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Department of Energy
Washington, DC 20585

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DNF SAFETY BOARD

April 30, 1996

The Honorable John T. Conway
Chairman
Defense Nuclear Facilities Safety Board
625 Indiana Avenue, N.W.
Washington, D.C. 20004

Dear Mr. Conway:

Enclosed is the revised version of the "UF_6 Cylinder Program System Requirements Document" dated April 26, 1996. The original version of the systems requirements document (SRD) was delivered to the board on November 30, 1995, fulfilling the first commitment to the board as described in the attachment to Secretary O'Leary's October 16, 1995, letter, subject: "Implementation Plan for Defense Nuclear Facilities Safety Board Recommendation 95-1." Also enclosed are change pages for the Systems Engineering Management Plan (SEMP) that was originally provided to the board on March 31, 1996. The SEMP has been modified to maintain consistency with the revised SRD.

In your letter to Under Secretary Grumbly of January 22, 1996, you noted that "the SRD, in general, provides requirements that are consistent with the intent of Recommendation 95-1." Also enclosed with the letter were six board comments regarding the SRD, and your letter requested that the board be informed of their resolution and any plans for revision of the SRD.

In his February 16, 1996, letter to you, Acting Under Secretary Grumbly enclosed the Department of Energy's responses to each board comment. He also stated that by April 30, 1996, the Department would submit an amended SRD reflecting the responses and any additional changes and clarifications resulting from preparation of other Recommendation 95-1 Implementation Plan commitments. The enclosed document is the Department's fulfillment of that commitment.

Sincerely,

Ray A. Hunter

Ray A. Hunter, Deputy Director
Office of Nuclear Energy,
Science and Technology

2 Enclosures

96/1800

LOCKHEED MARTIN

K/TSO-001, Rev. 2
CONTROLLED DOCUMENT

UF_6 Cylinder Program
System Requirements Document

April 26, 1996

EM and Enrichment Facilities
Technical Support Organization

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

UCN-13675 (6 6-95)

96/1800

K/TSO-001, Rev. 2
CONTROLLED DOCUMENT

UF_6 Cylinder Program
System Requirements Document (SRD)

EM and Enrichment Facilities
Technical Support Organization

April 1996

Prepared by
Environmental Management and Enrichment Facilities
Oak Ridge, Tennessee 37831-7603
managed by
Lockheed Martin Energy Systems, Inc.
for the
U. S. Department of Energy
under contract
No. DE-AC05-84OR21400

UF_6 Cylinder Program System Requirements Document (SRD)

APPROVALS

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TABLE OF CONTENTS

EXECUTIVE SUMMARY 1

1. SCOPE 3
   - 1.1 Purpose 3
   - 1.2 System Overview 3
     - 1.2.1 Mission 3
     - 1.2.2 Background 4
   - 1.3 Organization and Description 5
     - 1.3.1 Development 5
     - 1.3.2 Requirements Structure 7

2. APPLICABLE DOCUMENTS 7
   - 2.1 Governing References 7
   - 2.2 Guidance Reference 8

3. SITUATION ANALYSIS 9
   - 3.1 Program Status 9
   - 3.2 Interface with Subsequent Phases 14
   - 3.3 Baseline Considerations and Assumptions 15
   - 3.4 Definition of Major Objectives 19
     - 3.4.1 Achieve and Maintain Acceptable Risk 19
     - 3.4.2 Achieve and Maintain Cylinder Integrity 20
     - 3.4.3 Improve Conduct of Operations 20
     - 3.4.4 Evaluate and Monitor Containment Integrity of Cylinders 20
     - 3.4.5 Administer the System 20

4. FUNCTIONAL ANALYSIS 21
   - 4.1 Functional Analysis Process 21
   - 4.2 System Definition 21
     - 4.2.1 System Functions 27
     - 4.2.2 System Components 27
   - 4.3 Functional Relationships 32
   - 4.4 Functions Crosswalk with Major Objectives 34

5. REQUIREMENTS TO ACHIEVE MAJOR OBJECTIVES 35
   - 5.1 Requirements to Achieve and Maintain Acceptable Risk 38
     - 5.1.1 Define the Safety Envelope 38
     - 5.1.2 Operate within the Safety Envelope 40
   - 5.2 Requirements to Achieve and Maintain Cylinder Integrity 41
     - 5.2.1 Mitigate Deterioration of Cylinders 41
     - 5.2.2 Mitigate Damage to Cylinders 43
     - 5.2.3 Manage Non-Compliant Cylinders 44
     - 5.3 Requirements to Improve Conduct of Operations 46
     - 5.3.1 Improve Process Controls 46
     - 5.3.2 Improve Staffing and Training 47
     - 5.3.3 Monitor System Performance 48
   - 5.4 Requirements to Evaluate and Monitor Containment Integrity 48

5.4.1 Monitor Containment Integrity 48
5.4.2 Evaluate Containment Integrity 51
5.5 Requirements to Administer the System 51
5.5.1 Obtain Resources 51
5.5.2 Integrate the System Operations 52

6. NEXT STEPS 53

LIST OF REFERENCES 54

APPENDIX A

APPENDIX B

EXECUTIVE SUMMARY

The Department of Energy manages an inventory of uranium hexafluoride through the Uranium Hexafluoride Cylinder Program; the program mission is continued safe storage of the uranium hexafluoride inventory until its ultimate disposition. Lockheed Martin Energy Systems, Inc., the managing contractor, is applying Systems Engineering principles to the cylinder program to strengthen and integrate program activities. This System Requirements Document is the first of four documents to be developed in the application of Systems Engineering principles to the program. It contains the requirements necessary to achieve the program mission and illustrates the rationale and intent of the requirements and the applicable standards.

This document will be used in the decision-making process to determine necessary program activities for compliance with the stated requirements. The decision-making process will be documented in the Systems Engineering Management Plan, the next in the series of documents associated with the application of Systems Engineering principles to the program. The requirements and rationale herein will be updated as the program generates new information and the standards governing the program change.

This System Requirements Document specifies the requirements for the program during the current, storage phase of the program, and it provides the initial segment of the flow-down process, to demonstrate that the system used to achieve program objectives complies with applicable standards. The requirements apply to both technical and management aspects of the program. During development of the requirements, consideration was given to maintaining the flexibility in subsequent phases of the program, which include dispositioning of the depleted uranium hexafluoride and decommissioning the facilities and equipment.

The requirements were identified through the following steps as illustrated in Fig. 1.

- **Conduct Situation Analysis**: Major objectives for the program were developed by articulating the current configuration of the system, reviewing the situation to determine focus areas that are necessary to meet the mission, and delineating and verifying baseline considerations and assumptions.
- **Define System Functions**: The system used to meet program objectives was defined in terms of components and activities for various operational states, (e.g., routine and off-normal), which are described in four operational functions. These four operational functions are: (1) surveillance and maintenance, including maintenance coating; (2) handling and stacking; (3) transfer of UF_6 contents; and (4) off-site transport. The key relationships between these functions were also specified.
- **Determine Requirements**: The operational functions were compared to the major objectives to determine the system and technical requirements for successfully meeting the program mission. To complete this functional analysis, the standards (applicable Department Of Energy Orders, federal regulations, industry codes, etc.) that govern the requirements were identified. Deviations from applicable standards are fully addressed, to ensure safe operation. An iterative process of reviewing the requirements for applicable standards and reviewing potential standards for necessary requirements established the quality and comprehensiveness of the requirements identified herein.

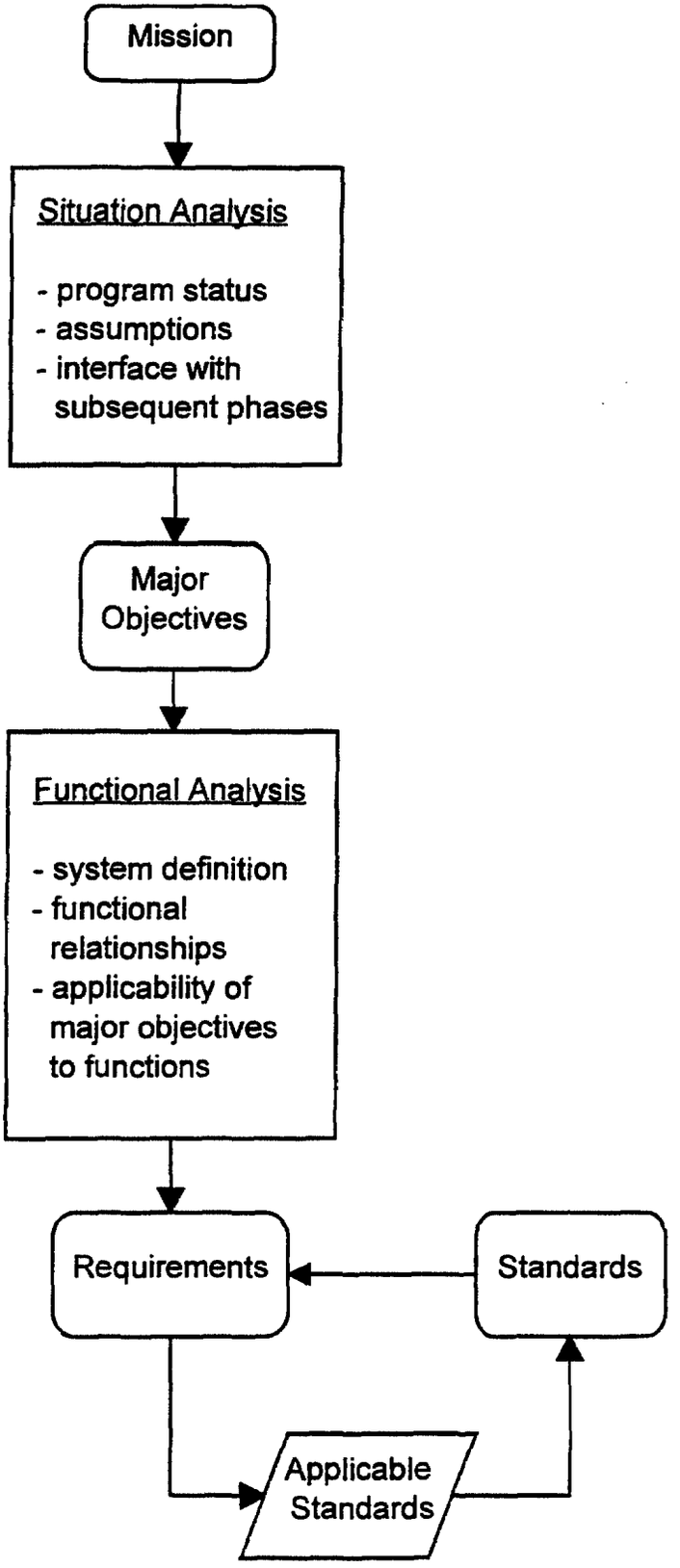

Figure 1. Requirements Development Process

1. SCOPE

The following section describes the application of Systems Engineering principles to the storage phase of the UF_6 Cylinder Program. In particular, this defines the development and application of system requirements.

1.1 Purpose

This System Requirements Document (SRD) illustrates the process of determining the requirements for the uranium hexafluoride (UF_6) Cylinder Program during the storage phase. The requirements are in part defined in applicable legislation, regulations, orders, directives, codes, and standards. The SRD provides the initial segment of the flow-down process to ultimately demonstrate system compliance with applicable requirements. These requirements include technical and management aspects of the program. In cases where a requirement has no governing reference, the requirement is derived in support of the program mission. In the development of the storage phase requirements, consideration was given to maintaining the flexibility in subsequent phases of the program (dispositioning of uranium hexafluoride (UF_6) and decommissioning of existing facilities and equipment).

The requirements define the basis for actions necessary to achieve the program mission. Therefore, the SRD is integral to the configuration by which the system used to meet the program mission is controlled. Management to the SRD (flow-down to implementing activities) is accomplished through the Systems Engineering Management Plan (SEMP). The SEMP will incorporate a requirements analysis that provides the decision-making rationale for developing activities. Thus, by derivation these activities will demonstrate compliance with applicable codes and standards. This decision-making function will enable the integration of various aspects of the system and will define activities consistent with the program mission. The utility of the SEMP largely depends on the quality and thoroughness of this SRD. The activities are carried out through the overall Program Management Plan (PMP). Necessary development actions before implementation are managed through the Engineering Development Plan (EDP). Actions within the EDP and PMP generate new information, expertise, and experience. This information is iterative feedback into the SEMP integrated decision-making process for producing and improving requirements.

1.2 System Overview

1.2.1 Mission

The UF_6 Cylinder Program mission is to safely store the existing DOE-owned $_6$UF inventory managed at the Oak Ridge K-25 Site, and the Paducah (PGDP) and Portsmouth (PORTS) Gaseous Diffusion Plants until ultimate disposition of the UF_6. The average ages of cylinders in storage at K-25, PGDP, and PORTS are 29, 21, and 20 years, respectively. Much of this UF_6 inventory has been stored for many years without adequate surveillance and maintenance of facilities sufficient to meet the current program mission; therefore, corrective actions are critical to a viable system.

The next phase of the program, dispositioning the UF_6 inventory, is under development. The final phase, decommissioning of the facilities, will be integrated into the decontamination and decommissioning (D&D) of the diffusion cascades at the aforementioned sites. The SRD does not encompass the requirements for these subsequent phases. However, the SRD does establish the interface between the storage phase and these subsequent phases, including the impact on requirements stated herein. These interfacing requirements establish continuity for the program and it's system to transition to subsequent phases.

1.2.2 Background

DOE has about 47,000 large-capacity cylinders containing about 555,000 metric tons of depleted uranium hexafluoride (DUF_6) in long-term storage. DUF_6 is generated during the operations of the gaseous diffusion process; withdrawn from the diffusion cascade as a gas; liquefied; drained into steel cylinders, where the material solidifies at subatmospheric pressure; and then stored outdoors in cylinder yards. Initially, DUF_6 was withdrawn into 2½-ton cylinders, but during the 1950s 10-ton cylinders were used. In 1958, use of 14-ton cylinders was initiated. Most (94%) of the DUF_6 storage cylinders have 5/16-inch-thick shells and are called "thin wall" cylinders; the rest have 5/8-inch-thick shells and are called "thick wall." The thin wall cylinders were designed as economical storage containers that meet the pressure and temperature conditions required during liquefaction.

After a significant inventory was produced, outdoor storage facilities evolved independently at the sites. Cylinder yards are constructed of either concrete or compacted gravel, and cylinders are stacked in two-tiered rows on wooden or concrete saddles. The handling equipment used to stack these cylinders in double-tiered rows has also evolved, from mobile cranes to specially designed tractors that grasp and lift the cylinders with hydraulically actuated tines.

Until 1990, surveillance consisted of an annual nuclear materials inventory of the cylinders. The K-25 cylinder yards were surveyed in May 1990 to provide input for planning long-term corrosion monitoring of cylinders. Cylinder valves with corrosion and evidence of potential valve leakage were discovered. A subsequent valve survey in June 1990 at PORTS revealed two cylinders with breached side walls. Investigation of these cylinder breaches determined that the causes were mechanical tears caused by impact from adjacent cylinder lifting lugs.[1] Subsequent inspections of stored DUF_6 cylinders revealed four breached cylinders at K-25. Two breaches were attributed to handling damage, and two were most likely initiated by external corrosion resulting from substandard storage conditions.[2] Another breached cylinder resulting from handling damage was discovered at PGDP.

The risk to personnel health and safety, and the potential environmental impact posed by these cylinder breaches and valve leaks, are low by nature of the system. The UF_6 inventory is stored as a solid. Reaction deposits formed when UF_6 is exposed to the atmosphere in the presence of the mild steel containers have a self-sealing nature. The uranium is depleted in the fissionable isotope of the UF_6 to the point that the hazard is mostly chemotoxic, not radiological. These factors contribute to the low risk incurred from these and potential additional failures. This low risk was confirmed by

analysis of the air and soil samples collected near the breaches at PORTS and by subsequent weighing of the cylinders. Although the risk posed by these breaches is low, the existence of breached cylinders heightened the importance of a comprehensive, long-term, three-site cylinder management program.

In 1992 a cylinder integrity management plan was developed to address concerns within the storage yards and to establish the initial premise of the program today.[3] To establish more rigor within the program and further ensure that the inventory is stored safely, a Systems Engineering approach is being adopted. The quantity of DUF_6 primarily drives the scope of the program managed by DOE. However, the program also encompasses the DOE-owned natural assay and low-enriched (<5% ^{235}U) UF_6 inventories stored at these sites.

1.3 Organization and Description

1.3.1 Development

The storage phase is ongoing, and the development and implementation of Systems Engineering will run concurrent with the existing activities. Aspects of the current program will be evaluated from a Systems Engineering perspective and modified as the evaluation dictates.

The development of the SRD necessitated an analysis of the current system functions and their current configuration. This analysis is graphically depicted in Fig. 2. In preparation for functional analysis, the configuration of the current system was articulated in a situation analysis. Major objectives for the program were developed from the situation analysis in keeping with the program mission. In support of the major objectives, the program was bounded by delineating and verifying baseline considerations and assumptions. To initiate the functional analysis, the functions of the storage phase (surveillance and maintenance (S&M), handling and stacking, contents transfer, and off-site transport) were defined in terms of respective components and activities. These components and activities include hardware, personnel, command media or documentation, support functions, system activities, and interfaces with organizations regulating and performing the activities. The components and activities for each function were identified for relevant operational states including start-up, shutdown, routine, and off-normal. The interrelations among these functions were delineated, and the interface of the current phase of the program (storage) with subsequent phases was evaluated. This later evaluation was performed to ensure flexibility and success in the dispositioning and decommissioning phases of the program. To complete the functional analysis and determine the system and technical requirements for successfully executing the program mission, the defined operational functions were evaluated in the context of the major objectives. In many cases requirements are grouped into categories facilitating the rationale and intent of the requirements. Where applicable DOE Orders, regulations, industry codes, and standards govern these requirements, they are referenced. Deviations from applicable standards are fully identified, to ensure safe operations. This process reflects the adaptation of Systems Engineering into an existing system, where many activities within the system are defined and underway.

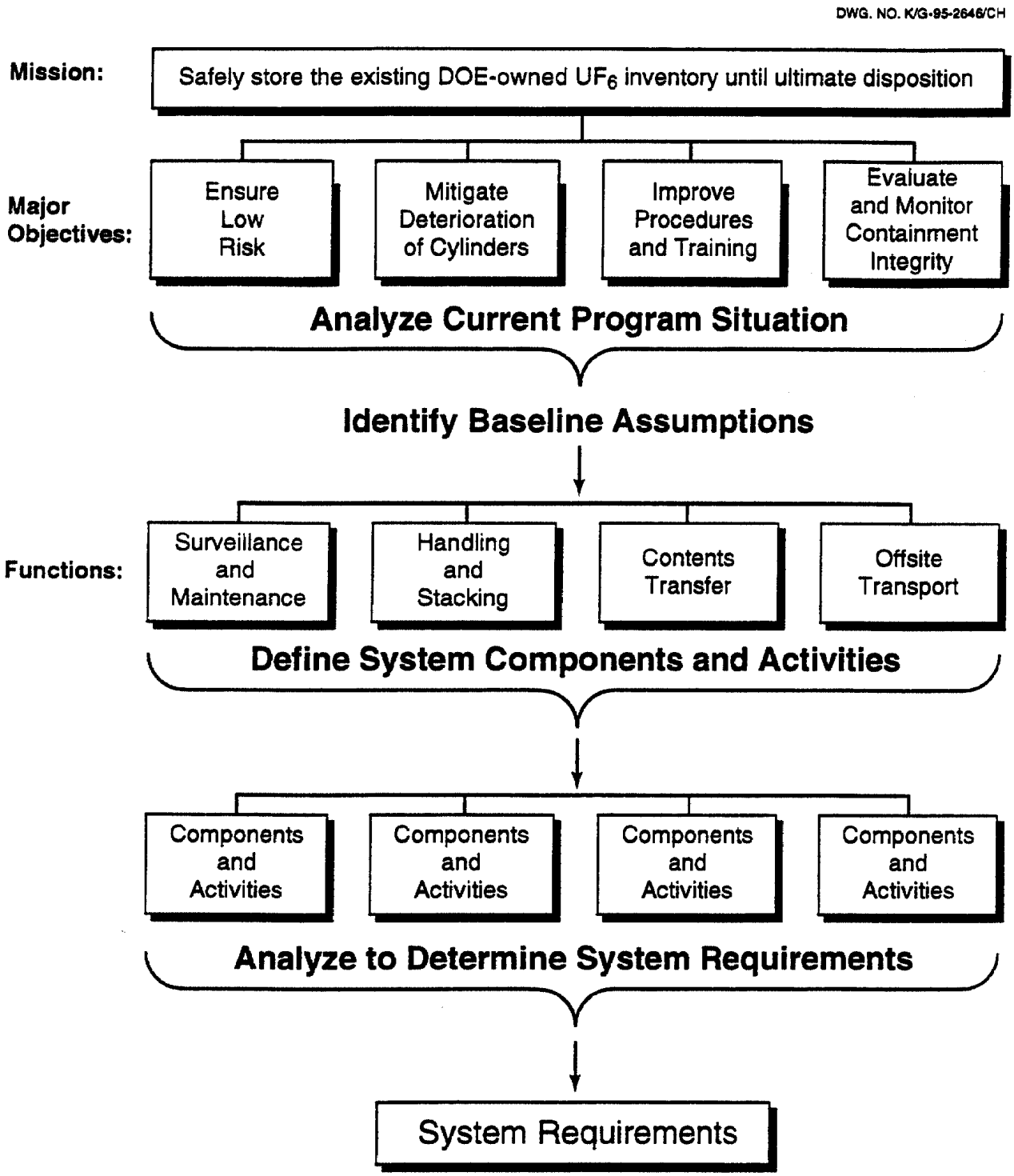

Figure 2. Development of System Requirements

1.3.2 Requirements Structure

Requirements are identified as system-level requirements and subordinate, technical requirements. The compilation of system requirements represent a comprehensive listing of essential characteristics the system must maintain to accomplish the program mission. The technical requirements provide specificity to the system requirements where needed to ensure actions are fully compliant with the intent of the system requirement. Standards are identified for system and technical requirements.

The requirements are documented where specific rationale logically dictates the need for a requirement. The purpose for listing requirements immediately following the rationale is to clearly show the development and intent of each system requirement and facilitate its application in the SEMP. Applicable standards and governing documents for specified requirements are identified in [*brackets*] following each requirement. The [*brackets*] are the means for locating requirements in the body of this document. Where a requirement, as specified by [*brackets*], does not have an applicable standard or governing document, the standard is considered to be managed within the program. These standards are denoted in the text by [*Derived*]. Requirements identified in the Situation Analysis and Functional Analysis are captured in the requirements listed in Section 5..

2. APPLICABLE DOCUMENTS

As effected by Requirements Change Notice Number OR35 to Contract Number DE-AC05-84OR21400, dated October 1, 1995, DOE Environmental , Safety and Health (ES&H) directives were deleted and contract activities were subjected to alternative DOE approved ES&H requirements.

2.1 Governing References

Appendix A of this document lists only the regulatory and guidance source documents currently comprising this contractual ES&H basis for requirements' identification. The list was generated from the Standards Management Information System data base and includes federal and state regulations, executive orders, DOE orders and standards. These standards and requirements are modified in a controlled manner under the contract's requirements change notice process. Events that may initiate a change to the contract requirements include modification, addition or deletion of federal and state regulations or DOE orders and standards. As Systems Engineering proceeds for the UF_6 Cylinder Program, appropriate requirements from the contract basis and as derived will continue to be incorporated into the system SARs and procedures.

2.2 Guidance Reference

Essential and fundamental features of Lockheed Martin Energy Systems (LMES), Inc. environmental and safety programs are identified and summarized in *Safety Management Program Support Nuclear and Hazardous Facilities*.[4] This report addresses requirement sources, scope, and/or gradation for the following programs:

Standards Management	Criticality Safety
Radiation Protection	General Environmental Protection
Industrial Hygiene	Radioactive and Hazardous Material Waste Management
Maintenance	Initial Testing and In-Service Surveillance
Conduct of Operations	Fire Protection
Training	Human Factors
Quality Assurance	Emergency Management
Configuration Management	Decontamination and Decommissioning
Occurrence Reporting	Safety Analysis Review and Unreviewed Safety Question Determination

Subsequent to development of system requirements in support of major objectives, specific source requirements pertinent to the UF_6 Cylinder Program were identified by subject matter experts. Refinement of this initial "mapping" of source requirements to system requirements, definition of activities and subsequent verification of compliance and adherence to standards will continue throughout the UF_6 Cylinder Program Systems Engineering process. Results of initial "mapping" appear in Section 5, *Requirements to Achieve Major Objectives*. The source requirements identified in this manner are listed below:

1. 10 CFR 830.120, *Quality Assurance*
2. 10 CFR 835, *Occupational Radiation Protection*
3. 29 CFR 1910, *Occupational Safety and Health Standards*
4. 49 CFR 173.420, *Uranium Hexafluoride (Fissile and Low Specific Activity)*
5. DOE 440.1, *Worker Safety and Health Program*
6. DOE 4330.4B, *Maintenance Management Program Maintenance*
7. DOE 4700.1, *Project Management System*
8. DOE 5400.1, *Environmental Protection*
9. DOE 5400.5, *Radiation Protection of the Public and Environment*
10. DOE 5480.7A, *Fire Protection*
11. DOE 5480.10, *Radiological Control*
12. DOE 5480.11, *Radiation Protection for Occupational Workers*
13. DOE 5480.18A, *Accreditation of Performance-Based Training for Category A Reactors and Nuclear Facilities*
14. DOE 5480.19, *Conduct of Operations Requirements for DOE Facilities*
15. DOE 5480.20A, *Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities*
16. DOE 5480.21, *Unreviewed Safety Questions*
17. DOE 5480.22, *Technical Safety Requirements*

18. DOE 5480.23, *Nuclear Safety Analysis Reports*
19. DOE 5480.24, *Nuclear Criticality Safety*
20. DOE 5480.26, *Trending and Analysis of Operations Information Using Performance Indicators*
21. DOE 5480.28, *Natural Phenomena Hazard Mitigation*
22. DOE 5480.31, *Startup and Restart of Nuclear Facilities*
23. DOE 5481.1B, *Safety Analysis and Review System*
24. DOE 5633.3B, *Control and Accountability of Nuclear Materials*
25. DOE 5700.6C, *Quality Assurance*
26. DOE 6430.1A, *General Design Criteria,* including all applicable regulatory requirements referenced in Section 0106 and all references standards and guides in Section 0109
27. DOE/ORO-651, Rev. 6, *Uranium Hexafluoride: A Manual of Good Handling Practices*
28. Amended Consent Decree, State of Ohio (DRAFT- under negotiation)
29. ANSI N14.1, *Uranium Hexafluoride - Packaging for Transportation*
30. ASME Boiler and Pressure Vessel Code
31. DOE-HDBK-1090-95, *DOE Handbook - Hoisting and Rigging*
32. National Board Inspection Code

3. SITUATION ANALYSIS

The following section provides the development of the program's major objectives rationale. The major objectives are established to focus the management of the program on key aspects necessary to meet the program mission. These objectives stem from an understanding of: (1) the current status of the program used to achieve program objectives, (2) the interface of the storage phase (current phase) with subsequent phases (UF_6 disposition and decommissioning of the storage facilities), and (3) the bounding assumptions for the program. To complete the situation analysis, the major objectives are identified and defined for application in the functional analysis used to determine the necessary requirements of the system.

3.1 Program Status

The program status documents the current understanding of the condition of the program including known deficiencies and concerns, and actions taken to date to reduce the risks within the program. number of general and specific system problems and deficiencies have been identified through self assessments and improvements in management practices. Conditions and factors that have contributed to the causes date back to when DOE and predecessor agencies began placing DUF_6 in storage. The fundamental cause is that a risk analysis for the UF_6 Cylinder Program has not been adequately documented. Additional contributing causes include the absence of a defined life-cycle cylinder maintenance program, lack of appropriate resource application at the onset of long-term storage, lack of adequate operational controls used to place cylinders in their current locations, inadequate integration of system operations, and absence of a well-defined mission leading to the ultimate disposition of DUF_6 stored in cylinders.

These past general program management deficiencies have resulted in the following conditions:

1. A number of cylinders were permitted to remain for extended periods in ground contact and in storage yards where drainage was not maintained. This condition, in conjunction with no maintenance of a protective coating, has resulted in accelerated corrosion of cylinder bodies and the through-wall corrosion (failure) of two cylinders. The mild steel composition of the cylinders corrodes at an accelerated rate under extended periods of wetness.
2. Before 1990, the system did not include a cylinder inspection program, which caused the cylinders and storage conditions to deteriorate without updated characterization. This lack of characterization resulted in the unmitigated continued storage of breached cylinders, cylinders with leaky valves, cylinders with nameplates loose or on the ground, and the continued use of safety documentation that does not reflect current cylinder conditions.
3. Handling and stacking procedures and operations before 1990, resulting in the current storage configuration, are the cause of stacked cylinder arrays with insufficient spacing to facilitate inspection, configurations with less than desirable cylinder support, the impact failure of five cylinders, and other physical damage to the cylinders and protective coatings.

Many specific deficiencies have been identified concerning the long-term storage facilities and the cylinders. This section states the deficiencies identified to date and prioritizes them relative to risks. Further characterization and evaluation of risks will revise this prioritization. Prioritizing deficiencies will be used in the optimization of actions taken to reduce risks within the program. [DOE 4330.4B]

Table 1 categorizes identified deficiencies and potential deficiencies as: (A) Direct Container Integrity Concerns, (B) Storage Facility Concerns, (C) Uranium Control Issues, (D) UF_6 Transfer Issues, or (E) Other Issues. An estimated number of cylinders impacted by each deficiency is provided to illustrate the magnitude of these concerns. Efforts to correct many of these deficiencies have been expedited and are underway. Note that cylinders with deficiencies may appear in multiple categories (i.e., the total number of deficient cylinders is less than the sum of the numbers in the table).

Categories A, B, and C (Direct Container Integrity Concerns, Storage Facility Concerns, and Uranium Control Issues) are given priority over categories D and E (UF_6 Transfer Issues, and Other Issues). Categories A, B, and C have a potential to result in an undesirable occurrence while these cylinders are being used as long-term storage vessels, such as a release of uranium could occur, or the handling of mistaken uranium assays could result (i.e., DU thought to be normal or enriched and vice versa). Within the three priority categories, highest priority is given to breached cylinders, substandard facilities, and non-DU material deficiencies (A1, B1, and C1, respectively). An occurrence from these deficiencies is considered the most serious. Category D, UF_6 Transfer Issues, applies to the removal of the UF_6 from the subject containers and is relative to the subsequent UF_6 dispositioning phase of the program. Category E, Other Issues, is relative to best management practices in keeping with the long-term, safe storage of UF_6.

Table 1. Long-term Storage Inventory Potential Deficiencies		
Potential Deficiency		**Estimated Number of Cylinders Affected**
A	**Direct Container Integrity Concerns**	
A1	Breached cylinders - cylinders with holes in the cylinder shell	7
A2	Corroded cylinders - cylinders with visible pitting and/or scaling rust	22,000
A3	Leaking valves - valves and plugs that have recurring contamination	10
B	**Storage Facility Concerns**	
B1	Substandard Facilities - sinking or poorly drained load-bearing surfaces	12,000[a]
B2	Improper Support - upper tier cylinders supported by unsound points of contact	10,000[b]
C	**Uranium Control Issues**	
C1	Non-Depleted Material - normal and enriched material located in DU storage facilities	1,900
C2	ID Plates - loose or detached identification plates	4,000
D	**UF_6 Transfer Issues**	
D1	Fill-Limit Consideration - cylinders without certified internal volumes or cylinders filled above the current maximum allowable limit established in ORO-651	23,000
D2	Substandard Valves - valves with missing or cracked parts, Teflon tape on threads, bent stem, and/or improper engagement	12,000
D3	Plug Replacing Valves - plugs in place of valves	2,200[c]
D4	Physically Damaged Cylinders - cylinders that do not pass the inspection criteria established in ORO-651 for liquid transfer	2,100
D5	Cylinders Design hindrances- cylinders that will not fit into currently designed autoclaves	140
E	**Other Issues**	
E1	Inaccessible Cylinder - cylinders that cannot be accessed at both heads for a visual inspection	11,000[b]
E2	Above Internal Vacuum - cylinders with internal pressure above the ideal vacuum conditions	5,000

[a]As of end of April 1996, all but approximately 500 cylinders have been removed for yard reconstruction.

[b]As of October 1995

[c]Excludes empties

The highest priority is given to identifying and controlling breaches to minimize the release of uranium compounds and potential environmental insult or exposure (i.e., to Category A1). Identifying and controlling breaches also minimizes the criticality concerns with fissionable assays of material. A lesser priority is given to repairing or replacing cylinders. Until final resolution can be accomplished, patched breaches are periodically inspected and provisions are made to prevent any spread of uranium contamination from the cylinder.

Breaches can occur by any of three mechanisms: mechanical impact, external corrosion, or rupture from over pressurization. Other failure mechanisms, such as internal corrosion, have not proven to be realistic mechanisms within the scope of the storage program. However, further study may be warranted. Five breaches by impact from adjacent cylinders during stacking and two breaches by external corrosion have been identified. The investigation into the exact circumstances causing the breaches has provided information crucial to the management of long-term storage cylinder integrity. Cylinder rupture over pressurization requires a significant energy source (heat or internal pressure). No cylinder within the DOE complex has been accidentally ruptured; however, a cylinder has accidentally ruptured within the U.S. UF_6 industry. An overfilled cylinder was heated during a routine feeding operation. The investigation of this incident identified several contributing causes including the lack of recognizing the cylinder excessive weight, heating a closed system (closed valve), and a crude heat source control system. Excessive pressure has been experienced in the complex with a 30A model cylinder when, after filling with liquid UF_6 and set aside to cool, a detonation occurred resulting in a deformed cylinder. Investigation of this occurrence determined a UF_6/hydrocarbon exothermic reaction caused the over pressurization. The source of the hydrocarbon was identified as oil from a vacuum pump used in the cylinder cleaning operations. Both of these over pressurization occurrences have resulted in additional preventive controls for the emptying and feeding operations of cylinders.

Corroded cylinders, Category A2, are a product of external accelerated corrosion due to the design of the cylinder or due to its physical placement, (e.g., a skirted cylinder or cylinders in ground contact). The estimated number of cylinders for Category A2 does not include cylinders with degraded or absent protective coatings that atmospheric corrosion has affected. The protective coating is applied to provide an initial protection against rusting and it degrades with the aging of the cylinder or deficient cylinder handling. In addition to the protective coating, the cylinder shell thickness is designed with a minimum of 50 mils of corrosion allowance. Atmospheric corrosion (less than 1 mil per year reduction in wall thickness) is visually identified by a uniform rust-coated surface without scale or pits. The rate of shell thickness reduction from accelerated corrosion can vary greatly from general atmospheric corrosion rates.

Continued use of corroded cylinders will be subject to the scrutiny of the functional acceptance criteria and of possible corrective actions to be developed. The oldest design models include the 10-ton Model T, the 14-ton Model O, and 2½-ton 30A cylinders. These cylinders have been in storage the longest period of time without protective coatings and in areas not specifically designed for long-term storage. The criteria will determine if a corroded cylinder is unsafe for continued use. If the cylinder requires a maintenance coating, the shell surface will be prepared and a rust-protective

coating will be applied. If a cylinder is unsuited for continued storage, as determined by the functional acceptance criteria, it will be placed in a queue for transfer of its contents to another cylinder via to-be-established defective cylinder feed procedures.

Without the application of a protective coating or a change in the corrosive environment, cylinders that exhibit heavy scaling rust or pitting-type corrosion will continue to corrode at an above-normal rate, and their life expectancy will be reduced considerably from the projections based on general atmospheric corrosion rates. Scaling rust and pitting corrosion are results of extended periods of wetness imposed on the cylinder shell. Once initiated, the pits and scale, without proper maintenance, will continue to facilitate water retention. Extended wetness can occur on cylinders that by design retain rainwater or on cylinders that are stored in ground contact or in poorly drained yards. Cylinders that by design retain rainwater are cylinders with skirts and cylinders with channel-type stiffening rings. Although drain holes can be provided where water would collect, proper drainage can be obstructed by rust and foreign material or improper cylinder stacking orientation. Maintenance to ensure these drain holes stay clear is necessary.

Leaking valves and plugs, Category A3, have a potential to release small quantities of uranium. Leaks can to some extent be identified visually by recurring contamination. Leaks can be verified by an HF monitor and/or a radiation contamination survey. Leakage will be contained by tightening the valve/plug or by replacing the valve/plug. To date, valves verified as leaking have been mitigated.

Substandard facilities, Category B1, consist of yards that permit extended periods of wetness on cylinder surfaces due to poor drainage or settling to the extent that cylinders contact the ground. Cylinders on the bottom tier under these conditions corrode at the six o'clock position at an accelerated rate as discussed in Category A2. The corrective action is to remove these cylinders from substandard conditions as soon as technically feasible and either renovate the yard to meet current standards or no longer use the yard as a storage facility. PGDP yards C-745-F and C-745-G, which contain about 12,000 cylinders, have been identified as substandard storage facilities. Other yards within the three sites have been identified as having sporadic substandard conditions. In these cases, subjected cylinders will be removed and placed in proper storage yards. This effort is underway.

Improper support, Category B2, consists of upper-tier cylinders that are not soundly supported by the bottom-tier cylinders because of improper placement (e.g., a narrow-stiffening-ring to narrow-stiffening-ring support or support from a lifting lug). These cylinders present a concern in the event of an earthquake, when an improperly supported cylinder could be dislodged and fall freely for a few inches to a new resting position. Structural analysis will determine if the subject cylinders will become breached from this free fall, and a safety evaluation will determine the impact from these possible breaches.

Non-depleted uranium, Category C1, is defined as cylinders that contain natural and enriched material are located in the DU storage facilities. Adequate uranium control is necessary to ensure that cylinders containing non-DU are not mistaken for cylinders containing DU and vice versa. All sites have a Nuclear Material Control and Accountability (NMC&A) organization that requires that the cylinder contents, including assay, are verified by records before the cylinder is serviced, processed, or shipped off site. The NMC&A uranium control requirements for keeping cylinders with different assays segregated will be followed. As an interim measure, subject cylinders that cannot be easily accessed for segregation have been identified.

Cylinders with loose, detached, or missing cylinder identification (ID) plates, Category C2, are another uranium control issue. Identification plates become loose or detached because of corrosion facilitated by moisture retention between the plate and the cylinder shell and by the dissimilar metals, stainless steel plate, and the mild steel shell. Loose and detached ID plates are occurring on the oldest cylinders in storage. National Board Inspection Code (NBIC) guidelines require that the original fabrication documentation be in-hand before ID plates are reattached. If the documentation can be obtained, ID plates will be reattached; if not, tags will be fabricated and attached. As minimum requirements, the replacement tags will indicate they are replacements and will give the cylinder identification number. Authorization to reattach tags will be documented and signed by appropriate personnel. Documentation will remain in the cylinder history file as long as the cylinder is in service.

Table 1 lists five potential defiencies in Category D that are relative only to material transfer operations and not long-term storage. These five potential defiencies are: (1) fill-limit consideration, (2) physically damaged cylinders, (3) substandard valves, (4) plug replacing valve, and (5) non-certified volumes. Transfer Issues also include the potential presence of hydrocarbon oil in the cylinder. Some cylinders were filled before use of the improved vacuum pump design, which eliminated the source of the hydrocarbon oil. Hydrocarbons and UF_6 produce an exothermic reaction. Mitigation of these potential deficiencies will be addressed as necessary in the control of the UF_6 transfer operations.

Table 1 defines the two other potential defiencies relative to long-term storage. These are: relocating inaccessible cylinders so that a more thorough visual inspection can be conducted and establishing an internal vacuum to ensure the integrity of the UF_6 contents. These potential deficiencies will be addressed accordingly through a risk-benefit cost optimization.

3.2 Interface with Subsequent Phases

No significant design and configuration changes within the system that would incrementally impact the decommissioning of cylinders, storage facilities, and equipment are anticipated. Current plans require the reconstruction of substandard facilities, to mitigate unacceptable conditions. However, if regulation changes (external governing documents) or cylinder conditions necessitate a configuration change, the incremental impact on the decommissioning phase could be significant. Examples of this potential impact include: (1) the need for additional precautions to protect against

environmental exposure, (2) more prescriptive cylinder access requirements, and (3) the establishment of cylinder standards for storage only (disassociated with transport standards). These examples could dictate a change in configuration such that indoor storage, single cylinder spacing, or mass cylinder replacements are considered. These options would impact the decommissioning phase with the consumption of additional real estate for storage, and the radioactive contamination of additional mild steel (i.e., the need for new cylinders). Impact on the subsequent dispositioning and decommissioning phases of the program will be considered when developing actions to accommodate regulation changes under the current storage phase. [10CFR830.120, DOE 5480.19]

The greatest incremental impacts on the decommissioning phase from current operations include decontamination and environmental remediation. These aspects are closely related when considering the current system. Support organizations provide oversight for compliance with requirements for contamination control. Environmental remediation is impacted primarily by degree of containment integrity. Containment integrity is a major element within the storage phase, and the requirements for such are specified in Section 5.4. Environmental monitoring in the current phase will be assessed to ensure the establishment of additional actions, if any, beyond current activities that are necessary to maintain compliance with applicable orders and regulations. Additional activities will be established such that environmental monitoring actions within the storage phase are balanced with potential environmental remediation in the decommissioning phase. [DOE 5400.1]

Operations within the current storage phase require a significant interface with the dispositioning phase currently under development. The condition of the cylinder will greatly influence the flexibility of the dispositioning phase (i.e., normal off-site transport and normal transfer of the contained UF_6). Deteriorated cylinders limit this flexibility. The cylinder contents also have some impact on the flexibility of the dispositioning phase. For example, the purity of the contents, the mass, and the internal pressure can impact the dispositioning operations. It is expected that the condition of a portion of the current cylinder inventory does not meet the minimum standards of Department of Transportation (DOT) and ANSI for off-site transport. However, the off-site transport of these cylinders for dispositioning is not a requirement at this time. As a contingency, engineering studies will evaluate the conditions of these cylinders and will propose solutions to the transportation and transfer operational constraints. In addition, the planning for UF_6 dispositioning is taking into consideration the condition of cylinders and necessary actions to accomplish disposition operations. [49 CFR, DOE 5700.6C]

3.3 Baseline Considerations and Assumptions

The following considerations and assumptions are provided to bound the scope of Systems Engineering. Many of these assumptions are current working assumptions that will be modified through developments defined in the EDP. The current working assumptions are identified as such to integrate the Systems Engineering approach with the current system.

1. *Risks are managed within the current system.* This assumption permits the program to continue planned operations concurrent with the safety analysis upgrade as authorized under the current safety basis. Planned operations are necessary to correct substandard conditions. This assumption does not preclude the program from pursuing reduction of risks.

2. *Effective risk management for handling degraded cylinders will not appreciably impact planned costs and relocation timing.* This statement assumes the degraded cylinder handling risks are accounted for in recent procedure improvements. Functional acceptance criteria under development will not necessitate additional controls that impact cost and timing of planned operations. This assumption is integrated into budget planning for cylinder handling operations.

3. *Current yard construction will result in storage surfaces with acceptable time of wetness.* This assumption permits the progression of yard construction while the definition of unacceptable/acceptable extended time of wetness is under development. Current design of yards derived from general outdoor construction standards is thought to be acceptable.

4. *Corrosion rates are variable and cylinder specific.* This statement is substantiated by the failure of two cylinders at the K-25 Site from external corrosion and the lack of thickness data obtained to date on other cylinders below 0.14 inches. This statement limits the usefulness of statistical wall thickness data when considering specific cylinders.

5. *Skirt corrosion necessitates priority corrective measures.* This assumption is based on limited thickness data collected, corrosion products collected from cylinder skirts, and subsequent projected rates of corrosion. This assumption substantiates the expedited implementation of cleaning and coating skirted regions prior to whole body painting.

6. *As more data are gathered through nondestructive analyses, structural analyses, visual inspections, valve monitoring, and experiences with failed cylinders, the majority of cylinders will be shown to comply with industry standards for storage; the condition of those cylinders that do not meet industry codes will be shown to present no imminent danger.* This assumption permits the near term storage of the DUF_6 in existing cylinders instead of the alternative configurations such as replacement of cylinders, restoration of cylinder thickness, or acceleration of the DUF_6 disposition phase.

7. *Cylinders to be replaced will be accommodated with existing transfer capabilities at PGDP and PORTS.* This assumes that only a small number of cylinders will need to be replaced. This statement is based on the continued working relationship with United States Enrichment Corporation (USEC) and the known number of cylinders to be replaced.

8. *Compliance with ANSI N14.1 is not necessary for continued safe storage of cylinders.* The impact of this assumption is minor within the current phase. However, the assumption limits the flexibility and economics of the subsequent phases because ANSI N14.1 is applicable for shipment of cylinders. The validation of this assumption requires the evaluation, determination, and approval of functional acceptance criteria and viable means to transport cylinders subject to the ANSI standard or under a DOT exemption for foreseeable shipments.

9. *Cylinder contents purity is reflective of the statistical sampling and analysis completed at the time of filling.* This assumption permits the planning and implementation of the dispositioning phase based on statistical purity information and is sufficient for continued storage.

10. *Cylinder contents reflect the NMC&A database records.* This assumption permits the shipment of cylinders in compliance with DOT requirements where a means to weigh cylinders for accountability is not available.

11. *The majority of X-745-C and K-1066-E yards are acceptable for continued use.* This assumption permits the continued planned use of these yards while storage criteria are under development.

12. *Cylinders with inaccessible plug ends do not require immediate priority action to verify containment integrity.* This assumption is substantiated by the verified conditions of accessible cylinders and by the verified conditions of the recently moved inaccessible cylinders.

13. *DOE will continue to regulate the inventory of DUF_6.* This assumption is based on the recent status of negotiations with the Ohio EPA on the regulatory jurisdiction of this inventory and enables DOE to continue to manage the inventory.

14. *Funding will be obtained to complete necessary activities as planned.* This assumption limits the amount of contingency planning necessary to ensure the mission will be successfully accomplished.

15. *The dispositioning phase of the DUF_6 inventory will be initiated in FY 2020 and progress at a rate of 5000 cylinders/year.[5] The cylinders of lesser integrity will be dispositioned first.* This assumption is used in determining the extent of corrective actions necessary and the degree of periodic maintenance implemented. This assumption is under review and will be revised through the programmatic environmental impact statement (EIS).

16. *The coating operation will result in cylinder coating life of 8 to 10 years.* This assumption is supported by the literature reviews, solicited vendor experience, and the value engineering study conducted by the program. This assumption will be used to size the coating capacity at each storage site and develop the surface preparation method.

17. *Requirements for the program that were not considered program specific are maintained and managed at the site level and are not contained in this SRD.* The program relies on the support organizations at each site to oversee adherence to applicable requirements and standards.

18. *Risks within the system will be prioritized and actions to reduce these risks will be optimized as practical.* The statement enables the program to manage risks and risk reduction activities within the system.

19. *Cylinders will be kept in outdoor storage in current climatic regions until ultimate disposition of the contained UF_6.* This assumption is the basis for sub-recommendation 2, paint cylinders, of the DNFSB recommendation 95-1. This assumption may be validated with the outcome of the Programmatic EIS.

3.4 Definition of Major Objectives

The major objectives of the storage program are promulgated from the situation analysis. The mission of the program is to safely store the existing DOE-owned UF_6 inventory until ultimate disposition. Current expectations are that the cylinders will continue to be used as storage vessels for the UF_6 material and the cylinders will remain in outdoor storage, until ultimate disposition. To achieve this mission in light of the current situation, five major program objectives have been formulated to assist in focusing and organizing various program activities. These major program objectives are:

1. Achieve and maintain acceptable risk.
2. Achieve and maintain cylinder integrity.
3. Improve conduct of operations.
4. Evaluate and monitor containment integrity.
5. Administer the system.

The objectives are intended to provide the framework for a risk management strategy for long-term storage of UF_6 in cylinders.

The following sections describe these major objectives and provide the rationale for their establishment.

3.4.1 Achieve and Maintain Acceptable Risk

This major objective ensures the program remains focused on a risk management strategy to identify risks, control them, and to further reduce them as feasible. Identified risks associated with the system used to meet the program mission include: (1) radiation exposure, (2) contact with surfaces contaminated with radioactive material, (3) exposure to toxic materials resulting from the release of UF_6 and/or reaction products, (4) standard industrial hazards, and (5) an environmental insult caused by the release of UF_6 and/or reaction products.

DUF_6 contained in cylinders presents a low radiation risk. Dose rates are estimated to be 2 mrem per hour at a distance of 1 foot from cylinders and 0.5 mrem per hour for persons performing general cylinder yard work. The remaining risks associated with the UF_6 Cylinder Program are related to the release of cylinder contents. Therefore, the primary focus of the program is to minimize risk by maintaining the containment integrity of the cylinders.

As stated in the mission, the program strives for safe operations. In order to prepare for, establish, and conduct operations the associated risks to personnel, the public and the environment must be articulated. These risks are a product of the hazards within the system and the probability they will materialize. After the hazards are identified and risks are evaluated, determining the initiating events and consequences, measures are established to lesson the likelihood of occurrence. In addition, mitigative measures are also pursued to minimize consequences. These defensive measures can be

in the form of design, engineering, and/or administrative controls. A graded approach to implementing defensive measures is taken to combat the severity of the risk recognizing design and engineering controls can provide greater assurance for protecting against initiating events and consequences.

3.4.2 Achieve and Maintain Cylinder Integrity

This objective reflects the storage phase of the program and the primary risk associated with this phase. Because the primary event of concern is loss of containment, a major objective to mitigate deterioration and maintain or improve existing integrity is established. Consequences including criticality; personnel, the public, and the environmental exposure to UF_6 and reaction products; contamination; and exposure to elevated level of radiation all have the common failure of loss of containment. This objective also stems from the lack of maintenance of cylinders and storage facilities in past years. This condition presents an elevated systemic risk to the program. Mitigating deterioration of the cylinders, particularly during the storage phase of the program, provides the greatest flexibility in the subsequent dispositioning phase.

3.4.3 Improve Conduct of Operations

Because the hazards within the storage phase are inherently low, the controls within the system to manage risks are primarily administrative controls. This objective addresses the quality assurance of these controls and their effectiveness in sustaining controlled risk. Administrative controls depend on the conduct of operations. Thus, conduct of operations is an integral portion of a safe system. Subsystems that provide accurate training, qualification, and work control including procedures, and procedure adherence comprise the essence of this major objective.

3.4.4 Evaluate and Monitor Containment Integrity of Cylinders

This objective also focuses on the current phase of the program, storage of the UF_6 inventory. This objective defines and maintains a status of conditions and establishes the forecasting information to ensure success of the program mission. This is accomplished by monitoring and evaluating cylinder and storage conditions, in addition to monitoring factors that degrade conditions for the purposes of forecasting. The monitoring of degradation factors establishes a proactive approach to potential system problems with containment integrity.

3.4.5 Administer the System

This objective is responsive to past deficiencies within the program (a lack of applied resources) and to the expected duration of the cylinder storage phase (through 2020). Obtaining and utilizing resources (financial, capital, and intellectual) are necessary to sustain a viable storage system. This objective encompasses the optimization and integration of resources to provide an efficient system, and a system that is responsive to changes in standards, and the development of subsequent system phases (e.g., dispositioning the UF_6).

4. FUNCTIONAL ANALYSIS

4.1 Functional Analysis Process

The functional analysis derives the requirements and applicable standards from the major objectives of the program (Fig. 2). In order to comprehensively determine the requirements for the program, it is necessary to first identify the system functional activities and components within the start-up, routine, shutdown, and off-normal states of operation for the fundamental system roles of surveillance and maintenance, handling and stacking, contents transfer, and off-site transport. The first task of the functional analysis was to define the system. A checklist method was used to define the system. This checklist method used key words to elicit the components and activities within the system at the various operational states. The key words used include: physical equipment, personnel, documents, support functions, and organization interfaces. The next task was to analyze the activities and associated components for each major objective to identify requirements necessary to meet the major objectives. Practicability dictated that the functional analysis process involve not only cylinder program management personnel and technical experts, but also subject matter experts from a broad range of other disciplines. Subject matter experts and their command media resources were relied upon to ascertain the applicability of orders, codes, and standards to the requirements. This methodology, which is depicted in Fig. 3, ensures that program requirements appropriately translate into compliance with existing applicable orders, codes, and standards, and that they ultimately support follow-down into procedures. During the functional analysis process, requirements were categorized to enable discrimination of the rationale and intent of the requirements.

4.2 System Definition

The system established to meet the program mission is the means by which containment is achieved. The system comprises components (such as the UF_6, cylinders, cylinder yards, cylinder-handling equipment, personnel, and financial resources) and activities (such as operations, management processes, and administration).

The system includes several operational functions to maintain the containment integrity of the cylinders. These operational functions are:

- Surveillance and Maintenance,
- Handling and Stacking,
- Contents Transfer, and
- Off-site Transport.

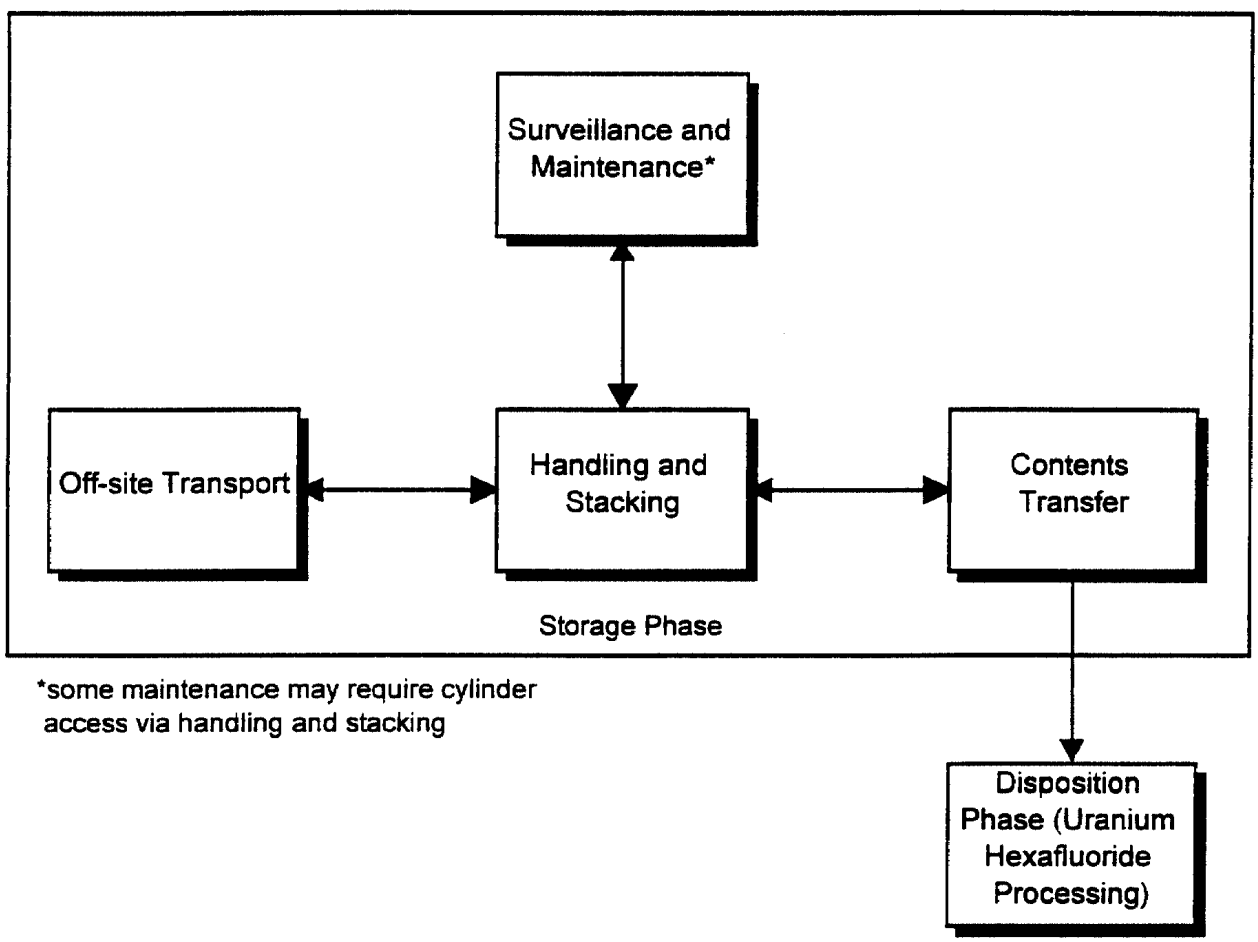

Fig. 3. Functional relationship of operations

The system encompasses facilities, hardware, support systems, and/or subsystems for each of these operational functions. The flow of the operational functions is illustrated in Fig. 4. In addition to the operational functions, the system requires development and administrative support functions such as engineering development to realign and sustain the system effectiveness in meeting the program mission.

The principle physical element of the system is the approximately 47,000 cylinders containing DUF_6. The cylinder population is generally characterized as follows.

1. About 86% are 14-ton cylinders, 9% are 10-ton, 4% are 2½-ton, and 1% are miscellaneous capacities.
2. The 10- and 14-ton cylinders are nominally 48 inches in diameter and range from 10 to 12 feet in length.
3. The 2½-ton cylinders are 30 inches in diameter, about 7 feet in length, have skirts, and have walls that are either ½ or 13/32 inches thick.
4. About 94% of the 10- and 14-ton cylinders are thin walled (5/16-inch wall thickness), and the rest of these cylinders are thick walled (5/8-inch wall thickness).
5. About 20% of the 10- and 14-ton cylinders have skirted ends, and the rest are without skirts.
6. Cylinders were procured on an "as needed" basis during five decades; consequently, vendors, designs, materials, etc., vary.
7. Distribution of the cylinders is as follows: 61% are stored at PGDP, 29% at PORTS, and 10% at the Oak Ridge K-25 Site.
8. The cylinders contain DUF_6 with a ^{235}U assay of less than 0.7%, enriched UF_6 less than 5% ^{235}U, and normal assay (nominally 0.71% ^{235}U) UF_6 .

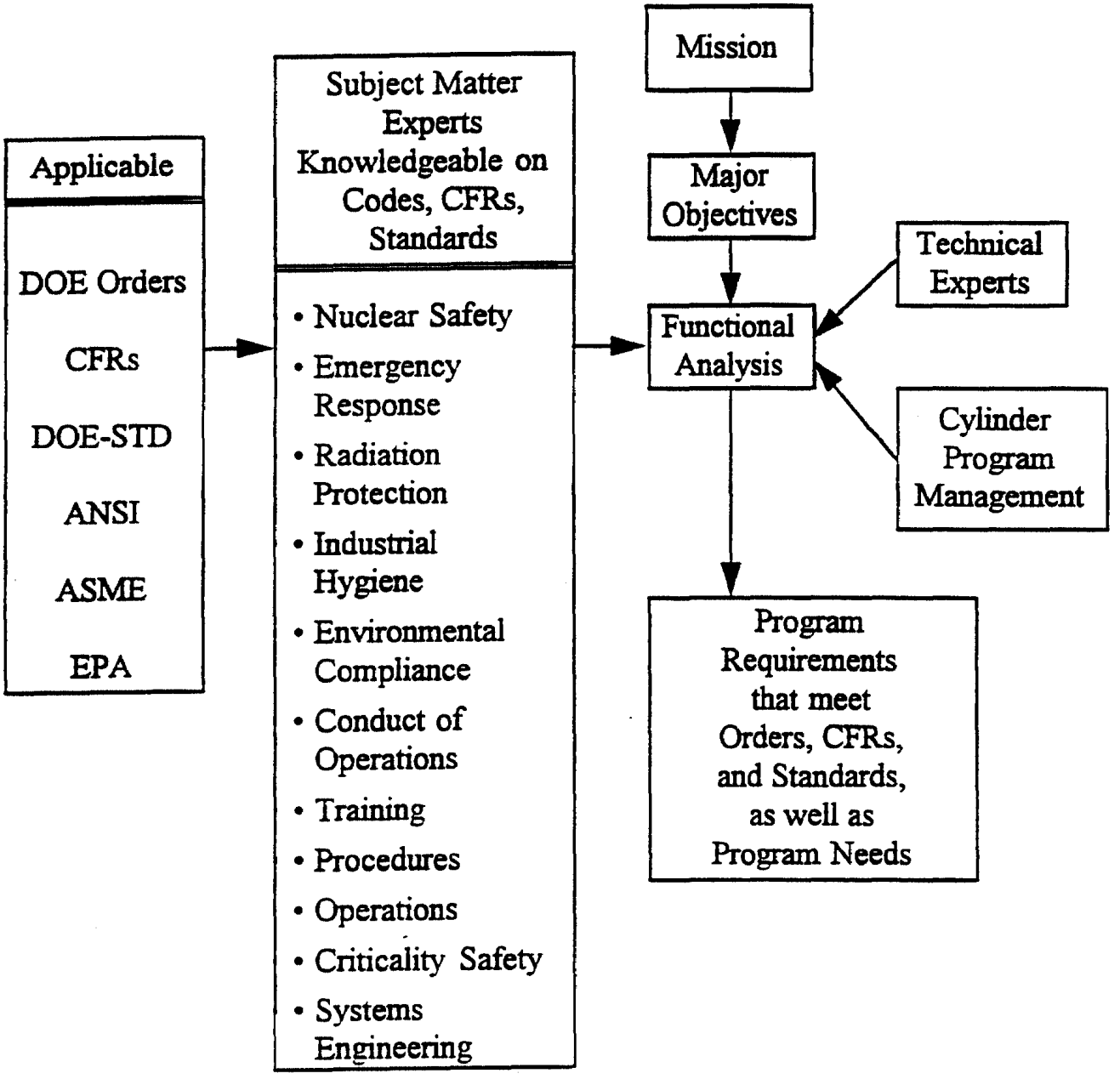

Fig. 4. Relationship of requirements to orders, codes, and standards

Cylinder designs have evolved over the years. Design modifications vary from lifting lug shapes and stiffening ring designs to a change in the reference grade of steel. The cylinder model types and the number of each type that have been in service are shown in Fig. 5.

Manufacturing standards have also changed over the years. Current manufacturing guidelines are contained in ANSI 14.1 and are primarily directed at the original cylinder duty cycle.

Storage yards are another physical element of the system and are constructed of either concrete or compacted gravel. Cylinders are typically double stacked on cylinder yards in straight double rows, and there is a small aisle between some double rows. Some of these aisles are currently wide enough to allow personnel access, but most are not wide enough to allow passage of mobile equipment. In most cases, the cylinder heads face the aisles, to facilitate inspection and inventory control. The bottom cylinders are positioned primarily on wood saddles, and a limited number of concrete saddles are currently in use. The top cylinders are positioned on two bottom row cylinders. Empty cylinders or heel cylinders may be triple stacked in straight rows with a small aisle between each double row. Currently there are two yards at PORTS, ten at PGDP, and five at the K-25 Site. These yards cover a combined surface area of about 3.3 million square feet. The addition and reconstruction of storage yards underway. The designation of current yards for each is as follows:

K-25 Site: K-1066-B, E, J, K, L
Portsmouth Site: X-745-C, E
Paducah Site: C-745-C, D, F, G, K, L, M, N, P, S

An additional physical element of the system is the cylinder handling equipment, which has also evolved over the years. Originally mobile cranes and removable bands were used to stack and unstack cylinders. Current handling equipment includes the cylinder stacker, which is used for stacking and unstacking as well as for transporting cylinders short distances. The "straddle carrier" is used for in-plant transport of cylinders. An additional device used for in-plant transport of cylinders is a specially designed trailer. Although there are slight variations in types of equipment items at the three sites, these are the principal pieces of hardware used to handle UF_6 cylinders.

Further elaboration of the system description is provided in documents that support the SRD such as safety analysis reports, and technical specification documents.

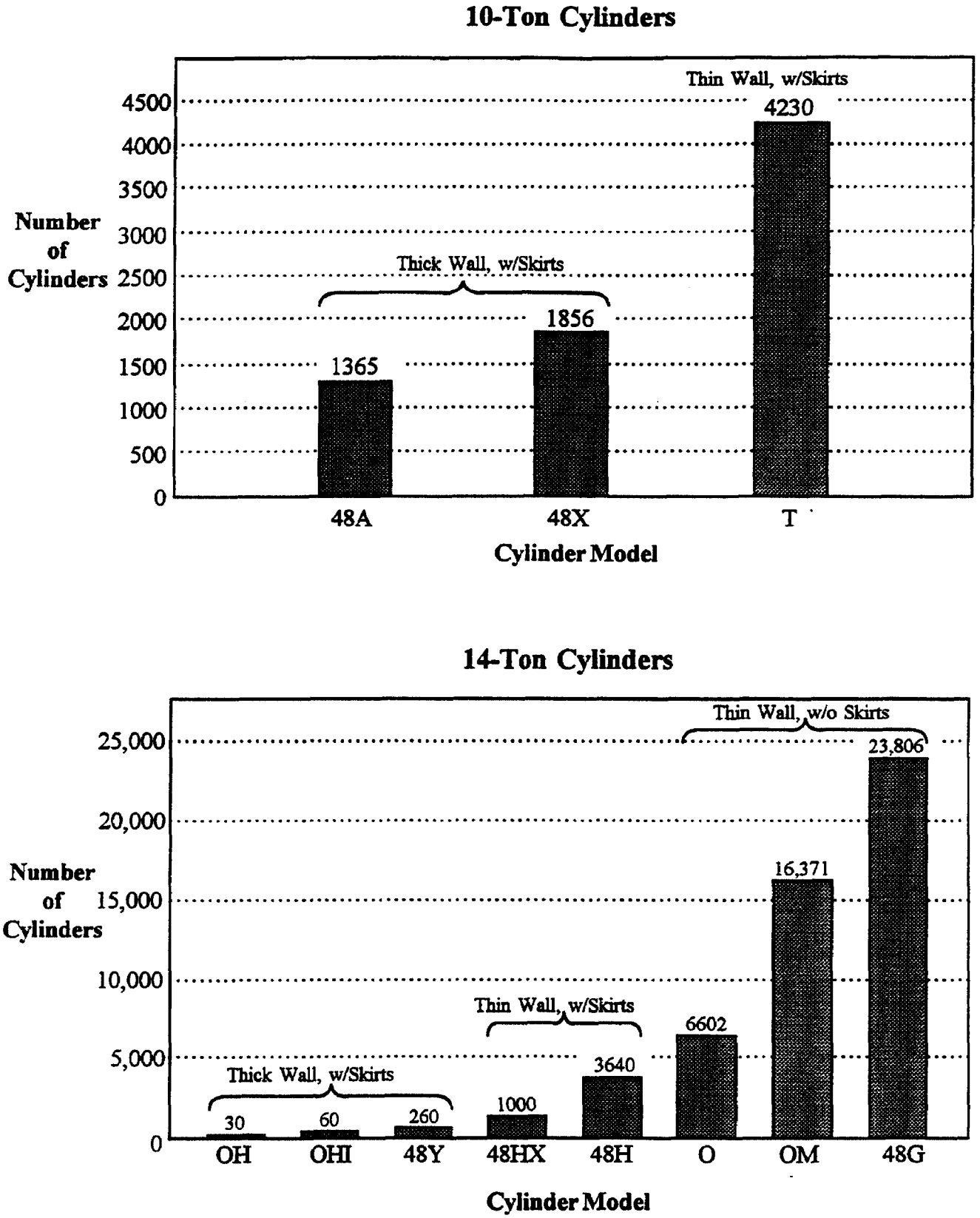

Fig. 5. Number of cylinders containing DUF_6, by model

4.2.1 System Functions

The four operational functions in the storage phase of the program are, as shown in Fig. 3. (1) surveillance and maintenance, (2) handling and stacking, (3) contents transfer, and (4) off-site transport of cylinders. Function 1, surveillance and maintenance, includes system activities to maintain cylinder and storage yard conditions. Function 2, handling and stacking, focuses on the on-site movement of cylinders and associated support activities. Function 3, contents transfer, addresses activities necessary to remove the cylinder contents. Function 4, off-site transport, includes the activities required to ship cylinders among the DOE facilities or to other locations. Functions 1 and 2 are expected to include significant activity for the next 5 to 10 years as substandard conditions are mitigated (e.g., cylinder storage yard reconstruction and cylinder coating maintenance). After this corrective actions period, these two functions are expected to focus on surveillance and maintenance activities, including maintenance of cylinder coating. Functions 3 and 4 are expected to involve a minimal number of cylinders, but these functions are necessary to support the program mission of safe storage and to facilitate the development of the dispositioning phase of the program. The near-term level of activity within these two functions is dependent on the population of cylinders found to be unacceptable and repairable for continued storage. Another impact on the level of activity in Function 4 is the possibility of inventory consolidation from three sites to two or one.

Section 4.2.2 provides a detailed listing of components in each operational function. Section 4.2.3 provides a detailed listing of activities within each operational function.

Adminstrative functions of the the system also consist of components and activities. These adminstrative components support the operational activities needed execute a viable system. The components include physical equipment (computers, informational databases, office space, etc.), personnel (program managers, support personnel, engineers, finance officers, etc.), and documents (business plan, performance metrics, contracts, etc.). Activities are comprised of subsystems or processes such as training and procedural development, configuration control, verfication, and work authorization.

Training and qualification specifications for personnel within the system are provided in Appendix B. These specifications are standardized by DOE Order 5480.20A.

4.2.2 System Components

The system components are categorized as physical equipment, personnel, support organizations, documentation, and organization interfaces and are shown in Lists 1 through 5. The physical equipment and personnel are further categorized by the system functions.

List 1. PHYSICAL EQUIPMENT

Surveillance and Maintenance Function

Blast media

Coating (including paint, thinner, and cleaners)

Communication equipment e.g., radios

Cylinders (including nameplates, stiffening, rings, lifting lugs, skirts and seam welds)

Cylinder coating facility or designated area and associated equipment

Cylinder stand/turning fixture

Cylinder surface preparation equipment

Cylinder valves and plugs

Decontamination equipment

Emergency patch equipment

Information databases (including inspection database)

Inspection, monitoring, and survey equipment

Maintenance equipment for cylinders and storage facilities

Personal protection equipment

Storage facilities (including concrete and gravel yards, saddles, yard lighting, alarms, run-off, catch basins, and fallouts)

Technical assessment equipment, i.e., ultrasonic thickness (UT) apparatus

UF_6 (including depleted, enriched, and normal)

Valve change out equipment

Wastes from coating operations

Yard boundary control signage

Handling and Stacking Function

(in addition to some equipment listed for the surveillance and maintenance function)

Communication equipment (e.g., radios)

Check weight cylinders

Crane (including associated hoisting & rigging (H&R) equipment)

Emergency patch equipment

Empty cylinder handler

Equipment certification devices (load cells, etc.)

Forklift (including cylinder handling attachments)

Full cylinder handler/stacker

Maintenance equipment

Straddle buggy

Trailers and tractors (including trailer saddles)

Contents Transfer Function

(in addition to some equipment listed for the handling and stacking function)

Cylinder decontamination facility and associated equipment

Decontamination wastes

Feed and withdrawal equipment (including associated safety systems)

Heat/pressure differential source

Maintenance Equipment

New cylinders; new valves, and plugs

Pigtails

Test and inspection equipment

Off-Site Transport Function

(in addition to some equipment listed for the handling and stacking function)

HP survey equipment

Overpacks

Rail cars

Trailers and Tractors

TIDs (tamper indicating devices)

Tie-down rigging

Valve covers

List 2. PERSONNEL

Surveillance and Maintenance Function

Chemical operators

Cylinder inspectors

Computer support personnel

Construction contractors

Decontamination operators

Emergency preparedness/response team

Envirn. monitoring technicians

Engineering support personnel

Equipment testing/inspection personnel

Health physics technicians

Health and safety representatives

Industrial hygiene technicians

Lab technicians

Line management/supervisor

Maintenance personnel

Material handlers

Metallurgists

NMC&A personnel

Nondestructive equipment personnel

Painters

Procedure writer

Qualified NBIC inspectors

Quality assurance and evaluation personnel

Records management personnel

Security officers

System safety engineers

Training personnel

Handling and Stacking Function

(in addition to some personnel listed for the surveillance and maintenance function)

Cylinder inspector

Equipment operator

H&R crew

H&R representative

Maintenance personnel

Operator to set saddles

Spotter

Contents Transfer Function

(in addition to some personnel listed for the handling and stacking function)

Maintenance personnel
Operator
Equipment test and inspection personnel

Off-Site Transport Function

(in addition to some personnel listed for the handling and stacking function)

DOT certified transportation "officer"
H&R crew
Health physics technician
Qualified inspector
Transport driver
Transportation safety representative

List 3. SUPPORT ORGANIZATIONS

Analytical Services
Business Management (Finance, etc.)
Chemical Operations
Compliance
Computer Support
Emergency Preparedness
Engineering
Environ. Monitoring
Equipment Test and Inspection
Facility Safety
Health Physics (HP)
Industrial Hygiene (IH)
Maintenance
NMC&A
Nuclear Criticality Safety
Operations
Procurement
Program Management
Quality Assurance
Records Management
Security
Self Assessment
Technical Services
Transportation safety
Uranium Material Handlers
Utilities
Waste Management

List 4. DOCUMENTATION

95-1 Implementation Plan
Bid specifications
Contracts
Design Drawings (yards, saddles, fixtures, cylinders, etc.)
DOT exemptions
Engr. Development Plan
Environmental Mgmt. Records
HP/IH survey reports
Inspection reports
Job performance analyses
Maintenance Records
Management plans
Materials & Transfer Records
Procedures
Program Mgmt. Plan
Recommendation 95-1
Safety basis documentation (risk analyses, hazard assessments, etc.)
Self-assessment reports
Shipping manifests and other DOT paperwork
Sys. Engr. Mgmt Plan
System Requirement Doc.
Technical logs
Technical reports
Technical Report to 95-1
Technical specifications
Training modules
Work Plans

List 5. ORGANIZATION INTERFACES

DOE
External standards bodies
Local, state, other federal agencies
Lockheed Martin Energy Systems
Lockheed Martin Utility Services
Other contracted organizations
Related industry companies
Site Management

4.2.3 System Activities

The activities specific to the program are shown in List 6. The activities are organized by function.

List 6. SYSTEM ACTIVITIES

Surveillance and Maintenance Function

Alarm maintenance
Boundary/access control/posting/maintenance
Coating touch-up
Containment integrity monitoring
Cylinder coating maintenance
Cylinder coating/surface preparation, etc.
Cylinder patching/repair operations
Data entry
Decontamination
Design (yard, saddles, etc.)
Environmental monitoring
Financial accounting
ID plate replacement
Inspections (routine, coating quality evaluation)
Inventory accounting
Inventory modeling
Maintain emergency readiness/response/drills
Monitoring equipment maintenance/certification
Occurrence reporting
Program planning
Radiation/criticality and other hazard surveys
Records management (UCLIM, NMC&A, procedures)
Safety analyses
Security monitoring
Self assessments/audits
Skirt cleaning/coating/drain hole drilling
Technical studies/monitoring/analysis
Thickness data acquisition
Valve replacement and/or decon
Valve/plug replacement
Waste disposal
Worker training
Yard construction/reconstruction
Yard maintenance (sweeping, lighting, mowing)

Handling and Stacking Function

Cylinder inspection
Cylinder lifting, hauling, and stacking
Emergency response/readiness
Equipment maintenance
H&R training
HP survey
NMC&A verification and authorization
Old saddle disposition
Operator training
Saddle placement/moving
UT testing

Contents Transfer Function

Authorization to transfer
Cylinder connections, heating
Cylinder inspection
Cylinder lifting and placement with building crane
Cylinder weighing
Feed and withdrawal preparation
HP monitoring
Investigation activities
Material control verification
Receiving cylinder preparation and connections
Safety systems testing monitoring
Transfer operation

Off-Site Transport Function

Cylinder pressure check
Cylinder shipment
Cylinder weight verification
DOT inspection of transport vehicle
DOT training
External inspection cylinder components and transport equipment
H&R to transport vehicle
HP survey
Installation of TIDs and valve covers
NMC&A verification/authorization
Securing cylinder on transportation vehicle
Stenciling of "radioactive LSA" on cylinder body
Transport authorization/documentation

4.3 Functional Relationships

The relationships between the functions is a key aspect to having a program of safe storage. Examples include: (1) cylinders must be handled and restacked to mitigate substandard storage conditions and reduce surveillance and maintenance risks and (2) it will be necessary to transfer the contents of cylinders found to be non-compliant with functional acceptance criteria and unrefurbishable to acceptable standards, also reducing surveillance and maintenance risks. Transfer of cylinder contents may involve off-site transport. Off-site transport may also be required to pilot or demonstrate the disposition of the DUF_6. Intra-site inventory consolidation, if found to optimize the system, would necessitate off-site transport of a large number of cylinders.

The primary interrelationship of these functions is the cylinder and an integrated set of acceptance criteria for cylinder condition that accommodates all functions. There are expected to be different criteria for each of the four system functions: surveillance and maintenance, handling and stacking, contents transfer, and off-site transport. Existing standards such as ANSI N14.1 and ORO-651 provide detailed criteria for specific functions, respectively off-site transport and liquefaction transfer of contents. ASME Boiler and Pressure Vessel code also provides design, construction, and maintenance standards for cylinders. A significant portion of the cylinder population does not meet the 1/4 inch minimum wall thickness for thin wall cylinders specified in these standards. The relationship between functional criteria will be addressed in the development of an integrated set of cylinder acceptance criteria. These criteria will enable the program to successfully meet its mission for the storage phase, will optimize the use of existing containers with respect to the overall system life cycle, and will optimize ultimate disposition flexibility.

Compliance with these acceptance criteria will necessitate continued maintenance and verification. Cylinders that do not currently meet the acceptance criteria, require other operational functions to initiate precautionary measures, including additional inspections and possible operations. Examples of this scenario include:

- The mass limit on cylinder contents is not a limiting criterion for the surveillance and maintenance function and is not verified within this function; however, safety precautions within the transfer function require that the mass content be verified, because some cylinders are above weight limits for routine heating. Heating overfilled cylinders could result in hydrostatic rupture.
- An internal vacuum is not a limiting criterion for the cylinder handling and stacking function and is not verified within that function. However, off-site transport standards require that the cylinder contents be at or below atmospheric pressure. These criteria are verified within the transport function, and it may be necessary to reduce internal pressure before shipment.

The program will establish maintenance and verification activities within each function to compensate for cylinders that do not meet the functional acceptance criteria. These activities will ensure the risks of processing cylinders from one function to another are sufficiently controlled. [DOE 4330.4B]

The capacity of a function is determined by the rate at which it can perform its intended actions. This rate is also interrelated to other functions. Examples include:

- The capacity to handle and restack cylinders from substandard storage conditions could impact the number of cylinders that meet acceptance vessel criteria in out-years and thus the number of cylinders requiring mitigative actions.
- The capacity to transfer the contents of unacceptable cylinders impacts the duration for which these cylinders have to remain in the surveillance and maintenance function. Risks with prolonged storage of unacceptable cylinders need to be balanced with the capacity to replace or repair these cylinders.

The program will ensure function capacity is made available commensurate with the impact on other functions. Other functional relationships include nuclear materials accountability control, contamination control, information from technical studies, and cylinder history records management. These relationships will be identified and appropriate controls verified and/or implemented to maintain continuity of the system. [*Derived*]

4.4 Functions Crosswalk with Major Objectives

Figure 6 provides an overview of the major objectives' applicability to the system functions. All major objectives are applicable to the entire system; however, this overview identifies the emphasis areas for each major objective. The overview provides the basis for the functional analysis used to determine program requirements.

As shown in Fig. 6, the major objective *Achieve and maintain acceptable risk* applies unilaterally across all system functions. A graded approach, depending on the potential consequences and frequency, is used to evaluate specific risks within each function. The greatest risks are within the cylinder contents transfer function where significant energy (heat to liquefy the contents) is introduced to the system.

Activities to support the major objective *Achieve and maintain cylinder integrity* are not unilaterally applied to all system functions. The greatest level of effort to mitigate deterioration is concentrated in the storage, and handling functions where cylinder operations are continuous. The primary actions associated with successfully meeting this objective include facility improvements, coating maintenance, and valve and plug maintenance. These actions do provide benefit to the transport and transfer functions by reducing risk and increasing program flexibility.

The *Improve conduct of operations* major objective is similar to the first objective, *Achieve and maintain acceptable risks*, and unilaterally applies to all system functions. Improving the conduct of operations from current conditions in all functions is accomplished through structured work control and training processes. The effectiveness of these administrative controls is a key element to successfully meeting the program mission.

Activities necessary to meet the major objective *Evaluate and monitor containment integrity* lie primarily in the surveillance and maintenance function of the system. However, the criteria for which these actions verify acceptable conditions consider all criteria within the system.

The fifth major objective *Administer the system* incorporates the support activities to maintain the operational functions. These support activities including obtaining financial, capital, and intellectual resources, integrating and optimizing these deployment of these resources among all operational functions. System responsiveness to external forces such as changes in regulations, and UF_6 dispositioning constraints is a part of this objective.

Major objective	Operational Function			
	surveillance and maintenance	handling and stacking	contents transfer	off-site transport
Achieve and maintain acceptable risk	<-------unilateral application------->			
Achieve and maintain cylinder integrity	<----emphasis area---->			
Improve conduct of operations	<-------unilateral application------->			
Evaluate and monitor containment integrity	<emphasis area>			
Administer the system	<-------unilateral application------->			

Fig. 6. Applicability of major objectives to system functions

5. REQUIREMENTS TO ACHIEVE MAJOR OBJECTIVES

Requirements for the UF_6 Cylinder Program are expressed as ***system requirements*** and more detailed ***technical requirements***. The system requirements represent a comprehensive list of essential characteristics necessary to successfully meet the program mission and major objectives. Technical requirements are subordinate to system requirements and provide the specificity necessary for safe operation of the system.

The system requirements within this document provide the framework for developing activities necessary to accomplish its mission. The Systems Engineering approach is being applied concurrently with an ongoing program, and many actions are in progress. The SEMP will establish the technical basis for system activities through an analysis of requirements contained herein and others as they are identified.

The requirements in the following section were developed through a functional analysis of the activities and components identified in Section 4. These activities were analyzed in the context of each major objective to determine what requirements needed to be established to accomplish the objective. To bound the development of requirements, the functional analysis considered only those standards that directly affect this program and its ability to meet its mission.

Categories of requirements under each major objective have been established. These categories are shown in Fig. 7. These categories are not requirements of the program. They summarize the rationale for the requirements.

Requirements were reviewed to identify applicable standards and governing documents. These standards are identified in brackets [] after each requirement. Section 2 provides a listing of standards and governing documents for the program. If a requirement does not have an applicable standard or governing document, the standard is considered to be derived within the program.

The following sections relate system requirements to the major objectives described in preceding sections of this document. The motivation for the development of these requirements within major objectives is to respond to the need expressed by the objective and, ultimately, to determine activities necessary to accomplish the objectives. Where necessary, technical requirements have been provided to support the specificity needed to accomplish the intent of the system requirement, major objective, and program mission. The technical requirements are identified by unique alphanumeric characters after the system requirement number.

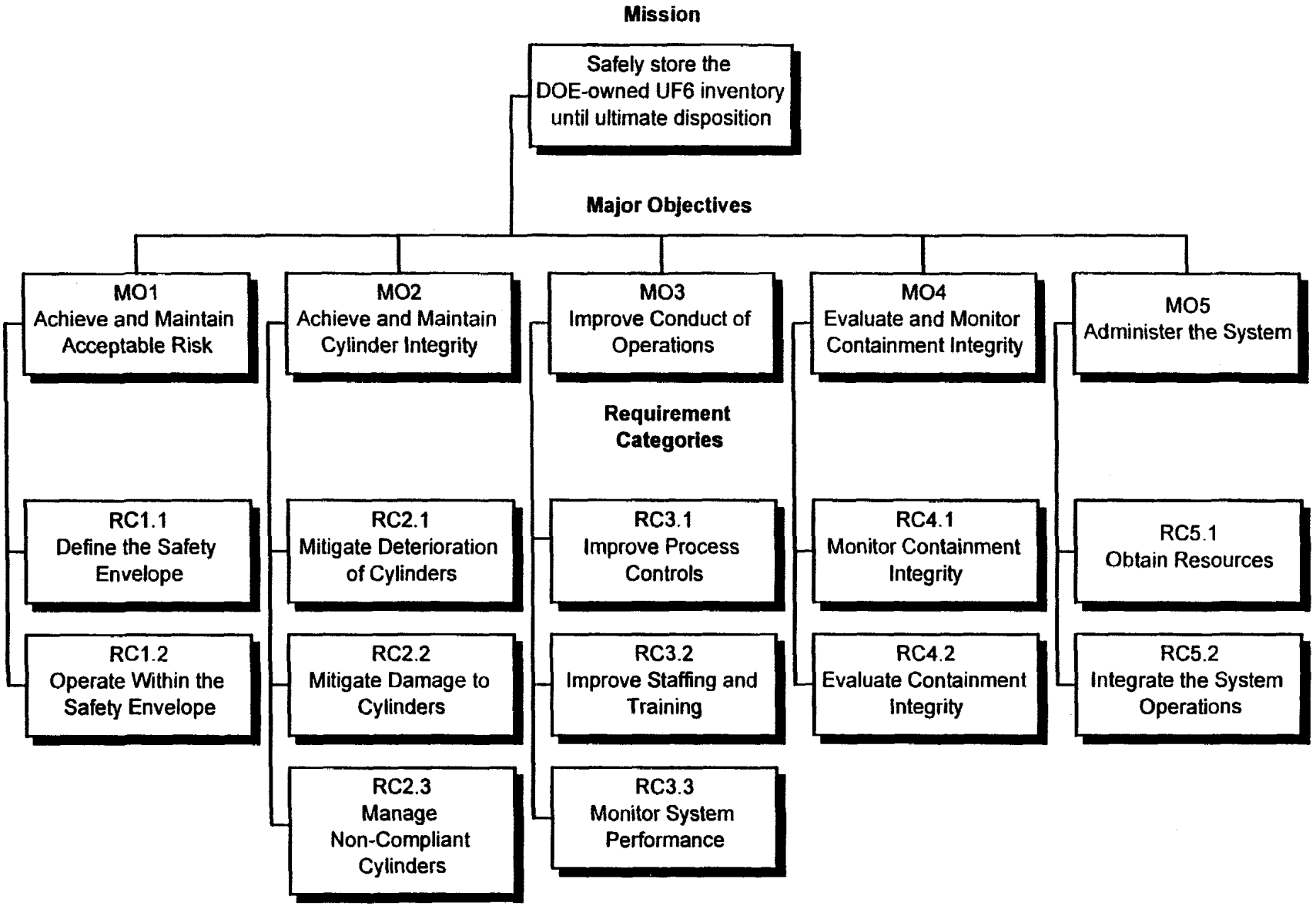

Fig. 7. Categories of requirements associated with major objectives

5.1 Requirements to Achieve and Maintain Acceptable Risk

5.1.1 Define the Safety Envelope

Major Objective (MO) 1, Requirement Category 1: Define the safety envelope for the storage of UF_6 and consider it in all system requirements, procedures, and program elements, that will take into consideration all DOE orders and pertinent laws, including state and federal.

Description and Rationale

In order to ensure a safe storage system, the system has to first be defined in terms of the form, fit and function of components and activities needed to operate. This definition provides a system description that is used to analyze the system for hazards and potential consequences and to integrate the functional flow of activities. The UF_6 Cylinder Program comprises a system currently in operation developed over decades of UF_6 processing. There is limited documentation on the technical basis of components within the system. The intent of first system requirement and subordinate technical requirements is to verify the existence of vital technical basis information for this system and to institute configuration control to maintain this basis for operation throughout the storage phase of the system. The degree to which the system description will be documented is dependent on the hazards and consequences identified for analysis beyond what the current description is capable of providing. An additional reason for developing a more rigorous system description is when integration of the system is found lacking to the degree that the mission and objectives of the program are in jeopardy of being met.

The remaining system and technical requirements within this requirement category focus on identifying, documenting, and maintaining current the hazards, risks, and controls to achieve and maintain acceptable risks. The minimal controls necessary to manage the risks within planned activities must be determined, to successfully maintain a safe program. Actions to identify and evaluate hazards and determine minimal controls define the safety basis for the system. This safety basis is the bounds for safe operation of the necessary system activities and instills a certain safety envelope. The ongoing activities and potential new activities within the system are then managed within the bounds defined by the safety basis. This requirement category defines and documents the hazards and their associated risks and consequences for clear dissemination to the work force and control within the safety basis.

An integral function of the safety basis is to grade the hazards. This hazard grading facilitates clear delineation of which hazards pose the greatest risk and where multiple controls (defense in depth) are necessary and most beneficial. The grading also establishes the basis for prioritizing risk reduction actions.

Requirements and Intent

The following requirements ensure the safety aspects of the system are defined, documented, and maintained.

1.1.1 The program technical configuration shall be defined and documented.

1.1.1a The functional relationships shall be identified to establish continuity of the system. [DOE 5480.19]

1.1.1b Storage history for each cylinder shall be documented and maintained for the service life of the cylinder. [10 CFR 835, DOE 5633.3B]

1.1.1c Functional relationships shall be documented. [DOE 5480.19]

1.1.2 Program hazards shall be identified and documented.

1.1.2a The system hazards shall be identified, evaluated, and documented as part of a complete safety analysis to define the safety envelope. [DOE 5480.23, 5480.22, 5480.24, 5480.7A, 6430.1A]

1.1.2b The hazards documented in the safety basis shall be periodically reviewed and updated to reflect a current definition of hazards within the system. [DOE 5480.21, 5480.23, 6430.1A]

1.1.3 The program risk(s) and required controls shall be documented.

1.1.3a Maintenance and verification activities within each operational function shall be documented. These activities are to compensate for cylinders in the system that do not meet all functional acceptance criteria. These activities ensure the risks of processing cylinders from one function to another are sufficiently controlled. [DOE 4330.4B]

1.1.3b The system risks and minimum controls shall be identified, evaluated, and documented as part of a complete safety analysis to define the safety envelope. [DOE 5480.7A, 5480.22, 5480.23, 5480.24, 6430.1A]

1.1.3c The safety basis shall be periodically reviewed and updated, to reflect a current safety analysis and risks within the system. [DOE 5480.23, 6430.1A]

1.1.3d Appropriate evaluations of compliance with the safety envelope shall be conducted when the safety basis is in question due to changes in procedures, work scope, and/or storage configurations. [DOE 5480.21]

1.1.3e Appropriate reviews and assessments shall be performed to ensure the preparedness of new activities and facilities, and the restart of activities as appropriate. [DOE 5480.31]

1.1.3f The concept of as low as reasonably achievable (ALARA) shall be incorporated in the risk management and reduction efforts within the program. [10 CFR 835, DOE 5400.5, 5480.10, 5480.11, 6430.1A]

5.1.2 Operate within the Safety Envelope

MO 1, Requirement Category 2: Operate within the safety envelope by instituting safety-related controls and monitoring for safety within the system.

Description and Rationale

Facilities and operations must be monitored to determine the presence of hazards and potential initiators. These hazards and initiators are identified in the safety analysis. This monitoring ensures compliance with the safety envelope and identifies where necessary ameliorative actions to maintain compliance with the safety envelope are needed. These ameliorative or corrective actions are prioritized to optimize the reduction of risks within the program.

Necessary controls to maintain acceptable risk within the system are identified through a safety analysis. These controls are invoked through Safety Management Programs at the respective storage sites by contracted personnel. These Safety Management Programs include such aspects as radiation protection, industrial hygiene, and emergency response.

Additional controls are instituted as a result of the uranium in storage being considered a "source material" as defined by the Atomic Energy Act (AEA). This designation requires accountability and security of the inventory. In order to stay within the safety envelope, mass and assay must be maintained. Movement, including off-site transport of cylinders containing accountable inventory, is controlled through an NMC&A program. Security within the facilities is maintained with appropriate perimeter fencing, routine patrols, and storage yard lighting.

Requirements and Intent

The following requirements are established to ensure facilities and operations are monitored for compliance with the safety envelope.

1.2.1 Required risk controls shall be implemented.

1.2.1a An industrial hygiene program shall identify and administer controls to ensure proper management of industrial hazards. [10 CFR 830.120, DOE 5480.19]

1.2.1b Accountability of the inventory shall be managed through a Nuclear Materials Control and Accountability program. This program provides the assay and mass quantities necessary for controlling fissile material relative to criticality concerns. [10 CFR 835, DOE 5633.3B]

1.2.1c Cylinders containing fissile material shall be segregated from non-fissile inventories and spaced in accordance with nuclear criticality control guidelines. [10 CFR 835, DOE 5480.24, 5633.3B]

1.2.1d The security of the UF_6 inventory shall be maintained in accordance with a safeguards and security program. This program specifies and maintains the periodicity of routine patrols and physical boundaries. The program also specifies other security specifications including lighting, as determined necessary. [DOE 5633.3B]

1.2.1e Cylinder storage in ground contact shall be prevented. Temporary placement of cylinders on the ground during relocation and staging operations is acceptable, but should not exceed specified duration. [10 CFR 835]

1.2.1f Contracted organizations shall operate within an established safety envelope. [10 CFR 830.120, DOE 5480.23]

1.2.1g Prioritization of deficiencies shall be used in the optimization of actions taken to reduce risks within the program. [DOE 4330.4B]

1.2.2 Performance shall be monitored and evaluated to identify potential risks within the program.

1.2.2a Facility safety walk-throughs shall be conducted regularly to identify initiators and determine ameliorative actions. [10 CFR 830.120, 10 CFR 835, DOE 5480.19, DOE 5700.6C, ORO-651]

1.2.2b The program shall establish system performance indicators in critical areas to determine the effectiveness of activities. [DOE 4700.1, 5480.26, 5700.6C]

5.2 Requirements to Achieve and Maintain Cylinder Integrity

5.2.1 Mitigate Deterioration of Cylinders

MO 2, Requirement Category 1: Mitigate deterioration of cylinders focuses on the degradation of cylinders from exposure to storage facility conditions.

Description and Rationale

Currently, the UF_6 is stored outdoors, in mild steel containers that are fully exposed to atmospheric conditions. The atmospheric conditions at the present storage facilities maintain a corrosive environment for mild steel, with high relative humidity and an abundance of precipitation. This configuration necessitates the comprehensive management of mild steel exposure to wetness. Mild steel exposure to wetness has ramifications on the overall program mission that warrant significant defense in depth. The primary control for minimizing cylinder time of wetness is proper drainage of the storage facilities and from cylinder bodies. The second level of protection is adequate ventilation and separation from regions with continuous high humidity regions (i.e., proximity to the ground).

The third level of defense is a protective coating to be maintained on cylinder bodies. Maintaining a coating is a new requirement for the existing system. Coating aspects such as toughness and durability need to be integrated with components that physically interface with coating such as

handling equipment and saddles. Establishing compliance with this requirement requires significant resources and time. To compensate for the duration of non-compliance with this requirement, cylinders will be prioritized for coating. This prioritization will include, among operational logistics, the present condition of cylinders and the projected corrosion rate(s).

Other potential initiators of loss containment involve the failure of valve and/or plug. Scenarios of valve/plug failure are specific to the function being imposed on the cylinder (surveillance and maintenance, handling and stacking, contents transfer, and off-site transport). However, generic scenarios involve the failure of the component and the release of UF_6 and reaction products as contamination or potential exposure for the worker and environment. An ingress of moisture to the ullage facilitates further degradation of the valve or plug. Substantial quantities of moisture in the cylinder can establish internal corrosion as a loss of a containment initiator. The interface of dissimilar metals (e.g., bronze alloy valve/plug connected to a mild steel container) can affect the integrity of the steel cylinder. The control of these initiators as determined by the program will be managed through a valve management program.

Requirements and Intent

2.1.1 A barrier between the cylinder mild steel containment surfaces and wetness shall be maintained.

2.1.1a A cylinder maintenance coating program shall be instituted to maintain cylinder coatings throughout the storage phase of the system. [10 CFR 830.120, 10 CFR 835, DOE 4330.4B]

2.1.1b The coating application and maintenance shall be prioritized and scheduled based on the knowledge of the present condition of the cylinder, the forecasted deterioration of wall thickness, and operational logistics with yard refurbishment, cylinder access, and location/density of priority cylinders. [10 CFR 830.120, 10 CFR 835, DOE 4330.4B]

2.1.1c Toughness, durability, and repair qualities shall be criteria in the review and acceptance of coatings and replacement coatings. [DOE 6430.1A]

2.1.2 Water retention on cylinders caused by cylinder structural features shall be minimized.

2.1.2a Skirt region drainage shall be promoted, to minimize corrosion. [10 CFR 830.120, 10 CFR 835, DOE 4330.4B]

2.1.3 Water retention on cylinders caused by cylinder support structures shall be minimized.

2.1.3a Cylinder saddles shall provide ventilation between the cylinder and the load-bearing surface. [10 CFR 830.120, 10 CFR 835, DOE 5480.19]

2.1.3b Cylinder saddles shall facilitate proper drainage from the cylinder and storage facility. [10 CFR 830.120, 10 CFR 835, DOE 5480.19]

2.1.4 Water retention on and adjacent to storage facilities shall be minimized.

2.1.4a Storage facilities shall be designed for the expected life of the storage phase of this program and for the expected operational activities. [10 CFR 830.120, 10 CFR 835, DOE 5480.28, 6430.1A]

2.1.4b Cylinders shall be stored on load-bearing surfaces that, when in use, drain properly (as determined by the program) and rigidly support handling equipment during operations. [10 CFR 830.120, 10 CFR 835]

2.1.4c Cylinders and supporting saddles shall be configured on storage facilities to facilitate proper drainage. [10 CFR 830.120, 10 CFR 835]

2.1.5 Cylinder valve and plug integrity shall be maintained to program standards.

2.1.5a A valve and plug integrity management program shall be established to minimize potential hazards, through monitoring and corrective actions, associated with the presence and failure of these components. [10 CFR 830.120, 10 CFR 835, DOE 4330.4B, ORO-651]

2.1.5b Failed valves and plugs including intermittent leaking shall be detected and corrected. [10 CFR 830.120, 10 CFR 835, DOE 4330.4B, ORO 651]

2.1.5c Valves with missing or damaged parts shall be replaced or the parts replaced to meet functional criteria. [10 CFR 830.120, 10 CFR 835, DOE 4330.4B, ORO-651]

5.2.2 Mitigate Damage to Cylinders

MO 2, Requirement Category 3: Mitigate damage to cylinders from operations.

Description and Rationale

Physical damage to the cylinder from processing can affect the containment integrity in varying degrees. Specific types of damage can be unique concerns to various system functions. The loss of protective coating is a concern to the surveillance and maintenance function, and gouges and dents can be a concern to the surveillance and maintenance function and the contents transfer function. The risk of this damage occurring lies primarily in the handling and stacking function of the program. Much of the potential damage lies in the areas where saddles and handling equipment contact the cylinder. This anticipated contact is managed by the design of the saddles and equipment and by the design and maintenance of the coating. Other, undesirable contact is controlled by configuration design of the storage array and through administrative control in handling procedures. Administrative control is also used as mitigative measure to identify for corrective action any damage that does occur.

To compensate for the cylinders in the system that have already incurred physical damage from processing, maintenance and verification activities will be instituted when processing cylinders between operational functions that have different acceptance criteria. These verification actions will ensure no cylinder is accepted without recognizing constraints due to cylinder condition or condition of the contents. In addition to these maintenance and verification activities, methods for processing

constrained cylinders (such as corroded cylinders and non-coded cylinders) will be established. Processing includes handling and stacking, off-site transport, contents transfer, and maintenance within the surveillance and maintenance function.

Requirements and Intent

To minimize damage to cylinders during the handling and stacking function, the following requirements have been established.

2.2.1 Cylinder containment integrity shall be maintained during handling, processing, and transport operations.

2.2.1a A viable means to transport cylinders off-site that do not meet DOT standards shall be determined for foreseeable shipments. [49 CFR, DOE 5700.6C]

2.2.1b Maintenance and verification activities shall be implemented within each operational function to compensate for cylinders in the system that do not meet the functional acceptance criteria. These activities ensure the risks of processing cylinders from one function to another are sufficiently controlled. [DOE 4330.4B]

2.2.1c Cylinder handling and stacking configurations that minimize potential impacts between cylinders shall be established. [10 CFR 830.120, ORO-651]

2.2.1d Engineering controls to reduce potential cylinder damage using existing equipment during stacking operations shall be evaluated. [29 CFR 1910, DOE HDBK-1090-95]

2.2.1e The design of new handling equipment shall consider additional controls to prevent coating damage on the body of the cylinder and cylinder damage by operator error when lowering cylinders for placement. [ORO-651]

2.2.1f New saddle design shall include the protection of cylinder coating. [DOE 6430.1A]

2.2.1g Operational controls for handling cylinders shall incorporate additional precautionary measures for handling degraded cylinders. [DOE 5480.19]

2.2.1h An NMC&A program shall control, through authorization, the movement and processing of the UF_6 inventory. [10 CFR 835, DOE 5633.3B]

2.2.2 Cylinder handling, processing, and transporting equipment operators shall be proficient.

2.2.2a Operators shall be qualified to verify their proficiency in the use of such equipment. [DOE 5480.20A]

5.2.3 Manage Non-Compliant Cylinders

MO 2 Category 3: Replace or repair unacceptable cylinders.

Description and Rationale

It is expected that, because of past storage practices, some cylinders will not meet the all functional acceptance criteria that are under development. See MO 4 for a discussion of the criterion's development. Cylinders that don't meet these criteria will be replaced or repaired. However, these

unacceptable cylinders are not expected to present an imminent danger to workers, the public, or the environment. The means for managing this population depends on the extent and nature of defiency and the size of the population. Currently, failed cylinders are few and the means to remove them from service is obtained from contracted services. DOE does not possess the ready capacity to replace or repair unacceptable cylinders. Method and capacity for managing unacceptable cylinders will be established in conjunction with determining the unacceptable population and the nature and extent of their deficiency.

The primary criterion for permanent repair of cylinders is compliance with ASME Boiler and Pressure vessel code. Based on discussions with private companies that have repaired boiler and pressure vessels, repairing corroded cylinders is a feasible alternative to cylinder replacement.

Requirements and Intent

2.3.1 ***Replacement cylinders, valves, and plugs shall be designed, manufactured, and procured in accordance with anticipated service life and configuration.*** [ANSI N14.1, DOE 6430.1A, ORO-651]

2.3.2 ***Personnel replacing/repairing cylinders shall be knowledgeable of deteriorated cylinder conditions.*** [10 CFR 830.120, DOE 5480.23]

2.3.2a Operators shall be trained on the risks and hazards of handling UF_6. [10 CFR 830.120, DOE 5480.20A, 5480.23]

2.3.3 ***Non-compliant cylinders shall be repaired or replaced to meet program standards.*** [ORO- 651]

2.3.3a The functional capacity to safely manage non-compliant cylinders shall be established in order to minimize the impact on the surveillance and maintenance function. [*Derived*]

2.3.3b Methods for processing non-compliant cylinders shall be established as necessary. [10 CFR 830.120, 10 CFR 835, DOE 5480.23, 5481.1B]

5.3 Requirements to Improve Conduct of Operations

5.3.1 Improve Process Controls

MO 3, Requirement Category 1: Improve work process controls for accomplishing the intent of operational activities.

Description and Rationale

Process controls within this requirement category focus on work controls from developing work plans and command media to authorizing and monitoring work activities. Work controls are instituted in the system to ensure operational activities comply with standards and meet the intent of the planned operations.

Administrative procedures are the primary controls within the system. Procedures are necessary to perform activities within all operational functions (surveillance and maintenance, handling and stacking, contents transfer, and off-site transfer). The quality of these procedures reflects the program's ability to control risks. Procedure development must consider the intent of the activity, the impact if not accomplished, the knowledge and skill of personnel performing the operation, and any site-specific requirements. The procedure development also considers the effectiveness of the training.

Maintaining this work control necessitates periodical review and update of procedures, work plans, and training modules to incorporate lessons learned, requirement changes, safety bases, and engineering development while maintaining three-site consistency. Monitoring of performance to ensure compliance with command media is an integral part of maintaining adequate work controls.

Requirements and Intent

*3.1.1 **The system configuration (physical components, functions, and documents) shall be controlled through a formal process.***

3.1.1a A configuration management process shall be instituted to control configuration items. [10 CFR 830.120]

*3.1.2 **Work controls, activities, procedures, work plans, and permits shall be developed, authorized, and implemented through a structured process.***

3.1.2a Procedures and work plans shall incorporate all the pertinent information (e.g., safety precautions, emergency response, lessons learned, and site specific requirements). [10 CFR 830.120, 10 CFR 835, DOE 5480.19, 5480.20A, 5480.23, 5633.3B, 5700.6C]

3.1.2b Procedures shall be reviewed and updated, to ensure three-site consistency and elimination of any procedural contradictions to ensure sufficient and uniform risk management within the program. [10 CFR 830.120, 10 CFR 835, DOE 5480.19, 5480.23, 5633.3B]

3.1.2c Any site-specific documentation requirements shall be identified and taken into consideration in the procedure process. [10 CFR 830.120, 10 CFR 835, DOE 5480.19, 5480.23, 5633.3B]

3.1.2d Performance shall be periodically monitored and assessed to determine procedures are being followed. [10 CFR 830.120, DOE 5700.6C]

5.3.2 Improve Staffing and Training

MO 3, Requirement Category 2: Improve staffing and training to ensure operational activities are conducted in a safe manner.

Description and Rationale

In addition to quality procedures the program needs current and effective training to procedures to successfully control initiators and to accomplish the intent of operations. Performing personnel will have the capacity to understand the intent of the operation and the safety aspects and will be able to demonstrate through performance the proper use of procedures. Safety aspects of the operation flow down from the safety basis. Performing personnel are to be generally knowledgeable of the program's safety basis.

To accomplish this category of requirements, a structured personnel selection and training is instituted. This process includes the training organization interfacing with the procedure development process to ensure training modules are current and effective. Personnel knowledgeable of specific procedures intent will periodically review training and the training modules, to ensure the intent is being presented accurately.

To maintain an effective training process, work performance will be monitored. This monitoring will provide the necessary information to verify the retraining frequency and the adequacy of the training course work.

Requirements and Intent

3.2.1 Personnel shall be selected, trained, and developed through a structured process.

3.2.1a Personnel shall be trained to provide understanding of the safety documentation. [10 CFR 830.120, 10 CFR 835, 29 CFR 1910, DOE 5480.19, 5480.18A, 5480.20A, 5480.23, 5700.6C]

3.2.1b Personnel shall be trained and retrained at frequencies determined by the training organization considering the potential consequences of the task, the complexity of the task, and the frequency with which it is performed. [10 CFR 835, 29 CFR 1910.120, DOE 5480.20A, 5480.23]

3.2.1c A database shall be utilized to cross-link training requirements (including training to procedures and training intervals) to training records. The data base shall be used to maintain training records current with procedure revisions. [10 CFR 835,

DOE 5480.20A, 5480.23]

3.2.1d A performance-based methodology shall be used for training. [10 CFR 830.120, DOE 5480.18A, 5480.20A, 5480.23]

3.2.1e Training modules shall incorporate all pertinent information (e.g., safety precautions, hazards, emergency response, lessons learned, and site specific requirements. [10 CFR 830.120, 10 CFR 835, DOE 5480.19, 5480.20A, 5480.23, 5633.3B, 5700.6C]

3.2.1f Performance shall be periodically monitored and assessed to determine the effectiveness of training. [10CFR 830.120, DOE 5700.6C]

5.3.3 Monitor System Performance

MO 3, Requirement Category 3: The performance of activities supporting the program will be periodically monitored and assessed to ensure the expected performance of the activities are being met.

Description and Rationale

The success of the program is supported by quality procedures and training to prepare performing personnel. To accomplish objectives, the actions taken by performing personnel have to complete the desired tasks, be performed in a safe manner, and achieve the intent of operation. Experience has shown actual performance can vary on an individual and crew basis and can evolve away from the intent of operation. This category of requirements ensures activities are performed such that the intent of the operation is being met.

Requirements and Intent

3.3.1 System functions shall be monitored to reinforce expectations for work performance and facility condition.

3.3.1a Conduct of Operation principles shall be applied to functions and operations within the system, to ensure the performance of actions accomplishes the intent. [10 CFR 830.120, DOE 5480.19]

3.3.1b Performance shall be periodically monitored and assessed, to determine that the intent of the operation is being fully met. [10 CFR 830.120, DOE 5700.6C]

5.4 Requirements to Evaluate and Monitor Containment Integrity

5.4.1 Monitor Containment Integrity

MO 4, Requirement Category 1: Containment integrity will be monitored to ensure the status of the condition of cylinders and storage facilities are safe and the surrounding environment not impacted to beyond standards.

Description and Rationale

Cylinders are the integral component in the storage phase of the program. They are used to contain the UF_6 inventory and provide the primary barrier between the UF_6 and worker, public, and the environment. Actions performed on these cylinders are outlined in the system definition discussed in Section 4.2.3. In order to ensure this integral component performs as desired within each function and within subsequent phases of the program (disposition and decommissioning), functional criteria for cylinders are necessary. These functional criteria will establish the minimum integrity necessary to safely perform operations using routine controls.

The cylinders in service were designed to ASME pressure vessel standards. All, except a small population, were manufactured to ASME standards and are code-stamped as such. Other standards related to the in-service use of UF_6 cylinders include ANSI and DOT standards for packaging and transport, and DOE ORO-651, *A Manual of Good Handling Practices for UF_6*. It is expected that, because of past storage practices, an undetermined number of cylinders does not comply with these standards. The primary cause of non-compliance is external corrosion resulting in cylinder wall thicknesses less than minimum standard thicknesses, and code stamped nameplates being displaced from cylinders. Data collected and preliminary analyses to date show these cylinders still have adequate structural integrity for continued storage of the UF_6 in the yards. Additionally, preliminary analyses show that non-compliant cylinder conditions are also safe for other functional operations. Program objectives discussed in Section 3.4 provide the emphasis to mitigate further deterioration of the cylinders and thus control the increase in the non-compliant population of cylinders.

It is the intent of the program to maintain compliance with industry standards applicable to UF_6 containers. This intent preserves the flexibility in the current storage phase and in the subsequent UF_6 dispositioning phase. However, substandard cylinders may be a candidate for near-term corrective action.

This category of requirements defines the standards by which non-conforming and non-compliant cylinders can be identified. An evaluation will be performed to determine minimum safe criteria for each system function. These minimum safe criteria in conjunction with an inspection and evaluation scheme enable the determination of the acceptability of individual cylinders and will provide the basis for an exception case to be presented to the standards organizations. The approved exception case will provide criteria for managing cylinders that do not meet current standards. Additional controls may be needed, to obtain an exception from the standards. Standards within the current phase and subsequent phases may dictate development of actions to upgrade the cylinders to standards.

Approved exceptions to standards, in conjunction with necessary additional controls, will be obtained before cylinders are processed through operational functions governed by industry standards.

Defense in depth principles are applied in the monitoring of containment integrity. The first line of

defense is the monitoring of cylinder degradation factors to predict the cylinder deterioration rates and proactively plan out-year maintenance. These degradation factors are evaluated and monitored on a graded approach. The second line of defense is the monitoring of cylinder degradation and storage yard conditions. These activities provide information to implement near-term preventive and corrective maintenance. Cylinder acceptance criteria and storage facility performance criteria are used in the development of monitoring procedures. The last line of defense is monitoring of cylinder containment and signs of loss of containment to the storage facility and surrounding environment.

This monitoring identifies when remedial actions are necessary. The typical method for monitoring of loss of containment is through radiation surveys. Monitoring of the environment for compliance with release limits is part of the last line of defense. Monitoring containment integrity will be performed through graded method(s) on risk-based periodicity.

Requirements and Intent

The following program requirements are established to monitor containment integrity.

4.1.1 Exposure to the environment shall be monitored.

4.1.1a Environmental monitoring actions within the storage phase shall be balanced with potential environmental remediation in the decommissioning phase. [DOE 5400.1]

4.1.1b Facilities shall be regularly surveyed for radiation and release of UF_6 and reaction products to evaluate program risks. [10 CFR 835, DOE 440.1, 5400.5, 5480.10, 5480.23]

4.1.2 Cylinder condition shall be monitored.

4.1.2a Cylinder functional acceptance criteria shall be defined to ensure safe operations within each system function. [10 CFR 830.120, 10 CFR 835, DOE 5480.23, ORO-651]

4.1.2b The applicability of industry standards, including ANSI 14.1 and the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code to operational functions shall be established. [10 CFR 830.120, 10 CFR 835, 49 CFR 173.420, DOE 5480.23, ORO-651]

4.1.2c Exceptions, as necessary, shall be obtained to maintain adherence with industry standards. [NBIC]

4.1.2d Inspection/evaluation methods for verifying compliance with functional acceptance criteria shall be developed and implemented to identify unsafe cylinders. [10 CFR 830.120, ORO-651, NBIC]

4.1.2e Cylinders shall be inspected on a risk-based periodicity to detect loss of containment. [ACD]

4.1.2f Cylinders shall be properly spaced to facilitate inspection. [10 CFR 835, 10 CFR 830.120, ORO-651]

4.1.3 Factors that affect cylinder condition shall be monitored.

4.1.3a Environmental and other factors affecting cylinder integrity shall be identified and evaluated to determine their effect (e.g., localized corrosion mechanisms that involve crevice, galvanic, packing nut, and hydrogen fluoride–related corrosion; corrosion under channel-type stiffeners and head/skirt region; impact of brittle fracture on cylinder storage). This evaluation determines what factors need to be monitored for proactive management and preventive measures. The rigor of this comprehensive evaluation is based on the degree of effect on the containment integrity. [DOE 5480.23, 5480.28, 6430.1A]

4.1.3b Cylinder degradation factors shall be monitored to collect forecasting and trending data. [10 CFR 830.120, DOE 5480.26]

5.4.2 Evaluate Containment Integrity

MO 4, Requirement Category 2: Evaluate containment integrity to determine cylinder conditions and predict future conditions.

Description and Rationale

The system includes about 50,000 cylinders in various physical conditions. This category of requirements ensures information generated is assimilated for use in guiding program decisions.

To ensure a safe configuration, the cylinder conditions must be known and monitored for adherence to specified standards. This category of requirements establishes the means for determining the condition of the cylinders with respect to acceptance criteria based on the cylinder and degradation monitoring data. The forecasting of cylinder conditions is also a part of this requirement category

Requirements and Intent

The following program requirements ensure cylinder conditions and acceptability are known.

4.2.1 Cylinders shall be categorized to ensure that risks are identified.

4.2.2 Cylinder conditions shall be forecast to direct surveillance and maintenance resources.

4.2.2a Specific information, as determined by the program, shall be tracked to project the current and future conditions of the system. [DOE 4700.1, 5480.26, 5700.6C]

4.2.2b Mechanisms to consolidate information for summary level decision-making determinations shall be developed. [DOE 4700.1, 5480.26, 5700.6C]

5.5 Requirements to Administer the System

5.5.1 Obtain Resources

Description and Rationale

An integral system function is to obtain and deploy adequate resources for achieving the program mission and major objectives. These resources include the financial, capital, and intellectual capabilities to comply with stated operational requirements.

Requirements and Intent

The following system requirements focus on obtaining the necessary resources to operate a safe system.

5.1.1 Financial resources to sustain the system shall be obtained and utilized.

5.1.2 Intellectual resources (operational, technical, financial expertise) to sustain the system shall be secured.

5.5.2 Integrate the System Operations

Description and Rationale

The system must be integrated to operate efficiently and effectively. Effective integration is established through the analysis of interface performance specifications and the traceability of requirements to the operational activities. This traceability must be keep current with evolving standards. The analysis of interface performance specifications is also a component of developing and controlling the system configuration discussed in requirement Category 1.1. To efficiently operate the system the configuration must be optimized. Optimization activities include operational logistics planning, and the identification and incorporation of new technologies and methods to reduce risks, time, and financial needs.

Requirements and Intent

The following system requirements are provided to integrate the system operations.

5.2.1 System and technical requirements shall be traceable from the program mission to implementing documentation.

5.2.2 The system configuration shall be optimized in accordance with life-cycle projections.

5.2.2a Impact on the subsequent program phases shall be considered in changes to the system configuration including modifications to accommodate regulatory changes.[10 CFR 830.120, DOE 5480.19]

5.2.2b The planning for UF_6 dispositioning shall take into consideration the condition of cylinders and compensatory actions to accomplish disposition operations. [10 CFR 830.120]

5.2.2c As part of continuous improvement, other methods for reducing time of wetness and cylinder degradation shall be evaluated. [10 CFR 830.120, 10 CFR 835]

6. NEXT STEPS

The requirements specified herein are used as the basis for identifying necessary program activities or changes in activities necessary to accomplish the program mission. The stated intent and rationale for the requirements have been provided in sufficient detail to ensure the utility of this SRD in comprehensive development of program activities. Activities are developed based on a requirements analysis conducted with participation from operating personnel and subject matter experts. These activities are identified and developed through the decision-making process to be documented in the SEMP and carried out in the EDP and PMP.

LIST OF REFERENCES

1. POEF-2086, ORNL/TM-11988, *Investigation of Breached Depleted UF_6 Cylinders*, E. J. Barber, et al, September 1991.

2. K/ETO-155, ORNL/TM-12840, *Investigation of Breached Depleted UF_6 Cylinders at the K-25 Site*, E. J. Barber, October 1994.

3. K/ETO-114, *UF_6 Long-Term Storage Cylinder Integrity Management Plan*, M. S. Taylor, et al, September 1992.

4. ES/ESH-66, *Safety Management Programs Supporting Nuclear and Hazardous Facilities*, W. R. Williams, August 1995.

5. Letter to L. P. Duffy from P. G. Sewell, *Plans for Ultimate Disposition of Depleted Uranium,* dated February 20, 1992.

APPENDIX A

Regulatory and Guidance Source Documents

Comprising the LMES ES&H Basis

Regulatory & Guidance Source Documents Comprising the LMES ES & H Basis

Document Number	Document Title
INPO 85-001	Performance Objectives and Criteria for Operating and Near Term Operating License Plans
INPO 85-015	Performance Objectives and Criteria for Construction Project Evaluations
INPO 87-030	Performance Objectives and Criteria for Corporate Evaluations
INPO 90-009	Guidelines for the Conduct of Design Engineering
NFPA 10	Portable Fire Extinguishers
NFPA 11	Low Expansion Foam and Combined Agent Systems
NFPA 11A	Medium- and High-Expansion Foam Systems
NFPA 11C	Mobile Foam Apparatus
NFPA 12	Carbon Dioxide Extinguishing Systems
NFPA 13	Installation of Sprinkler Systems
NFPA 14	Installation of Standpipe and Hose Systems
NFPA 15	Water Spray Fixed Systems for Fire Protection
NFPA 16	Deluge Foam-Water Sprinkler Systems and Foam-Water Spray Systems
NFPA 17	Dry Chemical Extinguishing Systems
NFPA 17A	Wet Chemical Extinguishing Systems
NFPA 18	Wetting Agents
NFPA 20	Standard for the Installation of Centrifugal Fire Pumps
NFPA 22	Water Tanks for Private Fire Protection
NFPA 24	Installation of Private Fire Service Mains and Their Appurtenances
NFPA 25	Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems
NFPA 30	Flammable and Combustible Liquids Code
NFPA 31	Installation of Oil-Burning Equipment
NFPA 33	Spray Application Using Flammable and Combustible Materials
NFPA 34	Dipping and Coating Processes Using Flammable or Combustible Liquids
NFPA 37	Installation and Use of Stationary Combustion Engines and Gas Turbines

Regulatory & Guidance Source Documents Comprising the LMES ES & H Basis

Document Number	Document Title
NFPA 40E	Storage of Pyroxylin Plastic
NFPA 43A	Storage of Liquid and Solid Oxidizers
NFPA 43B	Organic Peroxide Formulations, Storage of
NFPA 43C	Storage of Gaseous Oxidizing Materials
NFPA 43D	Storage of Pesticides in Portable Containers
NFPA 45	Fire Protection for Laboratories Using Chemicals
NFPA 50	Bulk Oxygen Systems at Consumer Sites
NFPA 50B	Liquefied Hydrogen Systems at Consumer Sites
NFPA 51	Design and Installation of Oxygen-Fuel Gas Systems for Welding, Cutting, and Allied Processes
NFPA 51B	Fire Prevention In Use of Cutting and Welding Processes
NFPA 52	Compressed Natural Gas (CNG) Vehicular Fuel Systems
NFPA 54	National Fuel Gas Code
NFPA 55	Compressed and Liquefied Gases in Portable Cylinders
NFPA 58	Storage and Handling of Liquefied Petroleum Gases
NFPA 69	Explosion Prevention Systems
NFPA 50A	Gaseous Hydrogen Systems at Consumer Sites
NFPA 70	National Electrical Code
NFPA 70E	Electrical Safety Requirements for Employee Workplaces
NFPA 72	Installation, Maintenance and Use of Protective Signaling Systems
NFPA 75	Protection of Electronic Computer/Data Processing Equipment
NFPA 79	Industrial Machinery
NFPA 80	Fire Doors and Windows
NFPA 82	Incinerators, Waste and Linen Handling Systems and Equipment
NFPA 86	Ovens and Furnaces
NFPA 86C	Industrial Furnaces Using a Special Processing Atmosphere

Regulatory & Guidance Source Documents Comprising the LMES ES & H Basis

Document Number	Document Title
NFPA 86D	Industrial Furnaces Using Vacuum as an Atmosphere
NFPA 88B	Repair Garages
NFPA 90A	Installation of Air Conditioning and Ventilating Systems Systems
NFPA 90B	Warm Air Heating and Air Conditioning Systems
NFPA 91	Exhaust Systems for Air Conveying of Materials
NFPA 96	Installation of Equipment for the Removal of Smoke and Grease-Laden Vapors from Commercial Cooking Equipment
NFPA 101	Code for Safety to Life from Fire in Buildings and Structures
NFPA 102	Assembly Seating, Tents, and Membrane Structures
NFPA 110	Emergency and Standby Power Systems
NFPA 111	Stored Electrical Energy Emergency and Standby Power Systems
NFPA 211	Chimneys, Fireplaces, Vents and Solid Fuel Burning Appliances
NFPA 214	Water Cooling Towers
NFPA 220	Types of Building Construction
NFPA 231	General Storage
NFPA 231C	Rack Storage of Materials
NFPA 232	Protection of Records
NFPA 241	Safeguarding Construction, Alteration, and Demolition Operations
NFPA 295	Wildfire Control
NFPA 306	Control of Gas Hazards on Vessels
NFPA 318	Protection of Cleanrooms
NFPA 321	Basic Classification of Flammable and Combustible Liquids
NFPA 327	Cleaning or Safeguarding Small Tanks and Containers
NFPA 385	Tank Vehicles for Flammable and Combustible Liquids
NFPA 386	Portable Shipping Tanks for Flammable and Combustible Liquids
NFPA 472	Professional Competence of Responders to Hazardous Materials Incidents

Regulatory & Guidance Source Documents Comprising the LMES ES & H Basis

Document Number	Document Title
NFPA 473	Competencies for EMS Personnel Responding to Hazardous Materials Incidents
NFPA 480	Storage, Handling and Processing of Magnesium
NFPA 481	Production, Processing, Handling and Storage of Titanium
NFPA 482	Production, Processing, Handling and Storage of Zirconium
NFPA 490	Storage of Ammonium Nitrate
NFPA 495	Explosive Materials Code
NFPA 496	Purged and Pressurized Enclosures for Electrical Equipment in Hazardous (Classified) Locations
NFPA 505	Powered Industrial Trucks
NFPA 512	Truck Fire Protection
NFPA 600	Industrial Fire Brigades
NFPA 664	Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities
NFPA 703	Fire Retardant Impregnated Wood and Fire Retardant Coatings for Building Materials
NFPA 704	Identification of the Fire Hazards of Materials
NFPA 780	Lightning Protection Code
NFPA 1002	Fire Department Vehicle Driver/Operator Professional Qualifications
NFPA 1021	Fire Officer Professional Qualifications
NFPA 1001	Fire Fighter Professional Qualifications
NFPA 1033	Fire Investigator Professional Qualifications
NFPA 1041	Fire Service Instructor Professional Qualifications
NFPA 1031	Professional Qualifications for Fire Inspector
NFPA 1141	Planned Building Groups
NFPA 1221	Installation, Maintenance and Use of Public Fire Service Communication Systems
NFPA 1403	Live Fire Training Evolutions in Structures
NFPA 1404	Fire Department Self-Contained Breathing Apparatus Program
NFPA 1406	Outside Live Fire Training Evolutions

Regulatory & Guidance Source Documents Comprising the LMES ES & H Basis

Document Number	Document Title
NFPA 1410	Training Standard on Initial Fire Attack
NFPA 1470	Search and Rescue Training for Structural Collapse Incidents
NFPA 1500	Fire Department Occupational Safety and Health
NFPA 1521	Fire Department Safety Officer
NFPA 1561	Fire Department Incident Management System
NFPA 1581	Fire Department Infection Control Program
NFPA 1582	Medical Requirements for Fire Fighters
NFPA 1901	Pumper Fire Apparatus
NFPA 1902	Initial Attack Fire Apparatus
NFPA 1903	Mobile Water Supply Fire Apparatus
NFPA 1904	Aerial Ladder and Elevating Platform Fire Apparatus
NFPA 1911	Service Tests of Pumps on Fire Department Apparatus
NFPA 1914	Testing Fire Department Aerial Devices
NFPA 1921	Fire Department Portable Pumping Units
NFPA 1931	Design of and Design Verification Tests for Fire Department Ground Ladders
NFPA 1932	Use, Maintenance, and Service Testing of Fire Department Ground Ladders
NFPA 1961	Fire Hose
NFPA 1962	Care, Use, and Service Testing of Fire Hose Including Couplings and Nozzles
NFPA 1963	Screw Threads and Gaskets for Fire Hose Connections
NFPA 1964	Spray Nozzles (Shutoff and Tip)
NFPA 1971	Protective Clothing for Structural Fire Fighting
NFPA 1972	Helmets for Structural Fire Fighting
NFPA 1973	Gloves for Structural Fire Fighting
NFPA 1974	Protective Footwear for Structural Fire Fighting
NFPA 1975	Station/Work Uniforms for Fire Fighters

Regulatory & Guidance Source Documents Comprising the LMES ES & H Basis

Document Number	Document Title
NFPA 1981	Open-Circuit Self-Contained Breathing Apparatus for Fire Fighters
NFPA 1982	Personal Alert Safety Systems (PASS) for Fire Fighters
NFPA 1983	Fire Service Life Safety Rope, Harness, and Hardware
NFPA 1991	Vapor-Protective Suits for Hazardous Chemical Emergencies
NFPA 1992	Liquid Splash-Protective Suits for Hazardous Chemical Emergencies
NFPA 1993	Support Function Protective Garments for Hazardous Chemical Operations
NFPA 1999	Protective Clothing for Medical Emergency Operations
NFPA 2001	Clean Agent Fire Extinguishing Systems
NFPA 8501	Single Burner Boiler Operation
NFPA 8503	Pulverized Fuel Systems
NIOSH PUB 86-115	CRITERIA FOR A RECOMMENDED STD. - OCCUP. EXPOSURE TO HOT ENVIRONMENTS
NQA-1	STANDARD QUALITY REQUIREMENT EVALUATION CRITERIA & SAFETY GUIDELINES
DOE-STD-1027-92	Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports
DOE-STD-1032-92	Guide to Good Practices for Operations Organization and Administration
DOE-STD-1073-93	Guide for Operational Configuration Management Programs
DOE/EM/RM/01EM-40MPR	EM-40 MANAGEMENT POLICIES AND REQUIREMENTS
DOE/EM/RM/02EM-40MP	EM-40 MANAGEMENT PLAN
DOE/EP-0108	Standard for Fire Protection of DOE Electronic Computer/Data Processing Systems
DOE/EV-0043	Standard on Fire Protection for Portable Structures
DOE/OR 1006	REQUIREMENTS FOR THE ACCOMPLISHMENT OF CONSTRUCTION PROJECTS UTILIZING A CONSTRUCTION MANAGEMENT CONTRACTOR QUALITY
10 CFR 60	ATOMIC ENERGY ACT 1994
10 CFR 71	Nuclear Regulatory Commission
10 CFR 820	Procedural Rules for DOE Nuclear Activities
10 CFR 830.120	Nuclear Safety Management (Quality Assurance Requirements)

Regulatory & Guidance Source Documents
Comprising the LMES ES & H Basis

Document Number	Document Title
10 CFR 835	Occupational Radiation Protection
10 CFR 1021	NEPA - Implementating Procedures and Guidelines - Final Rule
10 CFR 1022	Compliancy with Floodplain/Wetlands Environmental Review Requirements
18 CFR 1312	ARCHAEOLOGICAL RESOURCES PROTECTION ACT
29 CFR	Occupational Safety and Health Standards
29 CFR 1910	Occupational Safety and Health Standards
29 CFR 1910.95	Occupational Noise Exposure
29 CFR 1910.119	Process Safety Management of Highly Hazardous Chemicals
29 CFR 1910.120	Hazardous Waste Operations and Emergency Response
29 CFR 1910.141	Sanitation
29 CFR 1910.146	Permit-Required Confined Spaces
29 CFR 1910.1001	Asbestos, Tremolite, Anthophyllite, and Actiorolite
29 CFR 1910.1030	Occupational Exposure To Bloodborne Pathegens
29 CFR 1910.1200	Hazard Communication
29 CFR 1910.1450	Occupational Exposure To Hazardous Chemicals in Laboratories
29 CFR 1926	Occupational Safety and Health for Construction Work
29 CFR Subpart C	General Safety and Health Provisions
33 CFR 153	CLEAN WATER ACT
33 CFR 154	CLEAN WATER ACT
32 CFR 229	Archaeological Resources Protection Act
33 CFR 321	THE RIVER AND HARBOR ACT
33 CFR 322	CLEAN WATER ACT
33 CFR 323	Navigation and Navigable Waters
33 CFR 328	Definition of Water Regulations
33 CFR 329	Definition of Navigable Waters Regulations

Regulatory & Guidance Source Documents Comprising the LMES ES & H Basis

Document Number	Document Title
33 CFR 330	CLEAN WATER ACT
36 CFR	Federal Records; General
36 CFR 60	National Register of Historic Places
36 CFR 63	NATIONAL HISTORIC PRESERVATION ACT
36 CFR 65	NATIONAL HISTORIC PRESERVATION ACT
36 CFR 68	NATIONAL HISTORIC PRESERVATION ACT
36 CFR 78	NATIONAL HISTORIC PRESERVATION ACT
36 CFR 296	ARCHAEOLOGICAL RESOURCES PROTECTION ACT
36 CFR 800	Parks, Forests, and Public Property
40 CFR 11	National Resource Damage Assessments
40 CFR 50	CLEAN AIR ACT
40 CFR 53	Ambient Air Monitoring
40 CFR 58	CLEAN AIR ACT
40 CFR 60	Clean Air Act (Standards of Performance for New Stationary Sources)
40 CFR 61	CLEAN AIR ACT
40 CFR 68	Chemical Accident Prevention
40 CFR 69	Special Exemptions
40 CFR 72	Permits Regulations
40 CFR 82	Stratospheric Ozone Protection
40 CFR 109	Oil Removal Contingency Plans
40 CFR 110	CLEAN WATER ACT
40 CFR 112	CLEAN WATER ACT
40 CFR 116	Designation of Hazardous Substances
40 CFR 122	CLEAN WATER ACT
40 CFR 130	Requirements for Water Quality Plan and Management

Regulatory & Guidance Source Documents
Comprising the LMES ES & H Basis

Document Number	Document Title
40 CFR 133	Regulation on Secondary Treatment
40 CFR 141	SAFE DRINKING WATER ACT
40 CFR 142	SAFE DRINKING WATER ACT
40 CFR 143	SAFE DRINKING WATER ACT
40 CFR 144	SAFE DRINKING WATER ACT
40 CFR 146	SAFE DRINKING WATER ACT
40 CFR 147	State Underground Injection Program
40 CFR 148	SAFE DRINKING WATER ACT
40 CFR 165	FEDERAL INSECTICIDE, FUNGICIDE, AND RODENTICIDE ACT
40 CFR 171	FEDERAL INSECTICIDE, FUNGICIDE, AND RODENTICIDE ACT
40 CFR 191	ATOMIC ENERGY ACT
40 CFR 230	CLEAN WATER ACT
40 CFR 231	Clean Water Act
40 CFR 232	Activities Exempt from Dredge and Fill Permit
40 CFR 241	RESOURCE CONSERVATION AND RECOVERY ACT
40 CFR 243	RESOURCE CONSERVATION AND RECOVERY ACT
40 CFR 245	RESOURCE CONSERVATION AND RECOVERY ACT
40 CFR 246	RESOURCE CONSERVATION AND RECOVERY ACT
40 CFR 260	RESOURCE CONSERVATION AND RECOVERY ACT
40 CFR 261	RESOURCE CONSERVATION AND RECOVERY ACT
40 CFR 262	RESOURCE CONSERVATION AND RECOVERY ACT
40 CFR 263	RESOURCE CONSERVATION AND RECOVERY ACT
40 CFR 264	RESOURCE CONSERVATION AND RECOVERY ACT
40 CFR 265	RESOURCE CONSERVATION AND RECOVERY ACT
4O CFR 266	RESOURCE CONSERVATION AND RECOVERY ACT

Regulatory & Guidance Source Documents
Comprising the LMES ES & H Basis

Document Number	Document Title
40 CFR 266	RESOURCE CONSERVATION AND RECOVERY ACT
40 CFR 267	RESOURCE CONSERVATION AND RECOVERY ACT
40 CFR 268	RESOURCE CONSERVATION AND RECOVERY ACT
40 CFR 270	RESOURCE CONSERVATION AND RECOVERY ACT
40 CFR 280	TECHNICAL STANDARDS & CORRECTING ACTION PROCEDURES FOR THE ANALYSIS OF POLLUTANTS
40 CFR 300	COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, & LIABILITY ACT
40 CFR 302	COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, & LIABILITY ACT
40 CFR 370	EMERGENCY PLANNING & COMMUNITY RIGHT-TO-KNOW ACT
40 CFR 372	EMERGENCY PLANNING & COMMUNITY RIGHT-TO-KNOW ACT
40 CFR 403	Clean Water Act (General Pretreatment Regulations for Existing and New Sources of Pollution)
40 CFR 761	TOXIC SUBSTANCES CONTROL ACT
40 CFR 1500	NATIONAL ENVORNMENTAL POLICY ACT
40 CFR 1501	NATIONAL ENVORNMENTAL POLICY ACT
40 CFR 1502	NATIONAL ENVORNMENTAL POLICY ACT
40 CFR 1503	NATIONAL ENVORNMENTAL POLICY ACT
40 CFR 1504	NATIONAL ENVORNMENTAL POLICY ACT
40 CFR 1505	NATIONAL ENVORNMENTAL POLICY ACT
40 CFR 1506	NATIONAL ENVORNMENTAL POLICY ACT
40 CFR 1507	NATIONAL ENVORNMENTAL POLICY ACT
41 CFR	Federal Information Resources Management Regulation
43 CFR 3	NATIONAL HISTORIC PRESERVATION ACT
43 CFR 7	ARCHAEOLOGICAL RESOURCES PROTECTION ACT
49 CFR	Federal Motor Carrier Safety Regulations
49 CFR 107	Hazardous Materials Regulations
49 CFR 171	HAZARDOUS MATERIALS TRANSPORTATION ACT

Regulatory & Guidance Source Documents
Comprising the LMES ES & H Basis

Document Number	Document Title
49 CFR 172	HAZARDOUS MATERIALS TRANSPORTATION ACT
49 CFR 173	HAZARDOUS MATERIALS TRANSPORTATION ACT
49 CFR 174	HAZARDOUS MATERIALS TRANSPORTATION ACT
49 CFR 177	HAZARDOUS MATERIALS TRANSPORTATION ACT
49 CFR 178	HAZARDOUS MATERIALS TRANSPORTATION ACT
49 CFR 180	HAZARDOUS MATERIALS TRANSPORTATION ACT
50 CFR 17	ENDANGERED SPECIES ACT
50 CFR 222	ENDANGERED SPECIES ACT
50 CFR 225	ENDANGERED SPECIES ACT
50 CFR 226	ENDANGERED SPECIES ACT
50 CFR 227	ENDANGERED SPECIES ACT
401 KAR 30	KENTUCKY WASTE MANAGEMENT ACT
401 KAR 31	KENTUCKY WASTE MANAGEMENT ACT
401 KAR 32	KENTUCKY WASTE MANAGEMENT ACT
401 KAR 33	KENTUCKY WASTE MANAGEMENT ACT
401 KAR 34	KENTUCKY WASTE MANAGEMENT ACT
401 KAR 35	KENTUCKY WASTE MANAGEMENT ACT
401 KAR 36	KENTUCKY WASTE MANAGEMENT ACT
401 KAR 37	KENTUCKY WASTE MANAGEMENT ACT
401 KAR 38	KENTUCKY WASTE MANAGEMENT ACT
401 KAR 39	KENTUCKY WASTE MANAGEMENT ACT
401 KAR 40	KENTUCKY WASTE MANAGEMENT ACT
401 KAR 42	KENTUCKY UNDERGROUND STORAGE TANK ACT
401 KAR 47 & 48	KENTUCKY WASTE MANAGEMENT ACT
401 KAR 49	KENTUCKY WASTE MANAGEMENT ACT

Regulatory & Guidance Source Documents
Comprising the LMES ES & H Basis

Document Number	Document Title
401 KAR 5.010	KENTUCKY WATER POLLUTION CONTROL ACT
401 KAR 5.005	KENTUCKY WATER POLLUTION CONTROL ACT
401 KAR 5.015	KENTUCKY WATER POLLUTION CONTROL ACT
401 KAR 5.026	KENTUCKY WATER POLLUTION CONTROL ACT
401 KAR 5.029	KENTUCKY WATER POLLUTION CONTROL ACT
401 KAR 5.031	KENTUCKY WATER POLLUTION CONTROL ACT
401 KAR 5.045	KENTUCKY WATER POLLUTION CONTROL ACT
401 KAR 5.050	KENTUCKY WATER POLLUTION CONTROL ACT
401 KAR 5.055	KENTUCKY WATER POLLUTION CONTROL ACT
401 KAR 5.060	KENTUCKY WATER POLLUTION CONTROL ACT
401 KAR 5.065	KENTUCKY WATER POLLUTION CONTROL ACT
401 KAR 5.070	KENTUCKY WATER POLLUTION CONTROL ACT
401 KAR 5.075	KENTUCKY WATER POLLUTION CONTROL ACT
401 KAR 5.080	KENTUCKY WATER POLLUTION CONTROL ACT
401 KAR 5.090	KENTUCKY WATER POLLUTION CONTROL ACT
401 KAR 8.020	KENTUCKY WATER POLLUTION CONTROL ACT
401 KAR 8.030	KENTUCKY WATER POLLUTION CONTROL ACT
401 KAR 8.040	KENTUCKY WATER POLLUTION CONTROL ACT
401 KAR 8.050	KENTUCKY WATER POLLUTION CONTROL ACT
401 KAR 8.060	KENTUCKY WATER POLLUTION CONTROL ACT
401 KAR 8.070	KENTUCKY WATER POLLUTION CONTROL ACT
401 KAR 8.100	KENTUCKY WATER POLLUTION CONTROL ACT
401 KAR 8.150	KENTUCKY WATER POLLUTION CONTROL ACT
401 KAR 8.200	KENTUCKY WATER POLLUTION CONTROL ACT
401 KAR 8.250	KENTUCKY WATER POLLUTION CONTROL ACT

Regulatory & Guidance Source Documents Comprising the LMES ES & H Basis

Document Number	Document Title
401 KAR 8.300	KENTUCKY WATER POLLUTION CONTROL ACT
401 KAR 8.350	KENTUCKY WATER POLLUTION CONTROL ACT
401 KAR 8.400	KENTUCKY WATER POLLUTION CONTROL ACT
401 KAR 8.420	KENTUCKY WATER POLLUTION CONTROL ACT
401 KAR 8.440	KENTUCKY WATER POLLUTION CONTROL ACT
401 KAR 8.500	KENTUCKY WATER POLLUTION CONTROL ACT
401 KAR 8.550	KENTUCKY WATER POLLUTION CONTROL ACT
401 KAR 8.560	KENTUCKY WATER POLLUTION CONTROL ACT
401 KAR 50	KENTUCKY AIR POLLUTION CONTROL ACT
401 KAR 51	KENTUCKY AIR POLLUTION CONTROL ACT
401 KAR 53	KENTUCKY AIR POLLUTION CONTROL ACT
401 KAR 55	KENTUCKY AIR POLLUTION CONTROL ACT
401 KAR 57	KENTUCKY AIR POLLUTION CONTROL ACT
401 KAR 59	KENTUCKY AIR POLLUTION CONTROL ACT
401 KAR 61	KENTUCKY AIR POLLUTION CONTROL ACT
401 KAR 63	KENTUCKY AIR POLLUTION CONTROL ACT
5 USC	Freedom of Information Act
44 USC	Disposal of Records
CHAPTER 1200-1-7.01	TENNESSEE SOLID WASTE DISPOSAL ACT
CHAPTER 1200-1-7.02	TENNESSEE SOLID WASTE DISPOSAL ACT
CHAPTER 1200-1-7.03	TENNESSEE SOLID WASTE DISPOSAL ACT
CHAPTER 1200-1-7.04	TENNESSEE SOLID WASTE DISPOSAL ACT
CHAPTER 1200-1-7.07	TENNESSEE SOLID WASTE DISPOSAL ACT
CHAPTER 1200-1-11.01	TENNESSEE SOLID WASTE DISPOSAL ACT
CHAPTER 1200-1-11.02	TENNESSEE SOLID WASTE DISPOSAL ACT

Regulatory & Guidance Source Documents Comprising the LMES ES & H Basis

Document Number	Document Title
CHAPTER 1200-1-11.03	TENNESSEE SOLID WASTE DISPOSAL ACT
CHAPTER 1200-1-11.04	TENNESSEE SOLID WASTE DISPOSAL ACT
CHAPTER 1200-1-11.05	TENNESSEE SOLID WASTE DISPOSAL ACT
CHAPTER 1200-1-11.06	TENNESSEE SOLID WASTE DISPOSAL ACT
CHAPTER 1200-1-11.07	TENNESSEE SOLID WASTE DISPOSAL ACT
CHAPTER 1200-1-11.08	TENNESSEE SOLID WASTE DISPOSAL ACT
CHAPTER 1200-1-11.09	TENNESSEE SOLID WASTE DISPOSAL ACT
CHAPTER 1200-1-11.10	TENNESSEE SOLID WASTE DISPOSAL ACT
CHAPTER 1200-1-13.01	TENNESSEE HAZARDOUS WASTE MANAGEMENT ACT
CHAPTER 1200-1-13.02	TENNESSEE HAZARDOUS WASTE MANAGEMENT ACT
CHAPTER 1200-1-13.04	TENNESSEE HAZARDOUS WASTE MANAGEMENT ACT
CHAPTER 1200-1-15.01	TENNESSEE PETROLEUM UNDERGROUND STORAGE TANK ACT
CHAPTER 1200-1-15.02	TENNESSEE PETROLEUM UNDERGROUND STORAGE TANK ACT
CHAPTER 1200-1-15.03	TENNESSEE PETROLEUM UNDERGROUND STORAGE TANK ACT
CHAPTER 1200-1-15.04	TENNESSEE PETROLEUM UNDERGROUND STORAGE TANK ACT
CHAPTER 1200-1-15.05	TENNESSEE PETROLEUM UNDERGROUND STORAGE TANK ACT
CHAPTER 1200-1-15.06	TENNESSEE PETROLEUM UNDERGROUND STORAGE TANK ACT
CHAPTER 1200-1-15.07	TENNESSEE PETROLEUM UNDERGROUND STORAGE TANK ACT
CHAPTER 1200-1-15.08	TENNESSEE PETROLEUM UNDERGROUND STORAGE TANK ACT
CHAPTER 1200-1-15.09	TENNESSEE PETROLEUM UNDERGROUND STORAGE TANK ACT
CHAPTER 1200-1-15.10	TENNESSEE PETROLEUM UNDERGROUND STORAGE TANK ACT
CHAPTER 1200-1-15.11	TENNESSEE PETROLEUM UNDERGROUND STORAGE TANK ACT
CHAPTER 1200-3-3	TENNESSEE AIR QUALITY ACT
CHAPTER 1200-3-4	TENNESSEE AIR QUALITY ACT
CHAPTER 1200-3-5	TENNESSEE AIR QUALITY ACT

Regulatory & Guidance Source Documents Comprising the LMES ES & H Basis

Document Number	Document Title
CHAPTER 1200-3-7	TENNESSEE AIR QUALITY ACT
CHAPTER 1200-3-8	TENNESSEE AIR QUALITY ACT
CHAPTER 1200-3-9	TENNESSEE AIR QUALITY ACT
CHAPTER 1200-3-10	TENNESSEE AIR QUALITY ACT
CHAPTER 1200-3-11	TENNESSEE AIR QUALITY ACT
CHAPTER 1200-3-12	TENNESSEE AIR QUALITY ACT
CHAPTER 1200-3-14	TENNESSEE AIR QUALITY ACT
CHAPTER 1200-3-15	TENNESSEE AIR QUALITY ACT
CHAPTER 1200-3-16	TENNESSEE AIR QUALITY ACT
CHAPTER 1200-3-18	TENNESSEE AIR QUALITY ACT
CHAPTER 1200-3-20	TENNESSEE AIR QUALITY ACT
CHAPTER 1200-3-24	TENNESSEE AIR QUALITY ACT
CHAPTER 1200-3-26	TENNESSEE AIR QUALITY ACT
CHAPTER 1200-4-2	TENNESSEE WATER QUALITY CONTROL ACT
CHAPTER 1200-4-3	TENNESSEE WATER QUALITY CONTROL ACT
CHAPTER 1200-4-5	TENNESSEE WATER QUALITY CONTROL ACT
CHAPTER 1200-4-6	TENNESSEE WATER QUALITY CONTROL ACT
CHAPTER 1200-4-10	TENNESSEE WATER QUALITY CONTROL ACT
CHAPTER 1200-5-1	TENNESSEE DRINKING WATER ACT
EO 11990	Protection of Wetlands
EO 12088	Federal Compliance with Pollution Standards
EO 12777	Implementation of Section 311 of Clean Water Act
EO 12843	Procurement of Ozone Depleting Substance
EO 12856	Federal Compliance with Right-to-Know and Pollution Prevention Requirements
EO 12873	Federal Requisition, Recycling and Waste Prevention

Regulatory & Guidance Source Documents
Comprising the LMES ES & H Basis

Document Number	Document Title
EO 12898	Environmental Justice
EO 12915	Federal Implementation of the North American Agreement on Environmental Cooperation
EO 11514	FEDERAL AGENCY RECYCLING AND THE COUNCIL ON FEDERAL RECYCLING & PROCUREMENT & POLICY
EO 11593	FEDERAL AGENCY RECYCLING AND THE COUNCIL ON FEDERAL RECYCLING & PROCUREMENT & POLICY
EO 11988	FEDERAL AGENCY RECYCLING AND THE COUNCIL ON FEDERAL RECYCLING & PROCUREMENT & POLICY
EXEC ORDER 11990	FEDERAL AGENCY RECYCLING AND THE COUNCIL ON FEDERAL RECYCLING & PROCUREMENT & POLICY
EXEC ORDER 12088	FEDERAL AGENCY RECYCLING AND THE COUNCIL ON FEDERAL RECYCLING & PROCUREMENT & POLICY
EO 12580	FEDERAL AGENCY RECYCLING AND THE COUNCIL ON FEDERAL RECYCLING & PROCUREMENT & POLICY
EXEC ORDER 12777	FEDERAL AGENCY RECYCLING AND THE COUNCIL ON FEDERAL RECYCLING & PROCUREMENT & POLICY
EO 12780	FEDERAL AGENCY RECYCLING AND THE COUNCIL ON FEDERAL RECYCLING & PROCUREMENT & POLICY
EXEC ORDER 12843	FEDERAL AGENCY RECYCLING AND THE COUNCIL ON FEDERAL RECYCLING & PROCUREMENT & POLICY
EXEC ORDER 12856	FEDERAL AGENCY RECYCLING AND THE COUNCIL ON FEDERAL RECYCLING & PROCUREMENT & POLICY
Fed. Facility Agmt.	Federal Facility Agreement
FFCA/TCLP	Federal Facility Compliance Agreement/Toxicity Procedure Addressing Waste Characterization
OAC 1301:7-9	OHIO UNDERGROUND STORAGE TANK LAW
OAC 1501:15	OHIO WATER POLLUTION CONTROL ACT
OAC 3745-1	OHIO WATER POLLUTION CONTROL ACT
OAC 3745-3	OHIO WATER POLLUTION CONTROL ACT
OAC 3745-15	OHIO AIR POLLUTION CONTROL ACT
OAC 3745-16	OHIO AIR POLLUTION CONTROL ACT
OAC 3745-17	OHIO AIR POLLUTION CONTROL ACT
OAC 3745-18	OHIO AIR POLLUTION CONTROL ACT
OAC 3745-19	OHIO AIR POLLUTION CONTROL ACT
OAC 3745-21	OHIO AIR POLLUTION CONTROL ACT
OAC 3745-23	OHIO AIR POLLUTION CONTROL ACT

Regulatory & Guidance Source Documents Comprising the LMES ES & H Basis

Document Number	Document Title
OAC 3745-25	OHIO AIR POLLUTION CONTROL ACT
OAC 3745-27	OHIO SOLID & HAZARDOUS WASTE DISPOSAL LAW
OAC 3745:28-37	OHIO SOLID & HAZARDOUS WASTE DISPOSAL LAW
OAC 3745-29	OHIO SOLID AND HAZARDOUS WASTE DISPOSAL LAW
OAC 3745-30	OHIO SOLID AND HAZARDOUS WASTE DISPOSAL LAW
OAC 3745-33	OHIO WATER POLLUTION CONTROL ACT
OAC 3745-34	OHIO SAFE DRINKING WATER ACT
OAC 3745-35	OHIO AIR POLLUTION CONTROL ACT
OAC 3745-36	OHIO SOLID AND HAZARDOUS WASTE DISPOSAL LAW
OAC 3745-45	OHIO AIR POLLUTION CONTROL ACT
OAC 3745-49	OHIO AIR POLLUTION CONTROL ACT
OAC 3745-50	OHIO SOLID & HAZARDOUS WASTE DISPOSAL LAW
OAC 3745-51	OHIO AIR POLLUTION CONTROL ACT
OAC 3745-52	OHIO AIR POLLUTION CONTROL ACT
OAC 3745-53	OHIO AIR POLLUTION CONTROL ACT
OAC 3745-54	OHIO AIR POLLUTION CONTROL ACT
OAC 3745-55	OHIO SOLID & HAZARDOUS WASTE DISPOSAL LAW
OAC 3745-56	OHIO SOLID & HAZARDOUS WASTE DISPOSAL LAW
OAC 3745-57	OHIO SOLID & HAZARDOUS WASTE DISPOSAL LAW
OAC 3745-58	OHIO SOLID & HAZARDOUS WASTE DISPOSAL LAW
OAC 3745-59	OHIO SOLID & HAZARDOUS WASTE DISPOSAL LAW
OAC 3745-65	OHIO SOLID & HAZARDOUS WASTE DISPOSAL LAW
OAC 3745-66	OHIO SOLID & HAZARDOUS WASTE DISPOSAL LAW
OAC 3745-67	OHIO SOLID & HAZARDOUS WASTE DISPOSAL LAW
OAC 3745-68	OHIO SOLID & HAZARDOUS WASTE DISPOSAL LAW

Regulatory & Guidance Source Documents Comprising the LMES ES & H Basis

Document Number	Document Title
OAC 3745-69	OHIO SOLID & HAZARDOUS WASTE DISPOSAL LAW
OAC 3745-71	OHIO AIR POLLUTION CONTROL ACT
OAC 3745-75	OHIO AIR POLLUTION CONTROL ACT
OAC 3745-81	OHIO SAFE DRINKING WATER ACT
OAC 3745-100	OHIO SOLID & HAZARDOUS WASTE DISPOSAL LAW
OAC 3750-1	OHIO EMERGENCY PLANNING AND COMMUNITY RIGHT-TO-KNOW ACT
OAC 3750-10	OHIO EMERGENCY PLANNING AND COMMUNITY RIGHT-TO-KNOW ACT
OAC 3750-15	OHIO EMERGENCY PLANNING AND COMMUNITY RIGHT-TO-KNOW ACT
OAC 3750-20	OHIO EMERGENCY PLANNING AND COMMUNITY RIGHT-TO-KNOW ACT
OAC 3750-25	OHIO EMERGENCY PLANNING AND COMMUNITY RIGHT-TO-KNOW ACT
OAC 3750-50	OHIO EMERGENCY PLANNING AND COMMUNITY RIGHT-TO-KNOW ACT
Ohio AIP	State of Ohio Agreement in Principle
Ohio Regulation	Basic State Requirements Ohio Rules of Evidence
OR FFCA	Oak Ridge Facility Compliance Agreement
PGDP Admin. Order	Administrative Order by Consent for Paducah Gaseous Diffusion Plant
PGDP AIP	Agreement in Principle for Paducah Gaseous Diffusion Plant
PL101-508	POLLUTION PREVENTION ACT OF 1990
PL102-386	FEDERAL FACILITY COMPLIANCE ACT
PORTS Consent Decree	Portsmouth Consent Decree
PORTS Consent Order	Portsmouth Consent Order
Tenn Code	Basic State Requirements Tennessee Code Annotated
TITLE 68-211	TENNESSEE SANITARY LANDFILL AREAS ACT
TITLE 68-213	TENNESSEE SANITARY LANDFILL AREAS ACT
TN Oversight Agmt.	Tennessee Oversight Agreement (TOA)
TSCA FFCA	TSCA Federal Facilities Compliance Agreement for PCB Issues of Uranium Enrichment Facilities

Regulatory & Guidance Source Documents Comprising the LMES ES & H Basis

Document Number	Document Title
U. S. DOE Memo	Management of Cultural Resources at DOE Facilities
1300.2A	DOE Technical Standards Program
1360.2B	Unclassified Computer Security Program
1540.2	Hazardous Material Packaging for Transport - Administrative Procedures
4330.4A	Maintenance Management Program
4330.4B	Maintenance Management Program
4700.1	Project Management System
5000.3B	Occurrence Reporting and Processing of Operations Information
5400.1	General Environmental Protection Program
5400.4	Comprehensive Environmental Response, Compensation, and Liability Act Requirements
5400.5	Radiation Protection of the Public and the Environment
5480.3	Safety Requirements for the Packaging and Transportation of Hazardous Materials, Hazardous Substances, and Hazardous Wastes
5480.4	Environmental Protection, Safety, and Health Protection Standards
5480.5	Safety of Nuclear Facilities
5480.6	Safety of DOE Owned Reactors
5480.7A	Fire Protection
5480.8A	Contractor Occupational Medical Program
5480.9	Construction Safety and Health Program
5480.10	Contractor Industrial Hygiene Program
5480.11	Radiation Protection for Occupational Workers
5480.13	Aviation Safety
5480.15	Department of Energy Laboratory Accreditation Program for Personnel Dosimetry
5480.16	Firearms Safety
5480.17	Site Safety Representatives
5480.18A	Accreditation of Performance-Based Training for Category A Reactors and Nuclear Facilities

Regulatory & Guidance Source Documents Comprising the LMES ES & H Basis

Document Number	Document Title
5480.19	Conduct of Operations Requirements for DOE Facilities
5480.20	PERSONNEL SELECTION, QUALIFICATION, TRAINING, AND STAFFING REQUIREMENTS AT DOE REACTOR AND NON-REACTOR NUCLEAR FACILITIES
5480.21	UNREVIEWED SAFETY QUESTIONS
5480.22	TECHNICAL SAFETY REQUIREMENTS
5480.23	NUCLEAR SAFETY ANALYSIS REPORTS
5480.24	NUCLEAR CRITICALITY SAFETY
5480.25	SAFETY OF ACCELERATOR FACILITIES
5480.26	TRENDING AND ANALYSIS OF OPERATIONS INFORMATION USING PERFORMANCE INDICATORS
5480.28	NATURAL PHENOMENA HAZARDS MITIGATION
5480.29	Employee Concerns Management System
5480.30	General Design Criteria for Nuclear Reactors
5481.1B	Safety Analysis and Review System
5482.1B	Environment, Safety, and Health Appraisal Program
5483.1A	Occupational Safety and Health Program for DOE Contractor Employees at Government-Owned Contractor-Operated Facilities
5484.1	Environmental Protection, Safety, and Health Protection Information Reporting Requirements
5500.1B	Emergency Management
5500.2B	EMERGENCY CATEGORIES, CLASSES, AND NOTIFICATION AND REPORTING REQUIREMENTS
5500.3A	Planning and Preparedness for Operational Emergencies
5500.4A	PUBLIC AFFAIRS POLICY AND PLANNING REQUIREMENTS FOR EMERGENCIES
5500.7B	Emergency Operating Records Protection Program
5500.10	EMERGENCY READINESS ASSURANCE PROGRAM
5632.11	Physical Protection of Unclassified, Irradiated Reactor Fuel In Transit
5633.3A	Control and Accountability of Nuclear Material
5633.4	Nuclear Transactions: Documentation and Reporting

Regulatory & Guidance Source Documents Comprising the LMES ES & H Basis

Document Number	Document Title
5633.5	Nuclear Materials Reporting and Data Submission Procedures
5634.1B	Facility Approval, Security Surveys, and Nuclear Materials Surveys
5700.6C	QUALITY ASSURANCE
5820.2A	Radioactive Waste Management
6430.1A	General Design Criteria
N5480.5	IMPOSITION OF PROPOSED NUCLEAR SAFETY REQUIREMENTS
N5480.6	USDOE Radiological Control Manual
DE-AC05-84OR21400	Energy Systems/DOE Contract
Pres. Memo	Presidents Memorandum on Environment, Quality and Water Resource
AL 5610.01	PACKAGING & TRANS. OF NUCLEAR EXPLOSIVES, NUCLEAR COMPONENTS, & SPECIAL ASSEMBLIES
1240.2B	UNCLASSIFIED VISITS AND ASSIGNMENTS BY FOREIGN NATIONALS
1324.2A	Records Disposition
1324.4A	Micrographics Management
1324.5A	Records Management Program
1324.6	AUTOMATED OFFICE ELECTRONIC RECORDKEEPING
1324.8	RIGHTS AND INTERESTS RECORDS PROTECTION PROGRAM
1450.4	Consensual Listening-In To or Recording Telephone/Radio Conversations
1540.1A	Material Transportation and Traffic Management
1540.4	Physical Protection of Unclassified, Irradiated Reactor Fuel In Transit
1700.1	Freedom of Information
4010.1A	Value Engineering
5300.2D	Telecommunications: Emission Security (TEMPEST)
5300.4C	Telecommunications: Protected Distribution System
5480.31	Startup and Restart of Nuclear Facilities
5530.1A	Response to Accidents and Significant Incidents Involving Nuclear Weapons

Regulatory & Guidance Source Documents
Comprising the LMES ES & H Basis

Document Number	Document Title
5530.2	NUCLEAR EMERGENCY SEARCH TEAM
5530.3	RADIOLOGICAL ASSISTANCE PROGRAM
5610.1	Packaging and Transportation of Nuclear Explosives, Nuclear Components, and Special Assemblies
5610.10	NUCLEAR EXPLOSIVE AND WEAPON SAFETY PROGRAM
5610.11	NUCLEAR EXPLOSIVE SAFETY
5631.4A	Control of Classified Visits
5630.11A	Safeguards and Security Program
5630.12A	Safeguards and Security Inspection and Assessment Program
5630.14A	Safeguards and Security Program Planning
5630.15	SAFEGUARDS AND SECURITY TRAINING PROGRAM
5630.16A	Safeguards and Security Acceptance and Validation Test Program
5630.17	SAFEGUARDS AND SECURITY (S&S) STANDARDIZATION PROGRAM
5631.1B	SECURITY EDUCATION BRIEFING AND AWARENESS PROGRAM
5631.2C	PERSONNEL SECURITY
5631.6A	PERSONNEL SECURITY ASSURANCE PROGRAM
5631.2B	Personnel Security Program
5632.1B	Protection Program Operations
5632.2A	Physical Protection of Special Nuclear Material and Vital Equipment
5632.5	Physical Protection of Classified Matter
5632.6	Physical Protection of DOE Property and Unclassified Facilities
5632.7	Protective Forces
5632.8	Protection Program Operations - Systems Performance Tests
5632.9A	ISSUANCE AND CONTROL OF SECURITY BADGES, CREDENTIALS, AND SHIELDS
5634.3	Foreign Ownership, Control, or Influence Program
5635.1A	Control of Classified Documents and Information

Regulatory & Guidance Source Documents Comprising the LMES ES & H Basis

Document Number	Document Title
5635.3	Hand-Carrying Classified Matter on Air Carriers
5635.4	Protection of Unclassified Controlled Nuclear Information
5636.1A	PROHIBITION ON WIRETAPPING AND EAVESDROPPING
5639.1	INFORMATION SECURITY PROGRAM
5639.3	VIOLATION OF LAWS, LOSSES, AND INCIDENTS OF SECURITY CONCERNS
5639.5	TECHNICAL SURVEILLANCE COUNTERMEASURES PROGRAM
5639.6	Classified Computer Security Program
5639.7	OPERATIONS SECURITY PROGRAM
5650.2B	IDENTIFICATION OF CLASSIFIED INFORMATION
5650.3A	IDENTIFICATION OF UNCLASSIFIED CONTROLLED NUCLEAR INFORMATION
N4700.5	Project Management System
N5630.3A	Protection of Department Facilities Against Radiological and Toxicology Sabotage
ORIG 1321.1B	OAK RIDGE DIRECTIVES SYSTEM, OR DIRECTIVES MANUAL
ORIG N 1300.X1	OAK RIDGE OPERATIONS STANDARDS/REQUIREMENTS PROGRAM
SEN-22-90	DOE POLICY ON SIGNATURES OF RCRA PERMIT APPLICATIONS
SEN-29-91	PERFORMANCE INDICATORS AND TRENDING PROGRAM FOR DOE OPERATIONS
SEN-35-91	NUCLEAR SAFETY POLICY
SEN-37-92	WASTE MINIMIZATION CROSSCUT PLAN IMPLEMENTATION

APPENDIX B

This appendix provides the education, experience and training standards for personnel in the system. This information is provided from DOE Order 5480.20A.

1. Type indicates that the position was assessed as the following type position as described in 5480.20A Chapter I & IV
   - MGR Manager
   - SUP Supervisor
   - O Operators
   - T Technician
   - MA Maintenance Personnel
   - TS Technical Staff.
   - TQ Training Organization Personnel

2. Type indicates that the position was assessed as the following type position as described in 5480.20A Chapter I

   - S Subcontractor

PERSONNEL TRAINING AND QUALIFICATION STANDARDS

Surveillance and Maintenance Function

Type	Function	Education	Experience	Training
MGR	Line Manager	Baccalaureate in engineering or related science	Nuclear 4 yrs	Facility specific qualification based on background
SUP	Supervisor	High School Diploma or equivalent	Nuclear 3 yrs	Job specific qualification based on analysis. Certification required if working on fissionable material.
O	Cylinder Inspectors	High School Diploma or equivalent	Job Related 1 yr	Job specific qualification based on analysis.
T	Environ. Monitoring Technicians	High School Diploma or equivalent	Job Related 1 yr.	Job specific qualification based on analysis.
T	HP Technicians	Rad Con Requirements	Job Related 1 yr	Job specific qualification based on analysis that satisfies 10CFR835.
NA	Security Officers	No requirements in 5480.20A	NA	NA
O	Decontamination Operators	High School Diploma or equivalent	Combination of job related experience and education 3 yrs	Job specific qualification based on analysis. Certification required if working on fissionable material.
TS	Health & Safety Representatives	Baccalaureate in engineering or related science	Job Related 2 yrs Nuclear 1 yr	Job specific training and education based on assigned duties.

Type	Function	Education	Experience	Training
TS	NMC&A Personnel	Baccalaureate in engineering or related science	Job Related 2 yrs Nuclear 1 yr	Job specific training and education based on assigned duties.
T	Qualified NBIC Inspectors	High School diploma or equivalent	Job Related 1 yr	Certified per National Board Inspection Code Owner/User Certification.
O	Chemical Operators	High School Diploma or equivalent	Job Related 2-3 yrs	Job specific qualification based on analysis. Certification required if working on fissionable material.
O	Material Handlers	High School Diploma or equivalent	Job Related 1 yr	Job specific qualification based on analysis. Certification required if working on fissionable material.
MA	Maintenance Personnel	High School Diploma or equivalent	Maintenance Related: 1 yr	Job specific qualification based on analysis. Certification required if working on fissionable material.
TS	Metallurgists	Baccalaureate in engineering or related science	Job Related 2 yrs Nuclear 1 yr	Job specific training and education based on assigned duties.
T	Industrial Hygiene Technicians	High School Diploma or equivalent	Job Related 2 yrs Nuclear 1 yr	Job specific training and education based on assigned duties.
MA	Painters	High School Diploma or equivalent.	Maintenance Related 1 yr	Job specific qualification based on analysis.

Type	Function	Education	Experience	Training
TS	Quality Assurance and evaluation personnel	Baccalaureate in engineering or related science	Job Related 2 yrs Nuclear 1 yr.	Job specific training and education based on assigned duties.
T	Nondestructive equipment personnel	High School Diploma or equivalent	Job Related 1 yr	Qualified per American Society of Nondestructive Testing recommended practice SNT-TC-1A (Society of Nondestructive Testing - Technical Council - first document) or American Welding Society Certified Weld Inspector.
TS	System Safety Engineers	Baccalaureate in engineering or related science	Job Related 2 yrs Nuclear 1 yr	Job specific training and education based on assigned duties.
O	Emergency Preparedness/ response team	High School Diploma or equivalent	Job Related 2 yrs	Job specific qualification based on analysis. Certification required if working on fissionable material
TS	Procedure Writer	Baccalaureate in engineering or related science	Job Related 2 yrs Nuclear 1 yr	Job specific training and education based on assigned duties.
TQ	Training Personnel	High School Diploma or equivalent	Coordinator: Nuclear 2 yrs Onsite 6 mos Instructors: Consistent with material being presented	Education and/or training at or higher than the level of the normal student population in the subject area being taught.

Type	Function	Education	Experience	Training
T	Lab Technicians	High School Diploma or equivalent	Job Related 1 yr	Job specific qualification based on analysis.
S	Construction Contractors	NA	NA	"Meet the qualification requirements for the job to be performed."
TS	Engineering Support Personnel	Baccalaureate in engineering or related science	Job Related 2 yrs Nuclear 1 yr	Job specific training and education based on assigned duties.
T	Equipment Testing/ Inspection Personnel	High School Diploma or equivalent	Job Related 1 yr	Job specific qualification based on analysis.
NA	Records Management Personnel	No requirements in 5480.20A	NA	NA

Handling and Stacking Function

Type	Function	Education	Experience	Training
O	Spotter	High School Diploma or equivalent	Job Related 1 yr	Job specific qualification based on analysis. Certification required if working on fissionable material.
T	Cylinder Inspector	High School Diploma or equivalent	Job Related 1 yr	Job specific qualification based on analysis.

Type	Function	Education	Experience	Training
TS	Hoisting & Rigging Representative	Baccalaureate in engineering or related science	Job Related 2 yrs Nuclear 1 yr	Job specific training and education based on assigned duties.
O	Equipment Operator	High School Diploma or equivalent	Job Related 1 yr	Job specific qualification based on analysis. Certification required if working on fissionable material.
O	Operator to Set Saddles	High School Diploma or equivalent	Job Related 1 yr	Job specific qualification based on analysis. Certification required if working on fissionable material.
MA	Maintenance Personnel	No Requirements in 5480.20A	Maintenance Related: 1 yr	Job specific qualification based on analysis. Certification required if working on fissionable material.
O	Hoisting & Rigging Crew	High School Diploma or equivalent	Job Related 1 yr	Job specific qualification based on analysis. Certification required if working on fissionable material.

Contents Transfer Function

Type	Function	Education	Experience	Training
O	Operator	High School Diploma or equivalent	Job Related 1 yr	Job specific qualification based on analysis. Certification required if working on fissionable material.

Type	Function	Education	Experience	Training
MA	Maintenance Personnel	High School Diploma or equivalent	Maintenance Related: 1 yr	Job specific qualification based on analysis. Certification required if working on fissionable material.
T	Equipment Testing/ Inspection Personnel	High School Diploma or equivalent	Job Related 1 yr	Job specific qualification based on analysis. Certification required if working on fissionable material.

Off -Site Transport Function

Type	Function	Education	Experience	Training
O	Hoisting & Rigging Crew	High School Diploma or equivalent	Job Related 1 yr	Job specific qualification based on analysis. Certification required if working on fissionable material
T	Qualified Inspector	High School Diploma or equivalent	Job Related 1 yr	Job specific qualification based on analysis. Certification required if working on fissionable material
T	Health Physics Technician	High School Diploma or equivalent	Job Related 1 yr	Job specific qualification based on analysis that satisfies 10CFR835
O	Transport Driver	Not addressed in 5480.20A Licensed per DOT Regulations	NA	NA
TS	Transportation Safety Representative	Baccalaureate in engineering or related science	Job Related 2 yrs Nuclear 1 yr	Job specific training and education based on assigned duties.
TS	DOT certified Transportation "Officer"	Baccalaureate in engineering or related science	Job Related 2 yrs Nuclear 1 yr	Job specific training and education based on assigned duties.