe facility. The establishment of the severity of the events is called the design-basis event. A naturally occurring event that needs to be assumed for a design basis event may be tectonic (seismic, volcanic, ground rupture), hydrologic or meteorologic (storms, floods, hurricanes, tsunamis, seiches). Design basis events are typically assumed to occur for both the operating condition (normal) and for accident conditions (abnormal) to establish the envelope of potential hazardous situations that must be designed against.

Natural phenomena that may exist or that can occur in the region of a proposed site need to be identified and assessed according to their potential effects on the safe operation of the facility. The important natural phenomena that affect the facility design must be identified. These phenomena are considered different than the design events described above in that these are not severe events, rather they are normal active processes that are evaluated that may determine simpler design items such as the material of construction for non-critical items such as ramps, doorway overhangs, and covers for staged waste. Natural phenomena such as rainfall, snowfall, wind direction and speed, erosion rates presence of faults, landslide areas, and other natural events that could influence certain aspects of the design in addition to the design basis events discussed above are evaluated. Records of events within the region, including their severity, need to be evaluated for their reliability, accuracy, and completeness. Appropriate methods (including conservatism) are adopted for evaluating site characteristics of the region and the current state of knowledge about such events, and to select those external natural events, other than design basis events, on which the design of the facility would be based.

Example: A new facility for treating low-level and mixed low-level waste is proposed for a site in the northwest quadrant of the DOE site in Kansas. The particular region has severe downpours during the summer months, so the design of the facility includes drainage features to handle a severe rainfall of up to 4 inches per hour.

Human Activities. The region needs to be examined to identify past, present, and proposed man-made facilities and activities that could affect the safe operation of the facility. Man-made facilities or influences include such items as upstream dams and other alterations to drainage basin features, mining, highway construction, housing and industrial development, or establishment of protected areas or wilderness zones. Information regarding past, present, and potential occurrences are collected and evaluated for reliability, accuracy, and completeness. Appropriate methods (including conservatism) need to be adopted for evaluating the man-induced events within the region and the current state of knowledge about such events to select those events on which the design of the facility will be based.

Example 1: The projected improvements of a public highway through the Oak Ridge Reservation could affect the groundwater hydrology associated with the a new disposal facility, and should be evaluated.

Example 2: A proposed disposal facility is located upstream of a potential hydropower dam site. The impoundment associated with the potential dam could raise the water table underlying the site by 100 feet. The significance of this potential development should be evaluated as part of the site evaluation.

The site of a proposed low-level waste management facility needs to be evaluated with respect to the effects construction and operation of the facility may have on the populations and

environmental characteristics of the region, including the transportation of radioactive materials to or from the facility. The evaluation is based on the population and environmental characteristics of the region including:

1) the regional extent of external phenomena;

2) present and future population distribution;

3) present and proposed land and water uses in the region;

4) any special characteristics that would influence the consequences of releases of radioactive material during the life cycle of the facility.

The potential impact of the waste management facility construction, operation, and decommissioning also need to be evaluated, considering both usual and unusual regional characteristics.

> *Example: A new disposal facility is proposed to receive waste from other DOE sites. The new facility will accept wastes delivered by truck with an anticipated receipt of 40 trucks per day. The capability of the existing road system of handling an additional 40 fully loaded trucks per day should be evaluated and include the potential increase in the population in the nearby community.*

Site Selection for a Disposal Facility. The process of site selection for a new DOE low-level waste disposal facility is initially narrowed to the DOE reservation being considered for facility development, and the direction of the process is toward identifying the best site within the reservation. This is different from the way sites are selected for commercial low-level waste disposal facilities. Sites for commercial facilities are selected from large geographic areas where ownership of the land may be under private or public control. Site selection processes for commercial facilities are directed toward identifying sites that meet site suitability requirements, as defined in 10 CFR Part 61, Subpart D. For DOE site selection, rather than meeting suitability criteria for a site, the process seeks a site which will contribute to meeting the performance objectives and other specific technical requirements of DOE M 435.1-1. The requirement, therefore includes minimum site attributes that must be evaluated to determine their respective contributions towards meeting the performance objectives. This differing direction can lead to DOE sites being selected that are located adjacent to or within lands previously contaminated, or sites where existing characterization information supports the requirements of DOE M 435.1-1, and the costs of characterization, design, construction, operations, and closure are minimized.

The site selection process is a formalized activity that is documented, reviewed and approved by the DOE field organization and incorporates stakeholder interest to the extent appropriate. The

documentation of the site selection process needs to describe the method developed for selecting sites and the criteria used as a basis for including or excluding sites. These criteria must include the attributes listed in subrequirements (a), (b), and (c), at a minimum, and include additional site- and facility-specific selection criteria that address specific attributes that are important to site or facility operations. However, it is not intended that these criteria be used as exclusionary conditions to eliminate a site from being considered, but instead provide a measure of evaluation of the site's contributions to performance of the disposal facility. Use of existing facilities on DOE reservations should be considered to the extent practical. The minimum site selection attributes in the subrequirements are the most critical items that must be evaluated in order to respond to requirement IV.M.(1)(b) and IV.M.(1)(c). That is, these items are the most critical in terms of attributes of a site that must be avoided or that need to be prevalent in order that there is a reasonable contribution of the site towards achieving the performance objectives. As such, the specific attributes are discussed further in the following sections of this guidance.

The site selection process can and should be conducted using a reconnaissance level data base which is comprised of existing studies and available information on the various features of candidate sites within the DOE reservation. The data used in selecting a site need to be presented or referenced to provide a reasonable basis for site characterization and design investigations. The results of the site selection process lead to the identification of one preferred site for site characterization. The documentation of the site selection process also provides a useful contribution to the NEPA process, which must be addressed as part of the development of a low-level waste disposal facility.

The basic steps to be included in a site selection process for a low-level waste disposal facility are discussed in detail in the Nuclear Regulatory Commissions's NUREG-0902, *Site Suitability, Selection, and Characterization: Branch Technical Position*. For the purpose of site selection at DOE reservations, these steps are:

- Identification of the region of interest, which is the DOE reservation;
- Screening the region of interest to identify potential sites;
- Screening of potential sites against a common set of criteria to identify a slate of candidate sites; and
- Review the candidates sites in detail to identify a preferred site.

For DOE reservations, available information will likely be sufficient to complete these basic steps in the site selection process. Additional information, in the form of feasibility studies, conceptual designs, preliminary cost estimates, or performance evaluations can be useful in conducting the last step in the site selection process. The preferred site is usually the only site that is subjected to

detailed site characterization. If the site characterization program identifies a significant and unanticipated weakness, another candidate site could be considered for site characterization to the extent necessary to justify a preferred site.

> *Example: A new disposal facility is considered at INEEL where the preferred site is expected to have deep soil deposits and is located in close proximity to existing roads. A drilling program is initiated to establish the local site characteristics, which reveal shallow soil deposits. The preferred site is reconsidered and an alternative preferred site is selected where soil deposits are thicker, but the alternative preferred site is located further away from existing roads.*

Compliance with this requirement is demonstrated for low-level waste storage, treatment, and disposal facilities if the site evaluation comprehensively considers the environmental and geotechnical characteristics of the site, the design basis events, external man-induced events, and the effects of the low-level waste management facility on the region, and includes those features and events in the design of the facility. Compliance with the requirement is demonstrated for low-level waste disposal facilities if, in addition, the site evaluation comprehensively considers the site's capabilities in demonstrating whether it is located in a flood plain, tectonically active area, or in the zone of water table fluctuation, and is located where the projected volume of waste can be accommodated and where radionuclide migration pathways are predictable and erosion and surface water runoff can be controlled. All analyses and justifications for evaluation and controls must be part of the radioactive waste management basis for the facilities.

Supplemental References:

1. NRC. *Licensing Requirements for Land Disposal of Radioactive Waste,* 10 CFR Part 61, U.S. Nuclear Regulatory Commission, Washington, D.C.

2. NRC, 1982. *Site Suitability, Selection and Characterization: Branch Technical Position–Low-Level Waste Licensing Branch*, NUREG-0902, U.S. Nuclear Regulatory Commission, Washington, D.C., April 1982.

IV. M.(1) Site Evaluation. Proposed locations for low-level waste facilities shall be evaluated to identify relevant features that should be avoided or must be considered in facility design and analyses.

(b) Proposed sites with environmental characteristics, geotechnical characteristics, and human activities for which adequate protection cannot be provided through facility design shall be deemed unsuitable for the location of the facility.

Objective:

The objective of this requirement is to avoid sites for which postulated severe natural events cannot be protected from adequately through design and construction and to continue to have assurance that the public safety and health will be protected and the impacts on the environment will continue to be minimized.

Discussion:

This subrequirement provides a performance-based requirement on the use of facility design for meeting the public, worker, and environmental protection requirements of DOE O 435.1 and DOE M 435.1-1. The site, in most cases, functions as the primary barrier for protection against the hazards from the low-level waste management facility during the severe events that are characterized for the site. Engineering alone generally should not be relied upon to overcome weaknesses that are of a severity such that the site itself cannot be considered a contributor to or the primary barrier against the impacts of the design basis events. Facility design and engineering must, together with environmental and geotechnical characteristics, provide adequate protection of workers, the public, and environment in accordance with the performance objectives stated in DOE O 435.1.

For a proposed low-level or mixed low-level waste disposal facility, the determination that a postulated design basis event is so severe or a site is so weak that no amount of engineering or design can make the proposed site suitable is likely to require consideration of different events and a longer period of time than other types of waste management facilities. This is because the disposal facility must perform at a high level of performance for such a long time due to the hazards present from the disposed waste (especially in comparison to the planned short life of a storage facility, for example), and the delicate nature of the behavior of ground water and other geotechnical phenomena known to affect waste disposal sites. Additional detailed guidance on meeting this DOE M 435.1-1 requirement for low-level waste disposal facilities is discussed below under guidance for DOE M 435.1-1, Section IV.M.(1)(c).

The selection, characterization, and evaluation of the proposed site for a low-level waste management facility may identify external events which cannot be adequately addressed by design to achieve the goals and objectives of the requirements of DOE O 435.1.

> *Example: Area A has been selected for more detailed evaluation for construction of a new storage facility and low-level waste disposal facility. Flooding within Area A is determined to be too severe to consider any design adequate for providing reasonable assurance that the performance objectives will continue to be met for the time of compliance currently used (1000 years) for a low-level waste disposal facility. However,*

adequate facility design controls are identified which would allow construction and operation of the proposed storage facility.

For proposed sites that cannot meet the requirements of the Order and Manual Chapter IV, the requirement states that the preferred site for the facility must be declared unsuitable. The specific determinations of areas unsuitable for low-level waste management facilities should be thoroughly documented along with justifications for this conclusion. This documentation is retained as part of the evaluation of the site which is ultimately selected for full site characterization and development.

If no areas of a DOE reservation can be found that are suitable for establishment of a new low-level waste management facility, the Field Element Manager may need to conclude that the management of low-level waste at the DOE reservation is not appropriate, and shipment of waste to another DOE site or to a commercial site for treatment, storage, and/or disposal is appropriate. This information needs to be factored into the life-cycle planning information contained in the Site-Wide Radioactive Waste Management Program and into the Complex-Wide Radioactive Waste Management Program as soon as practical.

Compliance with this requirement is demonstrated if design basis external events are evaluated and a reasonable determination is made that proposed sites for low-level waste management facilities are either suitable or unsuitable based on the protection afforded by the proposed site and from facility design to address design basis external events. The analyses and documentation of the determination must be included as part of the facilities' radioactive waste management bases.

Supplemental References:

1. NRC, 1982. *Site Suitability, Selection and Characterization: Branch Technical Position--Low-Level Waste Licensing Branch*, NUREG-0902, U. S. Nuclear Regulatory Commission, Washington, D.C., April 1982.

IV. M.(1) Site Evaluation. Proposed locations for low-level waste facilities shall be evaluated to identify relevant features that should be avoided or must be considered in facility design and analyses.

(c) Low-level waste disposal facilities shall be sited to achieve long-term stability and to minimize, to the extent practical, the need for active maintenance following final closure.

Objective:

The objective of this requirement is to ensure the selection of proposed low-level disposal sites within DOE reservations that have positive attributes toward meeting the disposal performance objectives of DOE M 435.1-1, and to the extent practical, ensure that new low-level waste disposal facilities are not sited in locations which will inherently require long-term active maintenance to achieve disposal performance objectives.

Discussion:

DOE M 435.1-1 includes the general requirements for site evaluation and facility design in Section I.1.E.(18). This additional requirement, which applies to low-level waste disposal facilities, emphasizes the need for long-term stability and minimal maintenance. This requirement recognizes the importance of stability and minimal maintenance to the long-term performance of a low-level waste disposal facility.

The evaluation of the data collected during site selection and characterization must include the consideration of long-term stability and active maintenance following closure. Consideration of the site characteristics to achieve long-term stability in site selection and facility design minimizes the need for active maintenance following site closure. As part of the documentation for selecting a preferred site, the evaluation needs to demonstrate how long-term stability of the site was considered. Furthermore, data developed during site characterization that quantifies the long-term stability characteristics of the site are to be evaluated separately. Aspects of the site stability which need to be incorporated into the design of the facility to minimize active maintenance following site closure need to be identified.

Site characteristics, waste and container characteristics, operational practices, and disposal unit closure all contribute to long-term stability. Disposal site stability is a necessary performance parameter for meeting the requirements of DOE O 435.1. During site operations and in the closure and post-closure periods, any indication that stability may be compromised needs to be addressed immediately.

> *Example: Two sites are being evaluated as potential sites for a disposal facility. One site is underlain with limestone formations associated with karst development, and the other site is underlain by cemented sandstone. All other considerations being equal, the latter site is selected as a disposal site in favor of the greater potential long-term stability provided by the cemented sandstone formation.*

As part of site maintenance, site inspection to verify the stability of the site is appropriate. Closure planning also needs to address site specific stability. Specific elements which may need to

be addressed will likely be revealed through performance assessment maintenance, or from monitoring activities.

Site Characterization. The site characterization program has the objective of developing a quantitative database for design and performance assessment through field studies and laboratory testing. A program plan describing the nature and extent of the site characterization program for a preferred site is a valuable tool for guiding investigations. The objectives of a site characterization program are discussed in detail in the Nuclear Regulatory Commission's NUREG-0902, *Site Suitability, Selection and Characterization: Branch Technical Position*. For the purpose of site characterization at DOE sites, the following specific objectives for developing technical information are useful in developing a program plan.

- Providing a reasonable expectation that the performance objectives of DOE M 435.1-1 are likely to be met;
- Evaluating the ability of the site to contribute to the containment of low-level waste;
- Providing adequate information for design of a low-level waste disposal facility;
- Identifying the interaction between the site, waste containers, and low-level waste;
- Establishing data collection points, baseline environmental data, and some portion of the environmental monitoring program; and
- Identifying potential environmental impacts from construction, operation, and closure of the facility.

The site characterization program needs to be site-specific and flexible to allow for revisions in the program as data are developed. The program needs to be developed to allow for the collection of baseline environmental data for a least one year prior to construction, with extended periods of time preferred for parameters subject to seasonal or annual variations (see guidance on DOE M 435.1-1, Section IV.R.(3)(b)). For baseline environmental data, the collection points are selected to continue to serve as collection points throughout the life cycle of the facility, to facilitate meaningful interpretation of data. Regional data collected over extended periods of time are useful supplements to the site characterization program.

> *Example 1: A new low-level waste disposal facility site characterization program includes the investigation of the subsurface structure with the objective of confirming the absence of perched water. Specific parameters and measurements were selected through a recently performed data quality objectives effort for the characterization program.*

Drilling data indicate the presence of a perched water deposit on the perimeter of the proposed site. The subsurface investigation program is expanded to establish the extent of the perched water deposit and its significance with respect to the performance of the disposal facility.

Example 2: A new disposal facility characterization program erects a meteorologic tower to collect wind and precipitation data with the objective of confirming site conditions are representative of regional conditions. Specific parameters and measurements were selected through a recently performed data quality objectives effort for the characterization program. Initial data clearly indicate the site conditions differ from regional conditions. The frequency of data collection is increased and baseline monitoring program extended to provide sufficient data for design and performance assessment activities.

Basic elements of the site characterization program include meteorology, surface water hydrology, groundwater hydrology for both saturated and unsaturated media, geology, soils, water quality, site stability, air quality, ecology, land and cultural resources, and socioeconomics. Field studies are performed in a manner that does not compromise the integrity of the land to be dedicated to waste disposal. The extent of investigation in each of the topic areas is dependent on the site-specific characteristics of the preferred site. Data to be collected during the site characterization program need to be selected in accordance with the data quality objectives (DQO) process to ensure meaningful and wise use of resources. The quality assurance and record keeping requirements of DOE M 435.1-1 are followed for all aspects of site characterization to ensure that data records are maintained and retained throughout the life cycle of the facility. Documentation of the results of the site characterization program is used in facility design, performance assessment, waste acceptance criteria development, and in fulfilling the requirements of NEPA.

Site characterization program plans are reviewed and approved prior to initiation of investigations to ensure that important elements are included and unnecessary activities are not undertaken. The program is executed by skilled professionals with a multi-disciplinary team of experts representing environmental and facility monitoring, design, performance assessment, and waste operations. Routine reviews of collected data are performed to ensure the site characterization program is accomplishing its specific objectives. The site characterization program also needs to be integrated with other elements of facility development to ensure characterization information is correctly utilized in those other elements, principally the performance assessment and facility design.

Additional general guidance for site evaluation and siting of low-level waste disposal facilities is available from a variety of sources to be consulted (NRC Reg. Guide 4.19, DOE/LLW 64T,

DOE/LLW 75T Tab I, DOE/LLW 67T) and incorporated into site-specific investigations where appropriate.

Site Features Contributing to Stability and Prevention of Maintenance. The requirement to site facilities for long-term stability and to minimize active maintenance specifically states that these attributes are to be attained following closure of the low-level waste disposal facility. As discussed above, these attributes are necessary because the hazard from the disposed low-level waste will remain for years following closure. Disposal sites that do not require active maintenance following closure are more likely to be able to demonstrate a reasonable expectation that the disposal performance objectives will continue to be met. The following discussion provides additional information on site features that contribute to stability and prevention of maintenance at a site.

A low-level waste disposal site needs to be located in an area where hydrogeologic conditions allow reliable prediction of performance. Subsurface migration of radionuclides needs to be readily and confidently predictable. Such systems may be characterized by thick, partially saturated zones; low moisture flux through the burial zone; and/or geologic formations with permeability flow systems that are readily characterized.

A low-level waste disposal site also needs to protect the waste from contact with or intrusion of water. Materials that can be shaped into a final landscape that diverts offsite surface and subsurface water, combined with the resistance of the soil material to wind and water erosion and the ability of the soil material to support certain kinds of vegetation will contribute to the disposal facility remaining in a stable state.

A low-level waste disposal site needs to include characteristics of earth materials and water chemistry that favor increased residence times and/or attenuation of radionuclide concentrations in the subsurface. Attenuation of radionuclide concentrations and slow rates of migration will increase the retention of radionuclides near the burial trenches. Soil and water chemistry characteristics that favor retardation provide an additional safety factor in slowing the migration of many radionuclides.

> *Example: The site for the expansion of the low-level waste disposal facility at Site Y is considered very advantageous for this purpose. The site is underlain by a simple, sedimentary layered system consisting of clay and sand horizons which are relatively easy to conceptualize in mathematical modeling. The clay layer that will form the floor of the trench has been investigated thoroughly and the flow parameters are well understood. The layer will act as a retardant for migration of several critical radionuclides that will be disposed at the facility. Geomorphic investigations of the site have revealed no evidence of active geologic processes that would lead to erosion or*

other facility surface problems that would impact the ability of the site to maintain long-term stability.

Site Features that Should be Avoided. Particular features need to be avoided that contribute to site instability or transport of radionuclides from a site to potential receptors.

The disposal horizon needs to be outside of the transition zone between saturated and unsaturated flow, and preferably well above the transition zone or water table. Avoiding the transition zone requires extensive knowledge of the water table and its fluctuations. Factors to be evaluated include:

- Water table elevation and range of both seasonal and long-term fluctuations;
- Height of capillary fringe; and
- Thickness of material being excavated above the transition zone.

Complex flow systems, such as flow through cavernous, fractured, or jointed materials, may not be amenable to reliable predictions, and need to be avoided. A low-level waste disposal site needs to not be located where erosion caused by wind and water will jeopardize performance. During the required performance period, wind and water erosion needs to be at levels that would not cause intrusion on the buffer zone and/or waste cover in such a way as to uncover the waste, increase surface radiation levels above performance limits, or significantly shorten radionuclide release pathways.

Surface flooding or inundation needs to be avoided as such events can also accelerate transport of waste material and/or saturate the waste, increasing leachate formation and accelerating subsurface water flow.

Geologic hazards that could pose a threat to a low-level waste disposal site performance and which may need to be considered include:

- Seismic hazards associated with fault zones and earthquakes;
- Mass movement of earthen material, which can range from slow soil creep to slumping of oversteepened slopes to sudden massive slides of rock or debris;
- Volcanic activity; and
- Subsidence of the land surface, which frequently accompanies subsurface mining, withdrawal of oil, gas or water, or dissolution of geologic formations.

Example: The proposed site for the new Brown Facility Low-Level Waste Disposal Trenches is preferred because of its proximity to three operating treatment facilities at the Brown Site. However, the proposed disposal unit design will have the trench bottoms in the transition zone between the saturated zone and unsaturated zone, at least according to one study conducted several years before. Another more recent study indicates that the fluctuation has subsided, and that the trench bottoms are no longer in the transition zone. After further evaluations, the site for the proposed facility is moved to another location, still near the treatment facilities, but for which there is no dispute about the depth and extent of the transition zone.

Compliance with this requirement is demonstrated if low-level waste disposal facilities are sited so that natural features are present that contribute to the long-term stability of the disposal facility and helps minimize any need for maintenance after the facility is closed. Siting avoids any natural features present at the DOE reservation which would contribute to instability of the site or to migration of radionuclides from the site. Documentation of analysis of such features must be included in the radioactive waste management basis.

Supplemental References:

1. NRC, 1988. *Guidance for Selecting Sites for Near-Surface Disposal of Low-Level Radioactive Waste*, Regulatory Guide 4.19, U. S. Nuclear Regulatory Commission, Washington, D.C., August 1988.

2. NRC, 1982. *Site Suitability, Selection and Characterization: Branch Technical Position – Low-Level Waste Licensing Branch*, NUREG-0902, U. S. Nuclear Regulatory Commission, Washington, D.C., April 1982.

3. IAEA, 1994. *Siting of Near Surface Disposal Facilities*, Safety Series No. 111-G-3.1, International Atomic Energy Agency, Vienna, Austria, 1994.

4. DOE, 1987. *Site Selection: The Critical Path in Developing Low-Level Radioactive Waste Disposal Facilities*, DOE/LLW-64T, U.S. Department of Energy, National Low-Level Waste Management Program, Idaho Falls, ID, 1987.

5. DOE, 1992. *Site Characterization Handbook for Low-Level Radioactive Waste Disposal Facilities*, Revision 1, DOE/LLW-67T, U.S. Department of Energy, National Low-Level Waste Management Program, Idaho Falls, ID, 1992.

6. DOE, 1983. *Low-Level Radioactive Waste Management Handbook Series: Procedures and Technology for Shallow Land Burial,* DOE/LLW-13Td, U.S. Department of Energy, National Low-Level Waste Management Program, Idaho Falls, ID, 1983.

7. DOE, 1989. *Methodology for Compliance with DOE Order 5820.2A Chapter III: Management of Low-Level Radioactive Waste.* DOE/LLW-75T, Tab K, U.S. Department of Energy, National Low-Level Waste Management Program, Idaho Falls, ID, February 1989.

IV. M.(2) Low-Level Waste Treatment and Storage Facility Design. The following facility requirements and general design criteria, at a minimum, apply:

Objective:

The objective of this requirement is to ensure that a minimum set of facility requirements and general design requirements determined from hazards analyses or policy considerations are applied to low-level waste treatment and storage facilities.

Discussion:

The facility requirements and general design criteria included in DOE M 435.1-1, Sections IV.M.(2) (a) through (e), are included as requirements to ensure adequate protection of the public, workers, and the environment from nuclear hazards. The requirements contained in these sections apply to new and existing low-level waste management facilities, unless the requirement specifies otherwise.

During the development of DOE O 435.1 and DOE M 435.1-1 an analysis of the hazards associated with the management of waste indicated that appropriate facility safety requirements and general design requirements are essential to ensuring the protection of the public, workers, and the environment. Therefore the intent is to apply these requirements to all low-level waste treatment and storage facilities, both existing and new. However, it is recognized that in some cases it may not be practical, or possible, to apply these requirements to existing low-level waste facilities or operations. Such conditions as limited programmatic usage, expected short service life of the operation, or factors that make long-term, capital-intensive upgrades unreasonable may be bases for not applying the requirements. In such cases, an exemption to the requirement may be warranted. The Implementation paragraph of DOE M 435.1-1 provides for an exemption to a requirement provided it is processed in accordance with the requirements of DOE M 251.1-1A, *Directives System Manual.* Additionally, note that the low-level waste treatment and storage facility design requirements need to be applied using a graded approach. The considerations and

controls identified in Sections IV. M.(2)(a) through (e) may not be applicable to some facilities, such as an outdoor storage yard for packaged low-level waste. These requirements are not intended to preclude such storage by forcing use of only facilities which possess all the items listed in requirements (a) through (e). Instead, the requirements are applied, using a graded approach, where the treatment or storage facility possesses characteristics to which the requirements are applicable.

> *Example: At Site Z it is determined that the requirement in DOE M 435.1-1, Section III. M.(2)(e), Monitoring, for an existing low-level waste tank is unreasonable due to the planned short service life of the tank. The existing tank is not routinely being used and would only be used over the next 18 months for emergency storage of liquid low-level waste. A replacement for the tank is under construction. In accordance with DOE M 251.1-1A, Chapter VII, "Exemptions," an Exemption Request is prepared that supports the position that application of the requirement is not justified by any safety and health benefit. The exemption request also notes that procedures will be implemented to ensure a once per shift visual check to ensure no waste is inadvertently transferred to the tank. The Exemption Request is processed in accordance with the requirements contained in paragraph 4, Exemption Process, in Chapter VII.*

DOE M 435.1-1 also allows for the use of the "Necessary and Sufficient Closure Process" or the integrated "Safety Management System." Use of these processes for deriving facility design requirements that provide protection comparable to the requirements contained in DOE M 435.1-1, Sections IV.M.(2) (a) through (e) is also acceptable at sites where these processes are invoked by contract.

Application of these requirements to all existing low-level waste treatment and storage facilities may appear to contradict the direction or guidance provided by some other DOE Orders that are invoked by DOE M 435.1-1, Section I.1.E., *Requirements of Other Regulations and DOE Directives*. In such cases the requirements contained in DOE M 435.1-1 do apply.

> *Example: Section I.1.E.(18), Site-Evaluation and Facility Design, invokes DOE O 420.1, Facility Safety. Guidance to DOE O 420.1 states that the design criteria included in the Order are "applicable to the design and construction of new nonreactor nuclear facilities and for modifications to existing nonreactor nuclear facilities when modifications significantly increase the probability or consequences of a nuclear accident or require a change in the Technical Safety Requirements (TSRs) of a facility. The definition of 'significant' is intentionally left to the judgment of the proposing contractor and the approving DOE authority. In part, this is intended to allow upgrading of existing safety equipment or installation of minor new improvements without subjecting the process to onerous procedural requirements and thus discouraging improvements." Thus, under DOE O 420.1 an existing low-level waste management facility that is to be*

"insignificantly" modified does not have to meet the design requirements of DOE O 420.1. However, under DOE M 435.1-1, the same facility must meet the design requirements of DOE M 435.1-1, Section IV.M.(2) (a) through (e), or follow the DOE M 251.1-1A exemption process. The requirements contained in DOE M 435.1-1 have precedence, and should be implemented.

A "backfit" process has been discussed by the Department in the past to address changes that may be required through the imposition of a new DOE safety requirement. Such changes may be problematic for low-level waste facilities and systems that have been in existence for over 20 years. It is not the purpose of this order and manual to create such a process for the Department; however an existing or new field-office or Program Secretarial Office backfit analysis and review process may be applied to determine whether implementation of a proposed backfit could be justified on the basis of a substantial safety improvement or on a cost-benefit basis. One example of a candidate process is contained in expired DOE N 5480.5, *Imposition of Proposed Nuclear Safety Requirements*, which expired in 1993 because of an administrative provision. Another candidate process is described Draft DPOM-FS-300, "Treatment of Proposed Backfits," which was developed for the Office of Defense Programs, but not formally adopted. A third candidate process is documented in Westinghouse Savannah River Company, High Level Waste Management Engineering Procedure, ENG. 12, "HLWMD Backfit Analysis Procedure." For development of new backfit processes Nuclear Regulatory Commission requirements in 10 CFR 50.109 and 10 CFR 76.76 should be consulted.

Compliance with this requirement is demonstrated by documentation that supports the implementation of the requirements at DOE M 435.1-1, Section IV.M.2. (a) through (e), or documentation that supports the "Necessary and Sufficient Closure Process" or integrated "Safety Management System," or the DOE M 251.1-1A exemption process.

Supplemental References:

1. DOE, 1995. *Implementation Guide for Nonreactor Nuclear Safety Design Criteria and Explosives Safety Criteria*, Revision G, Draft DOE G 420.1-X, September 1995.

2. DOE, 1993. *Defense Programs Operations Manual, "Treatment of Proposed Backfits,"* Revision 0, Draft DPOM-FS-300, U.S. Department of Energy, Washington, D.C., February 5, 1993.

3. DOE, 1998. *Directives System*, DOE O 251.1A, U.S. Department of Energy, Washington, D.C., January 30, 1998.

4. DOE, 1998. *Directives System Manual*, DOE M 251.1-1A, U.S. Department of Energy, Washington, D.C., January 30, 1998.

IV. M.(2) Low-Level Waste Treatment and Storage Facility Design. The following facility requirements and general design criteria, at a minimum, apply:

(a) Confinement. Low-level waste systems and components shall be designed to maintain waste confinement.

Objective:

The objective of this requirement is to ensure the design of low-level waste storage and treatment facilities includes the installation of equipment capable of containing low-level waste so that releases that could result in exposures to workers or the public or that could contaminate the environment are minimized.

Discussion:

This requirement is invoked to address hazards identified during the safety and hazards analysis performed in support of the development of this order and manual associated with the unexpected or uncontrolled release of radioactive material from low-level waste treatment and storage facilities that could impact workers, the public, or the environment. In addition to the facility and general design requirements contained in DOE M 435.1-1, Section I.1.E.(18), the above requirement for low-level waste confinement must be met.

The term "confinement" is defined in the DOE M 435.1-1 Glossary as:

> "The control or retention of radioactive materials within as a designated boundary. Primary confinement systems are process enclosures and other spaces normally containing hazardous materials. Secondary confinement areas surround one or more primary confinement systems."

In broad terms the purpose of confinement systems is to minimize the spread of radioactive and/or hazardous materials and the release of these materials in facility effluents during normal operations, abnormal operations, and potential accidents. One usual function of process equipment is to provide primary confinement and prevent or mitigate radioactive and/or hazardous material releases to the environment. Process equipment that would be required to provide primary confinement includes tanks, piping, pressure vessels, pumps, valves, and glove boxes. Secondary confinement are those systems that provide the next level of confinement and can include process equipment, (e.g., double-walled tanks, double-walled piping systems), as well as curbing and diking of liquid storage tank areas, or secure or closed areas of buildings, that

further prevent or mitigate uncontrolled releases of radioactive and/or hazardous materials to the environment. The need for redundancy and the degree of redundancy in these systems is determined by the safety analysis process and maintenance concerns for both active and passive components.

For a specific low-level waste facility or operation the number and arrangement of confinement systems or barriers and their required characteristics needs to be determined on a case-by-case basis. Factors that are considered in confinement system design include type, quantity, form, and conditions for dispersing low-level waste material during normal operations and design basis conditions. As in implementation of all of the requirements of DOE O 435.1 and DOE M 435.1-1, the graded approach is used for determining the appropriate level of rigor in applying this control to the management systems employed at a particular low-level waste management facility.

For treatment systems involving liquid low-level waste, it might be appropriate for primary confinement to be provided by process equipment (i.e, pipes) and facility design to provide for secondary confinement (i.e, curbing and diking). For storage of dry low-level waste, primary confinement could be provided by an appropriate container.

> *Example 1: The low-level waste management facility at laboratory A manages various types of low-level waste. Primary and secondary confinement for liquid low-level waste streams is provided by a double-walled piping and tank system maintained in the lab for management of those waste streams. Analysis indicated that the confinement provided by the containers for dry process wastes is adequate.*
>
> *Example 2: Storage of low-level waste at Site B takes place on several outside storage pads at Area 5 that were designed and built several years ago. In order to implement the DOE M 435.1-1 storage facility confinement requirement, Site B conducts an analysis of the current storage conditions at all of these pads. On one pad, some waste containers are found to be in poor condition, and the confinement requirement is met by installation of a temporary berm around the pad until repackaging in overpacks can be accomplished. The containers on the rest of the pads are in good condition, and the analysis indicates that the confinement requirement is sufficiently met by the container itself.*

Engineering evaluations, trade-offs, and experience are used to develop practical designs that achieve confinement system objectives. The adequacy of confinement systems to effectively perform the needed functions needs to be documented and accepted through the facility or operation Safety Analysis Report or equivalent documentation.

The guidance for DOE M 435.1-1, Chapter II, *High-Level Waste Requirements*, presents detailed guidance for complying with the confinement requirement for high-level waste storage tanks.

That guidance is appropriate to be consulted for any details that may be needed for complying with the confinement requirement for low-level waste treatment or storage activities that are hazardous enough that the most rigorous implementation of the confinement requirement must be applied. The guidance for DOE M 435.1-1, Section II.P.(2)(b) refers to *Resource Conservation and Recovery Act* requirements and discusses guidance for confinement that may also be useful in establishing compliant confinement in accordance with this requirement for mixed low-level or liquid low-level waste storage facilities or activities that warrant strict confinement conditions.

Compliance with the requirement is demonstrated by designing low-level waste treatment and storage facilities including systems that provide primary and secondary confinement as appropriate based on safety analysis or equivalent documentation and documenting the analyses and rationales for such controls in the facility radioactive waste management basis documentation.

Supplemental References:

1. DOE, 1992. *Nuclear Safety Analysis Reports*, DOE 5480.23, U.S. Department of Energy, Washington, D.C., April 10, 1992.

IV. M.(2) Low-Level Waste Treatment and Storage Facility Design. The following facility requirements and general design criteria, at a minimum, apply:

(b) Ventilation.

1. Design of low-level waste treatment and storage facilities shall include ventilation, if applicable, through an appropriate filtration system to maintain the release of radioactive material in airborne effluents within the requirements and guidelines specified in applicable requirements.

2. When conditions exist for generating gases in flammable or explosive concentrations, ventilation systems or other measures shall be provided to keep the gases in a non-flammable and non-explosive condition. Where concentrations of explosive or flammable gases are expected to approach the lower flammability limit, measures shall be taken to prevent deflagration or detonation.

Objective:

The objective of this requirement is to ensure that the design of low-level waste treatment and storage facilities includes features to remove radioactive materials from airborne effluents that could endanger worker or public safety and/or the environment to levels allowed in regulations before they are released, and to preclude or mitigate the accumulation of flammable or explosive gases in the facilities which could lead to uncontrolled releases of radioactive materials.

Discussion:

This requirement is based on a similar requirement invoked to address a group of hazards that was identified by the safety and hazards analysis performed in support of the high-level waste chapter of this Manual. The analysis revealed that very hazardous conditions can result from unexpected and uncontrolled releases of radioactive material, either because of poorly designed ventilation systems or due to accumulation and ignition of flammable or explosive gases in high-level waste storage facilities. Similar circumstances occurring at a low-level waste facility are similarly problematic, and a similar requirement was believed to be justified to prevent exposures to workers or the public, radioactive leaks to the environment, and costs for damage mitigation and cleanup from unanticipated and/or uncontrolled airborne releases of radioactive material. Subrequirement IV.M.(2)(b)1. is discussed below under Airborne Effluent Filtration Systems and subrequirement IV.M.(2)(b)2. is discussed under Flammable and Explosive Gases.

Airborne Effluent Filtration Systems. The subrequirement to maintain radioactive material in airborne effluents from low-level waste management facilities to appropriate levels through the use of filtration systems is to be implemented using the graded approach. This requirement is intended to ensure that low-level waste management facilities have adequate filtration where necessary, not to dictate that each facility must have a particular type of air filtration or removal efficiency. Therefore, the safety analysis or assessment for each facility will provide the basis for determining the level of filtration required.

> *Example 1: A low-level waste treatment facility is constructed so low-level waste packages can be opened, the waste sorted, and the appropriate waste thermally treated. In order to ensure worker protection, the building ventilation system is constructed to draw air from radiologically clean areas, to radiologically-controlled areas and finally to airborne contamination areas such as glove boxes and thermal treatment equipment. Through the auditable safety assessment, it is determined that the potential exists for releases of radioactive materials through the exhaust system. The building exhaust system is therefore equipped with high-efficiency particulate air filters to ensure that releases are controlled to within limits. Monitoring is used to ensure the necessary removal efficiency is maintained by the air filter system.*

Example 2: A storage building is designed and operated to receive only closed containers of low-level waste and to perform nondestructive testing. Through the preparation of an auditable safety assessment it is determined that the potential for release of radioactivity in the building is very low. Consequently, the ventilation system provided for the building is only for climate control and not for contamination control. The building exhaust system is determined to not need any extra filtration to meet the requirements of applicable release standard, and the rationale and basis of the analysis are incorporated into facility safety documentation.

Standards for DOE compliance with airborne releases are contained in DOE 5400.5, *Radiation Protection of the Public and the Environment* and 40 CFR Part 61, *Clean Air Act* regulations. The limits for release cited in these documents are for the DOE site (i.e., all the activities of the Department), not for individual facilities. Therefore, the operational limits for any individual facility need to be established based on the potential impacts from all facilities on the site. Consistent with Departmental practices and an underlying principle in development of the *Radioactive Waste Management Manual*, airborne effluent releases need to be kept as low as reasonably achievable.

The number, size, and design of air filtration equipment needs to meet the performance requirements dictated by the safety analysis or assessment. The location of air filtration units in the ventilation system is established as close as practical to the source of contamination so as to minimize spread to the remainder of the ventilation system. The system is designed for ease of maintenance and periodic inspection and has provisions (test ports) to facilitate insertion of measuring devices for testing filter performance. Where larger loads are expected or predicted on the filtration systems (e.g., dusty condition), pre-filters need to be considered to extend the life of the main filter and reduce maintenance.

Flammable and Explosive Gases. The subrequirement addressing explosive or flammable concentrations of gases is intended to ensure that the design of facilities and equipment includes consideration of the potential for generating these types of gases. Generation of flammable or explosive gases has been a concern in the storage of liquid waste (e.g., high-level waste tanks), but also needs to be recognized as a potential problem in other situations, such as in treatment systems.

Where sampling data and safety analyses indicate a potential for accumulating gases in concentrations approaching the lower flammability limit, facilities and equipment shall be provided to prevent the conditions which could lead to fire or explosion. This is normally accomplished by the design and installation of ventilation equipment which provides enough air flow to maintain gases below flammable or explosive concentrations. In situations where gas evolution is episodic and the concentration of gases approaches the lower flammability limit for short periods of time in

spite of the ventilation system, spark-proof technology needs to be employed in the design of ventilation equipment so that the equipment itself does not become a source of ignition.

Attention to fire protection for the filtration system needs to also be considered to ensure the facility can perform under off-normal conditions. Guidance for protection of filtration systems in ventilation plenums for nuclear facilities is provided in the *Fire Protection Design Criteria* (DOE-STD-1066-97). This guidance addresses materials of construction, location of filters, fire ratings of protective walls, and internal detectors for fire and heat.

Other methods can be employed to prevent conditions which could lead to ignition of flammable or explosive gases. One such method is the introduction of a sufficient flow of inert gases into the headspace where flammable or explosive gases would accumulate. The inert gases need to be supplied at a rate that keeps the concentration of the flammable or explosive gases and of available oxygen/oxidants below levels that could result in deflagration or detonation. As with ventilation equipment, the specific conditions of gas generation and of providing an inert atmosphere in the headspace must be evaluated and a decision made as to whether spark-proof technology should be included in the design of the system.

Compliance with this requirement is demonstrated by analyses that support the level of filtration provided on a low-level waste management facility, and if airborne effluent monitoring data are available, a demonstration of compliance with the site-established operational guidelines for the facility. In addition, acceptable implementation is demonstrated by analyses, monitoring data, or both showing that the potential for generation of explosive or flammable concentrations of gases has been considered and where the potential exists, the presence of ventilation equipment or other means that prevent deflagration or detonation. The analyses and rationales for the selected controls must be documented in the radioactive waste management basis.

Supplemental References:

1. DOE, 1990. *Radiation Protection of the Public and the Environment*, DOE 5400.5, U.S. Department of Energy, Washington, D.C., February 8, 1990.

2. DOE, 1997. *Fire Protection Design Criteria*, DOE-STD-1066-97, U.S. Department of Energy, Washington, D.C., 1997.

3. EPA. *National Emission Standards for Hazardous Air Pollutants*, 40 CFR Part 61, U.S. Environmental Protection Agency, Washington, D.C.

IV. M.(2) Low-Level Waste Treatment and Storage Facility Design. The following facility requirements and general design criteria, at a minimum, apply:

(c) Consideration of Decontamination and Decommissioning. Areas in new and modifications to existing low-level waste management facilities that are subject to contamination with radioactive or other hazardous materials shall be designed to facilitate decontamination. For such facilities a proposed decommissioning method or a conversion method leading to reuse shall be described.

Objective:

The objective of this requirement is to ensure the incorporation of the concept of life-cycle waste management into the operations of radioactive waste management facilities to result in the minimization of radioactive waste that must be managed in the future from decontamination and decommissioning activities, and the reduction of facilities that must be dismantled due to contamination rather than re-used for another beneficial purpose**.**

Discussion:

During the analysis of requirements conducted in support of DOE O 435.1 and DOE M 435.1, life-cycle waste management concepts were applied to the generation of waste by waste management facilities as well as the generators of waste that send waste to waste management facilities. This requirement was developed to extend the life-cycle management concept to the design of waste management activities and facilities, with the explicit goal of minimizing the generation of waste, and also pointing to a beneficial use of the facility following its waste management use. Decontamination and decommissioning activities are also becoming a significant part of the life-cycle costs for low-level waste facilities. This requirement addresses this situation by trying to reduce the costs associated with disposition of waste management facilities following their use.

New low-level waste facilities are defined as those whose design basis was not approved prior to the implementation date of DOE O 435.1, with design basis as defined in the Manual Definitions. If a low-level waste facility's design basis is defined after the issuance date of DOE O 435.1, the requirements of this section are applicable. Application of these requirements to existing or low-level waste facilities that are to undergo significant modifications is left to the discretion of the Field Office management organization as to whether retrofitting with designed features that facilitate decontamination is reasonable. To support this decision an analysis needs to be conducted comparing the expected benefits by the application of these requirements to the costs

of implementing such measures. These costs include programmatic, resource, and schedule impacts as well as potential impacts such as additional worker exposures due to radiation and chemical hazards.

Design to Facilitate Decontamination. Decontamination is defined by the Implementation Guide to DOE O 420.1, *Facility Design*, as "the act of removing a chemical, biological, or radiological contaminant from or neutralizing its potential effect on a person, object, or environment by washing, chemical action, mechanical cleaning, or other techniques." In conjunction with DOE O 420.1, DOE M 435.1-1 requires that low-level waste facilities incorporate measures to reduce areas of contamination or to simplify decontamination of areas that may become contaminated with radioactive or hazardous materials. Examples of design features that need to be considered include:

- Service piping, conduits, and ductwork kept to a minimum in areas that could be potentially contaminated and, if included in such areas, their design arranged to facilitate decontamination.

- Cracks, crevices, and joints filled and finished smooth to prevent accumulation of contaminated material.

- Walls, ceiling, and floors in areas vulnerable to contamination finished with washable or strippable coverings.

- Metal liners, e.g., stainless steel cell lining, used in areas that have the potential to become highly contaminated with radioactive materials.

- Contaminated or potentially contaminated piping systems have provisions for flushing and/or cleaning.

- Accessible, removable covers for inspection and cleanouts provided.

- Construction materials that reduce the amount of radioactive materials requiring disposal and that are easily decontaminated.

Design to Support Decommissioning. Decommissioning, also defined in DOE O 420.1, is "the process of closing and securing a nuclear facility or nuclear materials storage facility to provide adequate protection from radiation exposure and to isolate radioactive contamination from the human environment." Design features that need to be considered to support decommissioning (or beneficial reuse) of the facility include:

- Use of modular radiation shielding, in lieu of or in addition to, monolithic shielding walls.

- Use of modular, separable confinements to preclude contamination of fixed portions of the structure.

- Designs that ease cut-up, dismantlement, removal, and packaging of contaminated equipment, such as glove boxes, air filtration equipment, large tanks, vessels, and ductwork, from the facility.

- Use of localized liquid transfer systems that avoid long runs of buried, contaminated piping; emphasis on localized batch solidification of liquid waste. Special provisions may also be included in the design to ensure the integrity of joints in buried pipelines.

- Piping systems that carry contaminated or potentially contaminated liquid that free drain by gravity.

- Location of exhaust filtration components of ventilation systems at or near individual enclosures to minimize long runs of internally contaminated ductwork.

- Equipment, including effluent decontamination equipment, that precludes to the extent practicable, the accumulation of radioactive or other hazardous materials in relatively inaccessible areas, including turns in piping and ductwork.

- Provisions for suitable clearances, where practical, to accommodate remote handling and safety surveillance equipment required for future decontamination and decommissioning.

- Use of lifting lugs on large tanks and equipment.

Decommissioning and Reuse Planning. Due to the high life-cycle costs of low-level waste facilities this subrequirement is also intended to promote post-mission planning of low-level waste facilities by requiring the identification of possible decommissioning methods or reuses of low-level waste facilities as early as possible. To meet this requirement low-level waste facility designs, or significant modification efforts, need to include analysis to determine the best decommissioning methods, using currently available technologies, and factor the results of this analysis into the facility's design. Likewise, if a reuse of the facility is envisioned, any features that can support this reuse mission need to be considered in the design effort.

Life-Cycle Asset Management, DOE O 430.1A, addresses deactivation and decommissioning requirements of DOE facilities. Refer to DOE O 430.1A and its Guides for further information and guidance on deactivation and decommissioning activities. Also refer to a new DOE Standard (see Supplemental Reference 3) on the integration of safety and health requirements into facility disposition activities.

Compliance with this requirement is demonstrated by the existence of design documentation that indicates decontamination was considered during the design of new low-level waste facilities or significant modifications to low-level waste facilities. Additionally, Site-Wide Radioactive Waste Management Program documentation demonstrates that post-mission planning was considered, as early as possible in the life of a facility, to assist in the identification of possible decommissioning methods or facility reuse.

Supplemental References:

1. DOE, 1995. *Implementation Guide for Nonreactor Nuclear Safety Design Criteria and Explosives Safety Criteria*, Revision G, Draft DOE O 420.1-X, U.S. Department of Energy, Washington, D.C., September 1995.

2. DOE, 1997. *Decommissioning Implementation Guide*, Draft G 430.1-4, U.S. Department of Energy, Washington, D.C., October 1, 1997.

3. DOE, 1997. *Integration of Safety and Health into Facility Disposition Activities*, Draft for DOE Complex Wide Review 9/26/97, DOE-STD-1120-98, U.S. Department of Energy, Washington, D.C., September 26, 1997.

4. DOE, 1998. *Life-Cycle Asset Management*, DOE O 430.1A, U.S. Department of Energy, Washington, D.C., October 14, 1998.

IV. M.(2) Low-Level Waste Treatment and Storage Facility Design. The following facility requirements and general design criteria, at a minimum, apply:

(d) Instrumentation and Control Systems. Engineering controls shall be incorporated in the design and engineering of low-level waste treatment and storage facilities to provide volume inventory and to prevent spills, leaks, and overflows from tanks or confinement systems.

Objective:

The objective of this requirement is to ensure that engineering controls are included in the design of low-level waste management facilities to minimize the likelihood of release of radionuclides that could lead to exposures or contamination of the environment.

Discussion:

The requirement for instrumentation and engineering controls is invoked to address a group of hazards that was identified by the hazards analysis performed in support of the development of this order and manual – the failure to promptly detect a release of radioactive material from low-level waste that could impact workers, the public, or the environment. This requirement is closely related to the previous design requirement for monitoring systems, but focuses on controls to prevent the loss of containment.

Engineering controls in this requirement are considered to be those systems or design characteristics that are provided to prevent the loss of containment from low-level waste management facilities, and to provide volume inventory data, where appropriate. Examples of engineering controls include flowmeters and level-sensing devices coupled with anti-siphon devices or shut-off valves, and any other instrumentation and controls that maintain sufficient freeboard within a storage vessel or unit. Other instruments and controls include devices that measure changes in characteristics of liquid waste, e.g., temperature, pressure, pH, and/or other characteristics providing a measure of a materials stability, that are combined with shutoff or diversion routing devices.

The graded approach is used in determining the appropriate level of rigor in incorporating engineering controls to the management systems employed at a particular low-level waste management facility. Rigorous application of this requirement may be most appropriate for circumstances involving treatment of liquid low-level waste, for example, where flowmeters and devices measuring characteristics of the waste in the feedline of an incinerator, are continuously operating. However, some handling situations involving bulk or solid low-level waste may need to invoke these controls as well, where a simple shutoff of the equipment could prevent overfilling or other hazardous conditions.

Loss of containment at a waste storage or treatment facility can result from overflows, spills, leaks, or siphoning of waste from a storage vessel. Incorporation of design measures at these facilities to prevent such loss of containment is necessary, but is not considered sufficient to meet this requirement. Equipment of this nature, in spite of rigid maintenance and surveillance, can fail over its expected service life. Therefore, to fully meet this requirement mitigative measures to reduce the loss of containment, are necessary. As discussed in guidance on confinement above, an engineered barrier to fully contain a leak or a diversion mechanism to channel the waste to a

desired location provides defense-in-depth for the circumstances where the engineering controls do not suffice. Guidance for Confinement (DOE M 435.1-1, Section IV.M.(2)(a)) provides additional details on these mitigative measures.

> *Example: At the Site Q Low-Level Waste Storage Facility, the engineering controls on the liquid low-level waste storage tank includes a waste feed line shut-off valve, which is activated by a tank level-sensing device, to prevent overflow of waste from the tank. As a further mitigative measure in the event the valve malfunctions, a double-contained overflow line is attached to the tank to channel any overfill to another waste tank that is maintained as a spare at the storage facility.*

The design of engineering controls to meet this requirement will most likely be directed by the facility-specific safety analysis for waste management facility. Such safety analysis may dictate that some of these engineering controls be designed as safety-class or safety-significant systems, structures, or components (SSC) to ensure they survive design-basis accidents. Use of the safety analysis process, as prescribed by DOE 5480.23, *Nuclear Safety Analysis Reports*, to identify the necessary engineering controls to meet this requirement for both new and upgrades to existing low-level waste treatment and storage facilities, is considered appropriate and encouraged.

Compliance with this requirement is demonstrated by the incorporation of engineering controls that provide: timely information to facility operations personnel regarding the volumes of waste being stored; automatic shut-off, anti-siphoning devices, and automatic sensing devices to provide timely information to operations personnel; and provide mitigative measures to minimize the spread of low-level waste in the event of loss of containment, which are based on facility safety analysis and documented in the required safety analysis documentation.

Supplemental References:

1. DOE, 1995. *Implementation Guide for Nonreactor Nuclear Safety Design Criteria and Explosives Safety Criteria*, Revision G, Draft DOE G 420.1-X, September 1995.

2. DOE, 1992. *Nuclear Safety Analysis Reports*, DOE 5480.23, U.S. Department of Energy, Washington, D.C., April 10, 1992.

IV. M.(2) Low-Level Waste Treatment and Storage Facility Design. The following facility requirements and general design criteria, at a minimum, apply:

(e) Monitoring. Monitoring and/or leak detection capabilities shall be incorporated in the design and engineering of low-level

waste treatment and storage facilities to provide rapid identification of failed confinement and/or other abnormal conditions.

Objective:

The objective of this requirement is to ensure the design of low-level waste management facilities includes the installation of equipment capable of identifying failures in containing low-level waste and other conditions that could result in exposures of workers or the public to radioactivity or contamination of the environment.

Discussion:

This requirement is invoked to address a group of hazards that was identified by the hazards analysis performed in support of the development of this order and manual -- the failure to promptly detect a release of radioactive material from low-level waste that could impact workers, the public, or the environment. This particular requirement addresses the design of monitoring systems directed toward prompt detection of acute releases (releases that are detectable visually or by some other gross indicator) that become apparent over a time frame of hours or days as well as to alert operators that a vessel (e.g., tank or bin) is approaching capacity so that overfilling can be avoided. Monitoring to detect releases that may be too small to be detected in a timely manner via volume changes is addressed in guidance on Requirements IV.R, Monitoring, later in this guidance.

As in implementation of all of the requirements of DOE O 435.1 and DOE M 435.1-1, the graded approach is used for determining the appropriate level of rigor in applying this control to the management systems employed at a particular low-level waste management facility. Also, monitoring for leakage and contamination spread needs to be performed by means appropriate for the type and character of radioactive waste being managed at the facility. Rigorous application of this requirement may be most appropriate for circumstances involving storage or treatment of liquid low-level waste, for example, highly acidic liquid waste in a single-walled, mild steel tank may require continuous monitoring coupled with alarms and transfer equipment. A treatment facility involving bulk or solid low-level waste may need to implement monitoring systems such as portable constant air monitoring systems designed to detect and measure airborne contamination spread from dry processes. A facility storing containerized low-level waste may rely on a program of container inspections to meet the needs for monitoring for leaks and abnormal conditions.

Example: Low-Level Waste Storage Building 560 was designed and built several years ago, and is currently empty. Site plans call for resuming use of the facility for storage of containerized low-level waste awaiting disposal. In determining how to implement the

DOE M 435.1-1 storage facility monitoring requirement, site management conducts an analysis of Building 560. The analysis indicates that there are no monitoring systems in place that would meet the requirement. A Building 560 container inspection program that involves weekly walk-throughs of the facility will be implemented to meet the storage facility monitoring requirement.

For transfer systems, designers may need to consider the use of continuous flow monitors to allow comparisons of total volume input to total volume output as an indicator of the integrity of the transfer system. The containment integrity of waste transfer systems can also be monitored for radiation levels in excess of those expected from residual waste in the transfer system.

A highly reliable means of monitoring for releases is the use of secondary confinement which is then checked for waste. It also offers the benefit of providing defense-in-depth in containment of releases of low-level waste.

Example: A liquid low-level waste transfer line from a storage tank to a treatment facilities is enclosed in a large diameter secondary containment tube. The transfer line and containment tube were constructed with sufficient pitch to cause any leakage into the containment tube to flow back to the storage tank area. The transfer line developed a leak at a coupling which was discovered when waste was found in the secondary containment at the storage tank area.

What constitutes rapid detection of failed confinement or abnormal conditions needs to be established for each facility, operation, or activity. Monitoring design requirements and engineering controls to address catastrophic failures will be established through the conduct of safety analyses. The failures and conditions being addressed by this requirement are those that are not catastrophic, but could result in releases of radioactivity or doses to workers or the public in excess of established limits if they were allowed to continue over a period of hours or days. Detection equipment needs to be designed to detect confinement failures or abnormal conditions rapidly enough that action can be taken before the situation degrades to the point that response and recovery would result in doses to workers that approach the dose limits for radiation protection of workers (10 CFR Part 835). Similarly if the failure releases radioactivity to a air or liquid effluent stream, detection needs to occur rapidly enough to prevent environmental releases from exceeding annual limits.

Compliance with this requirement is demonstrated by designing low-level waste systems with the capability to monitor waste volume and detect volume changes in a time frame that will allow implementation of corrective measures to limit public and worker doses to allowable levels and to limit releases to allowable levels, which are documented in the radioactive waste management basis for the facility.

Supplemental References:

1. DOE. *Occupational Radiation Protection,* 10 CFR Part 835, U.S. Department of Energy, Washington, D.C.

IV. M.(3) Low-Level Waste Disposal Facility Design. The following facility requirements and general design criteria, at a minimum, apply:

(a) Confinement. Low-level waste systems and components shall be designed to maintain waste confinement.

Objective:

The objective of this requirement is to ensure the design of low-level waste disposal facilities includes features and/or equipment capable of containing low-level waste so that releases that could result in exposures to workers or the public or that could contaminate the environment are minimized.

Discussion:

This requirement is invoked to address hazards identified during the safety and hazards analysis performed in support of the development of this order and manual associated with the release of radioactive material from low-level waste disposal facilities that could impact workers, the public, or the environment. In addition to the facility and general design requirements contained in DOE M 435.1-1, Section I.1.E(18), the requirement for low-level waste confinement must be met.

The purpose of confinement systems is to minimize the spread of radioactive and/or hazardous materials and the release of these materials in facility effluents during normal operations, abnormal operations, and potential accidents. For disposal facilities, confinement must also be provided after the facility is closed, for an extended period of time. Therefore, the design of the confinement systems or equipment for a disposal facility should include process equipment or features that will minimize the spread of radioactive material during the placement of waste (the operational period) and systems or equipment that will minimize the spread of radioactive material after the disposal unit has been closed and into the future. The consequences of losing confinement for the operational period of a disposal facility may be greater than the consequences if confinement were lost after closure, where the loss of confinement is generally characterized as a slow leak from a disposal unit. These differences in the characteristics of a possible loss of confinement must be considered in designing the appropriate confinement systems or equipment for a low-level waste disposal facility. The need for redundancy and the degree of redundancy in these systems for disposal facilities is determined by the safety analysis process and maintenance

concerns for the operational period and by the performance assessment and composite analysis and associated closure considerations for the post-closure period.

> *Example: At the Site S disposal facility, primary confinement during operations is provided by the trench shape of the disposal unit and depth of emplacement of the waste, and special offloading equipment being used, while post-closure confinement is being provided by layering of natural materials that have contrasting water retention properties on the bottom and sides of the disposal unit that create a capillary break.*

The number and arrangement of confinement systems or barriers and their required characteristics for a low-level waste disposal facility are determined on a case-by-case basis. Factors that need to be considered in confinement system design include type, quantity, form, and conditions for dispersing low-level waste material during operations and after closure, especially the design basis conditions postulated for the post-closure period. As in implementation of all of the requirements of DOE O 435.1 and DOE M 435.1-1, the graded approach is used for determining the appropriate level of rigor in applying this control to the management systems employed at a particular low-level waste disposal facility.

Compliance with this requirement is demonstrated by designing low-level waste disposal facilities including features and/or equipment that provide confinement for the operational period and following closure of the facility that are based on evaluations which are contained in the facility radioactive waste management basis.

Supplemental References:

1. DOE, 1992. *Nuclear Safety Analysis Reports*, DOE 5480.23, U.S. Department of Energy, Washington, D.C., April 10, 1992.

IV. M.(3) Low-Level Waste Disposal Facility Design. The following facility requirements and general design criteria, at a minimum, apply:

(b) Ventilation.

1. Design of low-level waste disposal facilities shall include ventilation, if applicable, through an appropriate filtration system to maintain the release of radioactive material in airborne effluents within the requirements and guidelines specified in applicable requirements.

2. When conditions exist for generating gases in flammable or explosive concentrations, ventilation systems or other measures shall be provided to keep the gases in a non-flammable and non-explosive condition. Where concentrations of explosive or flammable gases are expected to approach the lower flammability limit, measures shall be taken to prevent deflagration or detonation.

Objective:

The objective of this requirement is to ensure that the design of low-level waste disposal facilities includes features to remove radioactive materials from airborne effluents that could endanger worker or public safety and/or the environment to levels allowed in applicable requirements before they are released, and to preclude or mitigate the accumulation of explosive and oxidizer gases in the facilities which could lead to uncontrolled releases of radioactive materials.

Discussion:

This requirement is based on a similar requirement invoked to address a group of hazards that was identified by the safety and hazards analysis performed in support of the high-level waste chapter of this Manual and which also has been included for the design of low-level waste treatment and storage facilities. The analysis revealed that very hazardous conditions can result from unexpected and uncontrolled releases of radioactive material, either because of poorly designed ventilation systems or due to accumulation and ignition of flammable or explosive gases in high-level waste storage facilities. Similar circumstances occurring at a low-level waste disposal facility are similarly problematic, and a similar requirement was believed to be justified to prevent exposures to workers or the public, radioactive leaks to the environment, and costs for damage mitigation and cleanup from unanticipated and/or uncontrolled airborne releases of radioactive material.

The need for disposal facility ventilation systems to meet these requirements is anticipated for facilities that might impose operational and/or environmental conditions on waste containers and forms similar to those of a storage or treatment facility that requires ventilation. Generally, it is not expected that ventilation would be needed for outdoor disposal in trenches or pits. However, conditions similar to those in a storage or treatment facility might be present in an above-ground disposal vault configuration, for example, in which a spill could pose a danger to workers inside if not properly ventilated. The safety analysis documentation for the facility needs to address the hazards associated with the design of the specific disposal unit and the waste that is expected to be disposed, and include proper ventilation, as appropriate.

Guidance for subrequirement IV.M.(3)(b)1. is addressed above under Airborne Effluent Filtration Systems and subrequirement IV.M.(3)(b)2. guidance is discussed under Flammable and Explosive Concentrations in the discussion on meeting requirements IV.M.(2)(b)1. and IV.M.(2)(b)2. for low-level waste storage and treatment facilities.

Compliance with this requirement is demonstrated if ventilation systems are included in the design of low-level waste disposal facilities when appropriate that can be demonstrated will limit airborne radioactive effluents to applicable legal and/or regulatory limits and that will prevent the accumulation of explosive or flammable gases in concentrations that could result in an uncontrolled release of radioactive material.

Supplemental References:

1. DOE, 1990. *Radiation Protection of the Public and the Environment*, DOE 5400.5, U.S. Department of Energy, Washington, D.C., February 8, 1990.

IV. M.(3) Low-Level Waste Disposal Facility Design. The following facility requirements and general design criteria, at a minimum, apply:

(c) Stability. Low-level waste disposal facilities shall be designed to achieve long-term stability and to minimize to the extent practical, the need for active maintenance following final closure.

(d) Control of Water. Low-level waste disposal facilities shall be designed to minimize to the extent practical, the contact of waste with water during and after disposal.

Objective:

The objective of these requirements is to ensure that the design features of low-level waste disposal facilities provide for three basic objectives of safe and environmentally protective radioactive waste disposal: that the facilities will be stable for a long time; that little or no active maintenance is needed to maintain this desired stability after the facility is closed; and that contact of waste and water that could degrade waste forms or transport radionuclides is minimized.

Discussion:

During the safety and hazard analysis conducted in developing the requirements of DOE O 435.1 and DOE M 435.1, providing continued protection into the future from disposed waste was

identified as a measure to reduce potential exposures to the public, workers, and the environment. The analysis indicated that some controls are necessary after a low-level waste disposal facility has been closed and that it is prudent to address long term ramifications of the disposal of waste in the early stages of facility design. Certain features of design can be utilized to provide an additional depth of defense against exposure of workers, the public, or the environment to the hazards posed by the disposed low-level waste. These two design requirements for a low-level waste disposal facility implement two of the fundamental concepts embodied in 10 CFR Part 61, stability of the disposal site and control of surface and groundwater at the site.

Several features have been used in the designs of past low-level waste disposal facilities to achieve stability of the facility during and after disposal, to reduce the need for active maintenance once the facility is closed, and to control water so that there is little contact of waste with water, both before and after it is disposed. Engineering barriers/features can include use of rip cap, liners, and depth of cover. Many design features serve to meet both of these requirements at the same time. Also, some design features, when combined with operational practices, achieve the most benefit towards achieving the objectives of these requirements. Subrequirement IV.M.(3)(a) is discussed in the section below entitled, Stability, and subrequirement IV.M.(3)(b) is discussed in the section entitled, Control of Water.

Stability. The ability of a low-level waste disposal facility to remain stable for the long-term is a fundamental goal in the meeting the performance objectives for disposal of low-level waste as defined in Chapter IV, Section P.(1) of DOE M 435.1-1. The discussions on long-term stability in the Nuclear Regulatory Commission's rulemaking documentation and guidance for 10 CFR Part 61 note that site stability should be relied on for the indefinite future, and evaluated for a period of at least 500 years for purposes of presenting information on design of the facility in a license application. Long-term stability for DOE low-level waste disposal sites is to be considered an attribute that needs to be present for the indefinite future, and is determined on a site-specific basis from analysis of site conditions, any waste that requires structural stability, and the desired performance of the facility. Site-specific timeframes, therefore, should be used for design bases events or phenomena, where appropriate, when designing the facility to ensure long-term stability of the site for the purposes of meeting DOE O 435.1 and DOE M 435.1-1.

There are several principles in establishing the design of the facility that are key to the objective of long-term stability. First, the design features of the low-level waste disposal facility need to be directed toward the long-term isolation of the waste, the minimization of migration of radionuclides, and the avoidance of any need for continuing long-term active maintenance after closure. Second, the design of the facility needs to lead to closure and the development of a closure plan that provides assurance that the performance objectives will continue to be met into the future. Third, the disposal site needs to be designed to complement and augment wherever possible the ability of the disposal site's natural characteristics to assure that the performance objectives will continue to be met.

A low-level waste disposal facility needs to be sited and designed to permit efficient land utilization and maximum waste volume allocation, while maintaining long-term stability and isolation. Facility design is based on the projected waste volume and characteristics including the projected volume of waste to be disposed of over the life of the facility, chemical composition of the waste, radionuclide content and concentration, and the expected physical form in which the waste will be received. This information is used to estimate the number of disposal units required for the facility, and for determining the need for special engineered features. For example, based on projected receipts of high-activity low-level waste, special excavation designs such as slit trenches and auger holes may be required in order to provide adequate worker protection.

The spacing between disposal units needs to be considered in establishing the overall dimensions of units. Sufficient space between adjacent units is needed to assure disposal unit integrity, for example, the distance between disposal units is such that positioning and use of equipment at a newly excavated unit will not adversely affect the stability of the unit's walls and will not disturb nearby disposal units. Disposal unit spacing needs to also take into account the need for any buffer zone between disposal units and the boundary of the disposal facility that may be planned.

> *Example: The new disposal facility at the Brown Site has been designed using trench disposal units sized to dispose of approximately 6 months worth of waste receipts at a time. The design calls for the trenches to be separated from one another by 50 feet intervals, as configured after analysis of the expected trench side activities, including some vehicular traffic. A remedial action is taking place adjacent to the new facility, so a relatively large (300 feet) buffer zone is established between the two projects to address a concern of stakeholders regarding future continuing activities that may be necessary at the remedial action site.*

The design of individual disposal units also contributes to the long-term stability of the facility. The size of disposal units needs to be determined based on the physical size and topography of the disposal facility, the types and volumes of waste to be disposed, and the dimensions of waste containers to be buried. Soil characteristics, the need for equipment access and maneuvering space, and surface water drainage before, during, and after waste emplacement are considered in deciding on the size and type of disposal units. The depth of disposal units is also a site-specific design determination which is dependent on the depth of the ground-water table, the need for the stability of sidewalls, and the depth of disposal of certain categories of waste, if appropriate.

Disposal units generally are oriented parallel to topographic contours of the site. Slopes of the site should not be so steep as to result in significant elevation differences between sidewalls of a disposal unit. In addition, the elevation difference of the ground surface between one end of a disposal unit and the other end needs to be less that the combined thickness of the backfill overlying the waste and the disposal unit cover.

The planned sequence of use of disposal units over the facility lifetime needs to reflect the need to conduct adequate closure and stabilization operations, as each unit is filled. The location of roads and disposal unit covers, use of heavy equipment, establishment of vegetative cover, and management of surface water are planned such that operations may be conducted at each disposal unit without damage to closed disposal units. Location and access to fill and borrow areas are also planned to assure that they do not compromise the integrity of completed disposal units.

Final slopes of disposal units when shallow land trenches are used are designed to minimize erosion and failure of slopes. Both potential problems can be minimized by controlling the slope angle, particle size of the soil, degree of compaction or cementation, and vegetative cover. In arid regions, where infiltration of water is of less concern and where vegetation may be difficult to establish, gravel or cobbles may be used in place of vegetation to protect the slope.

> *Example: The trench sides at the Brown Site low-level waste disposal facility are sloped at a 80% angle, as configured by soil analysis calculations to remain stable, and are protected along the entire length of the trench by geofabrics. The trench at the end of the first row of trenches is designed to be only half as long as its predecessor trenches because the gradient of the site was beginning to increase, and more chance of instability would be likely if the same size trench was built.*

The disposal site is designed to enhance and not degrade the natural physical characteristics of the area that support long-term stability, and to minimize the consequences of potential abnormal events. Therefore, based on site characteristics, for example a large rainfall or expected damage from high winds, and the expected waste characteristics and forms, appropriate engineered barriers may be required to enhance the natural site characteristics for site stability. Primary concerns are to reduce the effects of erosion over time and to minimize the impacts to site stability by an abnormal event.

The use of common engineering materials to augment the long-term stability of a low-level waste disposal facility is to be carefully planned. A critical examination needs to be made of each component of a disposal unit and compared to that of the unit as a whole, and a determination made considering the cost and difficulty of utilizing these materials versus the benefits to maintaining stability. For example, geotextiles and geomembranes may not have a long design life, but they may contribute to the stability of the disposal unit as a whole by making placement of critical materials during closure much easier.

Control of Water. There are also some principles that are key to the objective of minimizing the contact of waste with water before, during, and after disposal. First, covers of disposal units need to be designed to minimize water infiltration to the extent practical, and to direct percolating or surface water away from the waste. Second, surface features need to direct surface water drainage away from disposal units at velocities and gradients which will not result in erosion that

will require ongoing active maintenance in the future. Third, the disposal unit needs to be designed to minimize the contact of waste with water during storage, the contact of waste with standing water during disposal operations, and the contact of wastes with percolating or standing water following disposal.

Disposal units are designed to minimize infiltration of water into the unit over the long term. Several factors must be considered in the design of the disposal unit to result in a disposal unit with sides and a cover which will behave as desired, including: the permeability of the natural materials the units will be constructed of and within, wind and water erosion, root penetration, animal burrowing, consolidation, subsidence, desiccation, freeze-thaw cycles, and frost heave. The design must evaluate whichever of these elements are applicable for a particular site and design, and ensure the impacts of these are accounted for in minimizing infiltration of water into the unit.

The cover is to be designed to facilitate drainage and should be several feet in thickness at its thinnest point, if appropriate. For example, at a humid site using the trench disposal method, clay barriers are desirable as part of cover systems because of its relatively low permeability. To assure the integrity of the clay portions of cover systems, it should be insulated from the surface geologic, atmospheric, and biotic processes by one of more layers of other types of materials. The cover should extend beyond the site walls of the unit and be directly tied into the surface drainage system at the original or modified grade to assure surface runoff is not directed along the sidewalls down into the unit. Cover design needs to include stabilization of some fashion to assure that it is not significantly affected by wind or water erosion. For example, in humid climatic regions, such stabilization can be achieved by planting of a shallow rooted vegetative cover.

A surface water management system may be necessary as part of the disposal facility design to minimize erosion and infiltration into disposal units. An adequate system will usually consist of three primary parts: collection, transport, and discharge. The collection part of the system is to collect runoff from disposal unit covers in drainage ditches. These ditches are sloped to allow transport of all the surface runoff to a drainage collector physically removed from the active disposal area to allow discharge of the water off-site. This type of system may be considered desirable for a shallow land trench or other near surface disposal facility within a humid or moderate climatic regime. Factors to evaluate the necessary requirements for a drainage system include the capability for managing a 10-year return flood and for diverting a postulated 500-year flood. Another method instead of this system for smaller sites could incorporate a uniform, crowned cover designed to remove the runoff by sheetwash.

> *Example: The spaces between trenches at the new disposal facility at the Brown Site are designed to steer water towards one of four collection areas in the facility. These collection areas then drain water to a central collection area away from both the low-*

level waste disposal facility, and the remedial action project which is adjacent to the facility for discharge.

Disposal units must be designed to drain effectively when water enters the disposal facility. Bottom drainage can be accomplished by designing the disposal unit floor to be covered with 2 - 3 feet of pervious material, such as sand, and to be sloped across the width of the unit to a french drain. The disposal unit floor and the french drain would be sloped along the length of the unit to sumps. The bottom layer would also serve as a barrier to the capillary rise of water from below. The base of a completed disposal unit should drain faster than water enters from the top and sides of the facility. Inclusion of a system like this serves to rapidly drain off water entering the disposal unit before it is covered and minimizes the time any infiltrating water would be in contact with the waste.

Example: At the new disposal facility at Site Y, trench bottoms are designed with a multi-layer system of geofabrics and natural materials that will drain water towards one side of the trench and then towards one end of the trench to a monitoring well location. The geofabrics protect the layers of natural material during operations, but are not relied upon for providing drainage characteristics. The cover design includes a multi-layered system that is designed to drain water away from the trenches and reduce infiltration, and includes a deep rooted grass cover on the top. The cover does not use any geofabric, since no activities are expected on the cover which would disturb its layering.

Void spaces between waste packages need to be filled with a freely-draining non-cohesive material, such as clean sand or gravel. These types of materials will promote rapid movement of water through the disposal unit. In addition, if the backfill has a sufficient contrast in permeability to the material in the disposal unit cap, capillary forces may promote unsaturated flow of interstitial water around the disposal unit instead of through it. Instead of a free-draining backfill, material with extremely low permeability, such as grout or concrete would be used. Clay-soil mixtures may not be suitable for backfill because of the difficulty in ensuring that void spaces are filled and the difficulty in achieving sufficient compaction to limit consolidation and permeability to acceptable levels.

Contact of waste with water during disposal operations must be minimized. Closing down site disposal operations until disposal units are free of visible water is one approach to achieving this. Active disposal units could be allowed to drain into a sump or into the inactive part of the unit before waste is emplaced. Keeping the volume of uncovered waste in the disposal units to a practical minimum is another approach to minimizing contact of waste with water, as is the practice of placing backfill over the waste as soon as possible after emplacement in the disposal unit. Acceptable low-level waste disposal facility operations are discussed in the guidance on DOE M 435.1-1, Section IV.P.(6).

Compliance with this requirement is demonstrated by the design features of the subject low-level waste disposal facility being focused on achieving and maintaining stability of the disposal site, minimizing the need for any active maintenance of the disposal facility following its closure, and preventing the contact of waste with water, both during operations of the facility and following closure, and these design considerations are justified and documented in the radioactive waste management basis for the facility .

Supplemental References:

1. NRC, 1982. *Technical Position Paper on Near-Surface Disposal Facility Design and Operation*, U.S. Nuclear Regulatory Commission, Washington, D.C., November 1982.

2. DOE, 1989. *Methodology for Compliance with DOE Order 5820.2A Chapter III: Management of Low-Level Radioactive Waste*. DOE/LLW-75T, U.S. Department of Energy, National Low-Level Waste Management Program, Idaho Falls, ID, February 1989.

IV. N. Storage and Staging.

The following requirements are in addition to those in Chapter I of this Manual.

(1) Storage Prohibitions. Low-level waste in storage shall not be readily capable of detonation, explosive decomposition, reaction at anticipated pressures and temperatures, or explosive reaction with water. Prior to storage, pyrophoric materials shall be treated, prepared, and packaged to be nonflammable.

Objective:

The objective of this requirement is to promote safe storage of low-level waste by eliminating from storage materials which could result in fires or explosions due to their reactivity or ignitability.

Discussion:

The safe storage of low-level waste can be jeopardized by the presence of materials which may ignite or explode. To avoid the potential for accidental releases from stored wastes, this requirement prohibits storage of materials that are known to be readily capable of ignition or explosion, or which may degrade over time to be ignitable or explosive. In establishing waste acceptance criteria for storage, waste managers must prohibit the acceptance of materials which have the potential of igniting or exploding. The following materials are not to be stored:

- Reactive metals - metals that can react violently with water, form potentially explosive mixtures with water, or ignite when exposed to air; e.g., non-stabilized uranium or plutonium metal turnings.

- Certain dried ion exchange resins - organic ion exchange resins which have been used for treating solutions containing nitrates have the potential of igniting or exploding if they are allowed to dry out.

- Cellulosic materials contaminated with strong oxidizers - cellulosic materials can spontaneously ignite in the presence of strong oxidizers, e.g., concentrated nitric acid.

- Volatile materials, if stored in areas of high temperatures - storage of volatile materials in closed containers subject to high temperature can result in pressurization of the container and, depending on the waste materials, evolution of flammable gases.

- Pyrophoric materials - nonradioactive materials which can ignite spontaneously are not to be packaged for storage. Radionuclides which may be pyrophoric are to constitute less

than 1% by weight of the container contents unless they are treated to eliminate the pyrophoric characteristic.

When waste with the characteristics described above have been generated, it is necessary to ensure that they are properly pre-treated or treated prior to placing them into storage. Treatment may consist of causing the reaction to occur under controlled conditions, e.g., oxidation of uranium turnings, or may involve the stabilization of waste materials so that they are no longer flammable or explosive.

Example 1: Some old glove boxes that contain laboratory equipment such as test tubes, plastic bottles, wooden utensils, record books, various unidentified materials, and some laboratory chemicals are being cleaned out at Laboratory A. Some bottles of nitric acid are included in the chemicals being discarded. The nitric acid is neutralized prior to placement in the waste container so that there is no interaction with the wooden utensils and any other cellulosic materials that might be in the lab waste.

Example 2: The fuel fabrication prototype facility at Site Z regularly generates waste containing uranium turnings from the fabrication of test fuel specimens and prototype targets. The turnings are solidified in a cement solution formulated specifically for this use in specially designed cans before being packaged in 55 gallon drums for shipment to a disposal facility.

Compliance with this requirement is demonstrated by having waste acceptance requirements which prohibit low-level waste that is ignitable or explosive from being accepted for storage unless it has been treated, and procedures for properly preparing such materials for safe storage.

IV. N.(2) Storage Limit. Low-level waste that has an identified path to disposal shall not be stored longer than one year prior to disposal, except for storage for decay, or as otherwise authorized by the Field Element Manager.

Objective:

The objective of this requirement is to limit low-level waste in storage, provide for the timely disposal of low-level waste, and to limit waste from being stored for indefinite periods of time. Low-level waste is to be actively managed so that final disposition can be achieved with a minimum of storage time during its life cycle.

Discussion:

The storage of low-level waste plays an important role in the management of low-level waste, and provides the opportunity to optimize treatment and disposal activities. The need to store low-level waste should be balanced with the potential risk that storage of the waste may present. During the development of the requirements in DOE M 435.1-1, the storage of low-level waste was identified as an activity that presented potential risk to the public, workers, and the environment. In addition, *The Complex-Wide Review of DOE's Low-Level Waste Management ES&H Vulnerabilities* (DOE/EM-0280) identified inadequate storage conditions for low-level waste and storage of low-level waste that has an identified path to disposal as vulnerabilities.

The primary requirement for the storage of low-level waste is in DOE M 435.1-1, Section I.2.F.(13), which charges the responsibility for safe storage with the Field Element Manager. Storage is defined as the collection and management of waste for the purpose of awaiting treatment or disposal, in such a manner as to not constitute disposal of the waste. Three scenarios for the collection and management of low-level waste are provided for in DOE M 435.1-1, Chapter IV, and discussed in this guidance.

1. The storage of low-level waste with an identified path to disposal.
2. The storage of low-level waste that does not have an identified path to disposal.
3. The accumulation of low-level waste for less than 90 days, referred to as staging.

This requirement is directed at the storage of low-level waste with an identified path to disposal and is intended to reduce the total amount of low-level waste in storage, provide for the timely disposal of low-level waste, and minimize the indefinite storage of waste in conditions that are or could become unsuitable. Life cycle planning for the management of low-level waste is required as part of the Site-Wide Waste Management Program and includes a documented understanding of the disposal options for the waste (see Section I.2.E.(1)). An identified path to disposal determination is based primarily on the ability of the waste to meet the waste acceptance requirements of a disposal facility and authorization of the disposal facility to accept that waste. Some waste may not have current disposal options, and thus has no identified path to disposal. A waste that can meet an existing disposal facility's waste acceptance requirements is considered to have an identified path to disposal.

> *Example: A site is indefinitely storing low-level waste that has a disposal option. The waste is characterized and could meet the requirements of an off-site disposal facility if repackaged. As of the issuance of DOE O 435.1 this low-level waste should be repackaged and received by a disposal facility within one year.*

One Year Storage Limit. Determination of the one year time limit is based on the dates recorded by receiving facilities consistent with the documented process for transferring responsibility of the

waste described in requirement DOE M 435.1-1, Section IV.K.(3). The staging of waste at any generator or treatment facility prior to acceptance by a storage facility need not be included in the one-year time limit. In addition, the staging by a disposal facility prior to disposal also need not be included in the one-year time limit. However, if multiple storage facilities are utilized during the life cycle management of the waste, the total combined storage time of all storage facilities is used to determine if the waste has reached the one-year limit for storage.

> *Example: Low-level waste is staged at a generator facility for two months prior to transfer to a storage facility. The waste is at the storage facility for five months and transferred to a treatment facility. The treatment facility holds the waste for two months and then treats the waste. The waste has been held in storage for a total of seven months and needs to be transferred to and received by a disposal facility within five months.*

The intent of this requirement is not that an undue focus be placed on the compliance or non-compliance with the one-year limit. In other words, the requirement is not intended to force heroic efforts to remove containers of low-level waste from storage for disposal before the one year is reached, or to cause additional handling of low-level waste so the storage clock can be restarted. Rather, the intent of this requirement is to focus attention of managers at the site towards ensuring that waste is being managed to disposal under reasonable time frames. If it appears that the storage limit will be exceeded, managers should evaluate the conditions of storage and determine a proper and safe course of action. The evaluation of the existing storage conditions needs to determine if the waste has undergone any changes that could impact the characterization data or container information that exists for the waste, such as damage to any waste containers, and whether continued storage under the same conditions will maintain the waste in a condition that it can be disposed without further treatment or characterization. The manager may also need to determine if the reasons for the extended storage period will be resolved any time soon, and if the answer could be no, then deciding if alternative management paths need to be identified for the waste.

Storage longer than one year can be justified if the conditions for such storage are approved by the Field Element Manager as part of the radioactive waste management basis for the facility. The conditions are to be based on the evaluations of the existing storage conditions and any steps that are necessary to provide for timely disposal of the waste conducted by the manager when it was determined that the one-year storage limit was not going to be met. For example, conditions specifying the additional storage period beyond the one-year which is authorized and some mandatory maintenance of containers (see guidance for DOE M 435.1-1, Section IV.N.(5)) may be appropriate when the radioactive waste management basis is amended to allow for additional storage time. These provisions should also include a date or time period (e.g., 1 year) when storage conditions will be reevaluated to determine if storage longer than one year can be continued and provisions for appropriate facility operations (such as container inspections) that ensure the hazards of the waste are still controlled.

Storage for Decay. Storage for radioactive decay for a period greater than 1 year for waste that has an identified path to disposal is allowed. Adequate justification and the supporting information for storage for decay is to be documented in the radioactive waste management basis for the facility in which the storage will take place. Adequate justification for storage for decay includes reduced cost, reduced risk, and the ability to achieve disposal that might not otherwise be available. When using storage for decay as a management option, waste acceptance requirements are to be developed for the storage facility that are compatible with the requirements for waste disposal. These waste acceptance requirements are part of the radioactive waste management basis for the storage facility approved by the Field Element Manager.

Mixed Low-Level Waste. Mixed low-level waste in storage may present a dilemma for determining compliance with the storage requirements. Some mixed low-level waste generated in the complex would fall into the category of not having an identified path to disposal, and should meet only the storage requirements for no path forward waste. However, some mixed low-level waste has an identified path to disposal, but must remain in storage for some period of time that exceeds one year, awaiting treatment processes or for other reasons. The Field Element Manager needs to determine the appropriate way to exempt this waste from the storage limit requirement.

Note that because the hazardous component of mixed low-level waste is subject to the *Resource Conservation and Recovery Act*, special requirements apply, including a prohibition on storage. In accordance with the *Resource Conservation and Recovery Act* Land Disposal Restrictions, storage of land disposal-restricted waste is prohibited, other than for the purpose of accumulation to facilitate treatment. Under the *Federal Facility Compliance Act of 1992*, DOE sites were required to develop Site Treatment Plans to bring stored mixed low-level waste into compliance with these requirements. The Site Treatment Plan needs to be consulted and any mixed low-level waste stored for the purpose of accumulation to facilitate treatment must meet *Resource Conservation and Recovery Act* storage requirements. There could be several ways within different scenarios that this requirement can be met, as illustrated by the examples below, however, there are basically four ways to show compliance with the requirement and include appropriate provisions in the radioactive waste management basis for the facility in which it is stored. These provisions should include a date or time period (e.g. one year) when the storage conditions will be re-evaluated to determine if storage longer than one year can be continued and provisions for appropriate facility operations (such as container inspections) that ensures the hazard from the radioactive component of the waste is still controlled.

Legacy Waste. Several questions have arisen concerning the ability of some Department facilities to comply with the one-year storage limit because they store “legacy low-level waste.” Legacy waste generally refers to large quantities of waste at a few DOE sites that has been in storage for more than one year already, and may require additional technical studies, characterization, treatment, or resources dedicated to it, to properly dispose of the waste. The entire volume of

legacy waste at these sites cannot be removed from storage under any reasonable scenario that implements the one-year storage limit. As discussed above, the intention of the requirement is not to force malicious compliance or heroic actions which would result in increased risk or safety concerns. Rather, the intention is that waste in storage longer than one year receives additional attention to ensure that the public, the workers, and the environment are protected from the hazards of the waste, and that progress is being made to dispose of the waste. There could be several ways within different scenarios that this requirement can be met, as illustrated by the examples below, however, there are basically four ways to show compliance with the requirement:

1) the radioactive waste management basis allows for storage for no more than one year.

2) the radioactive waste management basis allows for storage for no more than one year, or for storage for decay only for periods greater than a year, which are specified on a radionuclide basis.

3) the radioactive waste management basis allows for storage for more than one year, up to a specified period of time based on a documented technical evaluation that the waste can be stored in a manner that does not cause changes to the waste or waste packages that is detrimental to the safe storage of the waste, the final disposal of the waste or to meeting the disposal performance objectives.

4) the radioactive waste management basis allows for storage for decay (with specifics) and for storage for more than one year for other low-level waste, up to a specified period of time based on a documented technical evaluation that the waste can be stored in a manner that does not cause changes to the waste or waste packages that is detrimental to the safe storage of the waste, the final disposal of the waste or to meeting the disposal performance objectives.

The documented technical evaluation the requirement if one is necessary needs to include an analysis that describes the waste containers, the design of the waste containers, the design life of the waste containers, and the storage conditions for the container over its service life. The analysis needs to address the total anticipated storage period and should demonstrates waste container integrity will be maintained for the extended time period.

Example 1: Storage of low-level waste at Site A occurs in Building 700. The storage period never exceeds 9 months before it is shipped for disposal at Site X. The radioactive waste management basis for Building 700 approves this storage with no additional provisions.

Example 2: Storage of low-level waste at Site B occurs in Building 400. The storage of low-level waste occurs over various periods of time, but never greater than 15 months before it is shipped for disposal. The Field Element Manager determines, based on container integrity and storage configuration, that the 15 month period of time is acceptable and approves the radioactive waste management basis for Building 400 with no additional provisions.

Example 3: Storage of low-level waste at Site 900 includes storage for decay for three waste streams up to a period of 5 years, and for other low-level waste streams for 14 months. The radioactive waste management basis for the Site 900 storage facility allows for storage for decay for up to 5 years for the three waste streams only, based on an analysis of container integrity, with additional provisions ensuring segregation of decay waste from other waste.

Example 4: Storage of low-level waste at Site G is being done at the generator facilities, and it can last for up to 16 months prior to disposal. The radioactive waste management basis for the generator facility does not address storage. Exceedence of the one year storage limit is a non-compliance. (Also see guidance on Staging, DOE M 435.1-1, Section IV.N.(7) below)

Example 5: Hanford's Central Waste Complex (CWC) stores Mixed Low-Level Waste (MLLW), low-level waste, and transuranic waste from inclement weather. The bulk of the CWC inventory is MLLW received from both on and off site generators to be managed until treatment technologies become available and disposal is achieved. Because it is technically impossible to dispose of the CWC's MLLW inventory within one year and the waste has an identified path to disposal, a technical evaluation is prepared. The extended storage of MLLW at CWC is fully justified, determined to be safe, and is the preferred interim management technique. Documentation supporting this decision is included in the radioactive waste management basis for the CWC, as well as a description of the container inspection and reporting program already in place to ensure continued safe storage.

Compliance with this requirement is demonstrated by the existence of a radioactive waste management basis for the storage facility approved by the Field Element Manager that includes the time frames that waste are allowed to be stored, the necessary justifications for storage for decay, and the necessary technical evaluations if storage is to extend significantly beyond the one-year time frame.

IV. N.(3) Storage Integrity. Low-level waste shall be stored in a location and manner that protects the integrity of waste for the expected time of storage and minimizes worker exposure.

Objective:

The purpose of this requirement is to ensure that the selection of the location and method for storing low-level waste is made so that both workers and the containers of waste are provided with adequate protection.

Discussion

During the development of DOE O 435.1 and DOE M 435.1-1, the storage of radioactive waste was identified as an activity that presented potential risk to the public, workers, and the environment. Numerous weaknesses and conditions which could lead to release of waste or exposure of workers were identified during the safety and hazards analysis and subsequent reviews conducted in support of the Manual documentation. In addition the *Complex-Wide Review of DOE's Low-Level Waste Management ES&H Vulnerabilities* revealed inadequately or improperly stored low-level waste, which presents the possibility of human exposure to radiation and the potential for adverse environmental effects.

The Complex-Wide Review and the evaluations of storage that were conducted during development of the Order and Manual revealed a variety of current practices and lengths of storage for low-level waste. Low-level waste is stored in dense-pack arrays, in conditions exposed to the elements, and in modern, RCRA-compliant storage facilities. In addition, buildings not originally designed or intended for storage are sometimes used when other storage capacity is not available.

As discussed in the General Requirements guidance on storage (DOE M 435.1-1, Section I.2.F.(13)), a principal element of proper storage is ensuring that containers are protected from degradation and perform their intended function until disposal. This requires that containers be protected from mechanical damage and from environmental conditions that could degrade the confinement provided by containers.

Example 1: Due to a large decommissioning project generating unanticipated volumes of low-level waste, Site Z decided to store low-level waste outside until indoor storage space could be made available. In accordance with the Packaging and Transportation requirements, filtered vents were installed on the drums used for packaging the waste. However, in establishing the radioactive waste management basis for the outside storage pad, personnel failed to recognize the potential for precipitation entering the drums. Rain accumulated on the tops of the drums, then due to fluctuations in barometric

pressure, the drums "breathed" through the vents. Water was sucked in through the vents resulting in the need to repackage the waste to meet the waste acceptance requirements for disposal. Subsequently, any waste drums that had to be left outside were provided with protective covering from precipitation.

Example 2: Due to a large backlog of low-level waste, Site X is required to store low-level waste outside until it can be treated and/or disposed. The waste is stored in containers which prevent the entrance of precipitation (lid with lips extending down over the sides) and which resist corrosion (painted carbon steel). Controls are in place to limit mechanical damage from vehicles and other operations in the area. The containers are inspected on a monthly basis for deterioration and repaired as necessary to maintain containment of the waste (e.g., painted, contained). Personnel are only in the outside storage area during periods of inspections, container maintenance, and container movement. The outside storage has been analyzed and documented to provide adequate protection for the expected storage time. This storage maintains the integrity of the waste and minimizes worker exposure.

As noted earlier, low-level waste may be stored in facilities which were not originally designed for storage. If the facilities have the appropriate provisions (e.g., ventilation, fire suppression) for the type of waste being stored, their use is preferential to storing the waste containers outside and subjecting them to the elements. However, in making a decision to use a facility for storage and in developing a radioactive waste management basis for the activity, particular attention to protection of workers is needed. Waste is not to be stored in areas where workers are required to spend extended periods of time in performing other duties (i.e., any duties not related to managing and monitoring the waste). This limits the facilities or areas of facilities that could be used for waste storage to those that are excess to current site missions or those that are infrequently accessed as part of normal operations.

Compliance with this requirement is demonstrated if sites have storage capabilities for low-level waste that provide protection to waste containers so that their integrity will not be damaged through physical or chemical (corrosion) processes and that keep personnel from spending extended periods of time in the areas where low-level waste is stored.

Supplemental References:

1. DOE, 1996. *Complex-Wide Review of DOE's Low-Level Waste Management ES&H Vulnerabilities*, DOE/EM-0280, U.S. Department of Energy, Washington, D.C., May 1996.

IV. N.(4) Waste Characterization for Storage.

(a) Low-level waste that does not have an identified path to disposal shall be characterized as necessary to meet the data quality objectives and minimum characterization requirements of this Chapter, to ensure safe storage, and to facilitate disposal.

Objective:

The objective of this requirement is to establish, document, and maintain minimum characterization information for low-level waste that does not have an identified path to disposal. Minimum characterization information will facilitate future disposal because the historical knowledge of the waste is preserved. Characterizing low-level waste with no identified path to disposal will enable it to be stored safely and for disposal options to be evaluated. When a disposal option is ultimately identified the nominal characterization information necessary for it to be acceptable for disposal will be available.

Discussion:

The establishment and maintenance of characterization information is essential for the safe and effective management of low-level waste. During the development of the *Radioactive Waste Management Manual* (DOE M 435.1-1), the storage of low-level waste without a path to disposal was identified as an activity that presented potential for waste to exist without being adequately characterized. *The Complex-Wide Review of DOE's Low-Level Waste Management ES&H Vulnerabilities* (DOE/EM-0280) revealed that inadequacies and inaccuracies in characterization efforts complicate effective waste management activities and results in an increased risk of release to the environment and exposure to workers and the public.

> *Example: High activity low-level waste is stored in a generator facility hot cell. The waste is generally believed to have no identified path to disposal. However, because the waste has not been characterized, a path forward cannot be established and the historical knowledge of the waste is jeopardy of being lost or forgotten.*

The requirement to characterize all low-level waste is in DOE M 435.1-1, Section IV.I. In the interest of accuracy and future economics, characterization is necessary to facilitate future disposal of low-level waste without a path to disposal. If the characterization necessary for future disposal is not performed and documented in a timely manner, then the ability to dispose of the waste may be compromised. The storage of waste represents the opportunity for characterization information to be inadequately managed and ultimately lost or forgotten. This requirement is intended to capture characterization information, both direct and indirect (process knowledge,

materials accountability, etc.) so that when disposal options are available, characterization will not have to be repeated and possibly not required at all.

> *Example: A certain low-level waste stream has no identified path to disposal based on preliminary information. Prior to placement in storage the waste is nominally characterized as required and pertinent information concerning the process that generated the waste is documented. Some years later, a treatment facility is identified that is capable of accepting the waste and producing a waste form that meets the disposal facility waste acceptance requirements.*

Waste with no identified path to disposal needs to be characterized to provide the minimum information required for safe storage as well as other typical data elements required for disposal. An example of the typical characterization information that should be documented is that which would be required by an existing on-site disposal facilities waste acceptance requirements.

> *Example: A generator's preliminary information indicates that a certain low-level waste stream has no identified path to disposal. The site has no on-site disposal facility so the generator decides to characterize the waste as if complying with an existing off-site disposal facilities requirement. Characterization data are used to develop a safe storage configuration for the waste awaiting identification of a disposal option.*

Compliance with this requirement is demonstrated by documenting the characterization information for low-level waste with no identified path to disposal. The information includes the minimum data elements listed in DOE M 435.1-1, Section IV.I.(2) and the data quality objectives process is used for identifying the characterization parameters. In addition, any other characterization information that may facilitate future disposal is collected and maintained.

Supplemental References:

1. DOE, 1996. *Complex-Wide Review of DOE's Low-Level Waste Management ES&H Vulnerabilities*, DOE/EM-0280, U.S. Department of Energy, Washington, D.C., May 1996.

2. EPA, 1994. *Guidance for the Data Quality Objectives Process*, EPA QA/G-4, U.S. Environmental Protection Agency, Washington, D.C., September 1994.

IV. N.(4) Waste Characterization for Storage.

(b) Characterization information for all low-level waste in storage shall be maintained as a record in accordance with the

requirements for Records Management in Chapter I of this Manual.

Objective:

The objective of this requirement is to ensure that characterization information on waste in storage is maintained as a Federal record, providing a traceable path if future actions require knowledge of the original characterization information.

Discussion:

The establishment and maintenance of characterization information is essential for the safe and effective management of low-level waste. During the development of the *Radioactive Waste Management Manual* (DOE M 435.1-1), the storage of low-level waste, specifically long-term storage, was identified as an activity that presented potential for waste characterization information to be lost, forgotten, or otherwise mismanaged.

> *Example: Following characterization, it was determined that a specific low-level waste stream had no identified path to disposal. Many years later, a treatment facility was identified that might be capable of accepting the waste and producing a waste form that would meet a disposal facility's waste acceptance requirements. The complete original characterization information for the waste has been lost so an evaluation of the ability to meet the waste acceptance requirements of the treatment facility could not be performed without re-characterizing the waste.*

This requirement is applicable to all low-level waste in storage. Low-level waste with no identified path to disposal may be stored for extended periods of time pending the development of a disposal option. The characterization and waste container information must be maintained and retrievable regardless of the storage period.

The waste characterization and container information on waste in storage needs to be managed as a Federal record. The guidance on Waste Transfer (DOE M 435.1-1, Section IV.K) discusses the essential information elements relative to waste containers. Upon disposal of the waste the records are to be maintained as permanent records. DOE information management experts should be consulted for execution of this requirement.

> *Example: A low-level waste storage facility uses information management specialists to maintain a compliant records management system. In addition, training is provided that defines and addresses the procedures concerning the creation, collection, use, documentation, dissemination and disposition of records concerning the low-level waste.*

Compliance with this requirement is demonstrated by documented procedures for managing waste characterization and container information on low-level waste as a Federal record. The records are managed per the applicable polices and procedures for records management referenced in DOE O 200.1 and established at the applicable Field Element.

Supplemental References:

1. DOE, 1996. *Information Management Program,* DOE O 200.1, U.S. Department of Energy, Washington D.C., September 30, 1996.

IV. N.(5) Container Inspection. A process shall be developed and implemented for inspecting and maintaining containers of low-level waste to ensure container integrity is not compromised.

Objective:

The objective of this requirement is to prevent or minimize the potential exposure of workers and release of radioactive contamination to the environment that could result from allowing low-level waste containers to degrade. The requirement is intended to ensure that the containment function of the waste containers is routinely evaluated and action taken to ensure the waste remains contained.

Discussion:

The containment of low-level waste in containers is essential for its safe and effective management. During the development of the *Radioactive Waste Management Manual* (DOE M 435.1), inadequate or substandard waste containers and deterioration of containers of waste were identified as conditions that could result in the loss of waste containment and potentially impact workers, the public, or the environment. The General Requirements of the *Radioactive Waste Management Manual* (DOE M 435.1-1) assign the Field Element Manager responsibility to ensure all waste is stored in a manner that protects the integrity of the waste for the expected time of storage (Section I.2.F.(13). The responsibility for providing adequate storage that protects the integrity of waste containers is complemented by this requirement to routinely inspect the containers and correct any conditions of deterioration. This is particularly important for low-level waste that is to be in relatively long-term storage (e.g., waste for which a disposal facility is not identified). This requirement applies to all storage of low-level waste, not just storage performed at a designated storage facility.

Example: An incineration facility stages waste awaiting treatment. The treatment facility has established operational procedures for the frequent physical examination of

all waste containers. If containment of the waste is jeopardized their procedures are available for repackaging the waste, or repair of the waste containers.

Inspection. The inspection and corrective action process is intended to ensure that container integrity is maintained throughout the storage or staging period. The process needs to be tailored to the storage situation. Ideally, the storage configuration would allow visual or remote inspections of the outsides of waste containers. The inspection needs to look for:

- general condition of the waste container, such as areas of rust, scratches, and minor dents. The inspection process includes an evaluation of minor surface conditions as to their impact on the integrity of the container. Such conditions may not require action, but should be noted and corrected if there is a trend indicating eventual deterioration;

- functioning of the waste container closures, in place, and securely fastened;

- evidence of leakage, which may indicate unacceptable materials in the waste, inadequate internal packaging materials, (insufficient absorbent), or failure of the container;

- evidence of structural problems with the waste container such as buckling or split seams;

- bulging of the waste container indicating build up of pressure in the container, which may indicate inappropriate storage conditions (e.g., storing tightly sealed waste containers where they are subject to excessive heating), a condition inside the container that needs to be remediated, and the need to replace the container; and

- examination of waste container marking and labeling to ensure that they are maintained in a legible condition.

Example: Low-level waste is stored in rows two drums wide and two drums high with an aisle between the rows. The site procedure call for an operator to inspect the condition of the drums every two weeks and record any potentially adverse conditions.

Some older storage configurations (e.g., dense pack storage where there are multiple rows and layers of waste containers without access space between them) may not allow direct visual inspection. In such cases, the “inspection” may need to be done using remote or indirect techniques. Remote techniques include the use of video cameras which provide real time or recorded displays of waste containers which are not accessible for direct inspection. Indirect

methods include the use of radiation detectors to determine when a waste container has failed. To the extent possible, direct remote visual inspections are to be used in preference to indirect methods since indirect methods force the inspection and maintenance process into a reactive mode of fixing problems once they have occurred (as detected by an increase in radioactive contamination) rather than a proactive mode of preventing breaching of the waste containers.

> *Example: Drums stored in a dense pack array are in a building that has a continuous air monitor. To ensure adverse waste container conditions are detected as soon as practical, additional monitoring is performed on a routine basis. The additional monitoring involves the use of radiation detectors on extension probes to reach inside the array and a similar use of swabs to check for loose contamination within the array.*

Waste containers are to be physically examined on a routine basis to ensure that storage conditions have not caused the integrity of the container to be compromised. Waste containers that exhibit serious deterioration and a potential for containment of the waste to be jeopardized may need to be replaced.

> *Example: During the routine inspection of waste drums conducted every 30 days at a staging area a drum was identified as possibly damaged. Upon detailed examination, it was determined that a forklift had punctured the waste drum. The waste was repackaged and the old drum removed from service.*

Maintenance. The process for waste container maintenance should include capabilities for preventive actions as well as for corrective actions. Preventive actions would address minor conditions associated with ensuring waste containment. Actions might include cleaning and painting small areas on metal containers to curb corrosion that could eventually lead to compromising the container. The maintenance process also provides capabilities to respond to more serious conditions up to and including breaching of the container (e.g., from accidental puncture or corrosion).

Maintenance of a container(s) in response to acute conditions (i.e., conditions where there is a release or imminent threat of a release) needs to provide for prompt containment of the release, assessment of the situation, and remedying the situation. The immediate response is to ensure that release of contamination is controlled. Actions may be as simple as replacing a bolt and or closure ring on a drum, or covering a hole in a container with tape. More serious conditions may require placing the waste container in a catch tray or in an overpack. An assessment of the condition causing the breach or potential breach needs to be part of the process so that, if necessary, the causative factors can be corrected. If corrosion is affecting the waste container, the reason for the corrosion needs to be determined so an effective response can be made. If there is a corrosive material in the waste container, overpacking may only temporarily correct the problem. In such situations, it may be more appropriate to treat the waste or to provide a liner

that is resistant to corrosion. If there is buckling of the waste container or split seams, an assessment needs to be made of whether the contents are too heavy, whether the container is improperly designed, or whether the container was mishandled (e.g., dropped). In cases where an external event is the cause of the damage (e.g., a waste container is dropped or struck by equipment), repackaging or overpacking in a similar container may be appropriate.

> *Example: The inspection process in a storage facility identified a waste drum that was corroding even though the container was stored in acceptable conditions and the paint on the drum was in good shape. Storage facility personnel recognized that there was a need to investigate whether the contents of the container caused the corrosion. Evaluation of the container contents confirmed that the waste included a corrosive material. The waste was treated to neutralize the corrosion then repackaged in a similar container.*

The term maintenance does not imply that refurbishment of deteriorating waste containers is required. The premise of this requirement is that potential doses to workers is avoided. Therefore, overpacking may be the most appropriate action as opposed to a repackaging action requiring excessive handling of the waste and possible exposure.

Compliance with this requirements is demonstrated by: (1) a documented process for waste container inspection and maintenance; and (2) documentation for all waste container inspections and maintenance actions performed.

IV. N.(6) Storage Management. Low-level waste storage shall be managed to identify and segregate low-level waste from mixed low-level waste.

Objective:

The objective of this requirement is to prevent the commingling of low-level waste with mixed low-level waste.

Discussion:

The management of mixed low-level waste represents challenges not typically encountered with the management of low-level waste. The additional requirements imposed for the management of the hazardous constituent can represent additional management effort over that which is required for the radiological constituent. By identifying and segregating the two waste types, the amount of mixed low-level waste generated will be minimized and the effort and resources required to achieve final disposition of the waste will be minimized. Historical problems and current storage

conditions exist which indicate that a formal requirement to prevent the commingling of waste types is warranted.

> *Example: During the decontamination and decommissioning of an old laboratory a small quantity of mixed low-level waste is placed in a large wooden box with low-level waste. Segregation of the waste types is not done because it is believed that the waste will have to be repackaged for treatment in the near future. While in storage, the small amount of mixed low-level waste commingles with the rest of the waste in the wooden box. The entire contents of the wooden box must now be managed as mixed low-level waste.*

The management polices and procedures for the storage of all low-level waste need to address the identification of mixed low-level waste. Identification of mixed low-level waste needs to occur prior to the waste being placed in storage. The requirements that personnel must follow in managing (i.e., generating, transporting, treating, storing, or disposing) mixed low-level waste are primarily in 40 CFR Parts 260 through 270, or similar state regulations (see Section IV.B of this guidance).

The management polices and procedures for the storage of all low-level waste need to address the segregation necessary to avoid commingling the waste types. The segregation should be a combination of physical and procedural requirements.

> *Example: Low-level waste and mixed low-level waste is stored in the same building. Procedures have been established to prevent the waste types from coming in contact with each other. In addition, physical markers such as lines on the floor and rope barriers are in place to prevent inadvertent contact between the waste types. The entire system is based on the proper marking and labeling of the waste containers.*

Compliance with this requirement is demonstrated by: (1) a documented process for identifying mixed low-level waste in storage; and (2) documented operating procedures that prevent the storage of low-level waste in the same immediate area as mixed low-level waste.

Supplemental References:

1. DOE, 1996. *Complex-Wide Review of DOE's Low-Level Waste Management ES&H Vulnerabilities*, DOE/EM-0280, U.S. Department of Energy, Washington, D.C., May 1996.

2. EPA. *Standards for Owners and Operators of Hazardous Waste Treatment Storage and Disposal Facilities*, 40 CFR Part 264, U.S. Environmental Protection Agency, Washington, D.C.

IV. N.(7) Staging. Staging of low-level waste shall be for the purpose of the accumulation of such quantities of waste as necessary to facilitate transportation, treatment, and disposal. Staging longer than 90 days shall meet the requirements for storage above and in Chapter I of this Manual.

Objective:

The objective of this requirement is to allow for the safe temporary accumulation of low-level waste to facilitate its management without the accumulation being considered storage and thus bound by the associated requirements for storage.

Discussion:

The storage of low-level waste is an important function required for the effective management of low-level waste. The storage of low-level waste is defined as the collection and management of waste for the purpose of awaiting treatment or disposal capacity, in such a manner as to not constitute disposal of the waste. During the development of the requirements in DOE M 435.1-1, it was recognized that storage of waste for short periods does not require the same controls that storage of low-level waste for longer periods would require. A distinction between storage for less than 90 days and storage for periods greater than 90 days was made when the less-than-90 day storage is for the temporary accumulation of low-level waste to facilitate transportation, treatment, or disposal. This temporary action is referred to as staging, and is usually associated with a subsequent management step such as treatment or disposal. The term staging helps provide a distinction from "storage" in order to know when to apply the needed extra controls that are necessary when the waste is stored.

The 90-day period was chosen as a result of the requirements analysis conducted in developing the Manual to be consistent with best management practices as reflected in the management of hazardous waste in accordance with RCRA requirements. Since this time frame is already being adhered to for mixed low-level waste, extending this to all low-level waste is prudent and should not be overly burdensome to facility operations.

The staging of low-level waste should be considered an action that is primarily for the benefit of achieving the next management step for the waste safely and cost-effectively. For example, staging could include the accumulation of low-level waste by:

- a generator prior to shipment to a receiving facility;
- a treatment facility prior to treatment;
- a treatment facility following treatment; or

- a disposal facility prior to emplacement of the waste.

The staging of low-level waste needs to be addressed in the radioactive waste management basis for the facility that is performing the staging. Generators, treatment facilities, and disposal facilities that stage waste must ensure that the action of staging is included and authorized as part of their radioactive waste management basis for the affected facilities, operations, or activities.

Determination of the 90-day time limit shall be based on the date the waste is generated or treated and the date the waste was received at a treatment or disposal facility. The information regarding the dates for determination of staging periods needs to be documented consistent with the requirement for transfer of the waste, DOE M 435.1-1, Section IV.K.

As the one-year limit for storage, the intent of this requirement is not that a focus be placed on the compliance or non-compliance with the 90-day limit. The requirement is not intended to force shipment of low-level waste when the 90-day period is reached, or to cause additional handling of low-level waste that would result in increased risk or safety concerns. Rather, the intent of this requirement is to focus attention of managers at the site towards ensuring that waste is being managed to disposal under reasonable time frames. The requirement calls for accumulation of waste longer than 90 days to be subject to the storage requirements in Chapter I and IV of the *Radioactive Waste Management Manual* (DOE M 435.1-1). Staging longer than 90 days must be justified, the conditions for such storage met, and these practices approved by the Field Element Manager as part of the radioactive waste management basis for the facility.

There needs to be flexibility in the implementation of this requirement due to the complexities of management of low-level waste and the unpredictability of events as they affect planned operations. Thus, malicious compliance with the 90-day limit is not necessary, nor is it intended that no additional "staging" time can be allowed past the 90 days.

Example 1: Drums accumulating in an area awaiting shipment to a disposal facility for less than 90 days is identified as staging and is included in the radioactive waste management basis of the facility holding the waste.

Example 2: The drums described above are held for a period of 125 days. The Field Element Manager has evaluated the conditions at the facility and approves this period of time for staging in the radioactive waste management basis of the facility because the requirements for storage are being met.

Example 3: Some of the drums described above do not get loaded in the shipment that takes place at the end of the 125 days. This is a non-compliance. The radioactive waste management basis needs to include the rationale for storage of drums not picked up in

the accumulated amount and the conditions for their storage. One of the conditions is that the one-year storage limitation clock has already had 125 days expire.

Example 4: Low-level waste is accumulated at a treatment facility prior to repackaging and treatment. Typically, the total time waste is held before and after treatment is less than 90 days. However, certain treatment campaigns require the staging of waste at the facility for a longer period of time. The treatment facility has an approved radioactive waste management basis that includes contingency storage for these circumstances and includes meeting the applicable requirements for storage.

Compliance with this requirement is demonstrated by a staging program that limits the temporary storage of waste to only circumstances allowed in the requirement, including justifications for any staging that exceeds the 90-day period, which is documented in the radioactive waste management basis for the facility.

Supplemental References: None.

IV. O. Treatment.

Low-level waste treatment to provide more stable waste forms and to improve the long-term performance of a low-level waste disposal facility shall be implemented as necessary to meet the performance objectives of the disposal facility.

Objective:

The objective of this requirement is to ensure low-level waste is treated to meet disposal facility waste acceptance criteria, to achieve greater stability of the disposal site, and for a greater level of assurance that the disposal performance objectives are met.

Discussion:

During the development of DOE O 435.1 and DOE M 435.1-1, treatment of waste was identified as an activity that presented potential risks to the public, workers, and the environment. The hazards and requirements analyses identified certain characteristics of radioactive waste that would be unacceptable for long-term storage, leading to the need for treatment of such waste prior to its acceptance for storage. Several existing external regulations (e.g., *Clean Air Act* or RCRA) or other requirements (e.g., 10 CFR Part 835, *Occupational Radiation Protection* or DOE O 360.1, *Training*) were found to already address requirements pertaining to weaknesses and conditions that could potentially lead to adverse impacts. Consequently, the *Radioactive Waste Management Manual* DOE M 435.1-1, Section I.2.F.(14) assigns the Field Element Manager an umbrella, performance-oriented responsibility for ensuring that waste treatment is protective of the public, workers, and the environment. Treatment can also affect low-level waste disposal technologies and requirements. This requirement focuses attention on the treatment of low-level waste necessary to make waste acceptable for disposal.

The low-level waste treatment actions necessary to make waste acceptable for storage and disposal can be driven by dictated external requirements or requirements established by waste acceptance criteria. Waste acceptance requirements for a storage or disposal facility, established based on safe handling of the waste and on regulatory compliance, include minimum waste form characteristics and requirements for stability and other characteristics to enhance their performance. Treatment may range from actions as simple as sorting waste to remove materials which would make the waste unacceptable (e.g., aerosol cans) to solidification or vitrification.

Low-level waste may also be treated for programmatic needs. Programmatic needs include treatment to reduce the use of disposal capacity or to provide an additional protective barrier during transportation or storage of a controversial waste prior to its disposal.

Improved Waste Forms and Characteristics. The requirements for treatment of low-level waste are driven by the need for an improved waste from that provides additional protection while it is in storage or following its disposal. Minimum characteristics of waste that must be specified in disposal facility waste acceptance requirements are at DOE M 435.1-1, Sections IV.G.(1) (a) through (c). Characteristics of waste that are prohibited for waste going into storage are at DOE M 435.1-1, Section IV.N.(1). In order to meet the waste acceptance requirements derived and specified for these performance oriented requirements at storage and disposal facilities, some physical or chemical stabilization may need to be performed. Some minimum waste form requirements specific to low-level waste disposal facilities are at DOE M 435.1-1, Section IV.G.(1)(d). The disposal facility waste acceptance requirements provide for improved waste characteristics and waste forms, and low-level waste that cannot meet these minimum waste form requirements must be treated to meet the requirement prior to disposal. Liquid, pyrophoric, gaseous, infectious, toxic, and explosive wastes, must be treated prior to disposal to meet the minimum waste form requirements of a disposal facility. Guidance for the waste acceptance requirements provides discussions that can assist in the development of processes that will result in waste forms and packaged waste with the desired characteristics.

> *Example 1: Low-level waste consisting of contaminated metal turnings and fines is produced from a process at the Site G Fuel Fabrication Plant. An analysis indicates this waste is pyrophoric. A process is implemented at the Fuel Fab Plant to oxidize the turning and fines and add grout to packages to stabilize the material prior to shipment for disposal.*

> *Example 2: Low-level waste containing small amounts of volatile materials must be stored in Building 500 at the Brown Site. Building 500 is susceptible to high temperatures in the summer months, and it is unknown how long the waste must remain in storage. The waste is treated with a neutralizing agent and a solidification media prior to acceptance at the storage facility.*

Besides the prohibited storage characteristics specified in DOE M 435.1-1, Section IV.N.(1) and the minimum disposal waste form criteria that are specified in DOE M 435.1-1, Section IV.G.(1)(d), additional technical criteria for physical and chemical stability, waste compressibility, acceptable waste forms, liquid content, and other parameters may be specified by a specific facility's waste acceptance requirements. These criteria are based on safety considerations derived from the waste management facility safety documentation, or performance considerations derived from the performance assessment and composite analysis for a low-level waste disposal facility. The treatment processes and facilities must be developed and designed so that the desired waste form and characteristics are achieved with the treated waste form.

> *Example: The disposal facility at Site Q requires waste in the form of incinerator ash to be solidified. A solidification process is designed and installed as part of the Central*

Incineration Facility at Site Y to solidify incinerator ash with an approved grout in 55 gallon drums prior to shipping to Site Q for disposal.

Meeting Disposal Facility Performance Objectives. The requirement at DOE M 435.1-1, Section IV.G.(1)(a) calls for the establishment of acceptable activities or concentrations of specific radionuclides as determined by safety analyses, technical safety requirements, performance assessments, or composite analyses. As discussed in the guidance on meeting waste acceptance requirements, acceptable radionuclide activities or concentrations established through the performance assessment contribute to providing reasonable assurance that the performance objectives of a low-level waste disposal facility will be met. As discussed in that guidance, additional waste form stability requirements could be applied to some wastes with certain radionuclides to establish higher allowable activities or concentrations. As with the minimum waste form and characteristics requirements, treatment processes and facilities must be developed and designed so that the desired waste form and characteristics are achieved with the treated waste form. In the case of additional waste stability requirements that allow for higher allowable concentrations or activities of radionuclides, the desired waste form may need to last a significant period of time (e.g. 300 years) in order for there to be reasonable assurance that disposal performance objectives are met. In order for there to be confidence that a treated waste form will last for the desired period of performance, stringent controls on parameters will be necessary in the operation of whatever treatment process is developed and designed.

Example: A waste stream, composed primarily of long-lived actinides with the highest radionuclide concentrations being associated with ^{235}U and ^{238}U, is proposed for disposal at Site X. An evaluation of the results of the performance assessment and composite analysis engenders concern in some stakeholders about intruder protection and the assumptions used in the performance assessment. A treatment method is developed for this waste stream which results in a final waste form of a low grade glass shaped in rectangular blocks sized to fit tightly within approved boxes for burial at Site X at the bottom of waste disposal units. This treatment and disposal method creates a durable waste form for the long-term and satisfactorily addresses the concern regarding intruder protection.

Waste with No Path to Disposal. For waste that does not have an identified path to disposal, waste may need to be treated so the waste can be stored for an indefinite period of time. Some of the same considerations (i.e, physical or chemical stability, reducing liquids) need to be taken into account for the indefinite storage of waste. Treatment of waste that does not have a path to disposal must occur only after an analysis has been conducted that ensures the resultant waste form will not add to the no path forward condition. The proposed treatment needs to provide a reasonable assurance that the waste does not contribute to additional volumes of waste with no path to disposal. The analysis and justification needs to be part of the life-cycle planning

performed per the requirement for a Site-Wide Radioactive Waste Management Program, DOE M 435.1-1, Section I.2.F.(1).

The requirement to treat waste to meet the waste acceptance criteria of the appropriate storage or disposal facility is not intended to prohibit treatment for other reasons. Waste managers may elect to treat waste for programmatic reasons, but in so doing, must ensure that the waste will still meet the waste acceptance criteria of the facility(ies) to which it will be transferred, and ultimately for disposal.

Mixed Low-Level Waste. Treatment necessary to comply with agreements reached pursuant to the *Federal Facility Compliance Act of 1992* must be considered in making treatment decisions concerning mixed low-level waste. Site personnel need to ensure that commitments made in the Site Treatment Plans are met for both current and newly-generated low-level wastes. To the extent that other low-level waste streams could benefit from the same treatment as specified in the Site Treatment Plans, treating these wastes along with the mixed waste streams is included in the life-cycle waste management planning in the Site-Wide Radioactive Waste Management Program to ensure the most efficient waste management processing.

Compliance with this requirement is demonstrated when a treatment facility or process ensures that treated waste will meet the minimum waste form requirements of DOE M 435.1 and meet additional disposal facility-specific waste acceptance requirements for additional stability or long-term performance of facilities that will receive the treated waste.

Supplemental References:

1. *Resource Conservation and Recovery Act of 1976,* as amended, October 21, 1986.

2. *Federal Facility Compliance Act of 1992,* as amended, October 6, 1992.

IV. P. Disposal.

Low-level waste disposal facilities shall meet the following requirements.

(1) Performance Objectives. Low-level waste disposal facilities shall be sited, designed, operated, maintained, and closed so that a reasonable expectation exists that the following performance objectives will be met for waste disposed of after September 26, 1988:

(a) Dose to representative members of the public shall not exceed 25 mrem (0.25 mSv) in a year total effective dose equivalent from all exposure pathways, excluding the dose from radon and its progeny in air.

(b) Dose to representative members of the public via the air pathway shall not exceed 10 mrem (0.10 mSv) in a year total effective dose equivalent, excluding the dose from radon and its progeny.

(c) Release of radon shall be less than an average flux of 20 pCi/m^2/s (0.74 Bq/m^2/s) at the surface of the disposal facility. Alternatively, a limit of 0.5 pCi/1 (0.0185 Bq/l) of air may be applied at the boundary of the facility.

Objective:

The objective of these requirements is to ensure that all phases of low-level waste disposal (i.e., facility siting and design, operations, maintenance, and closure) are conducted in a manner that will result in a reasonable expectation that the disposal performance objectives will be met. The performance objectives are specific objectives that quantify, where possible, the desired protection of the public and the environment from disposed low-level waste.

Discussion:

As discussed in Section I.2.F.(15) of the guidance for Chapter I, General Requirements, the Field Element Manager is responsible for ensuring that low-level waste is disposed in a manner that protects the public, workers, and the environment. This protection needs to be afforded during all phases of the life of the low-level waste disposal facility, namely operations, closure, and post-closure. Since actual compliance with protection requirements for disposal of waste cannot be made before events occur, a prediction must be made of a disposal facility's capability of affording the required protection to decide whether waste will indeed be disposed safely. The performance objectives listed in this requirement provide criteria that define the desired level of protection of

the public and the environment from disposed low-level waste that leads to a comfort level that, when actually measured sometime in the future, compliance with real protection requirements will be easily achieved. Real-time worker protection is not a future concern, and is adequately defined in 10 CFR Part 835 and discussed in the guidance on DOE M 435.1, Section I.1.E.(13). The application of the performance objectives to waste disposed after September 26, 1988 coincides with the first issuance of DOE's requirement that performance assessments be prepared, and represents no change from existing requirements in DOE 5820.2A.

The performance assessment and composite analysis conducted on the disposal facility provide the reasonable expectation that the performance objectives will be met by establishing parameters, limits, and controls on the siting, design, operations, maintenance, and closure of the facility in order for there to continue to be an expectation that the criteria delineated in the objectives are met. The following guidance sections discuss the performance objectives for low-level waste disposal.

Disposal of low-level waste must be conducted in a manner that is protective of the public and the environment. The Department's requirements for radiological protection of the public and the environment are detailed in DOE 5400.1 and DOE 5400.5. These requirements apply to all activities at a DOE site. Consistent with established radiation protection practices articulated by the National Council on Radiation Protection (NCRP) and the International Council on Radiation Protection (ICRP), the projected dose attributable to any single source, practice, or activity should be some fraction less than the applicable overall dose limit. Depending on the particular source of concern, DOE, EPA, and the NRC have typically established limits of 10 to 25 percent (10 mrem [.10 mSv] to 25 mrem [.25 mSv]) of the primary dose limit for protection of the public (100 mrem [1 mSv]/year) to any particular source, although higher or lower fractions may be appropriate. The DOE performance objectives for low-level waste disposal are established with the goal of assuring that the single practice of low-level waste disposal will not consume more than 25 percent of the overall objective for protection, which is the primary dose limit of 100 mrem (1 mSv) in a year to members of the public.

Radioactive material contained in low-level waste will, over time, tend to migrate through environmental media. Because of the site-specific nature of such migration and potential eventual exposure to the public, the three specific performance objectives (a), (b), and (c), are defined to protect the public from all potential exposure pathways.

Impacts of low-level waste disposal on the public or the environment may not be realized until hundreds or thousands of years after the disposal facility has been closed. Due to the lengthy time-frame under consideration and the reliance on modeling of complicated natural processes, it is difficult to reliably predict impacts on the public or the environment. Therefore, it is not possible to provide absolute proof of a disposal facility's performance at some future time. Rather than proof, the requirement is stated in terms of a reasonable expectation. DOE M 435.1-

1 requires that a radiological performance assessment be prepared to provide a reasonable expectation that the performance objectives will not be exceeded. The performance assessment is an analysis of physical and chemical mechanisms that control the migration of radioactive materials through the environment to points of potential human exposure; it includes activities that future members of the public may conduct (e.g., drinking water, recreational activities) that could potentially result in exposure to the radioactive material.

Guidance for each specific performance objective is discussed in the following paragraphs.

All-Pathways Performance Objective. As noted above, consistent with established radiation protection practices articulated by the NCRP and ICRP, the projected dose attributable to any single source, practice, or activity should be some fraction less than the applicable overall dose limit. Depending on the particular source of concern, DOE, EPA, and the NRC have typically established limits of 10 to 25 percent (10 mrem [.10 mSv] to 25 mrem [.25 mSv]) of the primary dose limit for protection of the public (100 mrem [1 mSv]/year) to any particular source, although higher or lower fractions may be appropriate. This performance objective is used to provide a reasonable expectation that members of the public will not receive more than 25 percent of the primary dose limit of 100 mrem (1mSv) in a year from the disposal of low-level waste. The requirement is inclusive of all potential exposure pathways (e.g., groundwater, surface water, air) except for dose from radon and its decay products for which a separate performance objective is stated.

All pathways include any and all modes by which a receptor at the point of presumed public access (see discussion on point of compliance in guidance for DOE M 435.1-1, Section IV.P.(2)(b)) could be exposed to radioactive material migrating, via any and all environmental media (e.g., water, soil, biota, air), from the disposed waste. Per normal radiological protection practice, radon and its decay products are considered separately from other radionuclides. Even though a separate performance objective is established for the air pathway, the air pathway is, nevertheless, included in the all pathways dose calculation.

The performance objective is stated in terms of dose to representative members of the public to indicate that overly conservative assumptions are not made of the age, sex, or assumed activities of persons. The performance objectives are generally applied, through the performance assessment process, to hypothetical future members of the public, rather than to known and identified individuals.

Air-Pathway Objective. This performance objective requires a reasonable expectation that members of the public will not receive, via the air pathway alone, more than 10 mrem in a year, excluding the dose from radon and its progeny. This objective is drawn from the Environmental Protection Agency (EPA) National Emission Standards for Hazardous Air Pollutants (40 CFR Part 61, Subpart H). Consistent with 40 CFR Part 61, Subpart H, dose from radon and its

progeny are not included in assessing compliance with this performance objective. It should be recognized that the 10 mrem in a year limit is for all sources on the DOE site, not just from the disposal facility.

Radon Dose Objective. This performance objective requires a reasonable expectation that radon, either as a constituent of waste at the time of disposal or produced by radioactive decay following disposal, is not released from the disposal facility at a rate that would exceed the limit established in 40 CFR Part 61, Subpart H. Compliance with this performance objective, via the performance assessment, could address either of the two limits contained therein. The rate of radon release, over time, from the surface of the disposal facility could be projected for comparison with the flux limit. Alternatively, the concentration of radon in air could be projected for comparison with the concentration limit. In most cases, the ground surface emanation rate of 20 $pCi/m^2/s$ should be applied. However, in cases where the disposed waste radiologically resembles uranium or thorium mill tailings, the limit on air concentration may be warranted. Alternatively, doses from radon and progeny may be included in the assessment of compliance versus the 10 mrem in a year air pathway objective. In this case, assuming that compliance with the 10 mrem in a year dose limit is projected, radon need not be addressed separately.

Compliance with this requirement is demonstrated by the performance assessment for the disposal facility including documented conclusions that there is a reasonable expectation that the three performance objectives will be met at the facility.

Supplemental References:

1. DOE, 1996. *Interim Format and Content Guide, and Standard Review Plan for U.S. Department of Energy Low-Level Waste Disposal Facility Performance Assessments,* U.S. Department of Energy, Washington, D.C., October 1996.

2. DOE. *Format and Content Guide for U.S. Department of Energy Low-Level Waste Disposal Facility Performance Assessments and Composite Analyses,* DOE G 435.1-1, U.S. Department of Energy, Washington, D.C. (Under preparation.)

IV. P.(2) Performance Assessment. A site-specific radiological performance assessment shall be prepared and maintained for DOE low-level waste disposed of after September 26, 1988. The performance assessment shall include calculations for a 1,000 year period after closure of potential doses to representative future members of the public and potential releases from the facility to provide a reasonable expectation that the performance objectives identified in this Chapter are not exceeded as a result of operation and closure of the facility.

(a) Analyses performed to demonstrate compliance with the performance objectives in this Chapter, and to establish limits on concentrations of radionuclides for disposal based on the performance measures for inadvertent intruders in this Chapter shall be based on reasonable activities in the critical group of exposed individuals. Unless otherwise specified, the assumption of average living habits and exposure conditions in representative critical groups of individuals projected to receive the highest doses is appropriate. The likelihood of inadvertent intruder scenarios may be considered in interpreting the results of the analyses and establishing radionuclide concentrations, if adequate justification is provided.

(b) The point of compliance shall correspond to the point of highest projected dose or concentration beyond a 100 meter buffer zone surrounding the disposed waste. A larger or smaller buffer zone may be used if adequate justification is provided.

(c) Performance assessments shall address reasonably foreseeable natural processes that might disrupt barriers against release and transport of radioactive materials.

(d) Performance assessments shall use DOE-approved dose coefficients (dose conversion factors) for internal and external exposure of reference adults.

(e) The performance assessment shall include a sensitivity/ uncertainty analysis.

(f) Performance assessments shall include a demonstration that projected releases of radionuclides to the environment shall be maintained as low as reasonably achievable (ALARA).

(g) For purposes of establishing limits on radionuclides that may be disposed of near-surface, the performance assessment shall include an assessment of impacts to water resources.

(h) For purposes of establishing limits on the concentration of radionuclides that may be disposed of near-surface, the

performance assessment shall include an assessment of impacts calculated for a hypothetical person assumed to inadvertently intrude for a temporary period into the low-level waste disposal facility. For intruder analyses, institutional controls shall be assumed to be effective in deterring intrusion for at least 100 years following closure. The intruder analyses shall use performance measures for chronic and acute exposure scenarios, respectively, of 100 mrem (1 mSv) in a year and 500 mrem (5 mSv) total effective dose equivalent excluding radon in air.

Objective:

The objective of these requirements is to ensure that all aspects of low-level waste disposal (i.e., facility siting and design, operations, maintenance, and eventual closure) are analyzed in a performance assessment to provide a reasonable expectation that the disposal performance objectives will be met.

Discussion:

Impacts of low-level waste disposal on the public or the environment may not be realized until hundreds or thousands of years after the disposal facility has been closed. Consequently, potential effects of low-level waste disposal must be calculated by simulating the various chemical and physical processes that govern migration of waste constituents through the environment to locations where future members of the public may be exposed. The calculation must also include assumptions regarding the activities that future persons may engage in that would result in exposure. The performance assessment process is used as a management tool to provide assurance that waste disposal is not likely to result in future exceedance of the performance objectives discussed in DOE M 435.1-1, Section IV.P.(1).

September 1988 Date. The performance assessment includes in its analysis only waste disposed after September 26, 1988. This date was the effective date of DOE 5820.2A which is superseded by DOE O 435.1 and DOE M 435.1-1. With the issuance of DOE 5820.2A, DOE established controls over the disposal of low-level waste similar to those contained in 10 CFR Part 61, *Licensing Requirements for Near Surface Disposal of Radioactive Waste*. Rather than attempting to apply these controls retroactively to former waste disposal, the Department assumed that under CERCLA or NEPA it would address past disposal facilities, while all current and future controls and requirements would be applied to post-September 1998 waste.

Reasonable Expectation. Certainty of compliance with performance measures or absolute proof of a disposal facility's adequate performance at some future time is not possible. Rather, DOE M

435.1-1 requires that the radiological performance assessment be prepared to provide "a reasonable expectation" that the performance objectives will not be exceeded. The performance assessment process is used to aid siting, design, and operations of the low-level waste disposal facility. Results of the performance assessment are used to specify details of design (e.g., depth of disposal units, thickness of concrete), operational controls such as waste acceptance criteria, and/or closure requirements to ensure that the low-level waste disposal performance objectives will continue to be met. The intent of the reasonable expectation standard is to provide a demonstration that, considering the uncertainties in engineered and natural systems over long time periods, the actual performance will comport with its design. The intent is to produce a reasonable analysis that evaluates the entire disposal system rather than focusing too much on the conservatism of any one individual element of the system.

Compliance Time Period. The performance assessment is to consider a period of 1,000 years, after the disposal facility has been closed, to assess compliance with the performance objectives. This time is selected to encompass the likely processes and migration of radionuclides most likely to contribute to the calculated dose. Longer times of assessment are not used to assess compliance because of the inherently large uncertainties in extrapolating such calculations over long time frames.

This requirement also includes the provision for review and approval of the performance assessment by DOE Headquarters. As discussed in guidance on DOE M 435.1-1, Section I.2.E.(1), the Deputy Assistant Secretaries for Waste Management and Environmental Restoration have the responsibility for reviewing and approving performance assessments for low-level waste disposal facilities and issuing a disposal authorization statement. The guidance on DOE M 435.1-1, Section I.2.E.(1) discusses the review and approval process in detail.

The improvement of performance assessments and their subsequent compliance reviews and approvals has been the aim of much of the revisions to low-level waste management resulting from Defense Nuclear Facilities Safety Board Recommendation 94-2. Consequently, detailed guidance on conducting performance assessments is being developed for inclusion in DOE G 435.1-1, *Format and Content Guide for U.S. Department of Energy Low-Level Waste Disposal Facility Performance Assessments and Composite Analyses*. That document needs to be consulted for additional detailed discussions of the performance objectives, preparation of a performance assessment, and the interpretation of assumptions and other technical information and evaluations contained in a performance assessment. The requirement to do a performance assessment is augmented in DOE M 435.1-1 with the specific individual requirements ((a) through (h)) that limit and define the scope and content of the analysis in the performance assessment. These seven requirements ensure that certain aspects of the analysis are not left out, consider standard methodologies and parameters, and lead to certain conclusions so that controls on waste acceptance and disposal operations are defined appropriately. Guidance for each of these seven specific requirements is discussed below. As just mentioned, detailed guidance on conducting

performance assessments will be contained in DOE G 435.1-1, *Format and Content Guide for U.S. Department of Energy Low-Level Waste Disposal Facility Performance Assessments and Composite Analyses*. That document needs to be consulted for additional detailed discussions of these seven technical criteria that must be used in preparation of a performance assessment.

Reasonable Activities of the Critical Group. Performance assessment analyses should be based on reasonable activities of the portion of the exposed population likely to receive the highest dose (i.e., the critical group). However, the performance assessment analyses should not be based on "worst-case" assumptions. Rather, the analyses should be based on scenarios that represent reasonable actions of a typical group of individuals performing activities that are consistent with regional social customs, work, and housing practices, and expected regional environmental conditions at the time of the exposure scenario, and who are members of the critical group expected to receive the highest doses.

> *Example: The Site X performance assessment does not include a large-scale farming scenario because of the arid climate and the poor quality of soil prevalent in the area of the site.*

Point of Compliance. The initial assumption, or point of departure, for point of compliance in DOE M 435.1-1 for performance assessments is the point of highest projected dose or concentration beyond a 100 meter buffer zone. This is the point(s) in space, relative to the disposed waste, where the performance assessment is to provide a reasonable expectation of compliance with the performance objectives.

The concept of a buffer zone is inherent in defining a low-level waste disposal facility. The disposal facility is comprised of a number of disposal units (e.g., earthen trenches, tumuli, vaults), the space between disposal units, and space around the collection of disposal units. This latter space is called the buffer zone. The buffer zone provides some radionuclide containment capability, as well as controlled space to establish monitoring locations and, as necessary, modify or supplement the design of the disposal facility. Consistent with established radiation protection practices articulated by the National Council on Radiation Protection (NCRP) and the International Council on Radiation Protection (ICRP), the projected dose attributable to any single source, practice, or activity should be some fraction less than the applicable overall dose limit. Depending on the particular source of concern, DOE, EPA, and the NRC have typically established limits of 10 to 25 percent (10 mrem [.10 mSv] to 25 mrem [.25 mSv]) of the primary dose limit for protection of the public (100 mrem [1 mSv]/year) to any particular source, although higher or lower fractions may be appropriate. Setting the extent of the buffer zone at 100 (e.g., 25 mrem [.25 mSv]) meters ensures that active and new disposal facilities do not contribute an overly large portion of the total dose projected from all sources of radiation, particularly in the absence of final decisions on land use.

The requirement provides flexibility in establishing the extent of the buffer zone considering site-specific issues. In certain instances, e.g., if the disposal facility is located adjacent to the current DOE site boundary, it may be more appropriate to use a smaller buffer zone. In other cases, e.g., where the disposal facility is located far from the DOE site boundary, and the site's land-use planning does not envision relinquishing control of the site, a larger buffer zone, potentially extending to the site boundary, could be considered. In any case, justification for the selection of the buffer zone must be provided.

The justification for the selection of the point of compliance and size of the buffer zone is based on land use plans and commitments that have been negotiated during consent agreements or other regulatory actions. If land use planning has not progressed enough for commitments to exist, the justification could also be based on published information about site boundaries in documentation such as Environmental Impact Statements. The justification could also be based on the proximity of already existing contaminated areas or nearby operational facilities that establish a boundary, or which would render the 100 meter point of compliance as unreasonable.
The buffer zone is to be established based on land use planning and commitments, a reasonable judgement concerning nearby facilities and areas of contamination, and natural borders. The buffer zone cannot be established arbitrarily, or moved to a specific distance to achieve a disposal objective, such as accommodating a large concentration of a mobile radionuclide.

> *Example: A low-level waste disposal facility is located in a quadrant of the DOE site that includes several contaminated areas and other waste management facilities. The current land use plan negotiated with stakeholders at the site, and which is incorporated by reference in the Consent Order at the site, shows this land remaining under DOE control. The buffer zone for this facility is extended out to a point about half way between the disposal facility boundary and the site boundary.*

Natural Processes. Performance assessments need to consider reasonably foreseeable natural processes that might disrupt the intended performance of the disposal facility. Natural processes such as erosion and natural events, including severe storms, tornados, and seismic events can disrupt disposal facility barriers and result in release and transport of radioactive materials.

Low-level waste disposal facilities normally incorporate a number of barriers to reduce release and transport of radionuclides from the waste. Such barriers may include, but are not limited to, the waste form itself, packaging, engineered backfill (e.g., chemical buffering, low permeability), engineered features of the disposal unit (e.g., tumuli, vaults), and the closure design. All of these will, in time, be affected by natural processes and this phenomena should be evaluated in the performance assessment. For instance, corrosion will, in time, breach most containers; environmental conditions will, in time, consume the capacity of chemical buffers, and; erosion, burrowing animals, and intrusion by plant roots will eventually breach disposal facility closure caps. Such processes are considered to be reasonably foreseeable since, absent mitigative

measures, they take place in the present. Other processes or events, although not regularly occurring, are, nonetheless, reasonably foreseeable. Such events would include severe weather such as the probable maximum precipitation event leading to the probable maximum flood, and seismic events. Other processes, such as climate change, are considered to be too speculative for consideration in the performance assessment.

Example 1: The Brown Site disposal facility is located in a corner of "tornado alley" in southern Illinois. The processes considered in the Brown Site disposal facility performance assessment includes an analysis of tornado damaging the trench cap of a high-activity trench and allowing an increase in water infiltrating into the trench.

Example 2: The performance assessment for the Brown Site disposal facility does not include the onset of an ice age in Illinois during the analysis period, however the progression of a meander of the Scott River from its current location approximately 1/4 mile away to a new location within the site boundary and will be evaluated.

Dose Conversion Factors. Dose calculations in performance assessments will use established dose conversion factors for adults (i.e., reference man). The actual dose to a particular individual from a given exposure to radioactive material (external or internal) is dependent on a number of characteristics, including age and sex. However, performance assessments are not intended to predict doses to specific individuals or classes of persons. Rather, the calculations are to represent potential exposure to hypothetical future members of the general public. In such cases, the use of standard adult dose conversion factors is indicated. As indicated, only DOE-approved dose conversion factors shall be used. The currently approved DOE dose conversion factors are in Federal Guidance Report No. 11, EPA-520/1-88-020, for internal exposure, and Federal Guidance Report No. 12, EPA-402-R-93-081, for external exposure. The *Format and Content Guide*, DOE G 435.1-1, provides additional information on the current dose conversion factors which are considered approved.

Sensitivity/Uncertainty Analysis. One of the primary goals of the performance assessment process is to provide information to demonstrate that a given waste facility complies with the applicable limits. In accordance with the existing regulatory structure, these limits are expressed in terms of dose rates that have single values. Even though the dose rate estimates provided through performance assessments may also be expressed as single values, they have associated uncertainties. For this reason, it is recommended that a discussion of these uncertainties by included in expressing he outcomes of any performance assessments conducted in conjunction with waste disposal facilities. The goal of this discussion should be to bring these uncertainties to the attention of people who may interpret the outcomes of the assessments. It is also important to note the various input parameters used in conducting the performance assessments incorporate a host of conservatisms. As a result, the doses that will be experienced by any exposed population

groups will very likely be well below the estimates generated through performance assessment process.

The performance assessment must include an assessment of the sensitivity of the results to various model assumptions and an estimate of the degree of uncertainty inherent in the analysis. The sensitivity/uncertainty analysis should include the calculation of the maximum impact of the disposal facility beyond the 1,000 year period used for the compliance period, regardless of the time at which the maximum occurs.

Projections of environmental processes are inherently uncertain. Assessment of the sensitivity of the model results to assumptions, parameter values, etc., and the uncertainty in the model results, is necessary to support the determination that there is a reasonable expectation of meeting the performance objectives. At a minimum, this needs to include identifying the parameters that have the greatest impact on the projected doses, and varying these parameters through a reasonable range of values to imitate the uncertainty of the actual value of the parameter. Confidence in the conclusions can be bolstered by this varying of the sensitive parameters if it has little impact on the final results of the calculations.

Although the period of performance (i.e., the time over which the performance assessment is to provide reasonable expectation of compliance with the performance objectives) is 1,000 years, it may be helpful to extend the calculation to include the maximum impact (i.e., peak dose), even if the maximum is not realized for tens of thousands of years. This calculation may increase the understanding of the models used and the disposal facility performance, but are not used for determining compliance with the disposal performance objectives. Caution must be exercised when interpreting such results calculated thousands of years due to compounding of rounding and truncation errors which can cause results to be nonsensical. However, such calculations may help test the model or a specific aspect thereof. Conditions of operation on the facility may be considered to assist in understanding or discussing the complexity of uncertainties associated with some of the parameters in the performance assessment.

> *Example: The low-level waste disposal facility performance assessment at Site A includes the calculation to the peak dose. The peak is 50 mrem/yr, which occurs in the analysis at 8,500 years after closure. The performance assessment concludes from this result that the overall current understanding of the facility performance is consistent with the compliance finding at 1,000 years.*

Performance Assessment ALARA. In addition, to providing a reasonable expectation that the performance objectives will not be exceeded, the performance assessment also needs to show that low-level waste disposal is being conducted in a manner that maintains releases of radionuclides to the environment to levels that are as low as reasonably achievable (ALARA).

The goal of the ALARA process is not the attainment of a particular dose level (or, in this case, level of release), but rather the attainment of the lowest practical dose level after taking into account social, technical, economic, and public policy considerations. ALARA is meant to provide a documented answer to the question: "Have I done all that I can reasonably do to reduce radiation doses or releases to the environment?"

Performance assessments should include ALARA assessments that focus on alternatives for low-level waste disposal. The alternatives considered might include the use of different disposal unit covers, waste forms, containers, or other alternatives (e.g., concrete vaults versus earthen trenches) consistent with the situation being assessed. The rigor of the ALARA assessment, and its analysis of alternatives, needs to be commensurate with the magnitude of the risk and the decisions to be made. Depending on the situation, ALARA assessments can range from simple qualitative statements to elaborate quantitative assessments that consider individual and collective doses to members of the public.

> *Example: The Site A low-level waste disposal facility performance assessment includes an assessment of the three alternatives for certain high-activity waste streams of (1) structural stabilization, (2) placement in high integrity containers, and (3) disposing of the wastes in regular containers, but at the bottom of the trench. The results of the analysis are used in the conclusion section of the performance assessment in determining the waste acceptance criteria and disposal operational requirements for these wastes.*

Water Resources Analysis. Performance assessments include calculations of impacts to water resources. Such calculations can be used, as necessary, to establish limits on radionuclides that may be disposed in near-surface disposal facilities.

DOE M 435.1-1 does not specify the level of protection for water resources that should be used in a performance assessment for a specific low-level waste disposal facility. Rather, a site-specific approach, in accordance with a hierarchical set of criteria should be followed. This approach recognizes that there are no Federal requirements for protection of water resources for a radioactive waste disposal facility. The site-specific hierarchical approach, rather than mandating specific performance measures for all sites, is consistent with the Environmental Protection Agency strategy for groundwater protection, which recognizes that groundwater protection is a regional and local matter.

The hierarchy for establishing water resource protection is as follows:

- First, the DOE low-level waste disposal facility must comply with any applicable State or local law, regulation, or other legally *applicable* requirements for water resource protection.

- Second, the DOE low-level waste disposal facility must comply with any formal agreement applicable to water resource protection that is made with appropriate State or local officials.

- Third, if neither of the above conditions apply, the site needs to select assumptions for use in the performance assessment based on criteria established in the site groundwater protection management program and any formal land-use plans.

- If none of the above conditions apply, the site may select assumptions for use in the performance assessment for the protection of water resources that are consistent with the use of water as a drinking water source.

Intruder Analysis. Performance assessments include calculations of impacts to a hypothetical person who is assumed to inadvertently intrude into the low-level waste disposal facility. Such calculations are used to determine what is reasonable for near-surface disposal and may be used to establish limits on the concentration of radionuclides that may be disposed in near-surface (i.e., at depths less than about 30 meters) disposal facilities.

Protection of the inadvertent intruder is one of the four performance objectives that commercial near-surface disposal facilities for low-level waste must meet. The analysis used in the rulemaking for Part 61 for protecting an intruder was used as a practical means of establishing the classification system in Part 61 calling for structural stabilization of waste which have concentrations of certain radionuclides exceeding certain limits, and for deeper burial, or burial with an intruder barrier, of wastes with these higher concentration limits. The protection of the intruder also is the major reason that Greater-than-Class C low-level waste is considered to be generally unsuitable for near-surface disposal. Protection of the inadvertent intruder has also been recognized as a fundamental objective of radioactive waste management internationally, and is invoked at some disposal facilities for other types of radioactive waste in addition to low-level wastes.

Although DOE is committed to retaining control of land containing residual radioactive material, such as disposed low-level waste, it is nonetheless appropriate to consider the impacts of potential inadvertent intrusion. Intrusion should be considered as an accident scenario which could occur during lapses of institutional controls. It is a hypothetical situation assumed simply to provide a basis for determining the acceptability of waste for near-surface disposal and may be used for establishing concentrations of radioactive material in a near-surface disposal facility.

In the intruder assessment, institutional controls should be assumed to be effective in preventing intrusion for at least 100 years following disposal facility closure; longer periods may be assumed with justification (e.g., land-use planning, passive controls).

Two performance measures are to be considered in intrusion assessments. For chronic exposure (i.e., continuous or ongoing exposures over a period of time) scenarios, the performance measure is 100 mrem (1 mSv) in a year, total effective dose equivalent. For acute exposure scenarios (one time only events or single exposures), the performance measure is 500 mrem (5 mSv) in a year, total effective dose equivalent. Inadvertent intruder assessment involves formulating scenarios (i.e., sets of activities that the hypothetical person might engage in) and calculating the exposure resulting from the activities. Development of intruder scenarios needs to be consistent with best management practices and other current industry standards such as those issued by NCRP (National Council for Radiation Protection), ICRP (International Council for Radiation Protection), and others. Intruder scenarios need to consider the following:

- Intruders may carry out activities for no more than about a year before discovery.
- An intruder may perform reasonable activities consistent with regional social customs and well drilling, excavation, and construction practices, and the regional environmental conditions projected for the time that intrusion is assumed to occur.
- Intrusion events may involve random contact with waste.
- An intruder will usually take reasonable, investigative actions upon discovery of unusual materials.
- Intrusion events that contact waste may be assumed to be limited to drilling or simple excavation scenarios involving use of relatively unsophisticated tools and commonplace machinery.
- Doses calculated for an intruder will depend on waste disposal facility design and operating practices, and may be reduced by practices such as disposal below depths normally associated with common construction activities, use of intruder barriers or durable waste forms or containers, or distributed disposal of higher-activity waste.

The inadvertent intruder assessment needs to, at a minimum, consider the appropriateness of including an acute construction scenario, an acute well drilling scenario, and a chronic agriculture scenario. However, all these scenarios may not need to be assessed and development of actual scenarios should be done on a case-by-case basis.

Likelihood of Intruder Scenarios. The inadvertent intruder assessment is required by DOE M 435.1-1, IV.P.(2)(h), and must be included in the performance assessment. However, for the purposes of establishing waste acceptance requirements and other controls on the disposal facility, the likelihood of intruder scenarios may be addressed in the interpretation of the results of the

inadvertent intruder assessment. Justification of intruder scenarios' probabilities must be included if used in the intruder assessment. Similarly, the scenario chosen needs to be reasonable for the area being analyzed to be consistent with subrequirement IV.P.(2)(a). The *Standard Format and Content Guide*, DOE G 435.1-1, contains additional discussions of the inadvertent intruder assessment and the consideration of the results in establishing controls on the facility.

Compliance with this requirement is demonstrated by the performance assessment documentation including the use of the parameters and other information specified in the requirement, or, if an alternative parameter or method is used, a justification and basis for its use.

Supplemental References:

1. DOE, 1996. *Interim Format and Content Guide, and Standard Review Plan for U.S. Department of Energy Low-Level Waste Disposal Facility Performance Assessments,* U.S. Department of Energy, Washington, D.C., October 1996.

2. DOE. *Format and Content Guide for U.S. Department of Energy Low-Level Waste Disposal Facility Performance Assessments and Composite Analyses,* DOE G 435.1-1, U.S. Department of Energy, Washington, D.C. (Under preparation.)

IV. P.(3) Composite Analysis. For disposal facilities which received waste after September 26, 1988, a site-specific radiological composite analysis shall be prepared and maintained that accounts for all sources of radioactive material that may be left at the DOE site and may interact with the low-level waste disposal facility, contributing to the dose projected to a hypothetical member of the public from the existing or future disposal facilities. Performance measures shall be consistent with DOE requirements for protection of the public and environment and evaluated for a 1,000 year period following disposal facility closure. The composite analysis results shall be used for planning, radiation protection activities, and future use commitments to minimize the likelihood that current low-level waste disposal activities will result in the need for future corrective or remedial actions to adequately protect the public and the environment.

Objective:

The objective of this requirement is to ensure that a prospective assessment be conducted to assess potential dose to hypothetical members of the public from the aggregate of residual

radioactive material that is likely to remain on a DOE site and that is likely to add to the dose from an active or planned low-level waste disposal facility.

Discussion:

Through Recommendation 94-2, the Defense Nuclear Facilities Safety Board recommended that DOE's performance assessments for low-level waste disposal facilities consider all inventories of past, present, and future low-level waste in the analysis. DOE committed to addressing this concern by performing a composite analysis of all sources of radioactivity that may interact with the disposal facility to determine appropriate courses of action concerning the continued operation of a disposal facility. The composite analysis is prepared in addition to the performance assessment, which continues to be focused on specific facilities to establish design, operation, and closure parameters. The requirement in DOE M 435.1-1 maintains this commitment made in the 94-2 Implementation Plan as a requirement for low-level waste disposal facilities.

Low-level waste disposal is not the only DOE activity that will leave residual radioactive material on the DOE site when operations at the site have ceased. Environmental restoration activities will be conducted to mitigate releases from former operations such as disposal of liquid radioactive waste to soil columns, but will not generally result in the removal of all of the radioactive material. Facilities currently operating that involve the use of or handling of radioactive material will eventually be decommissioned. However, decommissioning will not necessarily result in the removal of all of the radioactive material.

The performance assessment for active and planned low-level radioactive waste disposal facilities is necessarily focused only on the disposal facility so that design and operational controls may be established to ensure that performance objectives will be met. Thus, the performance assessment does not provide information on potential future doses that may be received by members of the public from the disposal facility plus other sources; the composite analysis is used to provide that information.

The composite analysis is a reasonably conservative assessment of the cumulative impacts from active and planned low-level waste disposal facilities, and all other sources of radioactive contamination that could interact with the low-level waste disposal facility to affect the dose to future members of the public. The composite analysis provides a suggestion of what could conceivably happen if DOE did not act to protect public health and safety. It provides information that DOE can use for planning, establishing radiation protection activities, and/or making commitments concerning future uses of land or resources.

The composite analysis can use the information from the site-wide groundwater protection management program required in DOE 5400.1, *General Environmental Protection Program*. The results of the composite analysis can be used to update and modify the groundwater

protection management program to better meet site-wide and regional groundwater protection needs if appropriate. The results of the composite analysis are also used for updating and modifying land use planning documents, identifying those sources that most significantly contribute to the total projected dose and decide on priorities for remediation, or decide on closure alternatives for active or inactive disposal areas.

> *Example: The composite analysis for the Site A low-level waste disposal facility indicates that it is reasonable for the low-level waste disposal facility to operate unconditionally, given the contribution to potential future dose form other source terms at the site. However, it is noted that the decision to stabilize in place the contaminated zones in operable unit 37 accounts for over 75 percent of the projected composite dose at the site.*

As in the performance assessment, it is not possible to provide absolute proof of the performance of the various sources of radioactive material at some future time. Rather, the Manual requires that the composite analysis be prepared to provide a reasonable expectation that the performance measures are not likely to be exceeded.

Since the focus of the composite analysis is planning for future public radiological protection, the performance measure is drawn from the Department's requirements for public radiological protection. The primary dose limit of 100 mrem in a year, total effective dose equivalent, is the basic performance measure (DOE 5400.5). Consistent with established radiation protection practices articulated by the National Council on Radiation Protection (NCRP) and the International Council on Radiation Protection (ICRP), the projected dose attributable to any single source, practice, or activity should be some fraction less than the applicable overall dose limit. Depending on the particular source of concern, DOE, EPA, and the NRC have typically established limits of 10 to 25 percent (10 mrem [.10 mSv] to 25 mrem [.25 mSv]) of the primary dose limit for protection of the public (100 mrem [1 mSv]/year) to any particular source, although higher or lower fractions may be appropriate. To prevent the potential dose from the aggregate of sources analyzed from exceeding a significant fraction of the primary dose limit of DOE 5400.5, an administratively limited dose constraint of 30 mrem in a year is used. If the dose calculated in the composite analysis exceeds 30 mrem in a year, an options analysis must be prepared to consider actions that could be taken to reduce the calculated dose and to consider the cost of those actions. The composite analysis is to consider a period of 1,000 years after the disposal facility has been closed to assess compliance with the performance measures.

Composite analyses must be reviewed and approved by DOE Headquarters. As discussed in Section I.2.E.(1), the Deputy Assistant Secretaries for Waste Management and Environmental Restoration have the responsibility for reviewing and approving the composite analysis for low-level waste disposal facilities and issuing a disposal authorization statement based on the review.

The guidance on DOE M 435.1-1, Section I.2.E.(1) discusses the review and approval process in detail.

As discussed above, the improvement of performance assessments, their reviews and approvals, and the addition of the composite analysis to the required evaluations of low-level waste disposal facilities and their subsequent reviews and approvals has been the aim of much of the improvements to low-level waste management resulting from Defense Nuclear Facilities Safety Board Recommendation 94-2. Consequently, detailed guidance on conducting composite analyses is being developed for inclusion in DOE G 435.1-1, *Format and Content Guide for U.S. Department of Energy Low-Level Waste Disposal Facility Performance Assessments and Composite Analyses*. That document needs to be consulted for additional detailed discussions of the performance measures, preparation of a composite analysis, and the interpretation of assumptions and other technical information that goes into the evaluations contained in a composite analysis.

Compliance with this requirement is demonstrated by a documented composite analysis for the low-level waste disposal facility that evaluates the cumulative impacts from the facility and all other sources for radioactive contamination that could interact with the facility and add to the dose to future members of the public.

Supplemental References:

1. DOE, 1996. *Guidance for a Composite Analysis of the Impact of Interacting Source Terms on the Radiological Protection of the Public from Department of Energy Low-Level Waste Disposal Facilities,* U.S. Department of Energy, Washington, D.C., April 1996.

2. DOE. *Format and Content Guide for U.S. Department of Energy Low-Level Waste Disposal Facility Performance Assessments and Composite Analyses,* DOE G 435.1-1, U.S. Department of Energy, Washington, D.C. (Under preparation.)

IV. P.(4) Performance Assessment and Composite Analysis Maintenance. The performance assessment and composite analysis shall be maintained to evaluate changes that could affect the performance, design, and operating bases for the facility. Performance assessment and composite analysis maintenance shall include the conduct of research, field studies, and monitoring needed to address uncertainties or gaps in existing data. The performance assessment shall be updated to support the final facility closure. Additional iterations of the

performance assessment and composite analysis shall be conducted as necessary during the post-closure period.

(a) Performance assessments and composite analyses shall be reviewed and revised when changes in waste forms or containers, radionuclide inventories, facility design and operations, closure concepts, or the improved understanding of the performance of the waste disposal facility in combination with the features of the site on which it is located alter the conclusions or the conceptual model(s) of the existing performance assessment or composite analysis.

Objective:

The objective of these requirements is to ensure that performance assessments and composite analyses are updated as appropriate, whenever changes in their bases (assumptions, parameters, etc.) are contemplated or effected in order to maintain the validity and effectiveness of the controls which are based on the performance assessment and composite analysis.

Discussion:

As discussed in Section I.2.F.(15) of the guidance for Chapter I, General Requirements, since a low-level waste disposal facility will be in operation for many years, and waste receipts and knowledge concerning the disposal facility environs could change, maintaining the performance assessment and composite analysis through a regular schedule of evaluations is required by the manual.

The performance assessment provides a means whereby the long-term efficacy of the disposal facility is evaluated and provides input to disposal facility design, operational requirements, and waste acceptance criteria. The composite analysis is a planning tool to ensure that low-level waste disposal, in consort with other activities at the site, is not likely to compromise future radiological protection of the public. Because the performance assessment and composite analysis results are projections based on estimated waste and facility characteristics, they are technically uncertain. A maintenance program is needed to, over time, improve confidence in the results of the analysis and in the long-term plans for protecting public health and safety. Through the conduct of an assessment maintenance program, site operators can technically justify reducing the conservatism in the analysis based on acquiring data which support revising the analyses. The results of the revised performance assessment and composite analysis can result in revised waste acceptance criteria which could result in a lessening of constraints on waste receipts, less costly remediation alternatives, or in revised land-use controls.

Acquisition and consideration of field data represents a necessary component of the maintenance program. Performance assessment and composite analysis development and refinement represents a continuous process during the operational life of a disposal facility. Over the lifetime of the disposal facility, the performance assessment and composite analysis must be maintained and upgraded as additional information about the waste, environmental setting, and site is obtained. At closure of the disposal facility, a final performance assessment which analyzes all of the waste that has been disposed must be prepared and approved. During the post-closure period, it may also be necessary to revise the performance assessment and composite analysis according to the criteria stated above.

As discussed above, the improvement of performance assessments, the addition of the composite analysis to the required evaluations of low-level waste disposal facilities, and their reviews and approvals has been the aim of much of the improvements to low-level waste management resulting from Defense Nuclear Facilities Safety Board Recommendation 94-2. Similarly, maintenance of performance assessments and composite analyses has also been modified to improve the upkeep of the analyses and controls based on the assessments. Consequently, detailed guidance on maintaining performance assessments and composite analyses is being developed for inclusion in DOE G 435.1-3, *Maintenance Guide for U.S. Department of Energy Low-Level Waste Disposal Facility Performance Assessments and Composite Analyse*s. The *Maintenance Guide* will need to be consulted for additional detailed discussions of the maintenance of performance assessments and composite analyses once issued.

Compliance with this requirement is demonstrated by the implementation of a site-specific performance assessment and composite analysis maintenance program that includes research projects, field studies, and the results of monitoring to update the analyses.

Supplemental References:

1. DOE, 1996. *Maintenance of US Department of Energy Low-Level Waste Performance Assessments*, U.S. Department of Energy, Washington, DC, September 1996.

2. DOE. *Maintenance Guide for U.S. Department of Energy Low-Level Waste Disposal Facility Performance Assessments and Composite Analyses,* DOE G 435.1-3, U.S. Department of Energy, Washington, D.C. (Under preparation.)

IV.P.(4) Performance Assessment and Composite Analysis Maintenance.

(b) A determination of the continued adequacy of the performance assessment and composite analysis shall be made on an annual

basis, and shall consider the results of data collection and analysis from research, field studies, and monitoring.

(c) Annual summaries of low-level waste disposal operations shall be prepared with respect to the conclusions and recommendations of the performance assessment and composite analysis and a determination of the need to revise the performance assessment or composite analysis.

Objective:

The objective of these requirements is to ensure that the bases of the performance assessment and composite analysis (e.g., assumptions, parameters, waste inventory) remain valid and to ensure that results of testing, research, and development, and monitoring are considered in this determination and summary.

Discussion:

Because the analyses in the performance assessments and composite analyses are based on projections of waste receipts and parameter values that predict site behavior, annual summaries of actual disposal operations that include actual waste receipts and results of site research projects and monitoring, can assist in calibrating the performance assessment and composite analysis to be more accurate as the life of the facility goes on. The annual summaries are to tie the annual summaries to the conclusions of the performance assessment and composite analysis, and determine whether they continue to be the correct conclusions. As more and more of these annual summaries are factored appropriately into the maintenance of the performance assessment and composite analysis, the more the results are based on actual facility performance, and the more the conclusions can be relied on to provide a reasonable expectation that the performance objectives will continue to be met.

Performance assessment and composite analysis maintenance includes the routine review and revision, as appropriate, of the analyses. Reviews provide a mechanism for routine assessment of the controls derived from the analyses on waste disposal, source remediation, or land-use controls so that potential problems are identified and managed. The revisions ensure that there is cohesive documentation providing a reasonable expectation of meeting the performance measures. This use of the analyses is similar to the use of a safety analysis report. The assumptions and analyses in the performance assessment are used to establish a performance envelope and are translated into administrative and engineering controls (e.g., procedures, waste acceptance criteria, designs, land-use controls).

The reviews should include an assessment of relative test, research and development, and monitoring data that may have been obtained. This part of the review is two-fold. First, it ensures that the conceptual model(s), assumptions, parameters, etc. remain valid. Second, it enhances confidence in the model results and may result in a lessening of the degree of conservatism in the analyses. The annual reviews should be documented and retrievable.

As discussed above, the improvement of performance assessments, the addition of the composite analysis to the required evaluations of low-level waste disposal facilities, and the reviews and approvals for these analyses are among the improvements to low-level waste management resulting from Defense Nuclear Facilities Safety Board Recommendation 94-2. Similarly, maintenance of performance assessments and composite analyses has also been modified to improve the upkeep of the analyses and controls based on the assessments.

Compliance with this requirement is demonstrated by a documented process that results in annual summaries of the low-level waste disposal operations and a determination of the continued adequacy of the analyses.

Supplemental References:

1. DOE, 1996. *Maintenance of US Department of Energy Low-Level Waste Performance Assessments*, U.S. Department of Energy, Washington, D.C., September 1996.

2. DOE. *Maintenance Guide for U.S. Department of Energy Low-Level Waste Disposal Facility Performance Assessments and Composite Analyses*, DOE G 435.1-3, U.S. Department of Energy, Washington, D.C. (Under preparation.)

IV. P.(5) Disposal Authorization. A disposal authorization statement shall be obtained prior to construction of a new low-level waste disposal facility. Field Elements with existing low-level waste disposal facilities shall obtain a disposal authorization statement in accordance with the schedule in the Complex-Wide Low-Level Waste Management Program Plan. The disposal authorization statement shall be issued based on a review of the facility's performance assessment, composite analysis, performance assessment and composite analysis maintenance, preliminary closure plan, and preliminary monitoring plan. The disposal authorization statement shall specify the limits and conditions on construction, design, operations, and closure of the low-level waste facility based on these reviews. A disposal authorization statement is a part of the radioactive waste management basis for a disposal facility. Failure to obtain a disposal authorization statement

by the implementation date of this Order shall result in shutdown of the disposal facility.

Objective:

The objective of this requirement is to ensure that any conditions or limitations that are required on the operations of a low-level waste disposal facility or waste accepted at the facility that result from the review and approval of the performance assessment and composite analysis maintenance plans, monitoring plans, and closure plans are included in the radioactive waste management basis for the facility.

Discussion:

As discussed in DOE M 435.1-1, Section I.2.E.(1), following the review and approval of the performance assessment and composite analysis, maintenance plan, monitoring plan, and closure plan for a low-level waste disposal facility, a disposal authorization is to be issued that sets forth any necessary conditions for the design, construction, and operation of the disposal facility in order to maintain the reasonable assurance that the disposal performance objectives of Chapter IV of DOE M 435.1-1 will be met. The guidance on DOE M 435.1-1, Section I.2.E.(1) should be consulted concerning the differences in the issuance of a disposal authorization for a low-level waste disposal facility operated under DOE O 435.1 for the Office of Waste Management and for a facility operated under CERCLA for the Office of Environmental Restoration.

As discussed above, the improvement of performance assessments, the addition of the composite analysis to the required evaluations of low-level waste disposal facilities, and their reviews and approvals are among the improvements to low-level waste management resulting from Defense Nuclear Facilities Safety Board Recommendation 94-2. The issuance of a disposal authorization statement based on the reviews and approvals of the evaluations is considered a critical addition to these improvements. Consequently, detailed guidance on the review process and development of a disposal authorization statement is being developed for inclusion in DOE G 435.1-2, *Review Guide for U.S. Department of Energy Low-Level Waste Disposal Facility Performance Assessments and Composite Analyses*. DOE G 435.1-2 will need to be consulted for additional detailed discussions of the review of performance assessments and composite analyses once issued and the issuance of a disposal authorization statement.

Obtaining a Disposal Authorization Statement. As stated in the requirement, for a new low-level waste disposal facility, the disposal authorization statement must be obtained prior to construction of the facility. Because the performance assessment and composite analysis prepared prior to construction are preliminary, and will include parameters based on some assumptions, it is recognized that modifications will occur. Conditions included in the disposal authorization statement will need to indicate when and how modifications to the performance assessment, based

on design and construction, need to be included in performance assessment maintenance cycles or in other procedures or the facility waste acceptance criteria that are prepared following construction.

> *Example: DOE Site B has decided to establish a new low-level waste disposal facility. The preliminary performance assessment is prepared using conservative assumptions, is reviewed, and is approved at the site given the assumptions. The performance assessment, composite analysis, maintenance plans, monitoring plan, and closure plan are sent to Headquarters for final approval. A disposal authorization statement is issued and the site manager authorizes construction. The conditions in the statement include a requirement that the performance assessment be resubmitted following construction and prior to operations for review, accompanied by the waste acceptance criteria based on the revised performance assessment that incorporates any changes to the evaluation brought about by construction changes or new information.*

For existing low-level waste disposal facilities, the disposal authorization statement must be obtained in accordance with the schedule in the current version of the Complex-Wide Low-Level Waste Management Plan that is required by General Requirement I.2.D.(1). This schedule reflects current program planning and scheduling concerning active disposal facilities, and provides for the time necessary to collect data and perform the assessments required by the Disposal Section of Chapter IV of DOE M 435.1-1.

Basis for the Disposal Authorization Statement. The requirement for issuance of a disposal authorization statement includes review of not only the performance assessment and composite analysis, but also the performance assessment and composite analysis maintenance plans, preliminary disposal facility monitoring plan and preliminary closure plan. These documents contain analysis and controls that are closely related to each other. An understanding of how monitoring and closure are to be implemented in conjunction with the siting, design, construction and the other operational aspects of the low-level waste disposal facility is required to make a judgement as to whether there is and will continue to be reasonable assurance that the performance objectives for disposal are met. Guidance on the preparation and submittal of preliminary closure plans can be found in DOE G 435.1-1, Section IV.Q.(1), and on preparation and submittal of preliminary monitoring plans can be found in DOE G 435.1-1, Section IV.R.(3).

Contents of a Disposal Authorization Statement. The Disposal Authorization Statement will clearly indicate the disposal facility and design that is being authorized to operate. The statement will refer to the performance assessment and composite analysis documents reviewed as the basis for the authorization and state the primary features of the disposal facility important for understanding the authorization of operations of the facility. The maintenance, preliminary monitoring, and closure plans are also referenced along with primary information from those

documents and any other documents required to understand the authorization of operations of the facility.

Example: The Disposal Authorization Statement for the Site Y low-level waste disposal facility states that the performance assessment analysis and conclusions were based on the use of a concrete vault, as demonstrated in Engineering Drawing Y-23, the preliminary closure plan contained as Appendix B to the performance assessment (Site Document No. Y-344555), and additional information submitted in memorandum dated October 1, 1997.

Conditions and limitations for operations of the facility are clearly indicated in the disposal authorization statement. These include quantities, limitations, references, or codification of assumptions contained in the performance assessment, composite analysis, preliminary closure plan, and preliminary monitoring plan for emphasis and clarity. The conditions include any limitations or allowances required based on independent analysis of the disposal configuration and conditions being examined in the evaluations. The conditions also include any other limitations, responsibilities, or commitments that were needed to resolve issues during the review of the performance assessment and composite analysis or which will serve to answer questions that need to be resolved during the first years of operation of the disposal facility.

Example: The Disposal Authorization Statement for the Site Y low-level waste disposal facility includes the following conditions:

1. *Waste Acceptance Criteria documentation must include the limitations on radionuclide concentrations in waste packages as indicated in Table 42 of the performance assessment (Site Document No. Y-344555).*

2. *Monitoring of disposal facility performance shall be measured in accordance with the preliminary monitoring plan submitted as Appendix G with the performance assessment (Site Document No. Y-344555), but with one change in monitoring well location YMY-5 as described in attachment 2 to this Statement.*

3. *A final disposal facility monitoring plan reflecting information in attachment 2 to this Statement shall be submitted to the Field Element Manager for approval within 18 months of the date of this Statement.*

4. *Waste received containing U-233 should be tracked in the record keeping system of the disposal facility in a way that enables these disposed containers to be easily located on a site map.*

5. Disposal authorization is conditioned upon continual and satisfactory compliance with the above conditions.

Compliance with this requirement can be demonstrated by the existence of disposal authorization statements for active low-level waste disposal facilities that provide approval of and conditions for operation of the facility.

Supplemental References:

1. DOE, 1996. *Interim Format and Content Guide, and Standard Review Plan for U.S. Department of Energy Low-Level Waste Disposal Facility Performance Assessments,* U.S. Department of Energy, Washington, D.C., October 1996.

2. DOE, 1996. *Interim Review Process and Criteria for Department of Energy Low-Level Waste Disposal Facilities Composite Analyses,* U.S. Department of Energy, Washington, D.C., November 1, 1996.

3. DOE, 1996. *Guidance for a Composite Analysis of the Impact of Interacting Source Terms on the Radiological Protection of the Public from Department of Energy Low-Level Waste Disposal Facilities,* U.S. Department of Energy, Washington, D.C., April 1996.

4. DOE, 1998. *Department of Energy LLW Disposal Facility Federal Review Group, Performance Assessment and Composite Analysis Review Guidance Manual*, Revision 0, U.S. Department of Energy, September 1998.

5. DOE. *Review Guide for U.S. Department of Energy Low-Level Waste Disposal Facility Performance Assessments and Composite Analyses,* DOE G 435.1-2, U.S. Department of Energy, Washington, D.C. (Under preparation.)

IV. P.(6) Disposal Facility Operations. The disposal facility design and operation must be consistent with the disposal facility closure plan and lead to disposal facility closure that provides a reasonable expectation that performance objectives will be met. Low-level waste shall be disposed in such a manner that achieves the performance objectives stated in this Chapter, consistent with the disposal facility radiological performance assessment. Additional requirements include:

Objective:

The objective of this requirement is to ensure that the low-level disposal facility is operated in a manner that adheres to the requirements and limitations contained in and derived from the closure plan and performance assessment and the critical documents related to design and operational functions that provide reasonable assurance the disposal performance objectives will be met at the facility.

Discussion:

As discussed in the guidance for DOE M 435.1-1, Section I.2.E.(1), the safety and hazard analysis for management of radioactive waste conducted to develop the essential requirements for DOE O 435.1 and DOE M 435.1-1 indicated that disposal is the most critical activity requiring controls because disposal is intended to be the last function conducted on the waste, and yet, the potential hazards from disposed low-level waste will continue into the future. Thus, there are specific requirements for the protection of the public, workers, and environment that are critical to maintaining safe and effective disposal of radioactive waste management.

As already discussed, the performance assessment is considered a critical document in determining the controls that are needed for a specific disposal facility. The information evaluated in the performance assessment on closure of the facility, and the information presented in the preliminary closure plan for the facility represent the desired "end-state" of the facility that will function in a way that provides reasonable assurance the performance objectives will not be exceeded. This requirement is intended to emphasize the relationship between the assumptions in the performance assessment and closure plan concerning operation of the disposal facility and real-time activities performed at the facility.

Facility operations procedures need to be prepared to be site-specific and formally implement the design features as part of operations, along with those aspects of facility operations addressed in the performance assessment, closure plan, and other radioactive waste management basis activities and documents (e.g. waste acceptance criteria) that are derived from the performance assessment.

> *Example: The Campus Disposal Facility operating procedures includes procedure Closure-1, which requires capping of a disposal unit with a specific multi-layer cap. The procedure contains details in drawings and processes to result in placement of the cap. This cap design is derived from the preliminary closure plan for the facility, which calls for these multi-layer caps as part of surface-water control during the life of the facility to direct water away from the disposal units to preserve the integrity and stability of the disposal units for the final closure.*

Revisions of the closure plan, performance assessment, or waste acceptance criteria result in reviews of the procedures for waste operations to ensure that the radioactive waste management basis is preserved during operations, and that any updates to performance assessment assumptions that result in operational controls are reflected in an updated procedure.

> *Example: Based on a performance assessment update using new environmental data, it is decided that an area where disposal units were originally planned will be avoided. The operating procedures are updated to reflect the new locations of trenches.*

The following four subrequirements, DOE M 435.1-1, Sections IV.P.(6) (a) through (e), provide detailed requirements for specific operational functions of and procedures for a low-level waste disposal facility that the safety and hazard and requirements analysis conducted in developing DOE O 435.1 indicated were areas especially in need of controls to help achieve the goals of protecting the public and the environment that are embodied in the disposal performance objectives.

Compliance with this requirement is demonstrated by the waste disposal facility operational procedures being developed and implemented within prescribed conditions that are analyzed in and derived from the performance assessment and closure plan for the subject low-level waste disposal.

Supplemental References:

1. NRC, 1982. *Technical Position Paper on Near-Surface Disposal Facility Design and Operation*, U.S. Nuclear Regulatory Commission, Washington, D.C., November 1982.

IV. P.(6) Disposal Facility Operations.

(a) Operating procedures shall be developed and implemented for low-level waste disposal facilities that protect the public, workers, and the environment; ensure the security of the facility; minimize subsidence during and after waste emplacement; achieve long-term stability and minimize the need for long-term active maintenance; and meet the requirements of the closure/post-closure plan.

Objective:

The objective of this requirement is to ensure that operating procedures are developed, documented, and implemented for the critical functions listed in the requirement that are important to meeting the performance objectives for low-level waste disposal over the long term.

Discussion:

Waste disposal facilities are required to conduct day-to-day operations in support of the requirements contained in the manual. For waste disposal operations to achieve this goal, procedures must be developed, documented, and implemented to ensure acceptable operating conditions at the disposal facility are maintained. Provisions to be met for worker safety, protection of the public and the environment, security, minimizing the need for long-term maintenance, and meeting the closure/post-closure plan requirements are included in the radioactive waste management basis documentation. Other requirements contained in the radioactive waste management basis documentation may suggest the development and implementation of additional procedures beyond those areas identified in this requirement (e.g., monitoring plan, waste acceptance criteria). Any procedures need to be developed consistent with the requirements of DOE 5480.19, Conduct of Operations. Procedures developed and implemented for the topical areas derived from the radioactive waste management basis documentation need to be reviewed, approved, and adhered to by the management organization responsible for operating the waste disposal facility.

> *Example 1: A motorized electronic gate mechanism for access to the disposal facility fails and a manual override is actuated to open the gate for the facility. For security of the facility, which is required to have controlled access, plant security personnel are required by procedures to man the gate and control access until the gate is repaired.*
>
> *Example 2: Receipt of a non-standard waste package at the disposal facility is required by the operating procedures to be placed at a staging facility within the disposal facility fence until an exception for disposal of non-standard waste package is approved that includes the method for disposal. The disposal of a non-standard waste package and an approved exception are documented and filed in the record system as required by procedure.*

The operations of a waste disposal facility are described in the performance assessment for the facility. The waste management operations presented in the performance assessment form a basis for establishing procedures for facility operations. Operations performed that are not presented in the performance assessment are based on other radioactive waste management basis documentation and evaluated by the performance assessment and composite analysis maintenance program to ensure protection of the public and the environment is not likely to be compromised.

Similarly, procedures derived from the safety analysis report, closure plan, monitoring plan or other radioactive waste management basis documents should be evaluated to ensure worker safety, security, long-term active maintenance, and closure requirements are met.

Compliance with this requirement is demonstrated by operating procedures, including the procedures for exceptions and approval of exceptions, that are complete, suitable, and correct. The adherence to procedures in waste operations also demonstrates compliance with this requirement, and any deviations from documented procedures are reviewed, documented, and retained in the permanent records of the disposal facility.

Supplemental References:

1. NRC, 1982. *Technical Position Paper on Near-Surface Disposal Facility Design and Operation*, U.S. Nuclear Regulatory Commission, Washington, D.C., November 1982.

IV. P.(6) Disposal Facility Operations.

(b) Permanent identification markers for disposal excavations and monitoring wells shall be emplaced.

Objective:

The objective of this requirement is to ensure that physical identification markers are placed to locate trenches and monitoring wells so they will be able to be located in the future as an additional measure against inadvertent intrusion.

Discussion:

A two-dimensional grid system needs to be designed to locate all disposal excavations and monitoring wells on a map of the disposal site. The grid system is be referenced to a U.S. Geological Survey or National Geodetic Survey benchmark. The location of each monitoring location is recorded in a permanent locator system, such as a Geographic Information System. To facilitate use of this locator system, disposal facility operating procedures provide for orderly placement of all waste within the disposal facility, and all monitoring locations and equipment within the disposal facility are installed according to the strategy presented in the closure plan for the facility.

The location of all disposal units needs to be identified on the surface with permanent markers from which the boundaries of disposal units can be located. In order to be considered permanent, the markers should be made from materials known to withstand anticipated environmental

conditions with little to no degradation (e.g., granite), or made from materials with similar properties whose longevity can be demonstrated through test results or empirical data (e.g., stainless steel) . The markers are engraved or manufactured with significant information about the disposal unit and the waste disposed in it. These markers, along with the total area of the facility, are permanently recorded on the map of the disposal facility, and referenced to the required benchmark. Records of maps for the disposal facility are maintained as part of the permanent records required by Chapter I of the Manual. Maps of the disposal facility are also maintained with state authorities as permanent records for public use in the future.

Example: At the Mojo disposal facility, permanent markers are made from engraved granite and permanently installed at the head and foot of each disposal unit. Information engraved on the marker includes the disposal unit open and closing dates, the contents, and a reference to the identity of the location of records for the disposal facility.

Monitoring wells and other monitoring stations need to also be identifiable by a surface marker located above the natural grade. For a monitoring well, markers could be the riser of the wellhead above grade or stanchions installed around the wellhead to prevent damage.

Compliance with this requirement is demonstrated by permanent markers with appropriate information being permanently installed at closed disposal units of disposal facilities, or for operating facilities, a procedure for the design and location of these markers, and other important markers, like monitoring well locations.

Supplemental References:

1. NRC, 1982. *Technical Position Paper on Near-Surface Disposal Facility Design and Operation,* U.S. Nuclear Regulatory Commission, Washington, D.C., November 1982.

IV. P.(6) Disposal Facility Operations.

(c) Low-level waste placement into disposal units shall minimize voids between waste containers. Voids within disposal units shall be filled to the extent practical. Uncontainerized bulk waste shall also be placed in a manner that minimizes voids and subsidence.

Objective:

The objective of this requirement is to enhance the integrity of the disposed waste and the disposal unit to the maximum extent practicable by elimination of voids between waste packages within the disposal unit.

Discussion:

The stability of waste disposal units is an important element of minimizing the need for site maintenance or corrective actions, and ensuring the long-term performance of the disposal facility. Voids left within the disposal unit eventually are filled by natural processes which lead to subsidence of disposal unit covers and increased infiltration of water into wastes with subsequent increases in the release of radioactive materials to the environment. The minimization of voids within waste packages needs to be addressed in the facility waste acceptance criteria, and is required by DOE M 435.1-1, Section IV.G.(1)(d)1. Voids between waste packages are filled with natural materials, such as sand or grout, which are capable of flowing into voids with the objective of making the resulting total waste mass have a compressibility similar to the undisturbed natural materials adjacent to the disposal unit.

> *Example: Drums evenly stacked in disposal unit K at Facility Y are backfilled initially with a sand and gravel mixture that is similar to the layer of sandy soil excavated from the disposal unit.*

The overall objective in eliminating voids is to enhance disposal unit stability. Methods and procedures for waste emplacement in disposal units with waste packages designed to minimize void space within the disposal unit need to be used, so as to minimize costs of corrective actions after wastes have been emplaced. Use of waste packages with identical dimensions or which form a tesselated configuration and that can be stacked to minimize voids between waste packages is also appropriate.

> *Example: The use of B-25 and similar rectangular shaped boxes is mandated for all near-surface disposal units at Disposal Facility Y to minimize the void spaces between packages that would otherwise require filling.*

Prior to operational closure of the disposal unit, void space between the side walls of below grade disposal units and the wastes need to be filled and compacted to minimize the potential for instability of the overlying cover. Likewise, for above grade disposal units, the operational cover over the wastes needs to minimize void spaces between the cover material and the emplaced wastes.

Compliance with this requirement is demonstrated by the ratio of the compressibility of the resulting waste mass once voids have been filled within the disposal unit to the compressibility of the undisturbed natural materials adjacent to the disposal unit. The ratio achieved is as close to one as can be justified when compared to the costs of future corrective actions. The operating procedures for the disposal facility include this or another reasonable measure and the process by which it is determined that this measure is being met.

Supplemental References:

1. NRC, 1982. *Technical Position Paper on Near-Surface Disposal Facility Design and Operation,* U.S. Nuclear Regulatory Commission, Washington, D.C., November 1982.

IV. P.(6) Disposal Facility Operations.

(d) Operations are to be conducted so that active waste disposal operations will not have an adverse effect on any other disposal units.

Objective:

The objective of this requirement is to enhance the integrity of the disposed waste and the disposal unit to the maximum extent practicable by ensuring that ongoing operations do not adversely affect disposal units that are already filled.

Discussion:

Operations of a disposal unit need to not disturb the structural integrity of any other disposal units. Operations could include the excavation of a disposal unit in close proximity to an existing, operating disposal unit, which could disturb the soil column between the two disposal units. Similar operations associated with the placement of an operational cover which would destroy waste packages or move emplaced wastes should be avoided. The placement of monitoring wells within waste disposal units that would compromise the integrity of disposed wastes is another example of practices to avoid.

Example: Excavation of a new disposal unit is to begin prior to closure of the currently used disposal unit. Therefore, the next disposal unit is not excavated in the immediately adjoining unused land, but is excavated some appropriate distance away from the current disposal unit. Monitoring locations for the disposal unit being filled are planned for this space between the disposal units.

Waste operations procedures for minimizing adverse effects to filled disposal units need to be included into the procedures for placing wastes in disposal units. Information developed as part of the Radioactive Waste Management Basis include the necessary basis for establishing these procedures. Specific practices to be included (e.g., minimum spacing between disposal units, foundation conditions for above-grade disposal facilities) are dependent on the site geotechnical conditions, the disposal unit design, the characteristics of the waste packages disposed of in the disposal units, and the methods for waste emplacement. Designs for constructing and operating waste disposal units include packaging and waste package emplacement methods which will minimize the potential for adverse impacts to filled disposal units. Vehicle movement, backfill storage areas, waste staging within the disposal unit need to be designed to avoid waste disposal units which have been filled. Similarly, the design and construction of adjacent disposal units need to consider any potential impacts to filled disposal units.

Example: Backfill from excavation of disposal unit #10 is placed in a designated backfill borrow area rather than on any of the closed disposal units. Similarly, the drum lifting machinery operates on the side of the disposal unit adjoining unused land, rather than the side that adjoins closed disposal unit #9.

Compliance with this requirement is demonstrated by information in operating procedures which has been developed and implemented at the facility including sufficient instructions and processes on avoiding adverse impact on disposal units that are already filled.

Supplemental References:

1. DOE, 1990. *Conduct of Operations Requirements for DOE Facilities,* DOE 5480.19, U.S. Department of Energy, Washington, D.C., July 9, 1990.

2. NRC, 1982. *Technical Position Paper on Near-Surface Disposal Facility Design and Operation,* U.S. Nuclear Regulatory Commission, Washington, D.C., November 1982.

IV. P.(6) Disposal Facility Operations.

(e) Operations shall include a process for tracking and documenting low-level waste placement in the facility by generating source.

Objective:

The objective of this requirement is to preserve the knowledge of the location of specific wastes in the disposal unit and the detailed characterization information about the waste in the event corrective actions are necessary.

Discussion:

Operations procedures need to include a process for identifying the location of specific wastes or containers in the disposal unit and providing for a documented correlation of this location with the characterization information about the waste. A two-dimensional grid system such as discussed in the guidance for requirement IV.P.(6)(b) can be utilized to identify the location of waste packages within disposal units, and needs to similarly be recorded in a permanent locator system, such as a Geographic Information System. The records of the facility need to correlate the locations of the waste packages with the records of the waste characterization information transferred to the disposal facility with the waste. Preserving the location of the waste and the details of its characterization in the records facilitates future remedial or corrective actions, if necessary. Likewise, if a problem is suspected with a specific generator, then each of their packages could be located within the disposal unit for more scrutiny in monitoring, if necessary.

> *Example: The Site B disposal facility uses a computerized Geographic Information System that tracks the location of waste drums in disposal units. The Geographic Information System includes links to the Site B Waste Information Network, which correlates the package location with the specific waste disposal records for each package, which have been scanned into the Network. For any package in the disposal unit, the waste manifesting information can be examined and all the characterization information about the waste, as well as receipt date, disposal date, operators disposing, and other information.*

Compliance with this requirement is demonstrated by a record keeping system at the disposal facility that includes the location of disposed waste in the disposal units and correlates the disposed waste with characterization information on the waste in a permanent, retrievable, and traceable form.

IV. P.(7) Alternate Requirements for Low-Level Waste Disposal Facility Design and Operation. Requirements other than those set forth in this Section for the design and operation of a low-level waste disposal facility may be approved on a specific basis if a reasonable expectation is demonstrated that the disposal performance objectives will be met.

Objective:

The objective of this requirement is to allow for site-specific approval of alternative methodologies for establishing the design and operation of a low-level waste disposal facility other than use of the performance assessment and composite analysis as long as the disposal performance objectives for protection of the public and the environment in the future are met.

Discussion:

The use of the performance assessment, and the composite analysis as committed to in the *Implementation Plan, Defense Nuclear Facilities Safety Board Recommendation 94-2,* are fundamental to the Department's approach to providing disposal of low-level waste in a manner that protects the public and the environment from the long-term hazards of the waste. The use of any alternative methodologies in siting, designing, operating, closing, and maintaining a low-level waste disposal facility that do not employ the performance assessment and composite analysis must still provide a reasonable expectation that the performance objectives of DOE M 435.1-1, Section IV.P.(1) are met, and provide for an analysis that accounts for all sources of radioactive material that may be left at the DOE site and may interact with the disposal facility. The process for an exemption to the DOE M 435.1-1 requirements for the submittal of a performance assessment, DOE M 435.1-1, Section IV.P.(2) and composite analysis, DOE M 435.1-1, Section IV.P.(5) in accordance with the requirements of DOE M 251.1-1A, *Directives System Manual,* is necessary to demonstrate that an alternative methodology would provide adequate controls on disposal of low-level waste.

To provide sufficient information to the Deputy Assistant Secretaries for Environmental Restoration and Waste Management for them to exempt a facility from the performance assessment and composite analysis requirements, a demonstration of reasonable expectation that the performance objectives will be protective is necessary, including accounting for all sources of radioactivity, uncertainties, protection of inadvertent intruders or waste concentration and activity limits, and protection of water resources. Any calculational methodologies must be justified and verified, and parameters and assumptions used in the analyses must be justified.

Compliance with this requirement is demonstrated by an exemption to the requirements for a performance assessment and composite analysis approved by the Deputy Assistance Secretaries for Waste Management and Environmental Restoration, and supporting an analysis of the low-level waste disposal facility design and operations that provides a reasonable expectation that the performance objectives for disposal of low-level waste will be met and that accounts for all sources of radioactive material that may be left at the DOE site and may interact with the disposal facility.

Supplemental References:

1. DOE, 1998. *Directives System* and *Directives System Manual*, DOE O 251.1A and DOE M 251.1-1A, U.S. Department of Energy, January 30, 1998.

IV. Q. Closure.

The following requirements are in addition to those in Chapter I of this Manual.

(1) Disposal Facility Closure Plans. A preliminary closure plan shall be developed and submitted to Headquarters for review with the performance assessment and composite analysis. The closure plan shall be updated following issuance of the disposal authorization statement to incorporate conditions specified in the disposal authorization statement.

Objective:

The objective of this requirement is to ensure that critical information on low-level waste disposal facility closure analyzed in the performance assessments and composite analyses is documented in a preliminary plan that is submitted along with performance assessment and composite analysis for review and to ensure that any changes to the facility closure plan that is part of a condition of the disposal authorization statement is formally incorporated into the closure plan.

Discussion:

The safety and hazard analysis for management of radioactive waste conducted to develop the essential requirements for DOE O 435.1 and DOE M 435.1-1 indicated that disposal is the most critical activity requiring controls because the potential hazards from disposed radioactive waste continue into the future. One of the most important of controls for long term safety of disposed low-level waste is the closure plan for the facility, the elements of which represent the last line of defense against the possible interaction of buried radioactivity and the public, worker, or the environment. The development and implementation of a low-level waste disposal facility closure plan is a crucial function in assuring disposal is being conducted safely and effectively and will remain safe into the future.

As discussed in Section I.2.F.(8) of the guidance, it is the responsibility of the Field Element Manager to develop and implement closure plans for low-level waste disposal facilities. This section provides the detailed guidance on the contents and the development of closure plans for low-level waste disposal facilities.

Preliminary Closure Plan. A preliminary closure plan, containing the elements of the closure plan discussed below, must be submitted to Headquarters as part of the documentation for approving and issuing a disposal authorization statement. The preliminary closure plan includes the documentation of the closure of the disposal facility as analyzed in the performance assessment.

The closure plan has the purpose of defining the approach to be taken for ensuring the long-term protection of the public and the environment from the disposal of low-level radioactive wastes. Information gained from the performance assessment process provides a basis to be included in developing closure plans, and the results of the performance assessment process is used to revise and update the closure plan. Examples of information to be included in closure plans are the proposed covers for the disposal units, as analyzed in the performance assessment, vegetative covers over the disposal units and their long-term effectiveness, site grading and other long-term controls for minimizing erosion and infiltration, other specialized engineered features to minimize subsidence in disposal units and radionuclide migration, and long-term disposal facility monitoring.

The closure plan for a low-level waste disposal facility is reviewed and approved according to the requirements included in Chapter I, *General Requirements* of the manual. The closure plan addresses the three steps of facility closure, which are 1) operational or interim closure, 2) final facility closure, and 3) institutional control. The closure needs to address all activities to be performed following disposal operations, with those activities being selected to minimize the need for long-term maintenance and maximize the stability of the disposal facility. A period of active institutional control of 100 years is normally assumed in the analysis, however access is controlled, monitoring is performed, and custodial maintenance is performed until release of a closed disposal facility to unrestricted uses in accordance with the requirements of DOE 5400.5, *Radiation Protection of the Public and Environment,* are met. As a result, longer periods of institutional control may be assumed when justification is provided in documented plans which describe long-term site land use or site remediation. The closure plan includes the designs and approaches to be taken for each step in the closure process, and is coordinated with the monitoring plan for the disposal facility. Integration of the monitoring plan for the low-level waste disposal facility, the data to be collected, and closure planning is also discussed in the monitoring guidance associated with DOE M 435.1-1, Section IV.R.

> *Example 1: The closure plan at Oak Ridge includes the collection, monitoring, and management of leachate from the operating disposal facility and includes the commitment to continue leachate management for 100 years after final closure.*
>
> *Example 2: The closure plan for SRS includes the agreement between the State of South Carolina and DOE to continue institutional controls for an indefinite period of time.*

Update of the Closure Plan. An update of the closure plan, following issuance of the disposal authorization statement, is necessary to reflect the conditions included in the disposal authorization statement. Changes mandated in the disposal authorization statement that may cause a re-evaluation of the performance assessment need to also be addressed as part of the performance assessment maintenance program. The closure plan is a living document that is constantly updated through the operational life of the facility with specific information about

contents and partial closure (e.g., caps on trenches) of disposal units and other information necessary (e.g., monitoring locations) to result in the final closed state. Additionally, any information that is incorporated into the closure plan or any changes made to closure of the facility that would change assumptions used in the analysis in the performance assessment or composite analysis should be incorporated into those evaluations as part of the performance assessment maintenance program as soon as possible so that the extent of their impact on waste acceptance or other aspects of operation can be known and any required changes are made effective as soon as possible.

Example 1: A minimal closure plan is prepared for a new low-level waste disposal facility and incorporated into the analyses performed for the performance assessment. The review of the performance assessment and composite analysis for the disposal facility requires enhancements of the facility monitoring included in closure plan to ensure protection of the environment, because of findings presented in the composite analysis. The closure plan is updated following the issuance of the disposal authorization statement to reflect the findings of the review and the performance assessment is reviewed to evaluate the need for revision of the performance assessment. Any revisions to the performance assessment are performed through the performance assessment maintenance program.

Example 2: The preliminary closure plan is prepared for an existing disposal facility that provides for interim closure of the disposal facility awaiting the completion of the CERCLA process for final closure. The performance assessment is prepared using the interim closure plan as a conservative basis for final closure. The Disposal Authorization Statement requires the revision of the closure plan after the Record of Decision is signed from the CERCLA process. The closure plan is then revised and the performance assessment is revised to reflect the CERCLA ROD as part of the performance assessment maintenance program.

Part of Radioactive Waste Management Basis. The closure plan is part of the documentation for the radioactive waste management basis for a disposal facility. For new disposal facilities, the closure plan is approved and incorporated into the performance assessment and composite analysis prior to approval of the radioactive waste management basis for the facility. For operating disposal facilities, the closure plan is prepared and approved as part of radioactive waste management basis, but the approved closure plan does not need to be incorporated into the performance assessment and composite analysis prior to issuing the radioactive waste management basis for the facility. The approved closure plan is addressed as part of the performance assessment and composite analysis maintenance program for operating facilities. If the approved closure plan differs substantially from the assumptions for closure included in the performance assessment and composite analysis prepared for the issuance of the disposal authorization statement, a revision of the performance assessment and composite analysis may be

necessary to provide the needed assurance that the facility will meet the performance objectives included in the manual. Iterations and improvements in these documents which form the basis for facility operation need to continue throughout disposal facility operations and closure.

Example 1: A radioactive waste management basis statement is not prepared for a disposal facility because a preliminary closure plan was not provided with the performance assessment and composite analysis. After a preliminary closure plan is prepared and submitted to Headquarters, the Disposal Authorization Statement for the facility is issued with amendments to be included in the preliminary closure plan. Prior to the revision of the closure plan, and the review of the performance assessment and composite analysis for the need for revision, the radioactive waste management basis statement is prepared and approved, with conditions, based on the existing documentation for the facility.

Example 2: The approved closure plan for an existing disposal facility includes additional requirements for stabilization of wastes prior to final closure. The performance assessment is reviewed and revisions to the performance assessment are not necessary to account for the additional stabilization requirements, because the conclusions of the performance assessment are not changed as a result of changes in the closure plan.

Compliance with this requirement is demonstrated when preliminary closure plans are submitted to Headquarters for review with the performance assessments and composite analyses, and then revised within one year after the disposal authorization statement is issued to include the conditions specified in the disposal authorization statement.

Supplemental References:

1. DOE, 1992. *Considerations for Closure of Low-Level Radioactive Waste Engineered Disposal Facilities*, DOE/LLW-133, U.S. Department of Energy, National Low-Level Waste Management Program, Idaho Falls, ID, 1992.

2. DOE, 1990. *Guidance on Stabilization and Closure of U.S. Department of Energy Mixed And Low-Level Radioactive Waste Disposal Facilities*, DOE/LLW-82, U.S. Department of Energy, National Low-Level Waste Management Program, Idaho Falls, ID, 1990.

IV. Q.(1) Disposal Facility Closure Plans. Closure plans shall:

(a) Be updated as required during the operational life of the facility.

Objective:

The objective of this requirement is to ensure that conditions encountered or developed during the operation of a low-level waste disposal facility that will impact long-term safety and environmental considerations when the facility is closed are incorporated into the closure plan in a timely fashion.

Discussion:

As described in the guidance for DOE M 435.1-1, Section I.2.F.(2), a radioactive waste management basis is required to document the conditions of safe and efficient management of radioactive waste. The guidance for this section addresses maintaining the radioactive waste management basis for disposal facilities. The closure plan, as part of the radioactive waste management basis can be expected to need to be updated from the preliminary closure plan to an approved final closure plan. Additional updates can also be anticipated as the disposal facility matures from design to construction to operations. Changes in facility design and operations, additional information developed from monitoring data, or improved understanding of low-level waste disposal facility performance can lead to changes in the analyses and documentation for the facility, which could lead to changes in the closure plan. Updates of the closure plan are necessary to ensure that the radioactive waste management basis is current, and protective of workers, the public, and the environment.

Example 1: A disposal facility is designed to accept radon bearing waste at a certain level, but as the facility is operated, increased levels of radon bearing wastes are directed to the disposal facility. Revisions to the performance assessment and closure plan are made to reflect the change in operations. As a result of the new analysis in the performance assessment, a design change is made to accept the radon bearing wastes that includes an increase in the thickness of the cover and a corresponding increase in the depth of excavation of the disposal unit to maintain the same disposal capacity. The changes to the facility design are also reflected in the closure plan.

Example 2: During operations, monitoring program data reveal that moisture in the vadose zone beneath a disposal unit is greater than expected from a disposal unit subject to interim closure. Analyses in the performance assessment and closure plan are modified to test the impact of additional cover materials. As a result, the closure plan is updated to add additional material layers to the cover of the interim closed disposal

units. Subsequent monitoring data indicate a reduction in the moisture content beneath the disposal unit subject to interim closure. The closure plan is updated to reflect the change in the interim closure plan.

The determination of the need to update the closure plan for a disposal facility is site-specific. While the need to update the closure plan is site-specific, the primary purposes of closure must be maintained and can be expected to drive the need for closure plan updates. Changes in waste characteristics disposed of at the facility, which require enhanced facility performance to meet the performance objectives of the manual, could result in the need to update the closure plan. Likewise, excessive costs of implementing the closure plan, which includes elements not needed for meeting the performance objectives, could result in the need to update the closure plan.

Example: The closure plan for a disposal facility called for a thick cover to minimize the potential for root penetration into wastes by trees at Savannah River Site. The development of bamboo as a long-term method for reducing soil moisture and preventing the plant succession to pine forest is successfully demonstrated. The closure plan is subsequently updated to reflect the change in the closure plan from a thick cover to a thinner cover with bamboo plantings on top.

Occurrences of disposal unit subsidence during facility operations that indicate a lack of disposal unit stability could result in the need to update the closure plan. Similarly, unexpected releases of radionuclides from disposal units could lead to the need to update the closure plan to provide additional engineered controls or features to reduce the potential for future releases of radioactive materials. The determination of the need to update the closure plan is ultimately made when there is reason to suspect that the radioactive waste management basis for the disposal facility is no longer consistent with the actual performance of the disposal facility.

Example: Disposal unit subsidence is observed at Site B to an extent that exceeds the projections presented in the performance assessment. Corrective actions are initiated to stabilize closed disposal units with soil and inject grout into closed disposal units to stabilize them from future subsidence. The disposal facility waste acceptance requirements are revised to further reduce unstabilized waste from being accepted for disposal in operating disposal units. The closure plan is updated to include the units to be stabilized.

Compliance with this requirement is demonstrated by the closure plan for a disposal facility being a current representation of the planned facility closure and that the plans are also correctly represented in the performance assessment for the disposal facility.

Supplemental References:

1. DOE, 1992. *Considerations for Closure of Low-Level Radioactive Waste Engineered Disposal Facilities*, DOE/LLW-133, U.S. Department of Energy, National Low-Level Waste Management Program, Idaho Falls, ID, 1992.

2. DOE, 1990. *Guidance on Stabilization and Closure of U.S. Department of Energy Mixed And Low-Level Radioactive Waste Disposal Facilities*, DOE/LLW-82, U.S. Department of Energy, National Low-Level Waste Management Program, Idaho Falls, ID, 1990.

IV. Q.(1) Disposal Facility Closure Plans. Closure plans shall:

(b) Include a description of how the disposal facility will be closed to achieve long-term stability and minimize the need for active maintenance following closure and to ensure compliance with the requirements of DOE 5400.5, *Radiation Protection of the Public and the Environment.*

Objective:

The objective of this requirement is to ensure that the primary public health and environmental protection requirements are addressed in the closure plan, as well as the principal goals of achieving long-term stability and minimizing maintenance after closure.

Discussion:

The content of a closure plan should address all phases of the activities to be undertaken during the operational or interim closure, final facility closure, and institutional control. A closure plan applies to all phases of a facility's life, and is to reference monitoring activities described in the monitoring plan, data to be collected in support of the closure, and activities to be undertaken in response to the results of facility monitoring. Facility closure is to allow the disposal facility activities to cease in a way that the public and the environment is protected from the hazards from the disposed waste in accordance with DOE's requirements in its general radiation protection directive, which is currently DOE 5400.5, *Radiation Protection of the Public and the Environment*.

Example: The closure plan includes maps locating monitoring wells to be used throughout operations, interim closure, final closure, and institutional control. The closure plan includes the details of well construction, sampling frequencies, sampling

methods, monitoring parameters, and methods of analysis for each monitoring well. Also included are the data management methods, data analysis methods, data reporting and remedial action plan associated with the monitoring wells for the disposal facility.

The closure plan provides the details for accomplishing the closure requirements included in the facility design. The plan is specific to the disposal facility, the characteristics of the disposal site, and wastes disposed of at the disposal site. The plan provides a discussion of applicable DOE, Federal, State, and local closure requirements, (including DOE 5400.5), a detailed discussion of each activity to be performed during each phase of the closure process, and the relationship between the activities to achieve the desired result of minimum maintenance and long-term stability and little need for maintenance. The methods to be used for each of the closure activities are provided in the plan, including the final landscape and the methods to be employed to minimize infiltration of water into the disposal units. As part of this discussion, the plan explains how contaminant migration will be controlled in the near-term and the long-term. A detailed description of the cover designs for the disposal units and their intended performance is also included. Facility features which address the minimization of erosion by wind and water and prevent intrusion into the waste by plants and animals, are to be described in the plan.

Example: The closure plan identifies the number of lifts of cover material to be placed over disposal units, the thickness of each lift, the geotechnical specifications for each lift. The specifications for geotextiles between the various layers of the cover are identified, and any vegetative or rock cover at the ground surface are also included in the closure plan. The closure plan includes a discussion of the expected performance of the cover design and provides performance indicators for the cover design. The closure plan also provides a discussion of the corrective actions to be taken if the performance indicators are exceeded.

The closure plan includes a summary description of how the activities to be performed will place the facility into a configuration which will allow the performance objectives to be met in both the short-term and the long-term. The schedule for completing facility closure accompanies this presentation and shows each phase of closure including, the preparation and approval of related documents and permits such as the final performance assessment, composite analysis, safety analysis report, other permits, or state approvals.

Example: The closure plan provides a crosswalk summary of the elements of the closure of the facility and the performance objectives for the closure of the facility. The relationship between each feature included in the closure plan and the corresponding purpose of the feature with respect to the short-term and long-term performance of the facility is explained. How the various elements of the closure plan interface with minimizing the potential for the transport of contamination is provided. The closure plan includes the schedule for facility closure and all milestones for facility closure. Steps for

completing the closure of the facility are included with the dates for completion. The closure plan lists, as part of the schedule, all permits and documents to be completed as part of the closure of the disposal facility. Milestones are established for the completion of all documents and permits. The schedule includes allowances for review and approval of all documents and permits.

The closure plan needs to specifically address how closure activities will ensure the eventual compliance of the closed facility with the requirements for public and environmental radiation protection contained in DOE 5400.5, *Radiation Protection of the Public and the Environment*, (or 10 CFR Part 834 when it is promulgated). Aspects of closure activities that will put the facility into its final disposition, transition maintenance from active to passive, commence institutional controls, perform long-term monitoring, and institute final record-keeping, should be included in this discussion. If the facility is to be released for unrestricted release (see more guidance on DOE M 435.1-1, Section IV.Q.(2).(c)), the aspects of the closure activities that will ensure an adequate level of protection can be achieved following a time for institutional control (100 years), should also be discussed. This may include a discussion about the final cover cap thickness that was chosen to provide for very long-term stability and minimization of radioactive material release at the facility.

The closure plan needs to also include potential corrective actions to be taken at each stage of the closure process. The inspection program, the inspection methods to be used, and the criteria to be used for initiating corrective actions are described. Specific corrective actions are included for the occurrence of subsidence or the indication of contaminant migration. Other corrective actions to address potential issues such as uncontrolled site access, natural phenomena, failure of monitoring equipment, ponding of water or excessive infiltration, erosion, or the presence of undesirable flora or fauna are included, if applicable. The relationship between corrective actions and the monitoring program is clearly identified.

Compliance with this requirement is demonstrated by the closure plan including a reasonable representation of the closure conditions that will achieve stability of the disposal facility and reduce the need for active maintenance, and which can be demonstrated meets the requirements of DOE O 5400.5.

Supplemental References:

1. DOE, 1990. *Radiation Protection of the Public and the Environment*, DOE 5400.5, U.S. Department of Energy, Washington, D.C., February 8, 1990.

2. DOE, 1992. *Considerations for Closure of Low-Level Radioactive Waste Engineered Disposal Facilities*, DOE/LLW-133, U.S. Department of Energy, National Low-Level Waste Management Program, Idaho Falls, ID, 1992.

3. DOE, 1990. *Guidance on Stabilization and Closure of U.S. Department of Energy Mixed And Low-Level Radioactive Waste Disposal Facilities*, DOE/LLW-82, U.S. Department of Energy, National Low-Level Waste Management Program, Idaho Falls, ID, 1990.

IV. Q.(1) Disposal Facility Closure Plans. Closure plans shall:

(c) Include the total expected inventory of wastes to be disposed of at the facility over the operational life of the facility.

Objective:

The objective of this requirement is to ensure that the closure plan is updated throughout the operation of the facility to accurately reflect and consider all of the long-term hazards associated with the actual inventory of low-level waste disposed at the facility over its operational lifetime.

Discussion:

The closure plan for a disposal facility is required to provide an inventory of the wastes expected to be disposed of at the facility over its complete lifetime. This inventory includes the inventory estimates of each isotope expected to be included in waste, as well as the total inventory. The initial inventory estimates for a new disposal facility are likely to be subject to uncertainties because they are based on expected or projected waste volumes and attributes. As the facility operates and actual waste is disposed, periodic updates of the closure plan are made, as required by DOE M 435.1-1, Section IV.Q.(1)(a), to reflect the actual volumes and characteristics of the disposed waste and reduce the uncertainty in the total and isotopic inventory. The estimated inventory presented in the preliminary or initial closure plan is consistent with the inventory used in the performance assessment of the facility, and any limitations on inventory incorporated into the waste acceptance criteria. Should the inventory estimates included in the closure plan significantly exceed the inventory considered in the performance assessment, then the performance assessment and composite analysis may need to be revised in order to provide assurance the performance objectives for the disposal facility can be met.

Example: The actual inventory of the disposal facility is less than the inventory projected for the disposal facility in the original closure plan, which was approved as part of the Disposal Authorization Statement. The closure plan is updated to include the actual inventory and the new projections for the total inventory of the disposal facility. The performance assessment and composite analysis are reviewed to determine the need for revision based on the revised inventory estimates.

Compliance with this requirement is demonstrated by the inventory in the closure plan being demonstrated to be a reasonable representation of the total expected inventory of the disposal facility at the end of facility operations.

IV. Q.(2) Disposal Facility Closure. Closure of a disposal facility shall occur within a five-year period after it is filled to capacity, or after the facility is otherwise determined to be no longer needed.

Objective:

The objective of this requirement is to ensure that the disposal facility does not remain in an unmaintained state, leading to compromise of the ability of the disposal units to contribute to long-term stability and protection of the public, workers, and the environment.

Discussion:

The guidance for DOE M 435.1-1 emphasizes the importance of closure to the overall performance of disposal facilities. This requirement to promotes prompt closure of disposal facilities to minimize the exposure of wastes to natural phenomena. Five years from the time which a disposal facility is filled to capacity provides a sufficient period of time for closure to occur without having the disposal facility and the disposed wastes being allowed to degrade and become unstable.

This requirement identifies the time period allotted for disposal facility closure following the period of active disposal operations. The time period of five years is measured from the date the last waste package is emplaced in the disposal facility. Closure is considered complete when all of the activities outlined in the closure plan for disposal facility closure have been accomplished and the facility enters the institutional control phase of closure.

> *Example: A disposal unit accepts its last package of waste and interim closure of the disposal unit is completed. The remaining disposal units in the disposal facility continue to operate. Some time later, the last disposal unit accepts its last package of waste. The five year period for final closure of the disposal facility begins with the acceptance of the last waste package in the last disposal unit.*

Facility closure activities are intended to stabilize the site and minimize the need for ongoing active maintenance. Activities performed during this period include placement of intruder barriers, completion of final grading to ensure appropriate management of runoff and infiltration over the long-term, placement of erosion controls, and placement of site markers. At the end of the closure period, the facility is in a condition where only institutional control is required, which

includes site monitoring and minor custodial care. The closure activities are clearly described in the closure plan for the facility. Closure also includes the compilation and proper disposition and storage of all records in a retrievable manner in accordance with the General Requirements Chapter of the manual. Closure, as described in the closure plan, also includes the placement of permanent identification markers to locate disposal units and placement of monitoring equipment. The locations of these markers are recorded on the site maps of the disposal facility that are referenced to USGS or NGS survey control stations. The maps are filed with the facility records and with local governmental authorities (see IV.Q.(2)d)).

Example: The final closure plan includes a description of the activities to be performed for intruder protection, removal of surface facilities and debris, final grading, installation of monitoring equipment, establishment of stable vegetation, permanent marking of disposal units, and establishing and marking of the security system (e.g., fences and alarms) for the disposal facility. All of these steps for disposal facility closure are completed in the five years allowed by this requirement.

The actions taken during disposal facility closure are documented in the final closure plan. The documentation provides a comprehensive description of the facility at the end of facility closure, including monitoring activities, intruder barriers, and permanent markers.

Example: At the completion of final closure, the documentation of all of the actions taken are reviewed. All documentation is updated to include as-built drawings and specifications for the disposal facility. The final inventory of the disposal facility is updated along with the performance assessment and composite analysis for the disposal facility and included in the final closure plan.

Compliance with this requirement is demonstrated by the final closure being completed, including the required documentation, within five years after the acceptance of the last waste package at the disposal facility.

IV. Q.(2) Disposal Facility Closure.

(a) Prior to facility closure, the final inventory of the low-level waste disposed in the facility shall be prepared and incorporated in the performance assessment and composite analysis which shall be updated to support the closure of the facility.

(b) A final closure plan shall be prepared based on the final inventory of waste disposed in the facility, the plan

implemented, and the updated performance assessment and composite analysis prepared in support of the facility closure.

Objective:

The objective of these requirements is to ensure that necessary information associated with the final inventory of low-level waste disposed at the facility over its operational lifetime is incorporated into the performance assessment and composite analysis in support of the final closure of the facility, and then incorporated into the closure plan to provide protection of the workers, public, and environment from the long-term hazards posed by the disposal waste.

Discussion:

Final Inventory. Under this requirement, the expected inventory included in the closure plan must be updated to provide the final inventory of waste actually disposed of in the facility. The final inventory includes a complete listing of the total inventory, the inventory is of each radionuclide disposed, and the total volume of waste disposed. The final inventory provides a crosswalk with the waste manifests for each waste package disposed in the facility to facilitate the resolution of any specific issues related to the location, waste characteristics, waste packaging and concentrations of radionuclides present in the disposal facility. The final inventory used in updating the performance assessment to ensure the performance of the facility meets the performance objectives for low-level waste disposal following closure.

Final Closure Plan. The final closure plan incorporates all of the findings of the final update of the performance assessment and composite analysis and includes the final inventory for the disposal facility. The final closure plan clearly presents the steps to be taken to ensure long-term stability of the facility and site. The plan specifies the ongoing maintenance and monitoring activities to be performed during the period of institutional controls and the process for conducting any corrective actions that may be required.

Example 1: The final closure of the disposal facility includes the addition of one extra lift of topsoil over the disposal units. This additional lift is included in the final closure plan, and incorporated into the performance assessment for the disposal facility.

Example 2: The final inventory for the disposal facility is less than the expected inventory projected for the disposal facility in the existing documentation. The final closure plan is updated to reflect the reduced inventory. The performance assessment and composite analysis are also updated to include the reduced inventory, and the analyses and conclusions presented in the performance assessment are updated to reflect the final inventory in the disposal facility. Approval of the final documentation for the

disposal facility is obtained prior to completion of the final closure of the disposal facility.

Compliance with this requirement is demonstrated by the final closure plan documentation for the disposal facility including the final inventory of low-level waste disposed, the final inventory is incorporated into the performance assessment and composite analysis, and all analyses and conclusions are updated as appropriate.

Supplemental References:

1. DOE, 1999. *Maintenance Guide for U.S. Department of Energy Low-Level Waste Disposal Facility Performance Assessment and Composite Analyses,* (in preparation), U.S. Department of Energy, Washington, D.C., 1999.

IV. Q.(2) Disposal Facility Closure.

(c) Institutional control measures shall be integrated into land use and stewardship plans and programs, and shall continue until the facility can be released pursuant to DOE 5400.5, *Radiation Protection of the Public and the Environment*.

(d) The location and use of the facility shall be filed with the local authorities responsible for land use and zoning.

Objective:

The objective of these requirements is to ensure that institutional control will continue until the low-level waste disposal facility can be released for unrestricted use and that local land use records appropriately record the previous use of the land as a radioactive waste disposal facility to provide additional protection again misuse of the land and the possibility of an inadvertent intrusion.

Discussion:

Institutional Control. Institutional control, for the purposes of performance assessment, is typically assumed to last for 100 years. However, the actual period of institutional control, when DOE maintains a custodial presence and controls the use of the land, lasts until the facility can be released. A low-level waste disposal facility cannot be released until the requirements for public and environmental radiation protection of DOE 5400.5, Radiation Protection of the Public and the

Environment (or 10 CFR Part 834, when promulgated), for releasing a facility for unrestricted use are met. Institutional controls are no longer necessary for a facility released for unrestricted use.

For low-level waste disposal facilities, the period of institutional control could extend long beyond 100 years before the requirements of DOE 5400.5 are met. The closure plan includes the necessary activities to be performed during this period of institutional control to ensure the protection of the public health and the environment, such as facility monitoring, custodial maintenance, access controls, corrective actions, passive controls and restrictions, reporting requirements, and record keeping. The determination of the necessary activities to be performed during the institutional control period is based on the documentation and analysis included in the facility radioactive waste management basis, including the performance assessment, composite analysis, closure plan, and monitoring plan. Institutional control measures must be incorporated into the site's land use and stewardship plans and programs to ensure that control of the site is not compromised. Throughout the period of institutional control, the responsibility for maintaining the facility to protect the public and the environment rests with the Field Office Manager.

Location and Land Use Documentation. This requirement ensures that the previous use of the land for low-level waste disposal is a matter of public record to provide additional assurance that future generations will have knowledge of where the wastes are located. Local governmental authorities who are responsible for maintaining land use and zoning records need to be provided with maps of the disposal facility that identify the locations of all disposal units, permanent markers, monitoring locations, and the reference USGS or NGS benchmarks. These maps need to be supplemented with additional information documenting the wastes disposed of, the hazards of the waste, and the information needed to access the permanent records of the disposal facility maintained by DOE. This information is provided to the local authorities at the beginning of the institutional control period, in the unlikely event that a lapse of institutional control by DOE occurs. As advances in information technology are incorporated into the records maintained by local authorities (e.g., GIS data), the data needed to comprehensively describe the disposal facility are provided to the local authorities to ensure an accurate and complete record of land use at the facility is available to future generations.

> *Example: The DOE Field Office records the use of the land at the Z Site as a radioactive disposal facility with the local authorities responsible for land use and zoning. GIS information for the disposal facility has been developed, but the local authorities do not require GIS information to be included in the local records. DOE appends the filing of the record with the GIS information, in addition to providing maps of disposal units, permanent markers, monitoring locations, and USGS or NDA benchmarks, to provide the most complete record of the use of the land for radioactive waste disposal.*

Compliance with this requirement is demonstrated by the final closure plan including the information necessary to safely manage the disposal facility through the institutional control

period, up to and including release of the facility to the public, and the location of the disposal facility is made a part of the public record, including the maps, coordinates, reference benchmarks, and supporting documentation necessary to provide a complete understanding of the facility's location and contents.

Supplemental References:

1. DOE, 1990. *Radiation Protection of the Public and the Environment*, DOE 5400.5, U.S. Department of Energy, Washington, D.C., February 8, 1990.

2. DOE, 1992. *Considerations for Closure of Low-Level Radioactive Waste Engineered Disposal Facilities*, DOE/LLW-133, U.S. Department of Energy, National Low-Level Waste Management Program, Idaho Falls, ID, 1992.

3. DOE, 1990. *Guidance on Stabilization and Closure of U.S. Department of Energy Mixed And Low-Level Radioactive Waste Disposal Facilities*, DOE/LLW-82, U.S. Department of Energy, National Low-Level Waste Management Program, Idaho Falls, ID, 1990.

IV. R. Monitoring.

The following requirements are in addition to those in Chapter I of this Manual.

(1) All Waste Facilities. Parameters that shall be sampled or monitored, at a minimum, include: temperature, pressure (for closed systems), radioactivity in ventilation exhaust and liquid effluent streams, and flammable or explosive mixtures of gases. Facility monitoring programs shall include verification that passive and active control systems have not failed.

Objective:

The objective of this requirement is to specify minimum parameters for which information will be routinely collected and analyzed for the purpose of anticipating or identifying undesirable conditions in the management of low-level waste.

Discussion:

The safety and hazards analysis, conducted in support of developing DOE O 435.1 and DOE M 435.1-1, identified timely monitoring of radioactive waste management facilities as an effective mitigation of numerous weaknesses and conditions associated with all phases of the life-cycle of waste management. An analysis of existing Departmental requirements for environmental monitoring in DOE 5400.1 and DOE 5400.5 found that they were applicable to all radioactive waste types and all radioactive waste management facilities. Many of the individual conditions that warranted monitoring evaluated in the safety and hazards analysis are already monitored due to the implementation of these Order requirements. These two DOE Orders are implemented by DOE M 435.1-1, Section I.1.E.(7).

However, while the general environmental monitoring program and the environmental monitoring plans mandated by these DOE Orders are adequate for most circumstances, they were judged to not be sufficient in requiring identification of specific warning signs of impending conditions that would lead to releases, especially for storage of liquid low-level waste. DOE M 435.1-1, Sections IV.R.(1) and IV.R.(2) address these aspects of additional monitoring for low-level waste facilities. Also, the environmental monitoring requirements did not sufficiently address monitoring of the performance of a low-level waste disposal facility, for identification of specific signs that assumptions made in evaluations of the facility (i.e., performance assessment) were incorrect or for warning signs of conditions that should be addressed in a timely fashion to prevent conditions that were not evaluated. DOE M 435.1-1, Section IV.R.(3) addresses additional monitoring needed for low-level waste disposal facilities.

Additionally, through the conduct of safety analyses, whether they are formal safety analysis reports or auditable safety analyses, facility personnel identify the quantity and form of radioactive and/or hazardous material to be handled at the facility and the operations for managing the waste. The safety analysis establishes a basis for defining the acceptable operations envelope for the facility, and provides the basis for technical safety requirements (TSRs). The technical safety requirements may include requirements for monitoring. Review of the safety analysis will determine if the analyses indicate other monitoring that would be prudent.

> *Example: An auditable safety analysis is performed as part of the startup of a waste storage facility which will store some low-level wastes with significant concentrations of alpha-emitting radionuclides. The safety analysis indicates that a monitoring and sampling system is required on the building exhaust system. Site personnel decide that alpha monitors will be installed in the waste storage bays in addition to the monitor that is on the building ventilation system.*

Parameters Specified. The minimum parameters specified in the requirement were selected based on their potential significance for anticipating and identifying undesirable conditions at low-level waste management facilities. Each facility's radioactive waste management basis should include an evaluation of the applicability and significance of the minimum parameters. This evaluation also needs to consider additional parameters to be sampled or monitored to ensure the protection of the public health, the environment, and the workers. If a minimum parameter specified in the requirement is deemed to be not applicable in any way to the active operation of that facility, then that justification should be included in the radioactive waste management basis and when approved constitutes an exemption to the manual.

The parameters need to be sampled or monitored with a frequency that is consistent with the need to detect changes in the facility performance. The precision and accuracy of measurement required is dictated by the expected variations in the parameters and the level of precision and accuracy needed to identify problems. The monitoring frequency for specific parameters is likewise determined based on the possible time variation of the parameter and the response time required to take mitigating action. For facilities that release radioactivity in effluents, frequent monitoring or continuous monitoring should be considered.

> *Example: A waste storage facility includes a storage tank that contains liquid low-level waste. The tank is equipped with an induced draft ventilation system. The tank includes monitoring capability for temperature, radioactivity in the ventilation system, and flammable or explosive mixtures of gases.*

The verification that controls and systems are functioning properly is based upon the nature of the low-level waste management activity and the potential impact resulting from a failure. Verification of active control systems for sampling and monitoring critical facility parameters may

require frequent visual inspections. Passive controls such as disposal facility caps may only require physical inspection once every year. Verification activities are part of the radioactive waste management basis as a condition for operation and documented appropriately.

> *Example 1: High activity, high hazard liquid low-level waste is stored in a single-shell tank within a subsurface vault. The volume and pressure of the waste tank are measured via remote transducers and monitored in a central control room. Verification that the tank has not leaked is deemed necessary and accomplished with routine video inspections of the vault floor.*

> *Example 2: After closure and capping of a low-level waste disposal facility, markers are placed for the purpose identifying the location of the disposal facility. Monitoring is determined to be necessary once a year to verify that the markers are in place and the facility cap has not subsided or eroded.*

All low-level waste facilities are required to apply the sampling or monitoring requirement for the specified parameters in the requirement using the graded approach. As previously noted, the methods used and the frequency should be commensurate with the significance of a change in the parameter. This graded approach can extend to determining that it is inappropriate or unnecessary to monitor or sample for the specified parameters, and the basis for such a determination documented.

> *Example: A waste storage facility includes a closed storage tank that contains liquid low-level waste. The tank includes monitoring capability for pressure only. Documentation exists that demonstrates that the contents are not capable of generating flammable or explosive mixtures of gases and the closed tank is not susceptible to changes in temperatures above or below the building's ambient temperature.*

Compliance with this requirement is demonstrated if monitoring or sampling for the stated parameters is performed for all facilities with a precision, accuracy, and frequency consistent with timely identification of developing problems and a justification exists in the approved radioactive waste management basis for those specified parameters which are not monitored or sampled.

Supplemental References:

1. DOE, 1988. *General Environmental Protection Program,* DOE 5400.1, U.S. Department of Energy, Washington, D.C., November 9, 1988.

2. DOE, 1990. *Radiation Protection of the Public and the Environment,* DOE 5400.5, U.S. Department of Energy, Washington, D.C., February 8, 1990.

IV. R.(2) Liquid Waste Storage Facilities. For facilities storing liquid low-level waste, the following shall also be monitored: liquid level and/or waste volume, and significant waste chemistry parameters.

Objective:

The objective of this requirement is to mandate regular observation of parameters that indicate the quantity of liquid low-level waste stored in tanks; (1) so that unexpected changes in quantity indications can be promptly checked to determine if they are a reflection of leakage or other problems; and (2) so that liquid low-level waste input to storage tanks will be monitored to avoid overfilling. The objective of this requirement also includes tracking of the chemical characteristics of the waste to anticipate and avert undesirable storage conditions.

Discussion:

This requirement specifies additional parameters that must be monitored at facilities storing liquid low-level waste. These are additional requirements beyond the requirements in Chapter I, as already discussed and they are in addition to the parameters required in DOE M 435.1-1, Section IV.R.(1) for all low-level waste facilities.

This requirement is based on a similar requirement invoked to address a group of high hazards that was identified by the hazards analysis performed in support of the high-level waste chapter of this Manual. The hazards analysis performed to guide development of DOE O 435.1 and DOE M 435.1-1 revealed that very hazardous releases can result from containment failure of a component or from failure to stop transfer of high activity liquid waste when the receiving vessel (e.g., tank or bin) is full. Similar circumstances occurring at a high activity low-level waste liquid storage facility are similarly problematic, and a similar requirement was believed to be justified to prevent any additional exposures or workers, radioactive leaks to the environment, and costs for damage mitigation and cleanup from unanticipated liquid storage tank problems.

The requirement addresses the operation of monitoring systems to detect storage tank or transfer equipment failure that is of sufficient magnitude to cause a detectable volume change as well as to alert operators that a storage tank is approaching capacity so that overfilling can be avoided. The monitoring capability could be coupled with operational devices such as automatic shutoffs and bypasses and with alarms that will alert operators that action is needed to prevent or mitigate a release, if warranted by the risks associated with the specific wastes being stored. Regardless of the hazard of the waste being stored, leak detection equipment and inspection of diking of the contents of liquid waste storage facilities need to be included in the monitoring program consistent with the requirements in DOE 5480.22 to prevent any unplanned releases of any liquid waste in storage.

Liquid Level or Waste Volume. Some changes in liquid level or waste volume can occur normally due to slight changes in temperature or pressure. This requirement also addresses measuring liquid level or waste volume in a storage tank for the purpose of prompt detection of acute releases (releases that are detectable visually or by some other gross indicator) and more chronic releases that become apparent over a time frame of hours or days.

> *Example: A large diameter liquid low-level waste storage tank includes a mechanical level indicator that is read and recorded daily. The level indicator remained stable for six months following the last waste addition to the tank. The level indicator readings then began to show a downward trend that totaled two inches over a two week period. The level indicator change alerts operators of a potential problem that requires further investigation.*

Surface level is a relatively straightforward parameter to monitor for detection of leakage from a liquid waste storage system. In general, the surface level in a storage tank is an appropriate indicator of waste volume. However, operations and mechanisms that could change the volume in a tank must be considered to ensure all unexplainable level changes are investigated and to discount explainable level changes.

Gas generation and evaporation as well as intentional additions to and removals from the storage tanks must be accurately accounted for if the waste liquid level (or volume) is to be used to monitor for leakage. Also, consideration needs to be given to the separate monitoring of the liquid fraction and sludge or solid fraction present in the tank, if layering of the waste is present.

> *Example 1: In the tank in the example above, an unexpected chemical reaction generates gas that is trapped within the waste matrix or under a semipermeable layer of waste that retards percolation of the gas to the surface of the waste. This mechanism maintained the apparent surface level of the waste in the tank even as liquid was leaking out.*

> *Example 2: Operating personnel at a storage facility calculate the evaporation loss expected from a liquid low-level waste tank based on an assumed radionuclide inventory. The actual radionuclide inventory is much smaller than that assumed, so the actual heat generation rate is much smaller than that assumed. Overestimation of the waste volume change due to evaporation resulted in failure to detect leakage that was incorrectly assumed to be evaporative loss.*

Chemical Characteristics. Experience with situations threatening confinement of liquid radioactive waste in storage tanks led to the part of the requirement focused on monitoring chemical characteristics. Chemical characteristics of waste that are not compatible with the material of construction of waste tanks or transfer equipment often presage containment failure. The frequency of monitoring and the identification of significant tank chemistry parameters should

be determined on a facility- and tank-specific basis. Selection of parameters is based on the need to protect the public health, the environment, and workers. Monitoring is performed to provide statistically valid information of the relevant tank chemistry and any detected changes in the chemistry of the tank.

> *Example: Some very minor volumes of laboratory spill waste are planned to be added to liquid storage tank YTR. Tank YTR is made of carbon steel and has been in service since 1978. The pH of the spill waste is measured and adjusted to a pH of 12 to meet the waste acceptance requirements for waste transfers to the tank. The pH testing of tank YTR waste is part of routine monitoring.*

For liquid low-level waste tanks for which corrosion control or other structural integrity issues are indicated, the document entitled, *Guidelines for Development of Structural Integrity Program for DOE High-Level Waste Storage Tanks*, can be consulted for guidance on establishment of processes and programs to address the storage tank problems. Appropriate use of the graded approach is to be utilized when implementing corrosion control or other programs for storage tanks that will store liquid low-level waste that is less hazardous than the tanks addressed in the BNL document.

Graded Approach. A graded approach needs to be applied to implementation of this requirement for monitoring to detect acute releases promptly. The first consideration for a graded approach is that monitoring parameters and frequencies for liquid waste storage tanks should be specific for each tank. Also, the frequency of monitoring should be selected to detect changes commensurate with the potential risks of the specific waste being stored. For example, highly acidic liquid waste in a single-walled, mild steel storage tank may require continuous monitoring coupled with alarms and transfer equipment. On the other hand, mildly radioactive and chemically stable liquid waste that has been in storage for a long period of time may only need a simple mechanical liquid level reading once per week.

Compliance with this requirement is demonstrated by developing operational procedures for liquid low-level waste storage tanks to monitor waste liquid level, waste volume, and tank chemistry so that waste volume or chemistry changes are detected in a time frame that will allow implementation of corrective measures to limit public and worker doses and to prevent unplanned releases of stored liquid waste.

Supplemental References:

1. DOE, 1992. *Technical Safety Requirements*, DOE 5480.22, U.S. Department of Energy, Washington, D.C., February 25, 1992.

2. DOE, 1997. *Guidelines for Development of Structural Integrity Programs for DOE High-Level Waste Storage Tanks*, BNL-UC-406, Brookhaven National Laboratory, Upton, NY, January 1997.

IV. R.(3) Disposal Facilities. A preliminary monitoring plan for a low-level waste disposal facility shall be prepared and submitted to Headquarters for review with the performance assessment and composite analysis. The monitoring plan shall be updated within one year following issuance of the disposal authorization statement to incorporate and implement conditions specified in the disposal authorization statement.

Objective:

The objective of this requirement is to ensure that critical information on disposal facility performance monitoring is documented in a preliminary plan that is submitted along with the performance assessment and composite analysis for review and approval. This information is important in establishing conditions for authorizing the disposal of low-level waste and will help ensure that any changes to the disposal facility performance monitoring that is a condition of the disposal authorization statement is formally incorporated into the documented monitoring plan in a timely manner.

Discussion:

As previously discussed, the general environmental monitoring program and the environmental monitoring plans required in the General Requirements Chapter did not sufficiently address monitoring of the performance of a low-level waste disposal facility for identification of specific signs that assumptions made in evaluations of the facility (i.e., performance assessment) were incorrect or for specific warning signs of conditions that should be addressed in a timely fashion to prevent conditions that were not evaluated. This requirement for monitoring low-level waste disposal facilities, and all of the subrequirements that follow, are additional requirements beyond the Chapter I requirements which are applicable to all facilities. This requirement calls for the inclusion of performance monitoring information in the review of the performance assessment and composite analysis for a disposal facility so that the results of the evaluations can be used to establish the monitoring plan that will become part of the radioactive waste management basis for the disposal facility.

Preliminary Monitoring Plan. A preliminary monitoring plan, containing the elements of the monitoring program discussed in the guidance for DOE M 435.1-1, Section IV.R.(3)(b), must be submitted to Headquarters as part of the documentation for the disposal authorization statement

(DOE M 435.1-1, Section IV.P.(5)). The preliminary monitoring plan is a documentation of the monitoring performed in support of the performance assessment and composite analysis, and any preliminary changes or additions to the monitoring that reflect the results of the evaluations as submitted. Results of the performance assessment and composite analysis could result in the identification of a specific type of performance monitoring being included in the preliminary monitoring plan (e.g., trench cap subsidence), the identification of specific monitoring locations, or a recommended frequency for monitoring. The relationship of the monitoring plan with the performance assessment and composite analysis is discussed in detail in the next section of guidance for DOE M 435.1-1, Section IV.R.(3)(a).

> *Example: A disposal facility submits a performance assessment and composite analysis along with a preliminary closure plan to Headquarters, but does not submit a preliminary monitoring plan. The disposal authorization statement is not issued until the preliminary monitoring plan is submitted.*

Monitoring Plan Contents. Several purposes are addressed in the formulation and execution of a monitoring program for a low-level radioactive waste disposal facility. To address all purposes and conduct a program which is cost-effective requires planning which takes into consideration the characteristics of the disposal site, the wastes, and the disposal technology. Monitoring programs and their plans, which include routine analysis and interpretation of data collected, can be expected to reduce life-cycle costs of disposal by early detection of unexpected events and initiation of corrective actions, and improvements in the understanding of the performance of the site and waste disposal technology.

> *Example: To ensure the monitoring at the low-level waste disposal facility at Site R is cost-effective and is effective in determining early detection of unexpected events, it does not include vadose zone monitoring because a determination is made that, due to the thinness of the vadose zone, it does not have a major role in the determination of the long-term performance of the disposal facility*.

The monitoring plan includes a tabular summary of the media to be monitored, the methods to be used, the methods for analysis of collected samples, the methods of reporting, frequency of data collection, and action levels based on the data collected. All sampling is performed according to the appropriate procedures, with those procedures clearly described in the monitoring plan.

The plan includes a schedule for implementing the monitoring plan, and estimates of the resources required for the implementation of the monitoring plan. The plan describes the conduct of the program by a multi-disciplinary team of skilled professionals representing the various components of the monitoring program (e.g., air pathway, groundwater, closure cap, etc.).

Review and Approval of Monitoring Plan. As discussed earlier, a preliminary monitoring plan for a low-level waste disposal facility must be submitted along with the performance assessment and composite analysis for review prior to issuance of a disposal authorization. Therefore, review and approval of the monitoring plan for a low-level waste disposal facility would be conducted by the Field Element Manager, and the approved monitoring plan then becomes part of the radioactive waste management basis for the disposal facility. The authors of DOE O 435.1 intended that, to the extent practicable, the documentation of the plans, their reviews and approvals, and reporting of trends and other results of the monitoring data would be incorporated into the environmental monitoring plan required under DOE 5400.1. This incorporation may not be able to be accomplished initially, as the monitoring locations, media, and frequencies will be in a state of flux until all of the low-level disposal facility radioactive waste management basis is finalized. After the basis is finalized, this incorporation into the general environmental monitoring program may be easier to accommodate, and a phasing in of the information into the general environmental program may be appropriate.

Updating the Preliminary Monitoring Plan. An update of the monitoring plan, following the issuance of the disposal authorization statement, must be prepared within one year of issuance of the disposal authorization statement and should reflect all of the conditions concerning monitoring that are in the disposal authorization statement. Conditions in the disposal authorization statement become part of the radioactive waste management basis for the disposal facility as they reflect items to be implemented to maintain a reasonable expectation that the performance objectives will continue to be met after disposal operations have ceased.

Changes in the performance assessment and composite analysis that may be necessary because of changes in the monitoring plan or data generated by the environmental monitoring program are to be addressed as part of the performance assessment and composite analysis maintenance program.

Compliance with this requirement is demonstrated if a preliminary monitoring plan including the elements of the monitoring plan discussed in the following sections is submitted to Headquarters with the performance assessment and composite analysis for review, and a process to incorporate changes to the performance monitoring program for the low-level waste disposal facility is established that will include any changes to the monitoring based on the disposal authorization statement in an updated monitoring plan within one year of issuance of the authorization statement from Headquarters.

Supplemental References:

1. DOE, 1988. *General Environmental Protection Program*, DOE 5400.1, U.S. Department of Energy, Washington, D.C., November 9, 1988.

2. DOE, 1990. *Radiation Protection of the Public and the Environment*, DOE 5400.5, U.S. Department of Energy, Washington, D.C., February 8, 1990.

IV. R.(3) Disposal Facilities.

(a) The site-specific performance assessment and composite analysis shall be used to determine the media, locations, radionuclides, and other substances to be monitored.

Objective:

The objective of this requirement is to ensure that the monitoring program is appropriately designed and administered in a way that supports the analysis and evaluations conducted in the performance assessment and composite analysis and the conditions under which the disposal facility may operate based on the review and approval of these assessments.

Discussion:

This requirement serves to tailor the disposal facility performance monitoring to reduce uncertainties in assumptions made and evaluations conducted while developing the performance assessment and composite analysis and formulating the conditions under which the facility can operate. This requirement for monitoring low-level waste disposal facilities is an additional monitoring requirement beyond the requirements in Chapter I, as discussed in the guidance for DOE M 435.1-1, Section IV.R, and is applicable to all low-level waste disposal facilities.

Site-specific performance assessments and composite analyses are required for all low-level waste disposal facilities by DOE M 435.1-1, Sections IV.P. (2) and (3). These documents have the purpose of evaluating the long-term performance of the disposal facility and providing reasonable assurance that the performance objectives for low-level waste disposal are met. Assessments of the long-term performance of natural systems often have large uncertainties, and include many assumptions of the behavior of natural systems over extended periods of time. The performance assessment and composite analysis of a disposal system identifies these uncertainties and assumptions along with the results. An effective way to verify assumptions, reduce uncertainties, and build confidence in the results and conclusions of the performance assessment and composite analysis is to monitor the performance of the disposal facility.

Thus, the performance assessment and composite analysis are used as primary tools for establishing the monitoring plan to collect data to develop an understanding of the actual performance of the disposal facility. The performance assessment and composite analysis should provide sufficient information to identify the important migration pathways for the transport of

radionuclides, primary mobile radiological and chemical constituents, logical monitoring locations, monitoring parameters, and sampling frequencies.

> *Example: The performance assessment results for a low-level waste disposal facility indicate that one geologic strata is an especially important pathway for radionuclide release via groundwater. The preliminary monitoring plan states the importance of this strata, and indicates that two principal wells will be added to the site monitoring locations in this strata when the disposal facility becomes operational.*

Likewise, data collected from the monitoring program provide needed information to refine the performance assessment and composite analysis, as part of the maintenance program for the performance assessment and composite analysis, evaluate the conservativeness of the results of the performance assessment, and provide ongoing assurance that the results contained in the performance assessment are representative of the actual performance of the facility.

> *Example: The monitoring program installed at a low-level waste disposal site includes a surveying program of disposal unit covers to detect any subsidence of disposal unit covers. More serious subsidence is occurring than was evaluated in the performance assessment. The performance assessment is re-evaluated using the results of the monitoring data, by analyzing more severe subsidence. Even more frequent subsidence monitoring is instituted while further analysis of the situation is taking place.*

Technical personnel involved in the preparation and revision of the performance assessment and composite analysis should work closely with those personnel involved in the monitoring program to evaluate the results derived from facility monitoring. Revisions to the performance assessment, should be reviewed to determine if the changes affect the monitoring plan.

> *Example: The performance assessment for a low-level waste disposal facility is revised in response to monitoring data indicating the generation of leachate more quickly than expected. As a result of the revision, additional monitoring locations close to the disposal units are added to the monitoring plan, several monitoring locations distant from the disposal units are deleted from the monitoring plan, soil monitoring is added to the monitoring plan, additional parameters are added to the monitoring plan, frequencies of sampling are increased, and advanced vadose zone monitoring methods are introduced.*

The monitoring plan also needs to be coordinated with the disposal facility closure plan and safety analysis report to ensure the data needs derived from these separate documents are incorporated into the monitoring plan, and data collected by the monitoring program are incorporated into revisions of these documents.

Example: Referring to the previous example, the closure plan is modified to provide additional lifts of clay material to reduce long-term infiltration, and additional worker monitoring is introduced at the disposal facility to ensure worker doses are ALARA.

Compliance with this requirement is demonstrated if the performance monitoring plan for the low-level waste disposal facility demonstrates that the media, locations, radionuclides, and other substances being monitored are based on performance assessment and composite analysis results.

Supplemental References:

1. NRC, 1989. *Environmental Monitoring of Low-Level Radioactive Waste Disposal Facility*, NUREG-1388, U.S. Nuclear Regulatory Commission, Washington, D.C., 1989.

2. NRC, 1983. *Subsurface Monitoring Programs at Sites for Disposal of Low-Level Radioactive Waste*, NUREG/CR-3164, U. S. Nuclear Regulatory Commission (by U.S. Army Corps of Engineers Waterways Experiment Station), Washington, D.C., 1983.

3. DOE, 1990. *Environmental Monitoring for Low-Level Waste Disposal Sites: Low-Level Management Handbook Series*, Revision 2, DOE/LLW-13Tg, U.S. Department of Energy, National Low-Level Waste Management Program, Idaho Falls, ID, 1990.

IV. R.(3) Disposal Facilities.

(b) The environmental monitoring program shall be designed to include measuring and evaluating releases, migration of radionuclides, disposal unit subsidence, and changes in disposal facility and disposal site parameters which may affect long-term performance.

Objective:

The objective of this requirement is to specify the minimum parameters that must be monitored at all low-level waste disposal facilities. Monitoring of these parameters can alert operators of changing conditions that could be caused by problems associated with the disposal of low-level waste at the facility. This requirement adds the specific monitoring for disposal facility performance for the long-term in addition to the monitoring requirements that are required in Chapter I.

Discussion:

This requirement identifies the elements of environmental monitoring programs for low-level waste disposal facilities. This monitoring requirement for low-level waste disposal facilities is an additional requirement beyond the requirements of Chapter I, as discussed in the guidance for DOE M 435.1-1, Section IV.R, and is applicable to all low-level waste disposal facilities.

Elements to Be Monitored. A successful performance monitoring program for low-level waste disposal facilities monitors, at a minimum, the elements described in the requirement, and monitoring is conducted through the entire life-cycle of the facility. Therefore, a successful monitoring program actually begins prior to the facility even being constructed. Since the Department has many existing facilities already, much of this guidance is moot, except if an existing facility is to be expanded. This guidance first discusses the pre-operational monitoring program that is established in order to effectively monitor for the specific elements discussed in the requirement.

Pre-Operational Monitoring. Pre-operational monitoring of a new disposal site or the expansion of an existing disposal site to determine baseline conditions will be conducted as required by DOE M 435.1-1 as part of the Site Evaluation (DOE M 435.1-1, Section IV.M.(1)). This activity needs to be performed for at least one year prior to construction of a disposal facility. Because much of the environmental data collected by monitoring programs is influenced by seasonal events, one year of data represents an absolute minimum for data collection for new disposal sites. Longer periods of baseline monitoring data collection extending to five or more years provide a better data base. Media selected for monitoring needs to be those most likely to be affected by site development and waste disposal operations. Monitoring locations for all media are selected to provide an uninterrupted stream of data throughout site development, facility operations, facility closure, and post-closure. Pre-operational monitoring provides site characterization information, site suitability information, and provide records for public information.

> *Example: A new disposal facility at INEEL is proposed. Pre-operational monitoring data are collected for a five year period to ensure the meteorologic and soil data are reflective of the long-term trends associated with the site. Since the alternative sites are widely distributed across the site, extended data records are needed to differentiate between the various alternative sites.*

For expansions of existing disposal sites, pre-operational monitoring needs may be less demanding, because of the similarity of the site expansion to the existing disposal site. Consequently, the extent of pre-operational monitoring for the expansion of existing disposal sites may be less intensive with respect to the number of monitoring locations for each media, but the duration of pre-operational monitoring is consistent with the monitoring for new disposal sites to provide a meaningful baseline for the expanded disposal facility.

Many DOE low-level waste disposal facilities may be in close proximity to other waste management facilities. These nearby waste management facilities may be associated with the release and migration of radionuclides to the disposal facility. For such cases, the importance of the baseline monitoring program is increased. The monitoring plan for such facilities may need to be more comprehensive to allow for a separation of existing contamination from any contamination which might be introduced by the low-level waste disposal facility, and address multiple sources of contamination to assure that any release from the low-level waste disposal facility would not lead to exceeding the performance objectives addressed by the performance assessment and composite analysis.

> *Example: A new disposal facility is proposed that is adjacent to an existing operating facility which includes old disposal units closed over 30 years ago. The baseline monitoring data for the new facility indicate the migration of contamination from the old disposal units. The pre-operational monitoring program is extended in time to provide a more extensive baseline data base for separating the performance of the old disposal facility from the new disposal facility.*

Operational Monitoring. Once a baseline or pre-operational characterization of the disposal facility has been established and the facility has begun operations, operational monitoring required for low-level waste disposal facilities is directed toward the specific elements identified in the requirement.

Effluent Monitoring. The primary purpose for operational monitoring is to verify compliance with applicable effluent requirements and limits (e.g., NPDES, NESHAPS), evaluate the effectiveness of effluent treatment and control, and identify environmental problems requiring mitigation or corrective action. (Also see next discussion on Evaluation of Monitoring Data). Effluent monitoring during operations typically involves routine sampling and analysis, using methods that will capture any release of contamination that might occur, such as water runoff to storm drainage systems during storms, or tritium migration within disposed waste masses. Effluent monitoring is also used to detect hydrologic failure of engineered disposal systems, such as concrete disposal vaults. This type of monitoring can be accomplished by monitoring engineered sumps, or moisture present outside the disposal vaults.

Operational monitoring that is directed toward the detection of effluents needs to be performed as close as reasonable to the waste emplacement operations, including the consideration of monitoring within the disposed waste mass. Radionuclide releases from facility operations can potentially occur to the atmosphere, soils, or water resources. Any operational effluent release from disposal facilities needs to be monitored, such as releases from leachate collection systems to the surface, groundwater, surface water, or atmosphere. These data, when compiled over a long period of time, provide indications of long-term trends and changes in operational conditions.

Radionuclide Release Detection. Monitoring equipment and location selection for radionuclide release detection is considered during facility design and construction, with emphasis on the earliest detection of migration. Operational monitoring directed toward the detection of the migration of radionuclides is intended to ensure that applicable standards and permit requirements are met, and assess potential radiation exposures to members of the public. This type of monitoring also is used to determine any effects on the environment or natural resources. The purpose of this type of monitoring is to characterize and define trends in the physical, chemical and biological condition of environmental media.

> *Example: Air sampling at the site boundary, biological monitoring of flora and fauna within the disposal facility, and analysis of groundwater in wells adjacent to the facility are performed as part of the monitoring plan to characterize and define trends in the physical, chemical, and biological condition of the environmental media at a disposal facility.*

Subsidence. While low-level waste disposal facilities are designed and operated to maximize the stability of the wastes and the disposal facility, subsidence remains a persistent problem at disposal facilities. The occurrence of subsidence is an early indication of needed corrective actions which should be performed. Monitoring for subsidence needs to be included in the monitoring plan with the schedule for implementation of subsidence monitoring following interim closure of a disposal unit and continuing throughout the closure and post-closure phases of the monitoring plan. The onset of subsidence is considered a potential failure in long-term stability and may need to be addressed by corrective action. Parameters to be considered in monitoring for subsidence include spatial surface monitoring of disposal unit covers, and may include monitoring of the moisture profile from the surface to the bottom of the disposal unit. Other disposal facility and site parameters which provide indications of long-term performance and stability of waste disposal facilities are also incorporated into the monitoring plan as interim closure is performed on filled disposal units.

Evaluation of Monitoring Data. Data collected from operational and post-operational environmental monitoring are reviewed and interpreted to identify: (1) compliance with applicable effluent requirements, limits, and/or permit conditions, or (2) changes in disposal facility or site parameters which may affect long-term performance. Analysis and interpretation of data include the identification of the changing trends in the data, identification of monitoring data requiring verification, identification of unanticipated results, and the identification of corrective actions to be taken as a result of data collected.

> *Example: A vadose zone monitoring system beneath a disposal unit provides data indicating a steady increase in moisture content. Review of the data reveals the unanticipated trend, and an investigation of the monitoring equipment identifies an*

instrument failure. The instrument is repaired and notations added to the data record of the existence of the failed instrument.

With respect to compliance, evaluation of monitoring data is used to determine if any releases from a facility are not within limits established by DOE 5400.1 and DOE 5400.5; technical safety requirements established in response to DOE 5480.22; or other release limits established by the radioactive waste management basis for the low-level waste disposal facility. Inclusion of the interpreted results from the monitoring program for this aspect of monitoring should be reported in the Annual Site Environmental Monitoring Report required by DOE 5400.1.

With respect to long-term performance of the low-level waste disposal facility to ensure the performance objectives are met, monitoring data are reviewed periodically against the action levels contained in the monitoring plan (see guidance on DOE M 435.1-1, Section IV.R.(3)(c)). This review is conducted routinely throughout the operational, closure and post-closure periods of the facility to evaluate the performance of the facility as compared to the results contained in the performance assessment and composite analysis, detect trends in the performance of the facility sufficiently in advance to allow for necessary corrective actions, and to provide justification for changes in the monitoring plan for the facility. Additional guidance on this aspect of monitoring data evaluation is provided with the discussion of Section IV.R.(3)(c).

Example: The monitoring data for the Site Q Low-Level Waste Disposal Facility were reviewed, and a need to revise the performance assessment because of the disparity between expected results and actual data was identified. Trending of data is initiated to follow future trends in the leachate generation data and corrective action plans are developed to mitigate potential releases.

Additional Guidance on Low-Level Waste Disposal Facility Monitoring. Numerous documents that contain generalized guidance on the development of environmental monitoring for low-level waste disposal facilities have been prepared (DOE/LLW-54T, DOE/LLW-13Tg, Rev. 2, NUREG-1388, NRC Reg. Guide 4.15, DOE/EH-0173T, DOE/EP-0023). This generalized guidance should be consulted for assistance with specific monitoring topics that are not addressed by this implementation guidance. It must be remembered, however, that the generalized guidance in these reference documents must be tailored to the specific site, facility, waste streams, and disposal technology being considered.

Compliance with this requirement is demonstrated if the environmental monitoring program collects and evaluates sufficient data on effluents, radionuclide releases, and subsidence to provide a sound basis for analyzing the long-term performance of the disposal facility.

Supplemental References:

1. DOE, 1988. *General Environmental Protection Program*, DOE 5400.1, U.S. Department of Energy, Washington, D.C., November 9, 1988.

2. DOE, 1990. *Radiation Protection of the Public and the Environment*, DOE 5400.5, U.S. Department of Energy, Washington, D.C., February 8, 1990.

3. DOE, 1992. *Technical Safety Requirements*, DOE 5480.22, U.S. Department of Energy, Washington, D.C., February 25, 1992.

4. DOE, 1991. *Environmental Regulatory Guide for Radiological Monitoring and Environmental Surveillance*, DOE/EH-0173T, U.S. Department of Energy, 1991.

5. DOE, 1981. *A Guide for Environmental Radiological Surveillance at U.S. Department of Energy Installations*, DOE/EP-0023, U.S. Department of Energy, Washington, D.C., 1981.

6. NRC, 1989. *Environmental Monitoring of Low-Level Radioactive Waste Disposal Facility*, NUREG-1388, U.S. Nuclear Regulatory Commission, Washington, D.C., 1989.

7. NRC, 1979. *Quality Assurance for Radiological Monitoring Programs (Normal Operations)--Effluent Streams and the Environment*, Regulatory Guide 4.15, U.S. Nuclear Regulatory Commission, Washington, D.C., February 1979.

8. NRC, 1983. *Subsurface Monitoring Programs at Sites for Disposal of Low-Level Radioactive Waste*, NUREG/CR-3164, U.S. Nuclear Regulatory Commission (by U.S. Army Corps of Engineers Waterways Experiment Station), Washington, D.C., 1983.

9. DOE, 1990. *Environmental Monitoring for Low-Level Waste Disposal Sites: Low-Level Management Handbook Series*, Revision 2, DOE/LLW-13Tg, U.S. Department of Energy, National Low-Level Waste Management Program, Idaho Falls, ID, 1990.

10. DOE, 1986. *Experience and Improved Techniques in Radiological Environmental Monitoring at Major DOE Low-Level Waste Disposal Sites*, DOE/LLW-54T, U.S. Department of Energy, National Low-Level Radioactive Waste Management Program, Idaho Falls, ID, 1986.

IV.R.(3) Disposal Facilities.

(c) The environmental monitoring programs shall be capable of detecting changing trends in performance to allow application of any necessary corrective action prior to exceeding the performance objectives in this Chapter.

Objective:

The objective of this requirement is to ensure that if data collected from the monitoring program indicates the facility is not performing as expected, that corrective actions will be initiated quickly to minimize potential impacts to the environment and the public health, and to maintain the reasonable assurance that the performance objectives will continue to be met.

Discussion:

This monitoring requirement for low-level waste disposal facilities is an additional requirement beyond the monitoring requirements in Chapter I, as discussed in guidance for DOE M 435.1-1, Section IV.R, and is applicable to all low-level waste disposal facilities. This monitoring requirement is closely associated with DOE M 435.1-1, Section IV.F, *Corrective Actions.* Data collected as part of the low-level waste disposal performance monitoring program are to be used as indicators for initiating corrective actions to address problems at low-level waste disposal facilities that could lead to exposures sometime far in the future.

This requirement emphasizes those elements of the monitoring plan for low-level waste disposal facilities directed toward performance monitoring. The primary purpose for additional monitoring requirements for low-level waste disposal facilities is to determine if the facility is performing as designed and analyzed. This requirement emphasizes the need to routinely analyze and interpret monitoring data as they are collected, using the performance assessment, composite analysis, safety analysis report, closure plan and disposal facility design documentation, to evaluate the actual performance of the facility as compared to the expected performance of the facility.

Detection of Changing Trends in Data. The methods for comparing monitoring data with the expected performance of the facility include trend analysis to examine any migration of radionuclides, subsidence, or other changes in monitoring parameters which are related to the long-term performance of the disposal facility. If a trend in surface water runoff or groundwater data indicates releases of radioactive or non-radioactive materials are more rapid than expected, the need for corrective actions must be established. In general, premature releases of radionuclides or elevated concentrations of radionuclides in environmental media are sufficient to initiate evaluation of corrective actions in detail. Early response to releases of radioactive or chemical contaminants reduces the overall costs of remediation, and can be expected to restore

facility performance that will be compliant with applicable requirements and the performance objectives for low-level waste disposal.

> *Example: The monitoring data from the Tumulus I disposal facility at Oak Ridge indicates elevated releases of tritium. Corrective actions were initiated to identify the source of the contamination, which was derived from a clogged french drain during the installation of the interim cover. The drain was repaired, and tritium releases were reduced to less than the action levels included in the monitoring plan.*

Low-level waste disposal facilities that utilize several types of disposal technologies need to develop monitoring plans to segregate the performance of the different technologies within the disposal facility. By not segregating the monitoring plan for the different technologies, the capability of determining which technology is primarily contributing to monitoring data is lost, and inappropriate corrective actions, if required, could result. The monitoring plan for facilities with multiple disposal technologies is necessarily more complex than facilities with a single disposal technology.

Corrective Actions. Should the monitoring program collect data that indicate radioactive material is migrating and the performance objectives may not be met, plans must be included in the monitoring plan for corrective measures. The identification of thresholds which indicate migration of radioactive materials potentially exceeding performance objectives and requiring corrective measures need to be developed as part of the monitoring plan.

> *Example: Results of the performance assessment and the discharge limits included in DOE 5400.5 were used to establish upper release limit from a drainage system surrounding a disposal unit. The action levels for initiating corrective actions were established as 10 percent of the release limit to provide sufficient time to take action before release limits are exceeded.*

Necessary corrective actions are determined based on the statistical significance of the monitoring data collected, the potential for exceeding the performance objectives or violating applicable DOE environmental, safety, and health requirements, the potential alternative corrective actions, the present costs of remediation, and the potential future costs of remediation. Each aspect needs to be evaluated with emphasis placed on the potential costs of future remediation. The potential for exceeding the performance objectives for low-level waste disposal needs to be determined in consultation with the performance assessment and composite analysis maintenance program. Necessary corrective actions need to be initiated as quickly as possible after the actions are justified. Necessary corrective actions include major additions to the facility to collect and contain radioactive materials, amendments to the cover design for the disposal unit, and changes in disposal facility operations. Likewise, corrective actions could include little more than simple repairs of components of the facility that failed prematurely, such as valves or drains.

While necessary corrective actions are most likely to be triggered by the performance assessment, because current disposal facility designs are not intended to have releases that could exceed regulatory limits for many years after closure, adherence to all of the requirements of all DOE Orders is important for continued operations of low-level waste disposal facilities.

The description of plans for corrective actions included in the monitoring plans for low-level waste disposal facilities need to be specific for each type of release (liquid, particulate, gaseous), and utilize a graded approach dependant on the magnitude of monitoring data exceeding the action levels. A single data point which exceeds an action level by less than ten percent does not necessarily warrant as severe a response as a series of data points in excess of 100% of the action levels. Exceeding any action level(s) warrants the notification of the responsible authority of the event occurring, as defined by the procedures for facility operations.

Action Levels. Determination of the thresholds which would indicate migration of radionuclides, and that the performance measures may not be met, are commonly expressed as action levels, which, if exceeded, have prescribed activities that must occur. Examples of responses to exceeding an action level include immediate notification of responsible authorities, immediate evaluation and documentation of the data collected, identification of changes in operations until the data can be verified and any necessary corrective actions are taken, and the development of mitigating actions to be undertaken to restore facility performance. The actions to be performed when action levels are exceeded need to be documented as procedures and included in the monitoring plans for low-level waste disposal facilities.

The action levels indicating performance objectives may be exceeded need to be established in consultation with the performance assessment and composite analysis maintenance program. These action levels are subject to revision as data are developed from the monitoring program that provide actual data on facility performance, but need to be established initially as part of the monitoring plan to ensure facility operations are likely to meet the performance objectives of DOE O 435.1.

Action levels for liquid, particulate, and gaseous releases need to be included in the monitoring plan, with monitoring locations established close to each disposal unit and with monitoring parameters and frequencies selected based on the results of the performance assessment. Action levels need to be determined for those radionuclides considered to be critical in understanding the performance of the disposal facility, with emphasis on mobile radionuclides, which are likely to be early indicators of any migration of radioactive material. Action levels may also be established for non-radioactive parameters (e.g., pH, moisture content), which may be appropriate as early indicators of the migration of radioactive materials. The locations for monitoring and the media to be selected that are associated with the specified action levels need to be based on the results of the performance assessment.

Example: Action levels for non-radioactive parameters are identified in the monitoring plan for pH and soil moisture content. The action levels were a change in pH of two points from the baseline monitoring data, and a 10% increase in moisture content above the baseline value.

Compliance with this requirement is demonstrated if monitoring programs for disposal facilities are capable of detecting possible changes in performance based on monitoring data collection and evaluation and identify action limits which are tied to corrective actions to be taken by procedures for disposal facility operations.

Supplemental References:

1. DOE, 1990. *Environmental Monitoring for Low-Level Waste Disposal Sites: Low-Level Management Handbook Series*, Revision 2, DOE/LLW-13Tg, U.S. Department of Energy, National Low-Level Waste Management Program, Idaho Falls, ID, 1990.

2. DOE, 1986. *Experience and Improved Techniques in Radiological Environmental Monitoring at Major DOE Low-Level Waste Disposal Sites*, DOE/LLW-54T, U.S. Department of Energy, National Low-Level Radioactive Waste Management Program, Idaho Falls, ID, 1986.