2.3 *DOE Documents:*[3]

DOE Order 460.1A Packaging and Transportation Safety

DOE Order 460.2A Departmental Materials Transportation and Packaging Management

DOE Order 414.1C Quality Assurance

DOE Manual M 435.1-1 Radioactive Waste Management Manual

2.4 *United States Code:*[3]

USC 2014 Definitions

2.5 *NRC Standards and Guides:*[3]

NUREG-1575 Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)

NUREG-1575, Supplement 1 Multi-Agency Radiation Survey and Assessment of Materials and Equipment (MARSAME)

NUREG-1576 Multi-Agency Radiologial Laboratory Analytical Protocols (MARLAP)

2.6 *Other Documents:*

EPA QA/R-2 Requirements for Quality Management Plans[4]

EPA QA/G-4 Guidance on Systematic Planning Using the Data Quality Objectives Process[4]

NQA-1-2000 American Society of Mechanical Engineers, 2008[4]

3. Terminology

3.1 *Definitions:*

3.1.1 *documents*—instructions, procedures and drawings that control policy, administrative, and technical information.

3.1.2 *records*—electronic, written, printed, microfilm, photographs, radiographs, or optical disks that contain data that are retained for their future value.

3.1.3 *waste acceptance requirements*—criteria and all other requirements that a facility receiving waste for treatment, storage, or disposal must meet to receive waste.

3.1.4 *waste acceptance criteria*—the technical and administrative criteria that a waste must meet to be accepted at a treatment, storage, or disposal facility.

4. Significance and Use

4.1 A waste management plan based on the contents of this guide will provide for the successful identification of potential waste streams anticipated from decommissioning activities, and provide a clear and concise methodology for the handling of identified waste from generation to final disposition.

4.2 The waste management plan will identify the general waste types, characterization, packaging, transportation, disposal, and quality assurance requirements for potential waste streams.

5. General Waste Types

5.1 *Radioactive*—Radioactive wastes are defined as discarded material in any form that must be managed for its radioactive content per federal or agreement state regulations. Radioactive wastes are further categorized into the following subclasses.

5.1.1 *High Level*—High level wastes are irradiated reactor fuel (spent nuclear fuel) and the highly radioactive material resulting from the reprocessing of irradiated reactor fuel, including liquid waste and any solid material derived from such liquid (10 CFR 60, DOE Manual M 435.1-1).

5.1.2 *Transuranic*—Transuranic wastes are any material containing alpha-emitting transuranic nuclides with half-lives greater than 20 years and in concentrations greater than 100 nanocuries per gram (3.7 kBq g^{-1}) (1×10^{-7} Ci/g) (DOE Manual M 435.1-1).

5.1.3 *By-Product Material*—By-product material wastes are any radioactive material (except special nuclear material) yielded in or made radioactive by exposure to the radiation incident to the process of producing or utilizing special nuclear material, and the tailings or wastes produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content (42 USC 2014(e)).

5.1.4 *Naturally Occurring and Accelerator Produced Radioactive Materials:*

5.1.4.1 *NORM (Naturally Occurring Radioactive Material)*—Any material that contains naturally occurring radionuclides. By-product material and the natural radioactivity of rocks, soils, or background radiation are not to be included (DOE Manual M 435.1-1).

5.1.4.2 *NARM (Naturally Occurring or Accelerator Produced Radioactive Material)*—Any material that contains NORM or accelerator-produced radioactive materials.

5.1.4.3 *TENORM (Technologically Enhanced Naturally Occurring Radioactive Materials)*—NORM whose composition, radionuclide concentrations, availability, or proximity to man have been increased by or because of human practices.

5.1.5 *Low Level*—Low level wastes are radioactive wastes that are not spent fuel, high level radioactive wastes, transuranic radioactive wastes, by-product material, or naturally occurring radioactive materials. Low level wastes are defined into categories per 10 CFR 61.55(a)(2)(i) and accompanying tables. Those categories include:

5.1.5.1 *Class A*—Class A wastes contain the lowest concentrations of radioactivity and typically are composed of short-lived radionuclides that generate no decay heat, do not need to be shielded, and decay to levels posing minimal potential human dose within 100 years. Class A wastes typically have an average concentration less than 100 GBq m^{-3} (2.7 Ci m^{-3}) and constitute the majority of generated radioactive waste.

5.1.5.2 *Class B*—Class B wastes contain the next lowest concentrations of radioactivity and typically are composed of greater quantities of short-lived radionuclides than Class A. Class B wastes typically have an average concentration of 3 TBq m^{-3} (81 Ci m^{-3}).

5.1.5.3 *Class C*—Class C wastes contain the highest concentrations of radioactivity acceptable for near-surface disposal. Class C wastes are typically composed of greater concentrations of short-lived radionuclides than Class A or B wastes, and may contain long-lived radionuclides. Class C

[4] U.S. Environmental Protection Agency, Quality Staff (281 1R), 1200 Pennsylvania Ave., NW, Washington, DC 20460. E-mail: quality@epa.gov

wastes on average have a concentration of 9 TBq m^{-3} (243 Ci m^{-3}) and will not decay to acceptable levels within 100 years.

5.1.5.4 *Greater Than Class C*—Greater Than Class C wastes are all radioactive wastes, defined as low level wastes, that do not qualify for near-surface disposal as defined in 10 CFR 61.

5.2 *Hazardous*—Hazardous wastes are solid wastes as defined in 40 CFR 261 that meet any one of the following four criteria:

5.2.1 Exhibits a characteristic such as ignitable, corrosive, reactive, or toxic as defined in 40 CFR 261, Subpart C,

5.2.2 Is identified as a listed waste under the F, K, P, or U lists as defined in 40 CFR 261, Subpart D,

5.2.3 Is composed of a mixture of a solid waste and a listed waste as defined in 40 CFR 261.3(b), or

5.2.4 Is a derived waste from the treatment, storage, or disposal of a listed waste as defined in 40 CFR 261.3(c)(2)(i).

5.3 *Mixed Waste*—Mixed Waste containing a RCRA hazardous material and an NRC regulated radioactive material.

5.4 *Co-mingled Waste*—Waste containing any CERCLA hazardous substance other than the CERCLA radioactive hazardous substances and any radioactive materials.

5.5 *PCB*—Polychlorinated Biphenyl (PCB) wastes are PCBs and PCB items that are subject to the disposal requirements of 40 CFR 761, Subpart D.

5.6 *Conventional*—Conventional wastes are any non-hazardous discarded material in any form that does not contain residual amounts of radioactivity above the limits of the treatment or disposal facility.

6. Characterization

6.1 The waste management plan should include a description of the waste characterization methodology. The waste characterization methodology should be of sufficient detail to ensure that physical, chemical, and radiological properties of the wastes are identified and known throughout the waste management process and that they are characterized with sufficient accuracy to ensure worker protection, proper segregation, treatment, storage, and disposal. Useful information relative to the characterization of waste streams can be found in Guide E1892. Waste characterization methodologies should focus on total data acquisition and be based on direct methods (surveys and sampling and analysis), and indirect methods (process knowledge). Characterization data should include information obtained from direct measurement, and from sampling and analysis of the waste materials. Guidance on direct measurement is contained in the MARSSIM and MARSAME documents.

6.2 *Sampling and Analysis*—The sampling and analysis of waste streams should be conducted in accordance with a written plan that identifies the data life cycle process. The data life cycle process is composed of three essential elements: planning, implementation, and assessment. Guidance for sampling and analysis can be found in the MARLAP manual.

6.2.1 *Planning*—The planning process is a project management tool that identifies and documents the qualitative and quantitative statements that define the data quality objectives process (for example, Practice D5792). A graded approach to the planning process should be considered based on the size, complexity, available resources, and level of quality control.

6.2.2 *Implementation*—Sampling and analysis plans should identify the target analyte(s), the sampling design and methodology as determined during the planning process, the quality control parameters, and the analytical requirements per the approved statement of work.

6.2.3 *Assessment*—The three-step assessment process is based on verification, validation, and data quality assessment.

6.2.3.1 Verification is a systematic process performed externally from the data generator that evaluates the laboratory delivered data set (that is, data package) against the deliverable requirements as stated in the laboratory statement of work. It also checks for completeness, consistency, comparability, and correctness of the data set.

(1) A verification report should be generated that identifies any correctable and non-correctable discrepancies associated with the data set. The report should be in a standard format and remain as part of the data package.

(2) Data verification should be an interactive process with the laboratory. It should provide appropriate feedback to address correctable and non-correctable discrepancies which result in opportunities to improve the analytical work prior to project completion.

6.2.3.2 Validation is a systematic process performed externally from the data generator that addresses the reliability of the data and provides assurance of the presence or absence of analytes. This process reviews the verification report, and laboratory-delivered data set, and applies defined performance-based criteria to qualify the data.

(1) A data validation report should be generated that identifies all data qualified based on the performance-based criteria. The report should be in a standardized format and remain as part of the data package.

6.2.3.3 The data quality assessment process is the "scientific and statistical evaluation of data to determine if they are of the right type, quality, and quantity to support their intended use." This process should not be limited to the verification and validation of data, but should encompass the entire sample collection and analysis process and its impact on data quality and usability.

(1) A graded approach based on the intended use of the data should be applied to the data quality assessment process. This should be done in such a manner that the three fundamental premises are satisfied:

(a) Are the samples representative?

(b) Are the data accurate?

(c) Can a decision be made?

6.3 *Process Knowledge*—A characterization methodology that relies on the knowledge of the physical, chemical, and radiological constituents of the materials associated with the waste generation process.

6.3.1 Process knowledge can be derived from Material Safety Data Sheets, historical analytical data, historic records, living memory, system descriptions, plans and drawings, manufacturing specifications, mass balance documentation,

procedures, and any other methods that adequately quantify the physical, chemical, and radiological constituents of a waste stream.

6.3.1.1 Process knowledge data should be within the acceptable range of certainty and precision as defined in the data quality objectives.

6.3.1.2 Process knowledge should be assembled into an auditable record such as a data package that at a minimum identifies the following: time of waste generation, waste generation process, analytical data, description of site-specific facilities, reference list of personnel interviewed, documents, databases, quality control methods, and data usability requirements.

6.3.1.3 To ensure proper characterization of the waste stream, limitations of process knowledge data should be assessed and documented. Verification of process knowledge data should be performed for significant hazardous or radioactive sources.

6.4 Alternate characterization methods such as: gross radiation measurements, nondestructive examination, nondestructive assay, and scaling factors can be used to characterize potential waste streams. The basis for these methods, their associated limitations, and data usability requirements should be documented in a process similar to that used for process knowledge.

6.5 Once waste streams are characterized and the data validated, they must be provided to those responsible for the packaging, storage, and transportation of these wastes. These data will be used in the confirmation of waste package contents, protection of workers, and in complying with shipping and disposal site waste acceptance criterion.

6.6 Characterization activities and results should be coordinated with Federal (NRC, EPA, DOE, DoD, etc.) officials as appropriate. Waste Compact, State of Origin, State of Disposal, and all states through which the waste will travel should also be considered when coordinating waste characterization activities.

7. Packaging, Storage, and Transportation

7.1 The waste management plan should address the packaging, storage, transportation and disposal of potential waste streams (10 CFR 61, 10 CFR 71, 29 CFR 1910.120, 40 CFR 261, 40 CFR 262, 40 CFR 761, 40 CFR 763, 49 CFR 172, 49 CFR 173, 49 CFR 397, DOE Order 460.1A, and DOE Order 460.2A). A graded approach to packaging, storage, and transportation that guarantees waste streams representing a greater hazard are subject to more stringent confinement, communication, and control requirements should be considered.

7.1.1 Early in the planning process, the final disposal facility or method should be identified. Waste characterization, packaging, storage and transportation must consider the waste acceptance criteria of the facility. The project quality assurance plan should also address requirements of the disposal facility.

7.2 *Packaging*—Waste packaging should be selected based on consideration of the full life-cycle of the waste and subsequent life-cycle management of the waste package. The goal should be to pack the waste only once. The selected waste packaging should be compliant with the packaging and transportation requirements (DOT, EPA, DOE, DoD, and NRC) and the waste acceptance criteria of the treatment, storage, or disposal facility, or combination thereof.

7.2.1 *Segregation*—The waste management plan should describe how wastes are to be segregated and packaged based on the identified waste type. Failure to do so may result in the commingling of waste streams and the generation of mixed or hazardous wastes, or both, that require more stringent life-cycle management. The waste management plan should also identify the waste criteria and packaging requirements of the treatment, storage, or disposal facility, or combination thereof, and how they are to be met.

7.2.2 *Containment and Protection*—Waste must be properly contained and the waste container must be protected from conditions that could cause container degradation or failure. The physical, chemical, and radiological attributes of the waste and any associated packing materials (that is, absorbents, stabilizers, solidification agents, shielding materials, etc.) needs to be considered to ensure compatibility and structural integrity of the selected container. Containers should be inspected prior to packing to ensure that they are free of defects that may cause a loss of container integrity. Waste placement within a container should be performed in such a manner that is not detrimental to container integrity. Void space within a container should be minimized to the extent possible per weight and other container limitations.

7.2.3 *Vents*—The use of mechanisms (that is, HEPA vents, permeable gaskets, etc.) that control the build-up of gases or pressure, or both, within waste containers should be considered during waste packaging. Gas evolution within a container may occur due to the physical, chemical, and radiological properties of the waste and any associated packing material (that is, radiolysis, decomposition), and environmental conditions. The build-up of pressure within a waste container may occur due to exposure to environmental conditions that can cause an imbalance between the internal and external atmospheric pressure of the waste container (that is, bulging drums). If vents are used, they must be HEPA filtered.

7.2.4 *Marking and Labeling*—Waste containers should be marked and labeled in such a manner that the waste characteristics and container information are clearly visible on the outside of any storage or packing array configuration. For drums of waste, acceptable marking or labeling placement is about every 90 to 120 degrees around the outside of the drum. For waste boxes, acceptable marking or labeling placement is on each exterior side of the box. The life-cycle management of the container should be considered when choosing the material or media, or both, for the marking or labeling.

7.3 *Storage*—The on-site storage or staging of waste should be considered as the accumulation and life-cycle management of the waste prior to transfer to the treatment, storage, or disposal facility, or combination thereof. The length of time for the on-site storage or staging of waste is dependent on the federal and agreement state regulations pursuant to the waste type and typically do not exceed 90 days.

7.3.1 *On-Site Storage/Staging Site Selection*—The life-cycle management of the waste type and container should be

considered when selecting the on-site/staging area location. At a minimum the site should be selected on a flat hard surface that has adequate drainage to prevent flood and rainwater pooling and is accessible by large container handling and emergency response equipment. The site boundaries should be clearly delineated and posted with signs identifying the waste type, associated hazards, the responsible party, contact information, and emergency response numbers.

7.3.2 *Container Inspection*—Waste containers placed in on-site storage/staging areas should be inspected on a weekly basis to ensure container integrity is maintained during the storage/staging process and prior to transport from the site. Visual inspection as well as inspection through direct or indirect methods should be used based on the specific array configuration of the waste containers in the storage or staging areas. Inspection results shall be documented. The scope of the waste container inspection should include the following as a minimum:

7.3.2.1 General external appearance of the waste container,

7.3.2.2 Signs of visible rust, scratches, or dents,

7.3.2.3 Container closures in place and securely fastened,

7.3.2.4 Evidence of leakage,

7.3.2.5 Evidence of structural problems,

7.3.2.6 Container deformation, and

7.3.2.7 Intact and readable markings and labelings.

7.3.2.8 If specific containers are required by code (for example, DOT), they should be verified.

7.3.3 The waste management plan should address the preventative and corrective actions for these conditions.

7.4 *Transportation*—The transportation of waste should be performed in such a manner that minimizes worker exposure, risk, and cost. A graded approach based on the waste type should be used when addressing the following: transportation planning, emergency planning, and projected shipment planning information.

7.4.1 *Transportation Planning*—The transportation planning process is a project management tool that documents the transportation planning activities that should occur once the need for a waste shipment has been identified. The transportation planning process confirms that the waste to be shipped was properly characterized and classified and that the federal and agreement state transportation regulations pursuant to the waste type have been identified. Additionally, the transportation and planning process ensures that the appropriate packagings has been selected and procured, the transportation modes and carriers have been evaluated, and the need for stakeholder involvement has been identified and planned.

7.4.2 *Emergency Planning*—The waste management plan should address the hazards and potential threats to a waste shipment and the appropriate emergency notification and response procedures.

7.4.3 *Projected Shipment Planning*—The waste management plan should address how and when to notify stakeholders of projected waste shipments so they can adequately plan/predict resources for inspections, emergency response, accident prevention, and public notification. The information provided should include: shipment dates, shipment origin and destination, number of shipments, security arrangements, description of material, packaging descriptions, modes of shipment, shipment routes, points of contact, emergency notification and response, and cleanup and recovery. The degree of notification and stakeholder involvement should be based on the level of associated hazard. A description of any required shipping manifest should be included as part of the shipment planning.

8. Quality Assurance

8.1 The waste management plan should identify the major components of the quality management system (Practice D5283, 10 CFR 830.120, DOE 414.1C, ASME NQA-1). It should require conformance to EPA QA/R-2, Requirements for Quality Management Plans, and EPA QA/G-4, Guidance for Data Quality Objectives. The major components should satisfy the objectives of planning, performing, and assessing the activities used during the life-cycle management of the potential waste stream. A graded approach should be taken when applying the requirements of the quality management system to any singular activity. The level of scope, depth, and rigor applied should be commensurate with the importance of safety, cost, schedule, and success of the overall program. The Waste Management Plan should incorporate the QA requirements from the two EPA quality references noted above. In general it should address:

(1) Organization and Responsibility,
(2) Quality Improvement,
(3) Documents and Records,
(4) Work Processes,
(5) Design Control,
(6) Procurement,
(7) Inspection and Acceptance Testing,
(8) Control of Measuring and Test Equipment,
(9) Management Assessments, and
(10) Independent Assessments.

9. Training

9.1 *Identification of Training Needs*—The Waste Management Plan should address any special training needs required to perform all work associated with characterization, handling, and disposal of the waste. The type of training, any required certifications, and the training requalification requirements should be specified. These training requirements should be listed in the Waste Management Plan.

9.2 *Training Records and Verification*—Provisions should be made to maintain permanent records of employee training status including the type and date of all training completed. The current training status should be verified prior to preforming work for each worker engaged in activities which require that they be trained.

10. Audits

10.1 *To Ensure Conformance*—An audit program should be established to help ensure compliance with procedures, rules, regulations, and the waste acceptance criteria of the site or facility which will receive the waste. The audit program should be tailored to the size and complexity of the decommissioning project, shipping regulations, and the requirements of the waste

receiving facility. Audit records should be maintained in permanent project files.

10.2 *For Process Improvement*—Lessons learned from audit findings should be incorporated into project procedures to improve the waste management process for decommissioning projects. This process for continued improvement will result in safer, less expensive, waste disposal practices.

11. Related Documents

11.1 *ASTM Standards*[2]: E1167 Guide for Radiation Protection Program for Decommissioning Operations

E1281 Guide for Nuclear Facility Decommissioning Plans

E1760 Guide for Unrestricted Disposition of Bulk Materials Containing Residual Amounts of Radioactivity

E1892 Guide for Preparing Characterization Plans for Decommissioning Nuclear Facilities

11.2 *Code of Federal Regulations*[3]: 29 CFR 1910, Occupational Health and Safety Standards, Section 119, Process Safety Management of Highly Hazardous Chemicals

40 CFR 260 Hazardous Waste Management System: General

40 CFR 268 Land Disposal Restrictions

11.3 *DOE Documents*[3]: DOE Order 420.1B, Chg 1, Facility Safety

DOE Order 435.1 Chg 1, Radioactive Waste Management

12. Keywords

12.1 decommissioning; waste characterization; waste disposal; waste management plan; waste packaging; waste transportation

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