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Contents: Maintenance Management

Effective Date: **December 2003**

Point of Contact: [Deputy Manager, Plant Engineering, Operations & Maintenance](#)

Section

Overview of Content (see section for full process)

[Introduction](#)

[1. Maintaining the Master Equipment List](#)

- Identify equipment or system that could require maintenance.
- Record and maintain information on Master Equipment List.
- Periodically review list.

[2. Determining Quality Class Designation](#)

- Record quality classification on the Master Equipment List for each item of equipment or system.
- Determine which maintenance program elements apply.
- Implement maintenance program.
- Periodically review Quality Class Designation and adjust program, as appropriate.

[3. Implementing a Maintenance Program](#)

- Determine time frame, scope, and resources for conducting self-assessment.
- Update Department/Division annual self-assessment plan, as necessary.
- Conduct self-assessment.
- Document and track any corrective actions to completion.

[4. Conducting Self-assessments](#)

[Definitions](#)

EXHIBITS

[Maintenance Program Requirements/Elements](#)

Forms

[Self-assessment Aid for Maintenance Program Requirements/Elements](#)

Training Requirements and Reporting Obligations

This subject area does not contain training requirements.

This subject area does not contain reporting obligations.

References

[Integrated Assessment](#) Subject Area

[Records Management](#) Subject Area

[Work Planning and Control for Experiments and Operations](#) Subject Area

Standards of Performance

Managers shall, as appropriate, establish performance objectives, indicators and targets; conduct self-assessments to collect data and monitor progress; and evaluate the data to identify strengths and weaknesses in performance, and areas for improvement.

Managers shall ensure that scopes of work properly consider all elements of the Laboratory's operational priorities.

Management System

This subject area belongs to the **Life Cycle Asset Management** management system.

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Introduction: Maintenance Management

Effective Date: **December 2003**

Point of Contact: [Deputy Manager, Plant Engineering, Operations & Maintenance](#)

This subject area describes the requirements for Department/Division maintenance management programs, using the graded approach. The application of the graded approach will be consistent with ESH&Q Risk Level A-1 Critical, A-2 Major, A-3 Minor, and A-4 Negligible. See the exhibit [Screening Guidelines for Work Planning & Control and Application of the Quality Graded Approach](#) in the [Work Planning and Control for Experiments and Operations](#) Subject Area. Based upon the quality designation, the subject area will set forth some requirements that apply to all Departments/Divisions, as well as define specific maintenance behaviors required for the equipment.

The Plant Engineering Division is responsible for maintenance management of all buildings, facilities, and equipment that is covered by the space-charge program. All other Departments/Divisions are responsible for maintenance management of their programmatic real property.

The purpose of this subject area is to provide procedures for the cost-effective maintenance and repair of BNL property. The subject area sets forth the following procedures:

- Facilities must be maintained in a manner that promotes operational safety, worker health, environmental protection, and property preservation. The program must be cost-effective and meet the requirements of the programmatic mission.
- Structures, components, equipment, and systems that are important to safe operation must be subject to a maintenance program to ensure that they meet or exceed their design requirements.
- Periodically, structures, systems, and components must be reviewed for deterioration or obsolescence that could threaten performance or safety.
- Budgeting and accounting for maintenance programs must be sufficient to maintain equipment in accordance with this subject area.

The objectives of this subject area are as follows:

- Ensure the reliability, safety, and operability of structures, systems, equipment, and components;
- Ensure compliance with environmental, safety, and health standards;
- Ensure responsibility, authority, and accountability for maintenance is clearly defined;
- Ensure there are effective programs to evaluate and measure the condition of facilities

and equipment;

- Ensure a graded approach is used. The depth of detail required and the magnitude of resources expended for a particular maintenance element should be commensurate with the element's importance to safe and reliable operation, environmental compliance, safeguards and security, programmatic mission, facility preservation, and/or specific facility requirements;
- Develop a maintenance program based on defensible requirements;
- Establish a system for self-assessment to evaluate the performance and effectiveness of the maintenance program.

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Subject Area: **Maintenance Management**

1. Maintaining the Master Equipment List

Effective Date: **December 2003**

Point of Contact: [Deputy Manager, Plant Engineering, Operations & Maintenance](#)

Applicability

This information applies to BNL staff who create and maintain the Master Equipment List for maintenance management programs in their Department/Division.

Required Procedure

Departments/Divisions are responsible for maintaining programmatic real property. The Plant Engineering Division is responsible for maintaining infrastructure real property assets.

The Department/Division designee does the following:

Step 1	Identify the programmed item of equipment or system that could require maintenance over its lifetime.
Step 2	Record and maintain this information on a Master Equipment List. See Guidelines below for data to be recorded.
Step 3	Periodically review the Master Equipment List.

Guidelines

It is recommended that a numbering system be used. Each equipment or system should be assigned a number. Numbers should be affixed to or written on the equipment. The Master Equipment List documents equipment or systems that could require maintenance over their life cycle.

Include the following data as appropriate:

- Manufacturer;
- Size;

- Model number;
- Serial number;
- Date purchased;
- Purchased price;
- Electrical information;
- RPM;
- Horsepower.

The Master Equipment List can range from a paper listing of equipment, to a database as appropriate, based on the amount of data being tracked.

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Subject Area: **Maintenance Management**

2. Determining Quality Class Designation

Effective Date: **December 2003**

Point of Contact: [Deputy Manager, Plant Engineering, Operations & Maintenance](#)

Applicability

This information applies to BNL staff who determine quality class designations for each item of equipment or system on their Departmental/Divisional Master Equipment List.

Required Procedure

Departments/Divisions are responsible for the maintenance of programmatic real property. The Plant Engineering Division is responsible for infrastructure real property assets.

The Department/Division designee does the following:

Step 1	Record the quality classification on the Master Equipment List for each item of equipment or system. Use the exhibit Screening Guidelines for Work Planning & Control and Application of the Quality Graded Approach in the Work Planning and Control for Experiments and Operations Subject Area as a tool to determine class.
---------------	---

Guidelines

Class designations guide the level of maintenance rigor that is applied to a particular equipment item over its lifetime. Class designations should be periodically reviewed and updated, as equipment items may be used in different applications over time.

References

[Work Planning and Control for Experiments and Operations](#) Subject Area
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3. Implementing a Maintenance Program

Effective Date: **December 2003**

Point of Contact: [Deputy Manager, Plant Engineering, Operations & Maintenance](#)

Applicability

This information applies to BNL staff who implement maintenance management programs.

Required Procedure

Departments/Divisions are responsible for the maintenance of programmatic real property. The Plant Engineering Division is responsible for infrastructure real property assets.

The Department/Division designee does the following:

Step 1	Uses the exhibit Maintenance Program Requirements/Elements to determine which maintenance program elements apply.
Step 2	Implements a maintenance program that meets the requirements and elements in the exhibit.
Step 3	Periodically reviews the Quality Class Designation and adjusts the maintenance program as appropriate.

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Subject Area: **Maintenance Management**

4. Conducting Self-assessments

Effective Date: **December 2003**

Point of Contact: [Deputy Manager, Plant Engineering, Operations & Maintenance](#)

Applicability

This information applies to BNL staff who plan and conduct self-assessments for the maintenance of programmatic real property.

Required Procedure

The Department/Division designee plans and conducts a self-assessment of their Maintenance Management Program in accordance with the [Integrated Assessment](#) Subject Area and does the following:

Step 1	Determine the time frame, scope, and resources necessary to conduct a self-assessment for the maintenance of programmatic real property. The scheduling of these assessments will be based on the priorities of each Department/Division performing the assessment.
Step 2	Update the Department/Division annual self-assessment plan as necessary to incorporate additional and/or obsolete programmatic real property.
Step 3	<p>Conduct the defined self-assessment. Some of the self-assessments should involve the review/observation of fieldwork.</p> <ul style="list-style-type: none"> • Use the exhibit Self-Assessment Aid for Maintenance Program Requirements/Elements as a tool to assist in the self-assessment of the maintenance program. <p>The Department/Division must ensure that changes identified to the maintenance management program are continually fed back into the review process.</p>
Step 4	At the conclusion of the self-assessment, document and track any corrective actions to completion using the Department/Division tracking system.

Note: Your Family ATS is recommended for tracking corrective actions.

References

[Integrated Assessment](#) Subject Area

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Elements	Quality Class Designation			
	A1 Critical	A2 Major	A3 Minor	A4 Negligible
Written Maintenance Procedures	x	x		
Equipment-specific Trained	x	x		
Initial and Post-Maintenance Testing	x	x		
Equipment Repair History and Vendor Information	x	x	x	
Requisitioning/Procurement	x			
Materials Control	x			
Condition Assessment Surveys	x	x	x	x
Preventive Maintenance	x	x	x	
Predictive Maintenance	x	x		
In-Service Surveillance	x	x		
Corrective Maintenance	x	x	x	x
Breakdown Maintenance or Run-to-Failure				x

Guidelines

Written Maintenance Procedures

- A combination of written guidance, worker skills, and work-site supervision is required to achieve the quality workmanship that is essential for safe and reliable operation of critical equipment and systems.
- Procedures should provide technical guidance to workers to ensure that work is accomplished systematically and correctly. This guidance should be technically accurate, complete, up-to-date, and presented clearly, concisely, and consistently.
- Guidance should be provided for developing and issuing procedures, including writing, verification, validation, approval, control periodic review, use, revision, and change control. Other factors, such as control of reference material, identifying and storing procedures, and maintaining accurate procedures, should be considered.
- Maintenance procedures should be written for the audience intended to use them and may consider:

- Format, purpose, and scope.
- Use of illustrations.
- Steps that could interrupt equipment or processes.
- Hold points, independent verification requirements, and data to be recorded.
- Systematic facility and system prerequisites, precautions, and limitations.
- Required special tools and materials, and manpower.
- Acceptance criteria, follow-on steps, and restoration instructions.
- Steps that inform operations personnel of expected alarms or equipment operations.
- Guidance to workers to notify the operations organization of maintenance that cannot be completed as originally planned or will be delayed beyond the anticipated schedule and/or across shift changes.
- Verification, which is a review to ensure the proper format and technical accuracy of a new or revised procedure. The format should incorporate human-factors principles and other administrative policies. A technical accuracy review should be performed to include a review of the procedure against the design requirement for that system or component.
- Maintenance should validate procedures to ensure that they are correct.
- The maintenance manager or designee should approve maintenance procedures.
- Procedures should be checked before they are used to ensure that the most current and correct revision is being used.
- Procedures or portions of procedures required to be in hand are reviewed step-by-step while performing maintenance, should be clearly identified.
- Supervisors should be notified immediately when a procedure cannot be followed or unexpected results occur. Work should be stopped, and the equipment or system should be restored to a safe condition.
- Responsibilities for the administration of the procedure program should be clearly defined.
- Procedures should be controlled in accordance with facility administrative requirements.
- A revision should be initiated when a change has been outstanding for an extended period, when a procedure has been affected by several changes, or when a single change becomes so extensive that the procedure is difficult to follow.
- Vendor manuals or portions of them and other reference materials should be technically accurate and up-to-date.

Equipment-specific Trained

- The maintenance organization should support and guide the training organization by
 - Defining jobs, tasks, skill levels, and responsibilities.
 - Defining training programs for each position.
 - Determining the content and emphasis of training.
 - Establishing and supporting training schedules.
 - Determining individual training needs based on education, training, experience, and skill level.
 - Providing instructors and trainers.
 - Establishing qualification criteria and qualifying individuals as they complete training.
 - Coordinating On-the-Job-Training (OJT).
 - Providing feedback on training.
 - Defining training programs and involving management, workers, and support groups.
 - The program should include the following:
 - Schedules that reflect the availability of qualified instructors, the facility, and trainees.
 - Independent study, classroom instruction, practical training, contractor training, and OJT.
 - Review of each trainee's education, experience, and skill level to determine which portions of the training can be exempted.
- OJT is practical, hands-on training in which employees learn through training conducted in the job environment.
- Key elements of OJT are the following:
 - Adherence to an OJT Program - Conduct the program in accordance with a formal facility defined program.
 - Qualifications of OJT Trainers - Use personnel who are qualified as OJT trainers.
 - Supervision and Control of Trainees - Instructors should
 - Observe work by trainees
 - Point out potential errors and their effects
 - Demonstrate industrial and radiological safety practices
 - Review information recorded by the trainees
 - Stress the importance of maintaining accurate records
 - Number of Trainees - Consider training effectiveness and effects on equipment when deciding the size of the training class.
 - Conduct of Maintenance by Trainees - The trainees may only independently perform maintenance on equipment for which they are qualified.

Initial and Post-maintenance Testing

- Post-maintenance testing should be performed to verify that equipment, systems, and components meet their design requirements when they are returned to service.
- Perform post-maintenance testing after preventive or corrective maintenance.
- Include in the post-maintenance testing program the following:
 - Test requirements
 - Identification of responsibilities
 - The scope of the testing, specified in approved procedures
 - A mechanism to track the status of the testing
 - Work package acceptance documentation
 - Coordination of multiple support groups
- Perform acceptance tests on new or modified equipment.

Equipment Repair History and Vendor Information

- A history of equipment repair and a vendor information program should be established to provide information for planning, and to support trend analysis.
- Use the repair history to support maintenance activities, upgrade maintenance programs, optimize the performance of the equipment, and improve its reliability.
- Define which data are recorded and how they are stored.
- Maintain maintenance history records for equipment that has ES&H impact or could adversely impact the operation of the facility.
- Correlate the maintenance records with the master equipment list.
- Review records periodically for adverse trends.
- Provide history records that contain the following:
 - Equipment identification
 - Maintenance records
 - Diagnostic and monitoring data
 - Vendor information
 - Modification information
 - Spare-parts information
- Use the maintenance history records in failure analysis, assessment of the maintenance program, outage planning, and budget preparation.
- Obtain vendor information and store it for easy retrieval.

Requisitioning/Procurement

- Parts, materials, and services required to perform maintenance activities should be available when needed.
- Provide a procurement process to insure that parts, materials, and services will be available for work.

- Specify the technical and quality assurance requirements in procurement documents.
- Include in the post-procurement activities considerations of storage and shelf-life.
- Obtain approval, through engineering controls, for deviations from the design specifications.
- Track high-priority and long-lead material.
- Develop the lessons learned from experience with procurement, including lead times, parts usage, and reliability of the supplier.
- Review the use of spare parts and their availability.
- Provide controls for defective and non-conforming material.
- Maintain quality assurance records for procurements.
- Obtain Material Safety Data Sheets (MSDS) for hazardous materials.

Materials Control

- Receiving, inspecting, handling, storing, retrieving, and issuing of equipment, parts, and materials for maintenance should be done in an appropriate manner to ensure successful installation.
- Meet the goal to have the right material in the correct quantity delivered on time, to the job site.
- Provide policies that describe the responsibilities and techniques for receiving, inspecting, handling, storing, retrieving, and issuing equipment, parts, and materials.
- Provide instructions for when special handling will be required.
- Inspect the material for conformance to specifications before release.
- Document receipt of the material.
- Identify and tag nonconforming materials.
- Provide a system that tracks purchase orders.
- Establish a program to control shelf-life.
- Segregate safety- and non-safety-related components when the requirements differ.
- Store materials according to the vendor recommendations.
- Identify, segregate and control flammable and hazardous materials.

Condition Assessment Surveys

- Inspect facility areas and installed equipment and systems at predetermined frequencies to insure that the equipment and systems are running as designed and that no facility issue is causing potential problems.
- Condition Assessment Surveys will range from simple walk bys to in-depth studies.
- Condition Assessment Surveys will provide early detection of potential problems to prevent wear, damage, or failure of equipment or systems.

- Incorporate inspection standards into inspection checklists.
- Standardize the Condition Assessment Survey process, which includes scheduling, and having inspections performed by trained individuals.
- Perform analysis to determine the proper corrective actions for known deficiencies.
- Base analysis on established standards and procedures.

Preventive Maintenance

Preventive maintenance (PM) includes periodic and planned maintenance actions taken to maintain a piece of equipment within design operating conditions and extend its life. Preventive maintenance will be performed to prevent equipment failure or downtime.

- Planned maintenance is typically done during outages or on spare or redundant equipment during facility operation.
- Preventive maintenance typically replaces consumed parts, such as belts and filters, or it requires inspection and adjustment of equipment.
- The preventive maintenance program should define the required maintenance and its frequency.
- Frequency should be based on such elements as predictive maintenance results, vendor recommendation, ALARA considerations, and monitoring of performance.
- Using the master equipment list, preventive actions and their frequencies are analyzed to identify periodic actions to improve equipment performance. The actions selected and their frequencies should be based on
 - Regulatory and code requirements
 - Vendor recommendations
 - Experience at this facility and similar facilities
 - Maintenance history
 - Engineering judgment
 - Cost/benefit evaluations
 - Minimizing personnel radiation exposure using the ALARA principles
 - Function, ease of replacement, and demonstrated reliability of equipment of system
 - Optimizing equipment or system availability during unit operating conditions
 - Operating history

Note: Each Department/Division must implement a system that requires approval/signoff by an appropriate level manager when the prescribed PM is being deferred (putting the work off until a later time).

Predictive Maintenance

Predictive maintenance uses technologies that allow forecasting of failures through monitoring and analysis of the condition of the equipment.

- The data gathered should be analyzed, trends should be identified, and the corrective actions should be defined.
- The program should provide data to the preventive maintenance program and provide and retrieve data on equipment history.
- Root causes should be determined, corrective actions taken, and results fed back into the program.
- When predictive maintenance requires in-process monitoring of the equipment, such action should specify the proper conditions, system configuration, and operating parameters should be specified to ensure that the data collected are comparable and that trends can be identified.
- Locations for equipment monitoring should be identified and marked to obtain consistent readings each time the predictive maintenance data is provided.
- Effective monitoring and diagnostic methods (predictive maintenance) are normally preferred to periodic internal inspections or equipment overhauls. These techniques can reduce maintenance errors, rework, and radiation exposure.
- Examples of predictive maintenance used at the Laboratory include overhead thermography, vibration analysis, oil analysis, and ultrasonic analysis.

In-service Surveillance

- Operational equipment needs to be periodically observed to look for abnormal conditions or evidence of problems.
 - An operator making rounds and recording relevant information, such as pressures and temperatures on a log sheet, usually accomplishes this surveillance.
- Another way to accomplish this surveillance, especially when equipment is not accessible or is located in a high radiation area, is to have the equipment monitored with sensors that are wired to a computer.
 - This monitors the equipment in a real-time mode and will send alarms to a central location, if an abnormal condition exists.

Corrective Maintenance

Corrective maintenance is the repair and restoration of equipment or components that have degraded or are malfunctioning. The need for corrective maintenance on equipment can be identified during preventive maintenance tasks by operations personnel making rounds, or by an alarm generation when equipment is set up to be monitored by sensors and computers.

- On A-1 or A-2 equipment items, root cause analysis should be performed when corrective maintenance is required. The output of that analysis

needs to be fed into preventive and predictive maintenance programs and possibly into maintenance training programs.

Breakdown Maintenance or Run-to-Failure

This type of maintenance program is for equipment that has the least impact on safe, reliable operations.

- Equipment is run until it breaks down.
- At the point of breakdown, corrective maintenance is performed to repair the equipment item and return it to service or to replace it.

Self-Assessment Aid for Maintenance Program Requirements/Elements

Does the Department/Division, in accordance with this Subject Area:		Comments
1. Use written maintenance procedures ?	Yes <input type="checkbox"/> No <input type="checkbox"/>	
2. Have equipment-specific trained workers ?	Yes <input type="checkbox"/> No <input type="checkbox"/>	
3. Conduct initial/post-maintenance testing ?	Yes <input type="checkbox"/> No <input type="checkbox"/>	
4. Retain equipment repair history and vendor information?	Yes <input type="checkbox"/> No <input type="checkbox"/>	
5. Maintain special requisition/procurement as needed?	Yes <input type="checkbox"/> No <input type="checkbox"/>	
6. Enforce materials control ?	Yes <input type="checkbox"/> No <input type="checkbox"/>	
7. Conduct condition assessment surveys ?	Yes <input type="checkbox"/> No <input type="checkbox"/>	
8. Conduct periodic and planned preventive maintenance ?	Yes <input type="checkbox"/> No <input type="checkbox"/>	
9. Utilize technologies for predictive maintenance ?	Yes <input type="checkbox"/> No <input type="checkbox"/>	
10. Periodically conduct in-service surveillance ?	Yes <input type="checkbox"/> No <input type="checkbox"/>	
11. Identify corrective maintenance during preventive maintenance?	Yes <input type="checkbox"/> No <input type="checkbox"/>	
12. Maintain equipment until it breaks down or runs-to-failure ?	Yes <input type="checkbox"/> No <input type="checkbox"/>	

Dept/Div Designee Signature	Date
Additional Approvals as Required	Date



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Effective Date: **December 2003**

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Term	Definition
approach	An action (or series of actions) taken to provide confidence that performance measures can be achieved. Examples include dedicated resources, formal project management controls, communications and training, work planning and controls, and use of Subject Matter Experts or external expertise.
assessment	Activity performed specifically for the purposes of evaluating the level of performance (or condition) to ensure it is maintained at expected levels and/or for identifying improvement opportunities.
class designation	An indicator using a weighted scale that is used once the ES&H and programmatic risks have been evaluated, e.g., A1 (Critical), A2 (Major), A3 (Minor), and A4 (Negligible).
condition assessment survey	An inspection of facility areas and installed equipment and systems at predetermined frequencies to ensure that the equipment and systems are running as designed.
corrective maintenance	The repair and restoration of equipment or components that have degraded or are malfunctioning.
document control	The act of ensuring that documents are reviewed for adequacy, approved for release by authorized personnel, and distributed to and used at the location where the prescribed activity is performed.
graded approach	<p>A process for determining that the appropriate level of analysis, controls, documentation, and actions necessary are commensurate with an item's or activity's potential to</p> <ul style="list-style-type: none"> • Create an environmental, safety, or health hazard; • Incur a monetary loss due to damage, or to repair/rework/scrap costs; • Reduce the availability of a facility or equipment; • Adversely affect the program objective or degrade data quality; • Unfavorably impact the public's perception of the BNL /DOE

	<ul style="list-style-type: none"> Unfavorably impact the public's perception of the BNL/DOL mission.
Master Equip-ment List	The labeling of all systems, equipment, components, and areas used in plant and programmatic applications.
measure	A specific performance expectation or assessment selected to achieve an objective or provide evidence that the objective is being achieved. Measures should be quantified where practical.
Operational Safety Envelope	The conditions/boundaries by which safe operation is maintained within a process or facility.
operations	Any activity involved with operating, monitoring, or maintaining a research facility, machine, or item of equipment.
predictive maintenance	Uses technologies that allow forecasting of failures through monitoring and analysis of the condition of the equipment.
preventive maintenance	Periodic and planned maintenance actions taken to maintain a piece of equipment within design operating conditions.
system	A combination of subsystems, assemblies, subassemblies, and components joined together to form the finished product or prime level of assembly (i.e., accelerator, reactor, detector, building).

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Revision History: Maintenance Management

Point of Contact: [Deputy Manager, Plant Engineering, Operations & Maintenance](#)

Revision History of this Subject Area

Date	Description	Management System
December 2003	<p>This subject area describes the requirements for Department/Division maintenance management programs, using the graded approach.</p> <p>This subject area provides procedures for the cost-effective maintenance and repair of BNL property. It contains the following procedures:</p> <ul style="list-style-type: none"> • Facilities must be maintained in a manner that promotes operational safety, worker health, environmental protection, and property preservation. The program must be cost-effective and meet the requirements of the programmatic mission. • Structures, components, equipment, and systems that are important to safe operation must be subject to a maintenance program to ensure that they meet or exceed their design requirements. • Periodically, structures, systems, and components must be reviewed for deterioration or obsolescence that could threaten performance or safety. • Budgeting and accounting for maintenance programs must be sufficient to maintain equipment in accordance with this subject area. 	Life Cycle Asset Management

This subject area replaces the following sections of the Operations and Maintenance Manual:

- IV-01 Maintenance Management, Implementation of DOE 4330.4B ;
- IV-02 Applicability Matrix for DOE Order 4330.4A, Chapter 1 - Non-nuclear Facilities;
- IV-03 Maintenance Management Programs;
- VI-00 Summary of DOE Order 4330.4A, Maintenance Management Program;
- VI-01 Summary of DOE Order 4330.4A, Chapter I, Maintenance of Non-nuclear Facilities;
- VI-02 Summary of DOE Order 4330.4A, Chapter II Maintenance of Nuclear Facilities;
- VI-03 Summary of DOE Order 4330.4A, Appendices, Acronyms;
- VI-03 Summary of DOE Order 4330.4A, Appendices, Definitions.

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