Y-12

Y/ES-013

**OAK RIDGE
Y-12
PLANT**

MARTIN MARIETTA

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**CRITERIA FOR THE SAFE STORAGE
OF LITHIUM METAL AND LITHIUM
COMPOUNDS AT THE Y-12 PLANT**

JULY 1995

**Compiled by S. O. Cox
Defense Programs**

**MANAGED BY
MARTIN MARIETTA ENERGY SYSTEMS, INC.
FOR THE UNITED STATES
DEPARTMENT OF ENERGY**

MASTER

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FOREWORD

Considerable quantities of lithium-based materials are being generated as a result of the nuclear weapons disassembly process. The lithium from these materials, in the form of lithium hydride (LiH) and lithium deuteride (LiD), is enriched in the lithium-6 (^6Li) isotope and is considered to be an accountable nuclear material. These materials are neither radioactive nor fissile, but they are integral components of nuclear weapons. The LiD functions as a fuel for thermonuclear fusion and the LiH functions as a neutron moderator. Current plans are to store such materials in a suitable chemical form until they are needed for building future weapons or for other undefined uses. Because no domestic capability exists for producing enriched ^6Li and because ^6Li is an integral component of nuclear weapons, it must be stored safely, securely, and in an environmentally compliant form.

This document and the companion document, *Assessment of Lithium and Lithium Compound Storage Issues at the Oak Ridge Y-12 Plant*, Y/ES-012 (July 1995), have been prepared at the request of the U.S. Department of Energy (DOE) Office of Defense Programs (DP) so that technical standards can be developed for the storage of lithium-based materials. This document contains the technical standards for the storage of lithium compounds.

Because programmatic needs, compliance regulations, and desirable materials of construction change with time, it is recommended that these standards be reviewed and amended periodically to ensure that they continue to serve their intended purpose.

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1. PURPOSE, SCOPE, AND EQUIVALENCY

1.1 PURPOSE

This standard provides the criteria for the safe storage of lithium metal and lithium compounds at the Y-12 Plant. The criteria provide for the indefinite storage of these materials in a safe, secure, and environmentally compliant form. Additionally, these materials should be retrievable at the end of the storage period in substantially the same chemical form as initially stored.

1.2 SCOPE

This standard shall apply to the storing of lithium metal (Li), lithium carbonate (Li_2CO_3), lithium chloride (LiCl), lithium hydride/deuteride (LiH/D), lithium hydroxide monohydrate ($\text{LiOH}\cdot\text{H}_2\text{O}$), and lithium phosphate (Li_3PO_4) in quantities in excess of 10 kg.

This criteria and Y/ES-012 do not address the criteria for in-process storage (IPS) of lithium materials. It is natural that during processing some portion of time for any material is spent in IPS waiting for the next operation to commence. While in IPS, the lithium materials processed at the Y-12 Plant are in a variety of configurations and subject to many different environments.

Also excluded from this standard is the storing of lithium-based materials inside a canned subassembly (CSA). Because of the increased complexity of the issues in this type of storage, it is being addressed as a separate standard.

1.3 EQUIVALENCY

This standard does not prevent the use of systems, methods, or devices of equivalent or superior quality, strength, fire resistance, effectiveness, durability, and safety in the place of those that are prescribed by this standard, if technical documentation is made available to demonstrate equivalency. Also, the systems, methods, or devices must be approved for their intended purposes.

2. ACRONYMS AND DEFINITIONS

2.1 ACRONYMS

CSA	Canned Subassembly
DOE	U.S. Department of Energy
IPS	In-Process Storage
IS	Interim Storage
Li_2CO_3	Lithium Carbonate
LiCl	Lithium Chloride
LiH/D	Lithium Hydride/Deuteride
$\text{LiOH}\cdot\text{H}_2\text{O}$	Lithium Hydroxide Monohydrate
Li_3PO_4	Lithium Phosphate
LTS	Long-Term Storage
MSDS	Material Safety Data Sheet
NFPA	National Fire Protection Association

2.2 DEFINITIONS

Approved - A condition or state that is acceptable to the "authority having jurisdiction."

Authority Having Jurisdiction - The organization, office, or individual responsible for approving equipment, installation, or procedure.

Combustible - In the form that is used and under the conditions that are anticipated, will ignite, burn, support combustion, or release flammable vapors when subjected to fire or heat.

Controlled Access - Access that is limited to those personnel deemed acceptable by facility management.

Compacted Form - A substantially solid form, as opposed to a powdered form.

Incompatible - Having the capability to cause adverse chemical or physical changes.

Li Metal - Refers to either pure lithium metal or to lithium alloys having the generally recognized properties of lithium metal.

Noncombustible - In the form that is used and under the conditions that are anticipated, will not ignite, burn, support combustion, or release flammable vapors when subjected to fire or heat.

Pallet - A portable platform for handling, storing, or moving materials.

Pressure Relief - A system or an apparatus for reducing a pressure buildup by exhausting the excess pressure.

Shall - Indicates a mandatory requirement.

Should - Indicates a recommendation or that which is advised but not required.

Storage Area - A building or portion of a building that is dedicated solely to storage of a particular material.

3. RELEVANT ORDERS, STANDARDS, AND DOCUMENTS

3.1 FEDERAL REGULATIONS

10 CFR 830.120, *Quality Assurance*.

29 CFR 1900 to 1910, *Occupational Safety and Health Standards*.

3.2 DEPARTMENT OF ENERGY ORDERS

DOE 5000.3B, *Occurrence Reporting and Processing of Operations Information*, July 1993.

DOE 5480.7A, *Fire Protection*, February 1993.

DOE 5480.10, *Contractor Industrial Hygiene Program*, June 1985.

DOE 5480.19, *Conduct of Operation Requirements for DOE Facilities*, May 1992.

DOE 5481.1B, *Safety Analysis and Review System*, September 1986.

DOE 5500.1B, *Emergency Management System*, February 1992.

DOE 5500.2B, *Emergency Categories, Classes, and Notification and Reporting Requirements*, February 1992.

DOE 5500.3A, *Planning and Preparedness for Operational Emergencies*, February 1992.

DOE 5500.4A, *Public Affairs Policy and Planning Requirements for Emergencies*, June 1992.

DOE 5500.10, *Emergency Readiness Assurance Program*, February 1992.

DOE 5633.3B, *Control and Accountability of Nuclear Materials*, September 1994.

3.3 NONGOVERNMENT PUBLICATIONS

NFPA 231, *Standard for General Storage*, National Fire Protection Association, 1990.

NFPA 485, *Standard for the Storage, Handling, and Use of Lithium Metal*, National Fire Protection Association, 1994.

NFPA 491M, *Manual of Hazardous Chemical Reactions*, National Fire Protection Association, 1991.

NWC TP 7078, Rhein, R. A., *Lithium Combustion: A Review*, Naval Weapons Center, December 1990.

Y/DZ-1006, Leckey, J. H., and L. E. Nulf, *Lithium Hydride Combustion and Storage*, Martin Marietta Energy Systems, Inc., Oak Ridge Y-12 Plant, April 1993.

Y/ES-012, *Assessment of Lithium and Lithium Compound Storage Issues at the Oak Ridge Y-12 Plant*, Lockheed Martin Energy Systems, Inc., July 1995.

4. SAFE STORAGE CRITERIA

The following safe storage criteria are established to minimize hazards to workers, the public, and the environment associated with the storage of lithium metal and lithium compounds. Lithium metal and lithium compounds to be stored at the Y-12 Plant shall be designated as IPS, assigned to Interim Storage (IS), or assigned to Long-Term Storage (LTS). IPS is considered an operational function and is not a part of this storage criteria.

Bases for the criteria are provided in Appendix A and are discussed in Y/ES-012.

4.1 GENERAL CRITERIA

The following criteria apply to all material forms and storage durations.

- A. Lithium material to be stored at the Y-12 Plant and with quantities greater than 10 kg shall be governed by these criteria.
- B. Lithium material shall not be stored in the vicinity of incompatible materials. The Material Safety Data Sheet (MSDS) shall be consulted to determine materials that are incompatible with particular storage materials.
- C. Pallets used to hold lithium material shall be constructed of nonflammable material.

4.2 INTERIM STORAGE (IS) CRITERIA

Lithium materials with anticipated programmatic use may be assigned to IS. The following criteria apply to IS.

4.2.1 Lithium Metal (Li)

Lithium metal storage containers shall meet the requirements in NFPA 485.

4.2.2 Lithium Hydride/Deuteride (LiH/D)

- A. LiH/D shall be stored in a compacted form.
- B. LiH/D shall be stored in dedicated, clean, moisture-free (no visible moisture) steel containers.

- C. LiH/D shall not be stored in containers that were previously used for the storage of incompatible materials such as acids, alcohols, ammonia, halogens, oxidizers, or water.
- D. LiH/D storage containers shall be sealed as specified by the container manufacturer.
- E. LiH/D storage containers shall be equipped with pressure relief vents. A nominal 6,895 n/m² (1 psi) relief pressure is adequate for most containers with a recommended relief mechanism for 55-gallon drums that actuates between 3,447 and 10,342 n/m² (0.5 and 1.5 psi).

4.2.3 Lithium Hydroxide Monohydrate (LiOH·H₂O) and Lithium Phosphate (Li₃PO₄)

- A. LiOH·H₂O and Li₃PO₄ shall be contained in polyethylene bags (or other compatible liners) that are stored in dedicated, clean, moisture-free (no visible moisture) steel containers.
- B. LiOH·H₂O and Li₃PO₄ shall not be stored in containers that were previously used for the storage of incompatible materials such as acids, alcohols, ammonia, halogens, oxidizers, or water.
- C. LiOH·H₂O and Li₃PO₄ storage containers shall be sealed as specified by the container manufacturer.

4.3 LONG-TERM STORAGE (LTS) CRITERIA

Lithium materials with no anticipated programmatic use should be converted to lithium carbonate (Li₂CO₃) or lithium chloride (LiCl). The following criteria apply to LTS.

- A. Li₂CO₃ and LiCl shall be contained in polyethylene bags (or other compatible liners) that are stored in dedicated, clean, moisture-free (no visible moisture) steel containers.
- B. Li₂CO₃ and LiCl shall not be stored in containers that were previously used for the storage of incompatible materials such as acids, alcohols, ammonia, halogens, oxidizers, or water.
- C. Li₂CO₃ and LiCl storage containers shall be sealed as specified by the container manufacturer.

4.4 STORAGE AREA

A lithium material storage area is defined as a building or a portion of a building that is dedicated solely to the storage of lithium material.

4.4.1 General

The following criteria for storage areas apply to all material forms and storage durations.

- A. Lithium material storage areas shall meet the fire protection requirements of DOE 5480.7A.
- B. Lithium material storage areas shall meet the requirements for safety analysis in DOE 5481.1B.

4.4.2 Lithium Metal (Li)

The following criteria for storage areas apply to all storage durations of lithium metal.

- A. Lithium metal storage areas shall meet the requirements in NFPA 485.
- B. Lithium metal storage areas which are part of a larger structure should be separated from adjacent areas in the facility by 2-hour, fire-rated enclosures.
- C. Lithium metal storage areas that are separate structures should be separated from other structures by a minimum of 15.24 m (50 ft).
- D. Lithium metal storage areas should be equipped with smoke detectors.

4.4.3 Lithium Hydride/Deutride

The following criteria for storage areas apply to all storage durations of LiH/D.

- A. LiH/D storage areas shall be equipped with automatic sprinkler protection unless otherwise approved by the authority having jurisdiction.
- B. LiH/D shall be stored in a building or in a portion of a building that is dedicated solely to LiH/D storage. If storage is only in a portion of a building, the LiH/D storage area shall be designated as such by standard signs and shall be separated from the remainder of the building by physical barriers.
- C. LiH/D storage areas shall be constructed of noncombustible materials.

- D. LiH/D storage areas shall not permit pipes or ducts containing water, aqueous liquids under normal use, steam, or flammable gases except those necessary to serve the area.
- E. LiH/D storage areas access shall be controlled.
- F. LiH/D storage areas shall not permit open flames, burning, cutting, or welding except as approved by fire safety personnel.
- G. Portable fire extinguishers containing Class D extinguishing agents or those that are tested and are shown to be effective for extinguishing lithium fires shall be permitted for protection from LiH/D hazards.
- H. LiH/D storage areas that are part of a larger structure should be separated from adjacent areas in the facility by 2-hour, fire-rated enclosures.
- I. LiH/D storage areas that are separate structures should be separated from other structures by a minimum of 15.24 m (50 ft).

4.4.4 LiOH·H₂O and Li₃PO₄

The following criteria for storage areas apply to all storage durations of LiOH·H₂O and Li₃PO₄.

LiOH·H₂O and Li₃PO₄ storage areas shall be equipped with automatic sprinkler protection unless sprinkler protection is specifically forbidden by the authority having jurisdiction.

4.4.5 Li₂CO₃ and LiCl

The following criteria for storage areas apply to all storage durations for Li₂CO₃ and LiCl.

Li₂CO₃ and LiCl storage areas shall be equipped with automatic sprinkler protection unless sprinkler protection is specifically forbidden by the authority having jurisdiction.

4.5 MATERIAL HANDLING

Material handling considerations are required to prepare lithium material for storage, to retrieve lithium materials from storage, and to conduct routine inspections and investigations. The following criteria for material handling apply to all material forms and storage durations.

- A. Material handling within lithium material storage areas shall meet the requirements for industrial safety in 29 CFR 1910.
- B. Material handling within lithium material storage areas shall meet the requirements for industrial hygiene in DOE 5480.10.
- C. Lithium material storage area operations shall meet the requirements in DOE 5480.19.
- D. MSDSs for all materials handled in lithium material storage shall be maintained and made available to all personnel.
- E. Lithium material storage areas shall meet the requirements for control and accountability of lithium materials in DOE 5633.3B.

4.6 INSPECTION AND SURVEILLANCE

Inspection and surveillance considerations are required to ensure that container integrity is maintained with a high degree of confidence.

4.6.1 General

The following criteria for inspection and surveillance apply to all material forms and storage durations.

Inspection and surveillance for lithium material storage shall meet the requirements in DOE 5633.3B.

4.6.2 Lithium Metal (Li)

The following criteria for inspection and surveillance apply to all storage durations for Li.

Lithium metal storage areas shall be inspected at least monthly.

4.6.3 LiH/D, LiOH·H₂O, Li₃PO₄, Li₂CO₃, and LiCl

The following criteria for inspection and surveillance apply to all storage durations for LiH/D, LiOH·H₂O, Li₃PO₄, Li₂CO₃, and LiCl.

LiH/D, LiOH·H₂O, Li₃PO₄, Li₂CO₃, and LiCl storage areas shall be inspected at least annually.

4.7 EMERGENCY MANAGEMENT

Emergency management considerations are required in the event of an emergency for any lithium material storage location. The following criteria for emergency management apply to all material forms and storage durations.

Lithium material storage areas shall meet the requirements for emergency management in DOE 5500.1B, DOE 5500.2B, DOE 5500.3A, DOE 5500.4A, and DOE 5500.10.

4.8 DOCUMENTATION

Documentation considerations are required to retain information about each lithium material storage location. The following criteria for documentation apply to all material forms and storage durations.

Lithium material storage records shall meet the requirements of DOE 5633.3B.

4.9 QUALITY ASSURANCE

Procedures and processes that are essential for assuring compliance with these criteria shall be covered by quality assurance. The following criteria for quality assurance apply to all material forms and storage durations.

- A. Lithium material storage shall meet the requirements for quality assurance in 10 CFR 830.120.
- B. Occurrence reporting and processing of lithium material operations shall meet the requirements of DOE 5000.3B.

APPENDIX A

BASES FOR LITHIUM STORAGE CRITERIA

The paragraphs in this appendix briefly provide the basis for the paragraphs in the body of this standard. For this reason, the numbering of the sections in the Appendix corresponds to that in the body of the standard.

1. PURPOSE, SCOPE, AND EQUIVALENCY

1.1 PURPOSE

No basis necessary.

1.2 SCOPE

No basis necessary.

1.3 EQUIVALENCY

No basis necessary.

2. ACRONYMS AND DEFINITIONS

2.1 ACRONYMS

No basis necessary.

2.2 DEFINITIONS

No basis necessary.

3. RELEVANT ORDERS, STANDARDS, AND DOCUMENTS

3.1 FEDERAL REGULATIONS

No basis necessary.

3.2 DEPARTMENT OF ENERGY ORDERS

No basis necessary.

3.3 NONGOVERNMENT PUBLICATIONS

No basis necessary.

4. SAFE STORAGE CRITERIA

4.1 GENERAL CRITERIA

- A. Basis is Y/ES-012, Section 4. Li materials specified in the scope are those Li materials known to be present in significant quantities at the Y-12 Plant. The 10 kg limit is a generally accepted delimiter among research quantities that could be found in a laboratory or a warehouse. Accidents involving quantities greater than 10 kg of material could be expected to be more severe than those involving less than 10 kg. Storage of quantities less than 10 kg is adequately governed by OSHA standards.
- B. Basis is the MSDS for the particular lithium material. Note that lithium metal is a very strong reducing agent and reacts vigorously with a variety of materials. See NFPA 485 for more information. The hydride ion of LiH readily combines with the hydrogen ion to form hydrogen gas, as discussed in the MSDS for LiH. Refer to NFPA 491M, for more information.
- C. Basis is Y/ES-012, Section 9, and *Lithium Combustion: A Review* (December 1990), which discuss the flammability characteristics of lithium material and the need to minimize the probability of an environmental fire igniting stored lithium material. Current storage practices described in Y/ES-012, Section 5, note that wooden pallets are being replaced with metal pallets.

4.2 INTERIM STORAGE (IS) CRITERIA

4.2.1 Lithium Metal (Li)

Basis is NFPA 485, Sections 5-1, *General Precautions*, and 5-2, *Solid Lithium Storage*.

4.2.2 LiH/D

- A. Basis is Y/ES-012, Section 9.4, and Y/DZ-1006, which discuss the reactivity of LiH/D with water and the combustion characteristics of LiH/D. By storing the material in compacted form, the water reaction rate (which generates hydrogen gas) is reduced significantly and the ignition temperature is raised significantly.
- B. Basis is Y/ES-012, Section 7.5, which discusses the reactivity of LiH/D with moisture and other materials. Appendix C.2 of that report discusses the container requirements for storage of LiH/D. It is anticipated that some corrosion of untreated steel containers will occur during the storage period, but the corrosion of the container is not likely to be significant enough to compromise the integrity of the stored LiH/D.

- C. Basis is Y/ES-012, Section 6.4, and the MSDS for LiH, which discusses materials incompatible with LiH. The hydride ion readily combines with the hydrogen ion (available from many sources) to form hydrogen gas.
- D. Basis is Y/ES-012, Appendix C.2, which discusses the container requirements for storage of LiH/D.
- E. Basis is Y/ES-012, Appendix B, which discusses the hydrogen pressure buildup inside sealed containers of LiH/D and the need for periodic pressure relief.

4.2.3 LiOH·H₂O and Li₃PO₄

- A. Basis is Y/ES-012, Appendix C.3, which discusses the container requirements for LiOH·H₂O and Li₃PO₄. It is anticipated that some corrosion of untreated steel containers will occur during the storage period, but the corrosion of the container is not likely to be significant enough to compromise the integrity of the stored material.
- B. Basis is Y/ES-012, Section 6.4, and the MSDSs for LiOH·H₂O and Li₃PO₄ which discuss incompatible materials.
- C. Basis is Y/ES-012, Appendix C.3, which discusses the container requirements for LiOH·H₂O and Li₃PO₄.

4.3 LONG-TERM STORAGE (LTS) CRITERIA

- A. Basis is Y/ES-012, Appendix C.3, which discusses the container requirements for Li₂CO₃ and LiCl. It is anticipated that some corrosion of untreated steel containers will occur during the storage period, but the corrosion of the container is not likely to be significant enough to compromise the integrity of the stored material.
- B. Basis is Y/ES-012, Section 6.4 and the MSDSs for Li₂CO₃ and LiCl, which discuss incompatible materials.
- C. Basis is Y/ES-012, Appendix C.3, which discusses the container requirements for Li₂CO₃ and LiCl.

4.4 STORAGE AREA

4.4.1 General

- A. Basis is DOE 5480.7A, paragraphs 5 and 9.

- B. Basis is DOE 5481.1B, Chapter 1. Although ${}^6\text{Li}$ is a nuclear material according to DOE 5633.3B, Figure I-1, lithium material is not fissile or radioactive and is considered non-nuclear for safety analysis.

4.4.2 Lithium Metal

- A. Basis is NFPA 485, Chapter 3.
- B. Basis is Y/ES-012, Section 9.3, and *Lithium Combustion: A Review*, which discuss the flammability characteristics of Li metal and the need to minimize the probability of an environmental fire igniting stored Li metal. Ideally, Li metal should be stored in an isolated facility. In the event of an uncontrolled lithium emergency, physical damage and health effects would then be considerably less. If the facility is part of another structure, a 2-hour fire-rated enclosure is recommended to permit emergency response personnel time to respond to and control a fire-related incident.
- C. Basis is Y/ES-012, Section 9.3, and *Lithium Combustion: A Review*, which discuss the flammability characteristics of Li metal and the need to minimize the probability of an environmental fire igniting stored Li metal.
- D. Basis is NFPA 485, Chapter 6. Since lithium metal storage areas are unlikely to be equipped with automatic sprinkler systems, it is desirable to use smoke detectors to alert personnel to incipient fires in the storage area.

4.4.3 Lithium Hydride Deuteride

- A. Basis is Y/ES-012, Section 9.4, and Y/DZ-1006, which discuss the flammability characteristics of LiH/D and the need to minimize the probability of an environmental fire igniting stored LiH/D. If the areas surrounding the storage facility are suitably free of combustible materials, it is reasonable for the authority having jurisdiction to specify that the area not be protected with sprinklers in order to minimize the inadvertent contact of sprinkler water with LiH/D.
- B. Basis is Y/ES-012, Section 9.4, and Y/DZ-1006, which discuss the flammability characteristics of LiH/D and the need to minimize the probability of an environmental fire igniting stored LiH/D.
- C. Basis is Y/ES-012, Section 9.4, and Y/DZ-1006, which discuss the flammability characteristics of LiH/D and the need to minimize the probability of an environmental fire igniting stored LiH/D.

- D. Basis is the MSDS for LiH, which discusses the reactivity of LiH with water and other materials that could be present in pipes, lines, or ducts.
- E. Basis is Y/ES-012, Section 9.4, which discusses the hazards associated with the storage of LiH/D. In order to minimize these hazards, it is necessary to restrict access to LiH/D storage areas to prevent untrained personnel from working in the storage area.
- F. Basis is Y/ES-012, Section 9.4, and Y/DZ-1006, which discuss the flammability characteristics of LiH/D and the need to minimize the probability of an environmental fire igniting stored LiH/D.
- G. Basis is Y/DZ-1006, which discusses extinguishing agents suitable for use on LiH/D fires.
- H. Basis is Y/ES-012, Section 9.4, and Y/DZ-1006, which discuss the flammability characteristics of LiH/D and the need to minimize the probability of an environmental fire igniting stored LiH/D.
- I. Basis is Y/ES-012, Section 9.4, which discusses the hazards associated with the storage of LiH/D.

4.4.4 LiOH·H₂O and Li₃PO₄

Basis is NFPA 231, Chapter 5.

4.4.5 Li₂CO₃ and LiCl

Basis is NFPA 231, Chapter 5.

4.5 MATERIAL HANDLING

- A. Basis is 29 CFR 1910, Subpart N.
- B. Basis is DOE 5480.10, paragraph 9.
- C. Basis is DOE 5480.19, paragraph 5.
- D. Basis is 29 CFR 1910.1200 (b) (4) (ii).

4.6 INSPECTION AND SURVEILLANCE

4.6.1 General

Basis is DOE 5633.3B, Chapter II, paragraph 3.

4.6.2 Lithium Metal (Li)

Basis is Y/ES-012, Appendix C, which discusses the need for periodically monitoring Li metal storage containers.

4.6.3 LiH/D, LiOH·H₂O, Li₃PO₄, Li₂CO₃, and LiCl

Basis is Y/ES-012, Appendix C, which discusses the container requirements for storage of these materials and the need for periodic evaluation.

4.7 EMERGENCY MANAGEMENT

Basis is DOE 5500.1B, paragraph 9.c; DOE 5500.2B, paragraph 9; DOE 5500.3A, paragraph 11; DOE 5500.4A, paragraphs 7 and 8; and DOE 5500.10, paragraph 9.

4.8 DOCUMENTATION

Basis is DOE 5633.3B, Chapter II, paragraph 2.

4.9 QUALITY ASSURANCE

- A. Basis is 10 CFR 830.120, Quality Assurance Requirements.
- B. Basis is DOE 5000.3B, paragraphs 7 and 8.

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