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NOT MEASUREMENT SENSITIVE

DOE G 433.1-1
9-5-01

Nuclear Facility Maintenance Management Program Guide for Use with DOE O 433.1

[This Guide describes suggested nonmandatory approaches for meeting requirements. Guides are not requirements documents and are not construed as requirements in any audit or appraisal for compliance with the parent Policy, Order, Notice, or Manual.]

U.S. Department of Energy
Washington, D.C. 20585

DISTRIBUTION:	**INITIATED BY:**
All Departmental Elements	**Office of Nuclear and Facility Safety Policy**

FOREWORD

This Department of Energy (DOE) Guide is approved by the Office of Nuclear and Facility Safety Policy (EH-53) and is available for use by all DOE components and contractors.

Beneficial comments (recommendations, additions, deletions, and any pertinent data) that may improve this document should be sent to—

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DOE Guides are part of the DOE Directives System and are issued to provide supplemental information regarding the Department's expectations of its requirements as contained in rules, Orders, Notices, and regulatory standards. Implementation Guides also provide acceptable methods for implementing these requirements.

DOE developed this Guide to supplement DOE O 433.1, *Maintenance Management Program for DOE Nuclear Facilities*, and the following directives and regulations:

- 48 CFR 45.509, Care, Maintenance, and Use; of Government Property;
- DOE P 450.4, *Safety Management System Policy*;
- 10 CFR 830, Nuclear Safety Management;[1]
- 10 CFR 834 (Proposed), Radiation Protection of the Public and the Environment;[2]
- 10 CFR 835, Occupational Radiation Protection;[3] and
- 29 CFR 1910.119, Process Safety Management of Highly Hazardous Chemicals.

This Guide includes direction previously issued in DOE 4330.4B, *Maintenance Management Program*.

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I. INTRODUCTION

DOE O 433.1 includes requirements that were previously contained in DOE 4330.4B, *Maintenance Management Program*, dated 2-4-94.[39] There are new requirements imposed under DOE O 433.1 that were not previously imposed under DOE 4330.4B, relating to Federal responsibilities for maintenance activities at DOE nuclear facilities. These are stated in paragraphs 4a, 4c, 4d, and 5 of the Order.

DOE O 433.1, *Maintenance Management Program for DOE Nuclear Facilities,* requires U.S. Department of Energy (DOE) contractors to develop and implement a maintenance management program for each nuclear facility under DOE cognizance. The following Directives and regulations require that the level of detail and magnitude of resources expended in the maintenance of a facility's structures, systems, or components be commensurate with their importance to safe and reliable operations of that facility:

- DOE P 450.4, *Safety Management Systems Policy*;
- DOE O 430.1A, *Life-Cycle Asset Management*;
- 48 CFR 45.509, Care, Maintenance and Use;
- 10 CFR 830, Subpart A, Quality Assurance,
- 29 CFR 1910.119, Process Safety Management of Highly Hazardous Chemicals;
- 10 CFR 834, Radiation Protection of the Public and the Environment (proposed);[2] and
- 10 CFR 835, Occupational Radiation Protection.

DOE O 433.1 further requires that each DOE contractor develop a maintenance implementation plan (MIP) defining the safety structures, systems, and/or components (SSCs) the nuclear facility comprises. Functional areas within the Integrated Safety Management System (ISMS) program and life-cycle asset management that overlap with functional areas within 10 CFR 830, Subpart A;29 CFR 1910.119;48 CFR 45.509; DOE 5400.5, *Radiation Protection of the Public and the Environment*; and 10 CFR 835 are intended to be complementary to one another, not duplicative efforts. Similar relationships exist with other nuclear safety requirements, such as Conduct of Operations[44] (lockout and tagout [84] procedures) and quality assurance [control and calibration of measuring and test equipment (M&TE)].[1] It is important to recognize that these complementary areas should not be developed and implemented as independent programs, but should be developed in concert with each other to ensure harmonious integration.[14]

This Guide describes a maintenance management program that would be acceptable to DOE for meeting the requirements of DOE O 433.1. An acceptable maintenance management program may be based on existing maintenance programs or on the development of new corrective, preventive, and predictive maintenance programs. This document brings together in one place the guidance for existing nuclear facility maintenance management program elements that previously resided in separate DOE Technical Standards (see Figure 1-A). It replaces 15 DOE

Technical Standards relevant to maintenance at DOE nuclear facilities and provides guidance to preserve the designed-in capability of SSCs important to nuclear safety and protection of the environment in accordance with laws, regulations, or DOE directives.

Proposed alternatives to the methods identified in the Guide do not normally require formal technical justification. However, if substantive differences exist between the intent of the Guide and the proposed alternative, both technical and managerial evaluation of the proposed alternative should be made to determine whether the proposed alternative satisfies the requirement.

The basic requirements of DOE Order 433.1 are to develop and implement a maintenance program for safety SSCs using a graded approach. The criteria for acceptability of the maintenance program are—

1. that the provisions are "sufficient to provide reasonable assurance that the facility safety structures, systems, and components are capable of fulfilling their intended function as identified in the safety analysis report (SAR)..."[48] and

2. that the maintenance program includes "(i) The safety structures, systems, and components identified in the SAR [in the absence of an approved SAR, the maintenance program shall include the safety structures, systems, and components identified in the Basis for Interim Operation (BIO)] and (ii) Management Systems consistent with the requirements of 10 CFR 830.122..."[1, 48]

10 CFR 830, Subpart A, and DOE O 414.1A, "Quality Assurance," also apply to all processes at nuclear facilities and necessitate certain elements that are contained within Maintenance Order 433.1. The guidance herein is compatible with 10 CFR 830, Subpart A and DOE O 433.1. Table 1-A shows the relationship of the basic nuclear facility maintenance management program elements of an acceptable maintenance program as contained in this Guide to other DOE Directives and the quality assurance (QA) process.

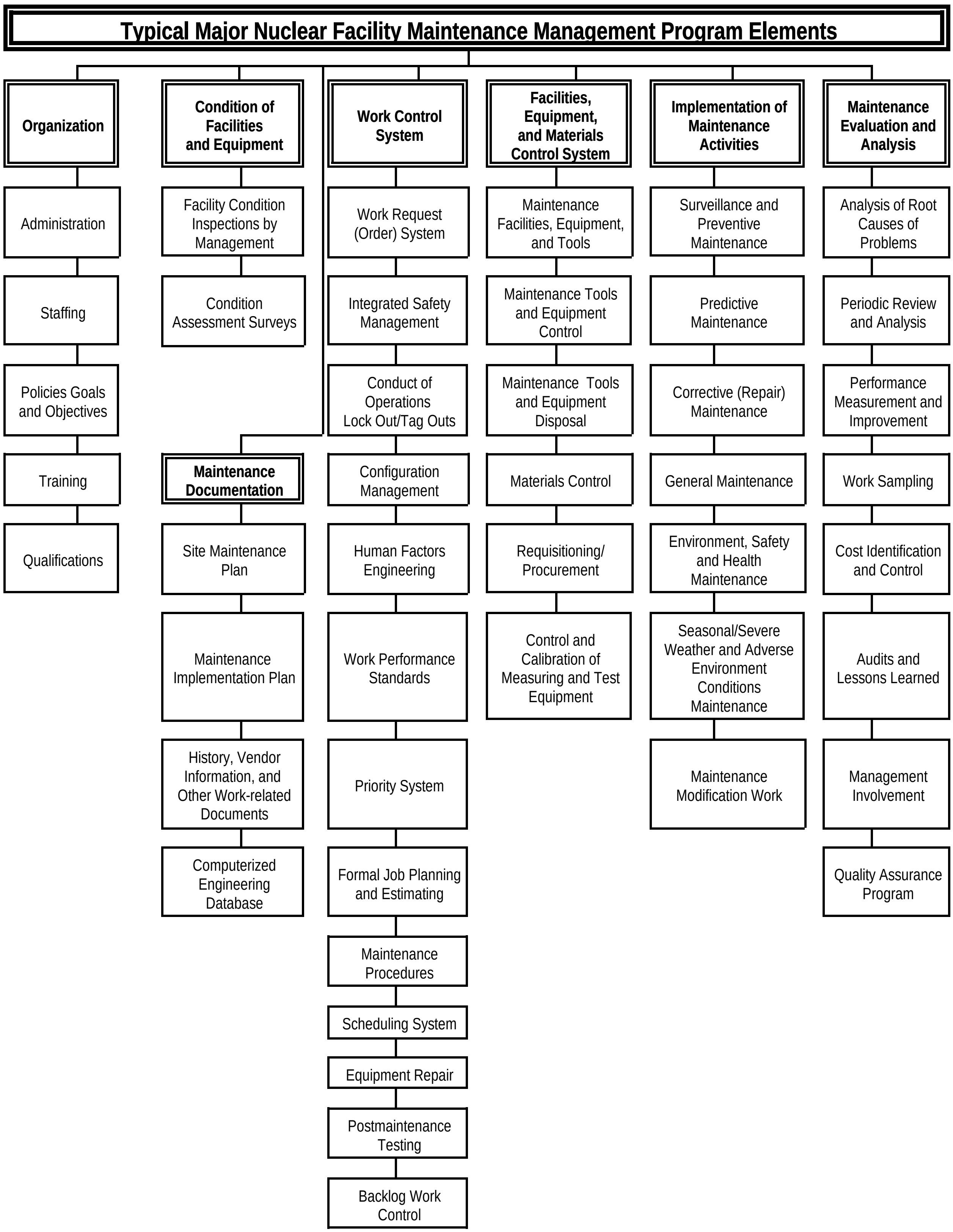

Figure 1-A. Typical Major Nuclear Facility Maintenance Management Program Elements.

Table 1-A. Crosswalk to Department of Energy Related Maintenance Documents

NUCLEAR							NON NUCLEAR	
MAINTENANCE ISSUE				NEW	NEW	OLD		
Item No.	Subject	Main Topic	Regulatory Requirement	DOE Requirement	Guidance	Previously Resided In	Regulatory Requirement	DOE Requirement
1	DOE Maintenance Philosophy	Purpose/ Introduction	10 CFR 830 10 CFR 835 29 CFR 1910.119 41 CFR Subtitle C 41 CFR 101-3 41 CFR 101 41 CFR 102 48 CFR 45.509 52 CFR 952.211.72 DEAR 970-5204-2 ISMS Principles 1, 4 DOE P 411.1 DOE P 430.1 DOE P 440.1 DOE P 450.1 DOE P 450.2A DOE P 450.4 DOE P 450.5	DOE O 433.1	DOE-EGS-95-01 DOE-EGS-98-01 DOE-EGS-98-02 DOE-EGS-99-01 DOE-EGS-99-02 DOE-EGS-00-01 DOE G 433.1-1 DOE-HDBK-1085-95 DOE-HDBK-1087-95 DOE-HDBK-1089-95	DOE G 450.4-1 DOE O 224.1 DOE O 231.1 DOE O 232.1A DOE O 414.1A DOE O 420.1 DOE 4330.4B-1 DOE 4330.4B-II-1 DOE 5400.1 DOE 5400.5 DOE 5480.19 SEN 35-91	PSM 29 CFR 1910.119 41 CFR Subtitle C 41 CFR 101-3 41 CFR 101 41 CFR 102 48 CFR 45.509 52 CFR 952.211.72	DOE O 224.1 DOE O 414.1A DOE O 430.1 DOE 1332.1A DOE 3790.1B
2		Cancellation		DOE O 433.1		DOE 4330.4B-2		
3		Scope		DOE O 433.1	DOE G 433.1-1	DOE 4330.4B-3		
4		Exclusions		DOE O 433.1		DOE 4330.4B-4		
5		References			DOE G 433.1-1	DOE 4330.4B-5		DOE O 430.1
6		Definitions and Acronyms			DOE G 433.1-1	DOE 4330.4B-6 18 DOE Nuclear Maintenance Standards		DOE O 430.1
7		Policy	DOE P 411.1 DOE P 430.1 DOE P 440.1 DOE P 450.1 DOE P 450.2A DOE P 450.4 DOE P 450.5	Various DOE		DOE 4330.4B-7 DOE P 430.1 DOE P 441.1 DOE P 450.4		DOE P 430.1
8		Objectives	10 CFR 835 48 CFR 45.509 DEAR	DOE O 433.1	DOE G 433.1-1	DOE G 450.4-1 DOE 4330.4B-8		
9	Federal Employee Roles in Nuclear Facility Maintenance	Responsibilities and Authority of DOE Employees Overseeing DOE Contractor Activities	FAR 10 CFR 835 52 CFR 952.211.72	DOE M 411.1-1A, (FRAM) DOE O 433.1	DOE G 433.1-1	DOE O 414.1A DOE 4330.4B-9 DOE P 411.1 DOE P 450.5		DOE P 450.5
10	Applicability of DOE Nuclear Maintenance Directives to DOE Contractors	Requirements DOE Employees Can Impose on DOE Contractors Operating DOE-Owned or Utilized and Controlled Property	10 CFR Subpart A 48 CFR 45.509 DEAR 970-5204-2 PAAA DOE 5400.5	DOE O 433.1	DOE G 433.1-1	DOE G 450.4-2 DOE O 414.1A DOE O 420.1 DOE O 440.1 DOE 4330.4B-10 DOE 5480.21 DOE 5480.22 DOE 5480.23 DOE P 450.4 DOE-STD-1073-93	48 CFR 45.103	DOE O 224.1 DOE O 430.1

Table 1-A. Crosswalk to Department of Energy Related Maintenance Documents (continued)

NUCLEAR							NON NUCLEAR	
MAINTENANCE ISSUE				NEW	NEW	OLD		
Item No.	Subject	Main Topic	Regulatory Requirement	DOE Requirement	Guidance	Previously Resided In	Regulatory Requirement	DOE Requirement
E1	Capital Asset Management Process for DOE Facilities Maintenance	Prioritization of Resources to Ensure that Sufficient Resources Are Budgeted In A Timely Manner to Accomplish The Nuclear Maintenance Program	FAR 48 CFR 7.1 52 CFR 952.211.72	DOE G 430.1-1 DOE O 130.1 DOE O 135.1 DOE O 433.1	DOE G 433.1-1	DOE O 420.1 DOE O 425.1 DOE 4330.4B-5b, 8g DOE P 450.5 DOE-STD-1073-93	48 CFR 7.1, Life Cycle Costs	DOE O 430.1 DOE O 130.1 DOE O 135.1 DOE 4010.1A DOE 4330.5 DOE O 130.1 DOE O 135.1
E2	Appropriate Use of DOE Facilities Maintenance Management Program Elements	Maintenance Organization and Administration	10 CFR 830, Subpart A Criterion 1 ISMS Principles 1,2,7	DOE O 433.1	DOE-EGS-95-01 DOE-EGS-98-01 DOE-EGS-98-02 DOE-EGS-99-01 DOE-EGS-99-02 DOE-EGS-00-01 DOE G 433.1-1 DOE-HDBK-1085-95 DOE-HDBK-1087-95 DOE-HDBK-1089-95	DOE 4330.4B-II: 1-8 DOE-STD-1051-93		
E3	Maintain Personnel Knowledge and Skills Needed to Effectively Perform Maintenance Activities	Training and Qualification of Maintenance Personnel	10 CFR 830, Subpart A Criterion 2 ISMS Principle 3	DOE O 433.1	DOE-EGS-95-01 DOE-EGS-98-01 DOE-EGS-98-02 DOE-EGS-99-01 DOE-EGS-99-02 DOE-EGS-00-01 DOE G 433.X-X-2000 DOE-HDBK-1085-95 DOE-HDBK-1087-95 DOE-HDBK-1089-95	DOE-HDBK-1003-96 DOE O 360.1 DOE O 414.1 DOE O 4330.4B-II: 8-14 DOE O 5480.20 DOE-STD-1012-92 DOE-STD-1059-93 DOE-STD-1060-93 DOE-STD-1061-93 DOE-STD- 1077-94		
E4	Facilities, Equipment and Tools Are Adequate to Support Maintenance Activities	Maintenance Facilities, Equipment and Tools		DOE O 433.1	DOE-EGS-95-01 DOE-EGS-98-01 DOE-EGS-98-02 DOE-EGS-99-01 DOE-EGS-99-02 DOE-EGS-00-01 DOE G 433.X-X-2000 DOE-HDBK-1085-95 DOE-HDBK-1087-95 DOE-HDBK-1089-95	DOE 4330.4B-II: 14-18 DOE STD 1067-94		
E5	A Proper Balance of Preventive and Corrective Maintenance to Ensure Nuclear Safety and Cost Effectiveness	Types of Maintenance	ISMS Principle 4 ISMS Function 1 10CFR 830, Subpart A Criterion 5 29 CFR 1910.119 48 CFR 45.509	DOE O 433.1	DOE-EGS-95-01 DOE-EGS-98-01 DOE-EGS-98-02 DOE-EGS-99-01 DOE-EGS-99-02 DOE-EGS-00-01 DOE G 433.X-X-2000 DOE-HDBK-1085-95 DOE-HDBK-1087-95 DOE-HDBK-1089-95	DOE 4330.4B-II: 18-24 DOE-STD-1052-93	48 CFR 45.509(a)(b)	DOE O 430.1

Table 1-A. Crosswalk to Department of Energy Related Maintenance Documents (continued)

NUCLEAR							NON NUCLEAR	
MAINTENANCE ISSUE				NEW	NEW	OLD		
Item No.	Subject	Main Topic	Regulatory Requirement	DOE Requirement	Guidance	Previously Resided In	Regulatory Requirement	DOE Requirement
E6	Maintenance Procedures and Other Work Related Documents Are Prepared and Used to Ensure Maintenance is Performed Safely and Efficiently	Maintenance Procedures	10 CFR 830, Subpart A Criteria 4, 5 ISMS Principles 5, 6 ISMS Functions 4, 5	DOE O 433.1	DOE-EGS-95-01 DOE-EGS-98-01 DOE-EGS-98-02 DOE-EGS-99-01 DOE-EGS-99-02 DOE-EGS-00-01 DOE G 433.1-1 DOE-HDBK-1085-95 DOE-HDBK-1087-95 DOE-HDBK-1089-95	DOE 4330.4B-II: 25-29 DOE-STD-1029-92 DOE 5480.19 DOE-STD-1073-93 DOE- STD-1029-92 DOE-STD-1030-96		DOE 5700.7C
E7	Coordination of Maintenance Activities is Implemented to Ensure Nuclear Safety Objectives Are Achieved	Planning, Scheduling and Coordinating Maintenance	10 CFR 830, Subpart A Criterion 1 ISMS Principles 1, 4 ISMS Function 1	DOE O 433.1	DOE-EGS-95-01 DOE-EGS-98-01 DOE-EGS-98-02 DOE-EGS-99-01 DOE-EGS-99-02 DOE-EGS-00-01 DOE G 433.1-1 DOE-HDBK-1085-95 DOE-HDBK-1087-95 DOE-HDBK-1089-95	DOE 4330.4B-II: 29-39 DOE 5480.19 DOE-STD-1030-96 DOE-STD-1050-93 DOE-STD-1073-93	48 CFR 45.509-1(c)	DOE O 430.1 DOE 5700.7C
E8	Management Control Over Maintenance Activities Ensures Safe Facility Operations	Control of Maintenance Activities	10 CFR 830 Subpart A Criterion 1, 5 ISMS Principle 2 1,2,7 ISMS Function 4	DOE O 433.1	DOE-EGS-95-01 DOE-EGS-98-01 DOE-EGS-98-02 DOE-EGS-99-01 DOE-EGS-99-02 DOE-EGS-00-01 DOE G 433.1-1 DOE-HDBK-1085-95 DOE-HDBK-1087-95 DOE-HDBK-1089-95	DOE 4330.4B-II: 43-50 DOE 5480.19 DOE-STD-1030-96 DOE-STD-1053-93 DOE-STD-1073-93		DOE 5700.7C
E9	Testing is Performed to Verify SSCs Will Perform Their Design Function When Returned to Service After Maintenance	Postmaintenance Testing	10 CFR 830, Subpart A, Criterion 8	DOE O 433.1	DOE-EGS-95-01 DOE-EGS-98-01 DOE-EGS-98-02 DOE-EGS-99-01 DOE-EGS-99-02 DOE-EGS-00-01 DOE G 433.1-1 DOE-HDBK-1085-95 DOE-HDBK-1087-95 DOE-HDBK-1089-95	DOE 5480.19 DOE 4330.4B-II: 50-54 DOE-STD-1039-93 DOE-STD-1065-94		
E10	Parts, Materials and Services Are Purchased and Available for Maintenance Activities	Procurement of Parts, Materials and Services	10 CFR 830, Subpart A, Criterion 7	DOE O 433.1	DOE-EGS-95-01 DOE-EGS-98-01 DOE-EGS-98-02 DOE-EGS-99-01 DOE-EGS-99-02 DOE-EGS-00-01 DOE G 433.1-1 DOE-HDBK-1085-95 DOE-HDBK-1087-95 DOE-HDBK-1089-95	DOE G 440.1-6 DOE 4330.4B-II: 56-59	48 CFR 46	DOE 2110.1A

Table 1-A. Crosswalk to Department of Energy Related Maintenance Documents (continued)

NUCLEAR							NON NUCLEAR	
MAINTENANCE ISSUE				NEW	NEW	OLD		
Item No.	Subject	Main Topic	Regulatory Requirement	DOE Requirement	Guidance	Previously Resided In	Regulatory Requirement	DOE Requirement
E11	Policies and Procedures Adequately Control Items Procured Until They Are Installed In Nuclear Facilities	Material Receipt, Inspection, Handling, Storage, Retrieval and Issuance	10 CFR 830, Subpart A, Criterion 7	DOE O 433.1	DOE-EGS-95-01 DOE-EGS-98-01 DOE-EGS-98-02 DOE-EGS-99-01 DOE-EGS-99-02 DOE-EGS-00-01 DOE G 433.1-1 DOE-HDBK-1085-95 DOE-HDBK-1087-95 DOE-HDBK-1089-95	DOE G 440.1-6 DOE 4330.4B-II: 59-63 DOE-STD-1071-94	48 CFR 46.5	
E12	Instruments are Accurately Calibrated to Ensure Reliable Performance of Tested Nuclear Facility Equipment	Control and Calibration of Measuring and Test Equipment	10 CFR 830, Subpart A, Criteria 5, 8	DOE O 433.1	DOE-EGS-95-01 DOE-EGS-98-01 DOE-EGS-98-02 DOE-EGS-99-01 DOE-EGS-99-02 DOE-EGS-00-01 DOE G 433.1-1 DOE-HDBK-1085-95 DOE-HDBK-1087-95 DOE-HDBK-1089-95	DOE 4330.4B-II: 64-69 DOE-STD-1054-93		
E13	The Availability, Storage and Issuance of Maintenance Tools and Equipment Adequately Supports Maintenance Activities	Maintenance Tools and Equipment Control	10 CFR 830, Subpart A, Criteria 3, 8	DOE O 433.1	DOE-EGS-95-01 DOE-EGS-98-01 DOE-EGS-98-02 DOE-EGS-99-01 DOE-EGS-99-02 DOE-EGS-00-01 DOE G 433.1-1 DOE-HDBK-1085-95 DOE-HDBK-1087-95 DOE-HDBK-1089-95	DOE 4330.4B-II: 70-72 DOE-STD-1069-94		
E14	Periodic Assessment of Facility and Equipment Condition is Performed to Identify and Correct Deficiencies	Facility Condition Inspection	10CFR830, Subpart A Criteria 3, 8	DOE O 433.1	DOE-EGS-95-01 DOE-EGS-98-01 DOE-EGS-98-02 DOE-EGS-99-01 DOE-EGS-99-02 DOE-EGS-00-01 DOE G 433.1-1 DOE-HDBK-1085-95 DOE-HDBK-1087-95 DOE-HDBK-1089-95	DOE O 420.1 DOE 4330.4B-II: 72-78 DOE- STD-1072-94	48 CFR 45.103 48 CFR 45.509-1(b)(d),	DOE 3790.1B
E15	Contractor Management Is Sufficiently Involved to be Knowledgeable and Technically Competent in Nuclear Facility Conditions and Operations	Management Involvement	10CFR830, Subpart A, Criteria 2, 10	DOE O 433.1	DOE-EGS-95-01 DOE-EGS-98-01 DOE-EGS-98-02 DOE-EGS-99-01 DOE-EGS-99-02 DOE-EGS-00-01 DOE G 433.1-1 DOE-HDBK-1085-95 DOE-HDBK-1087-95 DOE-HDBK-1089-95	DOE 4330.4B-II: 79-80 DOE STD 1068-94 DOE STD 1055-93 DOE P 450.4		

Table 1-A. Crosswalk to Department of Energy Related Maintenance Documents (continued)

NUCLEAR							NON NUCLEAR	
MAINTENANCE ISSUE				NEW	NEW	OLD		
Item No.	Subject	Main Topic	Regulatory Requirement	DOE Requirement	Guidance	Previously Resided In	Regulatory Requirement	DOE Requirement
E16	Historical Information is Trended for Maintenance Planning and Performance Indicators	Maintenance History	10 CFR 830, Subpart A, Criterion 3 41 CFR Subtitle C 41 CFR 101-3 41 CFR 101 41 CFR 102 48 CFR 45.509	DOE O 200.1 DOE O 433.1 DOE PDL 970.3	DOE-EGS-95-01 DOE-EGS-98-01 DOE-EGS-98-02 DOE-EGS-99-01 DOE-EGS-99-02 DOE-EGS-00-01 DOE G 433.1-1 DOE-HDBK-1085-95 DOE-HDBK-1087-95 DOE-HDBK-1089-95	DOE O 200.1 DOE O 210.1 DOE 4330.4B-II: 84-86 DOE-STD-1068-94		DOE O 200.1 DOE O 210.1
E17	Infrastructure Elements Identified as Part of a Facility Safety Basis Are Systematically Analyzed for Safety Implications	Analysis of Maintenance Problems	DEAR 970-5204-2 PAAA 10 CFR 830, Subpart A, Criterion 3 ISMS Principle 4	DOE O 433.1	DOE-EGS-95-01 DOE-EGS-98-01 DOE-EGS-98-02 DOE-EGS-99-01 DOE-EGS-99-02 DOE-EGS-00-01 DOE G 433.1-1 DOE-HDBK-1085-95 DOE-HDBK-1087-95 DOE-HDBK-1089-95	DOE-HDBK-7502-95 DOE O 200.1 DOE O 210.1 DOE O 225.1A DOE 4330.4B-II: 87-94 DOE 5480.21 DOE 5480.22 DOE 5480.23 DOE-STD-1004-92 DOE-STD-1027-92 DOE-STD-7501-95		DOE O 200.1 DOE O 210.1 DOE O 225.1A
E18	Modification Work is Controlled so That There Are No Increased Risks Involved With Facility Operations	Modification Work	10 CFR 830, Subpart A, Criteria 5, 6 ISMS Principles 7 ISMS Function 4	DOE O 433.1	DOE-EGS-95-01 DOE-EGS-98-01 DOE-EGS-98-02 DOE-EGS-99-01 DOE-EGS-99-02 DOE-EGS-00-01 DOE G 433.1-1 DOE-HDBK-1085-95 DOE-HDBK-1087-95 DOE-HDBK-1089-95	DOE O 420.1 DOE O 440.1 DOE 4330.4B-II: 94-95 DOE 5480.19 DOE- STD-1039-93 DOE-STD-1073-93 DOE-STD-1120-98	DOE 5700.7C	
E19	Potential External Climate and Environmental Impacts Are Forecasted and Addressed	Seasonal Facility Preservation Requirements	10 CFR 830, Subpart A, Criterion 3.8	DOE O 433.1	DOE-EGS-95-01 DOE-EGS-98-01 DOE-EGS-98-02 DOE-EGS-99-01 DOE-EGS-99-02 DOE-EGS-00-01 DOE G 433.1-1 DOE-HDBK-1085-95 DOE-HDBK-1087-95 DOE-HDBK-1089-95	DOE 3790.1B DOE 4330.4B-II: 96 DOE 5400.5 DOE 5480.19 DOE-STD-1064-94 DOE-STD-1073 DOE-STD-1120-98		DOE 4010.1A
E20	DOE Facilities Maintenance Management Program Success Model				DOE-EGS-95-01 DOE-EGS-98-01 DOE-EGS-98-02 DOE-EGS-99-01 DOE-EGS-99-02 DOE-EGS-00-01 DOE G 433.1-1 DOE-HDBK-1085-95 DOE-HDBK-1087-95 DOE-HDBK-1089-95	DOE 4330.4B-II		

Table 1-A. Crosswalk to Department of Energy Related Maintenance Documents (continued)

NUCLEAR								
MAINTENANCE ISSUE				NEW	NEW	OLD	NON NUCLEAR	
Item No.	Subject	Main Topic	Regulatory Requirement	DOE Requirement	Guidance	Previously Resided In	Regulatory Requirement	DOE Requirement
E21	Maintenance Implementation Plan	Reliable Performance of SSCs is Achieved Through Effective Planned Implementation and Control of Maintenance Activities	DEAR 970-5204-2 ISMS Functions 1, 5 ISMS Principles 1, 2, 7	DOE O 433.1	DOE-EGS-95-01 DOE-EGS-98-01 DOE-EGS-98-02 DOE-EGS-99-01 DOE-EGS-99-02 DOE-EGS-00-01 DOE G 433.1-1 DOE-HDBK-1085-95 DOE-HDBK-1087-95 DOE-HDBK-1089-95	DOE O 232.1A DOE O 414.1 DOE O 420.1 DOE O 425.1 DOE O 451.1A DOE O 452.1A DOE O 452.2A DOE 4330.4B DOE 5480.19 DOE 5480.21 DOE 5480.23 DOE 5480.22 DOE P 450.1 DOE P 450.2A DOE-STD-1120-98		
E22	Radiation Exposures Are Kept As Low As Reasonable Achievable (ALARA)	ALARA - Concept is Used to Keep Radiation Exposures to a Minimum	DEAR 970-5204-2 PAAA DOE 5400.5	DOE O 433.1	DOE-EGS-95-01 DOE-EGS-98-01 DOE-EGS-98-02 DOE-EGS-99-01 DOE-EGS-99-02 DOE-EGS-00-01 DOE G 433.1-1 DOE-HDBK-1085-95 DOE-HDBK-1087-95 DOE-HDBK-1089-95	DOE O 414.1 DOE P 441.1 DOE 4330.4B		DOE 3790.1B

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II. DISCUSSION

Experience has shown that operating facilities perform more efficiently when they have well-defined, effectively administered policies and programs to govern maintenance activities.[9] This implementation Guide has been prepared to assist DOE employees in the oversight of DOE contractor programs important to nuclear facility maintenance. For the purpose of this Guide, maintenance includes those functions performed primarily by mechanical, electrical, instrumentation and control, and material management/services procurement organizations. Although these organizations may have different managers, applicable sections of this Guide still apply to them and their functions. However, not all activities in the maintenance area are addressed. Some, such as methods for compliance with Technical Safety Requirements (TSR),[47] surveillance and in-service inspection (ISI) requirements, and the technical aspects of specific equipment maintenance, are not included because they involve nuclear-facility-specific situations requiring unique direction; however, use of this Guide should support and complement performance of those activities.

Several DOE enforcement actions have illustrated the need to take a comprehensive, graded approach to the establishment and implementation of maintenance work controls that is commensurate with the hazard and risk to workers and the public, as well as other factors. The examples illustrate the need to apply QA, safety management, Configuration Management, human factors engineering, Conduct of Operations, and other operational programs in an integrated fashion to control work at a nuclear facility, with a focus beyond the work involving equipment referenced in the SAR or TSR. The extent of these work controls should be graded as outlined in 10 CFR 830.3 (see DOE-HDBK-1085-95, DOE-HDBK-1087-95, DOE-HDBK-1089-95, DOE-EGS-95-01, DOE-EGS-98-01, DOE-EGS-98-02, DOE-EGS-99-01, DOE-EGS-99-02, and DOE-EGS-00-01). However, some contractors operating DOE nuclear facilities have narrowly construed "nuclear safety" to require a direct nexus between the regulated activity and public health and safety such that a violation of the requirements would be the immediate cause of a health or safety impact. This nexus is not so direct or the definition so narrow. The nexus might be as broad as the requirement to implement a QA program (QAP) that relates to nuclear activities. Violation of a QA requirement may not result in a direct or potential immediate threat to health or safety, but it could be an important link in a sequence of activities that could lead to a nuclear accident or radiological exposure. Some examples of the various DOE work-control noncompliances with 10 CFR 830 are outlined in the following paragraphs.

Sumps were being installed at a nuclear facility to contain any fluid spills and to preclude releases that might violate environmental restrictions. The sumps were not a nuclear safety feature but were being installed in an area that contained switchgear, cabling, and power feeds for the facility safety features. The sumps installation was not contained within the boundaries of the nuclear facility; however, several problems and noncompliances were involved in this work: (1) the work was performed without a procedure or work instruction, (2) workers were verbally told approximately where on the concrete floor to cut holes for sump installation, (3) no safety review was performed on what was located below the floor or on the potential safety impacts for work in the area, and (4) workers were verbally told to connect to a convenient power source, which could have resulted in an unreviewed connection to a safety related source and possibly unauthorized interruption of a safety-related power supply.

Although the immediate occurrence was a severe electrical shock to one of the workers and mild electrical shock to the work supervisor, the occurrence also had nuclear safety implications. With power feeds for safety equipment in the area, the potential existed for this work to cause loss of safety features intended to mitigate an accident or release.

In another example, a chemical tank explosion involved a non-safety-related tank containing a chemical liquid mixture, but no nuclear material. Evaporation changed the composition of the tank contents to a combustible mixture that exploded. The explosion caused severe damage to the facility, including blowing a hole in the building roof, which served as the confinement structure to contain any potential release of radioactive material. No radiological material was released; however, adjacent rooms contained nuclear material and could have been impacted in such an explosion. Additionally, various mitigating factors and equipment not referenced in the SAR potentially resulted in degraded performance of the emergency response function. These factors included the following: (1) failure to perform required surveillance of emergency breathing apparatus devices; (2) failures to make proper emergency response notifications; (3) failures to perform proper radiological surveys of workers potentially exposed to a release; and (4) failure of workers to take cover when such an alert had been announced. These failures illustrated the need to apply nuclear safety QA controls to work involving nonnuclear materials in a nuclear facility because of the potential to impact nuclear material and damage safety features. Additionally, these problems highlighted the need to ensure the quality of the emergency response program and supporting equipment.

In still another example, a fire and explosion occurred at a nuclear facility in which work involving nonnuclear material and not involving safety-related components identified in the SAR or TSR impacted nuclear safety. In this event, workers left a canister containing organic material unattended in an oven. Fortunately no nuclear material was present at the time. 10 CFR 830. work-control noncompliances related to this incident included (1) improper labeling on the canister, (2) lack of a procedure to control the work activity, and (3) informal communications on the work hazards involved and canister contents. This event also illustrates the need to control such work activities so they do not present a potential for release of nuclear material.

At another DOE nuclear facility, five workers received an unplanned but preventable radiological uptake. These workers were erecting scaffolding in support of electrical conduit cutting activities. At the same time and in the same area, other workers were cutting and removing pipe. The pipe cutting operation was being performed under a particular work procedure and Radiation Work Permit (RWP) that included requirements for use of respirators, personnel monitoring, and area monitoring. The work planning and work controls for the scaffolding set-up had no such controls, and, consequently, the workers performing this activity received radiological uptakes. The scaffolding work did not involve nuclear material, safety systems or features referenced in the SAR.[48] However, the work, performed in a nuclear facility had the potential for exposing workers to radiological harm.

Section 4 of this Guide describes each of the 18 maintenance management program elements important to a good maintenance program. Each element should be addressed in a MIP as discussed in Section 3. Each program element section is organized into three subsections. First, an introductory subsection briefly describes the objectives to be achieved; addressing each of the objectives is a requirement for an adequate maintenance program. Next, a discussion subsection describes the actions needed to accomplish the objectives and includes a brief explanation of why these actions are necessary or important. Finally, a guidelines subsection provides specific guidance for meeting the section objectives. In many cases, example situations accompany the guidelines. These examples have been provided for illustration to aid in understanding the guidelines and should not be construed as the only methods for meeting the intent of the guidelines.

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III. GUIDANCE

To implement a maintenance management program, the key responsible people must be identified and MIPs must be developed, approved, and implemented to ensure that the objectives are met. In addition, plant-specific procedures are needed that reflect the variations in facility type, purpose, and design. The MIP and specific procedures should be consistent with interfacing technical directives (e.g., QA and training).

This Guide describes the actions and procedures that, if used by DOE contractors in implementing the requirements of DOE O 433.1, will satisfy the intent of the Order; the Department of Energy Acquisition Regulation (DEAR), 48CFR 970.5204; DOE O 430.1A; 48 CFR 45.509; 29 CFR 1910.119; 10 CFR 830, Subpart A; DOE O 5400.5; 10 CFR 835; and 52 CFR 952.211.72.

1. DEFINITIONS, ACRONYMS, AND REFERENCES

1.1 DEFINITIONS

The following definitions are established to provide a clear understanding of maintenance management and to promote consistency with other requirements relating to property.

ACCEPTANCE TAG. The final receipt inspection identifier affixed to an item before placing the item in storage. It indicates all purchase requirements have been met.

ACOUSTICAL/ULTRASONIC TESTING. A technique used to measure acoustical emissions from components such as valves and heat exchangers. This technique is used to monitor valves for leakage and heat exchangers for proper flow rates. In addition, ultrasonic testing may detect weld crack propagation and check for piping erosion/corrosion effects.

ACTUAL MAINTENANCE COST. The actual costs spent on performing (corrective, preventive and predictive) maintenance actions. Corrective maintenance cost is the cost to repair failed or malfunctioning equipment, systems, or facilities to restore the intended function or design condition. Preventive maintenance cost is the cost of all systematically planned or scheduled actions required to prevent the failure of equipment, systems, structures, or facilities. Predictive maintenance cost is the cost to monitor, find trends, and analyze parameters, performance characteristics, properties, and signatures associated with equipment, systems, or facilities that are indicative of decreasing performance or impending failure.

ALARA (as low as reasonably achievable). The approach to radiation protection to manage and control exposures (both individual and collective) to the work force and to the general public to as low as is reasonable, taking into account social, technical, economic, practical, and public policy considerations. As used in this part, ALARA is not a dose limit but a process which has the objective of attaining doses as far below the applicable limits of this part as is reasonably achievable.

APPLICABLE. The characteristic of a preventive maintenance task when it is capable of improving the reliability of the component by modifying the way a component fails and its failure rate.

ASSETS. See Physical Assets.

ASSET MANAGEMENT SYSTEMS. Processes and/or procedures that are employed for nonprogrammatic management of a facility or physical asset.

AVAILABILITY. The time a mission critical SSC, machine, or system is available for use. From the overall SSC/equipment effectiveness calculation, the actual run time of a mission critical SSC/machine or system divided by the scheduled run time.

NOTE: Availability differs slightly from Asset Utilization (Uptime) in that scheduled run time varies between facilities and is changed by factors such as scheduled maintenance actions, logistics, or administrative delays.

BASELINE. A quantitative expression of projected costs, schedule, and technical requirements; the established plan against which the status of resources and the progress of a project can be measured.

BLANK FLANGE. A device installed in a mechanical system to stop flow.

BUILDING. A roofed structure that is suitable for housing people, material, or equipment. Also included are sheds and other roofed structures that provide partial protection from the weather.

CALIBRATION. The comparison of readings from the instruments being tested with validated readings observed on the measurement standards.

CANDIDATES FOR TRANSFER. Land and facilities that include (a) contaminated facilities for which DOE has responsibility or owns; (b) contaminated portions of facilities, if structurally independent and with separate utilities and support systems; (c) real property or related personal property that is ancillary to a candidate facility; (d) facilities otherwise agreed to by the DOE parties involved.

CERTIFICATION. An indication by the appropriate authority that the deviations determined in the calibration do not exceed specified limits.

CHECKOUT AND VERIFICATION. A form of postmaintenance testing using standard maintenance practices, as well as craft skills and knowledge, to prove that equipment is operable as designed.

COMPONENT. A piece of equipment, such as a pump, valve, motor, or instrument that is normally assigned a unique equipment identifier.

COMPONENT FAILURE. Loss of ability of a component to perform one or more of its functions.

COMPUTERIZED MAINTENANCE HISTORY ENGINEERING DATABASE. A set of computer software modules and equipment databases containing facility data with the capability to process the data for facilities maintenance management functions. This set provides historical data, report writing capabilities, job analysis, and more. The data describe equipment, parts, jobs, crafts, costs, step-by-step instructions, and other information involved in the maintenance effort. This information may be stored, viewed, analyzed, reproduced and updated with just a few keystrokes. The maintenance-related functions typically include—

- Maintenance cost and reliability data.
- Facility/equipment inventory.
- Facility/equipment history.
- Work input control.
- Job estimating.
- Work scheduling and tracking.
- Preventive and predictive maintenance.
- Facility inspection and assessment.
- Material management.
- Utilities management.

CONCEPTUAL DESIGN. The activities required to evaluate project design alternatives and to develop sufficient detail to baseline the scope, cost and schedule for project authorization.

CONDITION-DIRECTED TASK. A task performed when component performance or condition reaches a limit (either predefined or determined by engineering evaluation) measured by performance or condition monitoring test where continued satisfactory operation cannot be ensured.

CONDITION ASSESSMENT SURVEY (CAS). A periodic inspection of capital assets using universally accepted methods and standards. CAS results in a determination of the current condition of capital assets, their estimated time of failure, and the estimated cost to correct the identified deficiencies. CAS provides a consistent assessment of capital assets for planning purposes based on actual conditions.

CONDITION MONITORING. Tests and inspections that may be accomplished on an unobtrusive basis to identify a potential failure. Condition monitoring includes established predictive maintenance techniques.

CONTAMINATED FACILITIES. DOE facilities that have structural components and/or systems contaminated with hazardous chemical and/or radioactive substances, including radionuclides. This definition excludes facilities that contain no residual hazardous substances other than those present in building materials and components, such as asbestos-containing material, lead-based paint, or PCB-containing equipment. This definition excludes facilities in which bulk or containerized hazardous substances, including radionuclides, have been used or managed if no contaminants remain in or on the structural components and/or systems.

CORRECTIVE ACTION. The action required to bring a deficient item into conformity with a standard. For material deficiencies requiring maintenance action, the corrective action may consist of identifying the deficiencies, submitting a Work Request/Work Order for corrective activities, and tracking the deficiency. Deficiencies should be reported in accordance with applicable policies and procedures.

CORRECTIVE (REPAIR) MAINTENANCE. The repair of failed or malfunctioning equipment, system, or facilities to restore the intended function or design condition. This maintenance does not result in a significant extension of the expected useful life.

CRAFT SKILLS. A defined set of work skills that are considered common knowledge to a craft person performing work.

CRITICAL DECISION. A formal determination at a specific point in a project that allows the project to proceed. Critical decisions occur in the course of a project, for example, before conceptual design, execution, and turnover.

CRITICAL PARTS/ITEMS. Parts or items whose failure may cause personal injury, harm the environment, or jeopardize security or a vital plant mission.

DEACTIVATION. The process of placing a facility in a safe and stable condition including the removal of readily removable hazardous and radioactive materials to minimize the long-term cost of a surveillance and maintenance program that is protective of workers, the public and the environment.

DEACTIVATION PROJECT FINAL REPORT. The document prepared after the technical work has been performed and verified and that describes the deactivation project activities, accomplishments, final facility status, and cost and performance information.

DECOMMISSIONING. Takes place after deactivation and includes surveillance and maintenance, decontamination, and/or dismantlement. These actions are taken at the end of the life of a facility to retire it from service with adequate regard for the health and safety of workers and the public and protection of the environment. The ultimate goal of decommissioning is unrestricted release or restricted use of the site.

DECONTAMINATION. The removal or reduction of residual radioactive and hazardous materials by mechanical, chemical or other techniques to achieve a stated objective or end condition.

DEFERRED MAINTENANCE. Maintenance that was not performed when it should have been or was scheduled to be and which, therefore, is put off or delayed for a future period and reported annually.

DEFERRED MAINTENANCE COST. Maintenance cost that was not performed when it should have been or was scheduled to be and which, therefore, is put off or delayed for a future period. For the purpose of reporting deferred maintenance of DOE real property, deferred maintenance is that cost required to restore a facility to its current use as-built condition. Maintenance cost/work do not include the following:

- Regularly scheduled janitorial work such as cleaning and preserving facilities and equipment.
- Work performed in relocating or installing partitions, office furniture, and other associated activities.
- Work usually associated with the removal, moving, and placement of equipment.
- Work aimed at expanding the capacity of an asset or otherwise upgrading it to serve needs different from or significantly greater than those originally intended.
- Improvement work performed directly by in-house workers or in support of construction contractors accomplishing an improvement.
- Work performed on special projects not directly in support of maintenance or construction.
- Nonmaintenance roads and grounds work, such as grass cutting and street sweeping.

DEFICIENCY. Any condition that deviates from the designed-in capacity of an SSC and results in a degraded ability to accomplish its intended function.

DEFICIENCY TAG/STICKER. A small tag or adhesive-backed sticker that is used to identify a facility material deficiency. The form may be marked with a serialized number for administrative control, Work Order identification, and deficiency location by maintenance personnel.

DESIGN VERIFICATION. The process of independently reviewing, confirming, or substantiating the assumptions, inputs, methodology, and outputs used in a modification/maintenance work package. This verification ensures the design is correct and that the intended work should solve the identified problem without creating new problems.

DISABLED ANNUNCIATOR ALARM. A modification that disables the visual and/or audible alarm function of an annunciator.

DISPOSAL. Permanent or temporary transfer of DOE control and custody of real property to a third party who thereby acquires rights to control, use, or relinquish the property.

DISPOSITION. Those activities that follow completion of program mission, including, but not limited to, surveillance and maintenance, deactivation, and decommissioning.

DOCUMENTED POSTMAINTENANCE TESTING. Rigorous, formal documentation of postmaintenance testing.

DOE ELEMENTS. First tier organizations at Headquarters and in the field. Field Elements include all operations offices, field offices, energy technology centers, and power marketing administrations.

DOE FACILITIES. Any of the DOE-owned, leased, or - controlled facilities.

DOMINANT FAILURE MODE. The most probable failure mode of a component during its design life.

ECONOMIC LIFE LIMIT. The time a component is expected to remain in-service before the need for replacement of the component based on cost-effectiveness to reduce the frequency of age-related failures.

EFFECTIVENESS. The capability of a preventive maintenance task to improve component reliability to a given level under cost, implementation, and other constraints.

ELECTRIC CIRCUIT MONITORING. A technique used to determine the condition of a circuit and aid in fault location. This technique performs basic measurements such as inductance, capacitance, and resistance, and measures distance through time domain reflectometry. Electric circuit monitoring is effective in determining the condition of electrical connections, contacts, terminations, moisture damage, and damaged insulation and its location.

ENVIRONMENT, SAFETY, AND HEALTH (ES&H) MAINTENANCE. Maintenance that ensures safe, environmentally compliant facilities, whether facilities are in transition, in current use or not.

ELECTRICAL JUMPER. A temporary electrical connection that bypasses components within an electrical circuit, modifying the circuit design or configuration.

EQUIPMENT. The systems and devices used throughout DOE and commonly referred to as equipment are divided into three categories for the purpose of this Order. It is the intent of this definition to separately identify the installed equipment that can logically be considered as an integral part of a real property improvement from other types of equipment. The purpose of such a determination is to provide a uniform basis for analysis of various maintenance and repair costs. [DOE O 4330.4B]

1. Installed Equipment**.** This category includes the mechanical and electrical systems that are installed as part of basic building construction and are essential to the normal functioning of the facility and its intended use. Examples are heating, ventilating, and air-conditioning (HVAC) systems; elevators; and communications systems.

2. Programmatic Equipment**.** Equipment (both real and personal) dedicated for a specific programmatic use. Examples are accelerators, microscopes, radiation detection equipment, glove boxes, and hotcells.

3. Other Equipment**.** Some examples in this category are office machines, vehicles and mobile equipment, helicopters, airplanes, and computers and other automated data-processing equipment.

EXCESS. Physical assets that are not required for DOE needs and the discharge of its responsibilities.

FACILITY (FACILITIES). Land, buildings, and other structures, their functional systems and equipment, and other fixed systems and equipment installed therein, including site development features outside the plant, such as landscaping, roads, walks, and parking areas; outside lighting and communication systems; central utility plants; utilities supply and distribution systems; and other physical plant features. A building, utility, structure, or other land improvement associated with an operation or service and dedicated to a common function

FACILITY (FACILITIES) MANAGEMENT. A documented process by which facilities are operated and maintained.

FACILITY INFORMATION MANAGEMENT SYSTEM (FIMS). DOE's corporate database management system with the universe of DOE real property information, its status, and funds needed and requested for maintenance. FIMS is used for real property management and for reporting to the General Services Administration, Congress, and the public.

FAILURE. See definition of functional failure.

FAILURE CAUSE. The physical mechanisms or reasons that produced the failure.

FAILURE DATA ANALYSIS. Analysis of past component performance, maintenance, and repair histories to predict future availability, recognizing that historical data have predictive value only to the extent that the conditions under which the data were generated remain applicable.

FAILURE EFFECTS. The consequences of a failure.

FAILURE-FINDING TASK. A task performed to discover hidden failures when no other tasks are judged to be applicable and effective in detecting degradation in component performance.

FAILURE MODE. The particular type or manner of failure. A failure mode describes what may or has happened as opposed to what caused it to happen. For example, a motor-driven pump fails to run or a circuit breaker fails to open are different kinds of failure modes.

FAILURE MODE AND EFFECTS ANALYSIS (FMEA). A technique used to determine significant failure modes of critical components by analyzing the effect of the failure on a system or the facility and the likelihood of the failure mode to occur.

FAILURE RATE. The number of mission critical SSC failures divided by an interval such as time or cycles. The failure will change over time and can be greater than one (but will never be less than zero).

FAILURE RATE DATABASE. Facility specific or generic historical data on component failures and failure modes extracted from log books, maintenance records, Work Orders or other documents and computerized so that reliability parameters can be derived. An automated database of specific types of SSC failure rates and performance trends that can be used to scientifically justify appropriate changes to maintenance task/frequency intervals, based on empirical service history and operating experience. An effective preventive maintenance program needs a comprehensive component reliability and failure rate database. The database serves as a scientifically sound basis for compiling maintenance task/frequency intervals for a given type of SSC. Comparisons within the database may serve as a useful inspection tool when using probabilistic risk assessment techniques to identify vulnerable critical areas of SSCs important to safety.

FIELD ATTENDANT. Person responsible for the issuance and checking in of tools and equipment used in radiological areass during major maintenance activities or outages.

FIXED CONTAMINATION. Radioactive material that cannot be readily removed from surfaces by nondestructive means, such as casual contact, wiping, brushing or washing.

FUNCTION. The actions or requirements that a component or system should accomplish, sometimes defined in terms of performance capabilities.

FUNCTIONAL FAILURE. A failure that results in a loss of component or system function(s). The failure may be active or passive, evident or hidden.

FUNCTIONAL TEST. A test to verify the functional design. It should ensure that the as-built functions as intended under design basis conditions and is properly integrated into the facility systems for normal and transient conditions.

FUNCTIONALLY CRITICAL EQUIPMENT (FCE). Equipment whose failure results in a loss of system function or whose frequency and severity of failure have an adverse impact on facility operation. FCE may be an individual component or an entire subsystem.

GENERAL MAINTENANCE. Maintenance that preserves the life cycle of physical assets.

GRACE PERIOD. A time period after the scheduled completion date in which the activity may be completed without being considered overdue. This time period is normally 25 percent of the scheduled interval.

GRADED APPROACH. The process of assuring that the level of analysis, documentation, and actions used to comply with a requirement in 10 CFR 830 are commensurate with—

- the relative importance to safety, safeguard, and security;
- the magnitude of any hazard involved;
- the life cycle stage of a facility;
- the programmatic mission of a facility;
- the particular characteristics of a facility;
- the relative importance of radiological and nonradiological hazards; and
- any other relevant factor.

GROSS ERROR. An out-of-tolerance condition for an instrument in the Measuring and Test Equipment (M&TE) Program which may result in an unacceptable product. When a facility handbook has not been prepared or does not list gross error limits, any condition outside the calibration limits, defined by supervision in the group using the equipment, is considered a gross error.

HAZARD CATEGORIES. The consequences of unmitigated releases of radioactive and/or hazardous material are evaluated as required by DOE-STD-1027-92 and classified by the following hazard categories.

CATEGORY 1. The hazard analysis shows the potential for significant offsite consequences.

CATEGORY 2. The hazard analysis shows the potential for significant onsite consequences.

CATEGORY 3. The hazard analysis shows the potential for only significant localized consequences.

HAZARDOUS MATERIALS. Any solid, liquid, or gaseous material that is toxic, explosive, flammable, corrosive, or otherwise physically or biologically threatening to health. Oil is excluded from this definition.

HOT (DISCRETE) PARTICLE. A small, loose, highly radioactive particle. These particles are highly transportable because of their small size and electrostatic charge.

HOUSEKEEPING. The cleaning and preservation of a facility, its systems and components. Also used to refer to the condition of facility cleanliness, orderliness, and preservation.

HURRICANE WATCH. Alerts an area of a possible hurricane within the next several days. It is observed and detected by abnormal wind disturbances and/or low pressure areas moving toward a fixed area.

HURRICANE WARNING. Issued when winds are expected to be greater than 74 mph within the next 24 hours. There may be heavy rain or high water, or a combination of these.

INDEPENDENT VERIFICATION. Check by one or more knowledgeable individuals not involved in the actual work.

INDUSTRIAL SAFETY PROGRAM. The overall program designed to minimize work-related injuries and illnesses through the identification, assessment, and correction of unsafe work practices and conditions.

IN-SERVICE. Any SSC considered operating, operable, or in standby for the facility operating modes for which the SSC should be in place.

IMPLAUSIBLE FAILURE. A failure from a rare or unexpected failure mechanism during the service life of the component while operating under normal or emergency conditions.

INFRASTRUCTURE. All real property and installed equipment and personal property that are not solely supporting a single program mission.

INSULATION RESISTANCE (MEGGERING). A technique used to measure leakage currents in electrical insulation. This technique is used in monitoring degradation of electrical insulation of motors, generators, and cables.

IN-LEAKAGE DETECTION. A technique using helium detectors to locate pathways for the ingress of contaminants into steam, condensate, and feedwater systems. This technique has proven to be effective in detecting air in-leakage into condensers, valves, and flanges.

ITEM. Any spare part, consumable, equipment, or material. May include entire component, valve, motor, instrument, gasket, adhesive, seal, etc.

LANDLORD PROGRAM OFFICE (Landlord). The Headquarters Program Office responsible for the support, planning, acquisition, operation, maintenance, and disposition of physical assets related to infrastructure.

LAYDOWN AREA. Area on or close to a job site, designated and approved by the facility to be used by maintenance personnel for the materials and equipment used on the maintenance job, for the duration of the job.

LESSONS LEARNED. Any experience, example, observation, or insight that imparts wisdom and/or beneficial knowledge to an employee during the conduct of the technical, procedural, business, legal, or administrative tasks associated with the design, development, fabrication, operation, and/or test of any product or service.

LIFE-CYCLE. The life of an asset from planning through acquisition, maintenance, operation, and disposition.

LIFE-CYCLE PLAN. An analysis and description of the major events and activities in the life of a functional unit from planning through decommissioning and site restoration. The plan documents the history of the functional unit and forecasts future activities, including major line item and expense projects and their duration, relationships, and impact on life expectancy. The plan also describes maintenance practices and costs.

LIFTED LEAD. A conductor which is disconnected from its normal circuit.

LINE ITEM PROJECT. Those separately identified project activities that are submitted for funding and are specifically reviewed and approved by Congress.

MAINTENANCE. The proactive and reactive day-to-day work that is required to maintain and preserve facilities and SSCs within them in a condition suitable for performing their designated purpose, and includes planned or unplanned periodic, preventive, predictive, seasonal or corrective (repair) maintenance.

MAINTENANCE BACKLOG. The number of overdue incomplete maintenance Work Orders for either planned or unplanned maintenance activities, including backlog due to aging and deterioration of facilities or facilities related equipment not accomplished at the end of the fiscal year.

MAINTENANCE IMPLEMENTATION PLAN (MIP). A contractor's documentation of a maintenance management program at DOE nuclear facilities in conformance with the objectives of DOE O 433.1. If approved by DOE, the MIP and the program implementation and baseline activities part of the site maintenance plan constitute agreements between the DOE field element and the contractor on the implementation of DOE O 433.1.

MAINTENANCE IMPORTANCE GENERATOR. A computerized system using predetermined rules to compare data on a Work Request/Work Order and to establish relative-importance ranking for each maintenance job.

MAINTENANCE MANAGEMENT. The administration of a program utilizing such concepts as organization, plans, procedures, schedules, cost control, periodic evaluation, performance indicators and feedback for the effective performance and control of maintenance with adequate provisions for interface with other concerned disciplines such as health, safety, environmental compliance, quality control, and security. All work done in conjunction with existing DOE facilities and property is either maintenance (preserving), repair (restoring), service (cleaning and making usable), or improvements (modifications). The work to be considered under the DOE nuclear safety maintenance management program includes all of these attributes.

MAINTENANCE PROCEDURE. A document providing direction to implement DOE policy, comply with DOE and external directives, laws or meet operational objectives in a consistent manner. A procedure provides adequately detailed delineation of instructions, roles, responsibilities, action steps, and requirements for conducting maintenance activities.

MAINTENANCE WORK INSTRUCTIONS. Written instructions provided to maintenance workers directing them on how to perform specific tasks. The level of detail of these instructions is based on the complexity of the task, special engineering considerations/specifications, and skill levels of the workers performing the task (referred to as the “skill of the craft”).

MAINTENANCE WORK PACKAGE. A consolidated document used by maintenance organizations that contains all the necessary procedures, instructions and requirements to safely and effectively perform a maintenance task. A maintenance task should not be considered complete until all of the requirements of the Maintenance Work Package have been satisfied.

MASTER EQUIPMENT LIST (MEL). A detailed master list of equipment, components, and structures to be included in the maintenance program. This list includes both safety-related and non-safety-related systems and equipment.

MATERIAL DEFICIENCY. A system or component with a physical defect that does not conform to a specified standard.

MEAN TIME BETWEEN FAILURES (MTBF). The average or expected value of operating time between failures of a repairable item.

MEASURING & TEST EQUIPMENT (M&TE). Includes all devices or systems used to calibrate, certify, measure, gauge, troubleshoot, test, or inspect in order to control data or to acquire data to verify conformance to specified requirements. M&TE does not include permanently installed facility instrumentation, nor does it include test equipment used for preliminary checks where data obtained are not used to determine acceptability or verify conformance to established criteria.

MECHANICAL JUMPER. Temporary connection such as a spool piece, hose, tygon-type level indicator tubing, ducting, or piping that joins two systems together or bypasses a component within a system, thus altering the system’s design or configuration. This does not include hoses connected from system drains to floor drains or providing air to pneumatic tools or breathing apparatus through normal service connections.

MINOR MAINTENANCE. Maintenance actions for deficiencies on facilities, equipment or parts where all the following conditions are met.

- The component is not important to safety. If the component is important to safety, the portion or part being worked does not perform or affect safety or a safety function and is physically isolated.
- The component or part does not perform an environmental qualification (EQ) function.
- The integrity of the component will not be violated.
- Material substitution will not be involved.
- Disassembly of the component or part will not be required.
- Welding will not be performed on a component or part of the component that is important to safety or seismically mounted.
- Welding will not be performed on a pressure vessel.
- Welding will not be performed on system piping.
- A lockout/tagout will not be required.
- The work performed is of such a minor nature that a written procedure is not required. However, if a procedure exists, it may be used.
- “Documented” postmaintenance testing will not be required.
- The work is of such a simple nature that a detailed Maintenance Work Package and job planning package are not required.

MISSION CRITICAL. An SSC that is critical to DOE/facility mission (production related, safety-related or safety significant).

MOTOR-OPERATED VALVE TESTING. A technique used to measure and analyze key motor-operator parameters such as running current, voltage, stem thrust, limit and torque switch set-points, and valve stroke times. This technique is extensively used to provide accurate indication that the motor-operated valve operates as designed under actual system conditions of temperature, flow, and pressure. Motor-operated valve testing is also used to trend performance to identify degrading conditions.

NONREACTOR NUCLEAR FACILITY. Those facilities, activities or operations that involve, or will involve, radioactive and/or fissionable materials in such form and quantity that a nuclear or a nuclear explosive hazard potentially exists to workers, the public, or the environment, but does not include accelerators and their operations and does not include activities involving only incidental use and generation of radioactive sources in research and experimental and analytical laboratory activities, electron microscopes, and X-ray machines.

NUCLEAR FACILITY. Reactor facilities and nonreactor nuclear facilities.

OUTAGE. A condition that exists whenever normal production operations have ceased and all SSCs and processes are shutdown, properly aligned, or otherwise in an appropriate status, as a result of planned or unplanned occurrences.

PARTNERSHIP. A process in which individual stakeholders create a team approach to achieve mutual goals and objectives or to resolve problems.

PERFORMANCE CRITERIA. A condition or set of conditions that, when satisfied, indicate successful completion of the performance objective.

PERFORMANCE MEASURES. Any evaluation, comparison, or judgement toward meeting the performance objective.

PERFORMANCE MONITORING. Systematic monitoring and trending of the performance of selected facility SSCs to measure and assess the impact of any performance changes on overall facility efficiency, reliability, and availability.

PERFORMANCE OBJECTIVES. A statement of wants, needs, and expectations of customers that sets the direction for all contract effort.

PERFORMANCE TEST. A test of an SSC to verify that acceptable designed-in performance characteristics are being achieved; or, to detect any abnormal performance characteristics for which corrective actions may be needed. The documented test results should also be used to determine the effect of maintenance and operating activities on equipment performance so that either availability or reliability factors can be obtained.

PERFORMANCE-BASED MAINTENANCE. Tailoring the preservation or maintenance of SSCs important to safety in terms of results as approved in a DOE Safety Management System that is implemented under 48 CFR 970.5204.2. The use of measurable (i.e., in terms of quality, timeliness and quantity) performance standards and objectives where appropriate (i.e., use of a “graded approach”).

PERIODIC MAINTENANCE. Preventive, predictive or seasonal maintenance activities performed on a routine basis (typically based on operating hours or calendar time) that may include any combination of external inspections, alignments or calibrations, internal inspections, overhauls, and SSC replacements.

PERSONAL PROPERTY. See Physical Assets.

PHYSICAL ASSETS. All DOE-owned or DOE-used and -controlled land, land improvements, structures, utilities, motor vehicles, equipment, and components are included.

- REAL PROPERTY OR REAL ESTATE. Real property includes land, improvements on the land, or both, including interests therein. All equipment or fixtures (such as plumbing, electrical, heating, built-in cabinets, and elevators) that are installed in a building in a more or less permanent manner or that are essential to its primary purpose are usually held to be part of real property.

- RELATED PERSONAL PROPERTY. Related personal property means any personal property that, once installed, becomes an integral part of the real property in which it is installed or is related to, designed for, or specially adapted to the functional or productive capacity of the real property. The removal of related personal property will significantly diminish the economic value of the real property or the related personal property. Examples of related personal property are communications and telephone systems.

- PERSONAL PROPERTY. Generally, capitalizable property that can be moved or that is not permanently affixed to and part of real estate. Generally, items remain personal property if they can be removed without seriously damaging or diminishing the functional value of either the capitalizable property or the real estate. Examples of personal property are shop equipment and automated data-processing and peripheral equipment.

NOTE: **Real property includes facilities (e.g., buildings and other structural facilities) and personal property that is an integral part of real property (related personal property) or is related to, designed for, or specifically adapted to the functional or productive capacity of the real property, the removal of which would significantly diminish the economic value of the real property or the related personal property itself. Examples of related personal property are communication systems and telephone systems. Real property may also include triple-wide trailers or modular units joined together so that the structure is not portable and cannot be relocated without being dismantled and thus losing its identity. Normally, common-use items, including but not limited to general-purpose furniture, utensils, office machines, office supplies, and general-purpose vehicles, are not considered related personal property.**

PLANNED MAINTENANCE. Preventive or seasonal maintenance activities performed before SSC failure that may be initiated by predictive or periodic maintenance results, through vendor recommendations, or by experience/lessons learned. These include actions such as scheduled cold weather protection, valve repacking, replacement of bearings as indicated from vibration analysis, major or minor overhauls based on experience factors or vendor recommendations, and replacement of known life-span components. For example, repacking a valve because of packing leakage would be corrective maintenance, but scheduled repacking before leakage would be planned maintenance.

POLARIZATION INDEX. A technique used to measure the mechanical integrity of insulation. This technique is used to monitor degradation of electrical systems by measuring the ratio between 1-minute and 10-minute readings for insulation resistances.

POSTMAINTENANCE TEST (PMT). Applicable and appropriate testing performed following maintenance to verify that a particular SSC, piece of equipment, or process performs its intended function based on its design criteria and that the original deficiency has been corrected and no new deficiencies created. In some cases, the extent of a particular PMT may extend beyond the component or piece of equipment that has been repaired, replaced or modified to complete systems or processes, depending on the type of maintenance action performed and the affect that the component or piece of equipment has on the total system or process.

PURCHASE DOCUMENTS. Documents that describe the item(s) to be purchased. These include requisitions and purchase orders with equipment specifications and requirements.

PREDICTIVE MAINTENANCE. The actions necessary to monitor; find trends; and analyze parameters, properties, and performance characteristics or signatures associated with SSCs, facilities, or pieces of equipment to discern whether a state or condition may be approaching that is indicative of deteriorating performance or impending failure, where the intended function of the SSCs, facilities, or pieces of equipment may be compromised. Predictive maintenance activities involve continuous or periodic monitoring and diagnosis to forecast component degradation so that "as-needed" planned maintenance can be initiated before failure. Not all SSC, facility, or equipment conditions and failure modes can be monitored and diagnosed in advance; therefore, predictive maintenance should be selectively applied. To the extent that predictive maintenance can be relied on without large uncertainties, it is normally preferable to activities such as periodic internal inspection or equipment overhauls.

PRETRANSFER REVIEW. Serves to provide the safety basis and physical and administrative characteristics of the facility subsequent to the cessation of operations and before transferring the facility for the disposition phase. The objective of the review is to identify and evaluate, using a graded approach, the explicit boundaries of the facilities being transferred; their physical condition; extent, nature, and level of contamination (as appropriate on a case-by-case basis); inventories/estimates of types and quantities of special nuclear, fissionable, and toxic, hazardous, and radioactive materials; summary and evaluation of the safety basis and surveillance and maintenance requirements; and other elements to ensure that sufficient information is provided to facilitate an understanding of the facility and its surveillance and maintenance requirements. Documentation is generally expected to be provided from the analysis of available information, without extensive, new, characterization work.

PREVENTIVE MAINTENANCE (PM). Includes all those planned, systematic, periodic, and seasonal maintenance actions taken to prevent SSC or facility failures, to maintain designed-in operating conditions, and to extend operating life. The PM process takes into account the inevitability of failures in any simple or complex piece of equipment, although the consequences of failures can be controlled by careful design and effective maintenance. The reason for the failure incident can be apparent if basic differences between expected behaviors and the actual behaviors of SSCs are considered. These differences can be translated into possible failure modes. PM identifies any differences between actual and expected behavior of SSCs. Generally, regulatory and code requirements, DOE TSR for surveillances, in-service inspection and testing, vendor recommendations, and other forms of maintenance action and frequency selection based on engineering judgement or analytical methods are the pursuit of proactive planned maintenance.

PRIMARY STANDARDS. Calibrated by the National Institute of Standards and Technology (NIST) or other authoritative reference source. Its use should be restricted to the standards laboratory.

PROBABILISTIC RISK ASSESSMENT (PRA). The quantitative (statistical) estimation of the likelihood (probability) of occurrence and frequency (per year/per event/per unit of time) of accidents, considering reliability and accident mitigation factors to interpret various contributors, which are compared, ranked and place in perspective.

PROBLEM COMPONENT. A component whose past failures have caused a significant adverse impact on safety system availability, electrical generation, or maintenance cost.

PROGRAMMATIC MANAGEMENT. Functions that include planning and developing the overall program; establishing priorities; providing program technical direction; preparing and defending the program budget; controlling milestones; integrating all components of the program; providing public and private sector policy liaison; expediting interface activities and follow-up actions; and retaining overall accountability for program success.

PROPERTY. See Physical Assets.

PROPERTY, PLANT, AND EQUIPMENT. Tangible assets that meet the capitalization criteria, that are not intended for sale in the ordinary course of operations; and they have been acquired or constructed with the intention of being used, or being available for use by the entity.

PULLED CIRCUIT CARD. A circuit card that has been removed (or pulled to the point of disconnect) from its designated location so that the intended function has been disabled.

Q-LIST. An engineered, approved listing of safety class structures, systems, or components (SSCs).

RADIO FREQUENCY MONITORING. A technique used to detect internal arcing of an electrical generator. Generator arcing is caused by component failures such as stator winding insulation failure, conductor fatigue failure, or voltage breakdown because of reduced clearances between components that are at different voltages. The arcs cause short-duration current pulses containing measurable radio frequency signals.

RADIOLOGICAL AREA. Any area(s) within a controlled area (but not including the controlled area) defined as a “radiation area,” “high radiation area,” “very high radiation area,” “contamination area,” “high contamination area,” or “airborne radioactive area.”

RADIOLOGICAL PROTECTION DEFICIENCY. A condition that if allowed to exist may result in any of the following conditions, the contamination of personnel and areas, unnecessary radiation exposure, and generation of excessive radiological waste.

REACTOR. Unless it is modified by words such as containment, vessel, or core, means the entire nuclear reactor facility, including the housing, equipment, and associated areas devoted to the operation and maintenance of one or more reactor cores. Any apparatus that is designed or used to sustain nuclear chain reactions in a controlled manner, including critical and pulsed assemblies and research, test, and power reactors, is defined as a reactor. All assemblies designed to perform subcritical experiments which could potentially reach criticality are also to be considered reactors. Critical assemblies are special nuclear devices designed and used to sustain nuclear reactions. Critical assemblies may be subject to frequent core and lattice configuration change and may be used frequently as mockups of reactor configurations.

RECALL PROGRAM. A system to recall and service M&TE.

RELATED PERSONAL PROPERTY. See Physical Assets.

RELIABILITY. The probability that a component or system should perform its functions for a specified period of time when used within established operating parameters.

RELIABILITY CENTERED MAINTENANCE. A proactive systematic decision logic tree approach to identify or revise preventive maintenance tasks or plans to preserve or promptly restore operability, reliability and availability of facility SSCs; or to prevent failures and reduce risk through types of maintenance action and frequency selection to ensure high performance. Reliability centered maintenance is the performance of scheduled maintenance for complex equipment, quantified by the relationship of preventive maintenance to reliability and the benefits of reliability to safety and cost reduction through the optimization of maintenance task/frequency intervals. The concept relies on empirical maintenance task/frequency intervals to make determinations about real applicable data suggesting an effective interval for task accomplishment. The approach taken to establish a logical path for each functional failure is that each functional failure, failure effect, and failure cause be processed through the logic so that a judgement can be made as to the necessity of the task, and includes (1) reporting preventive maintenance activities, plans, and schedules; (2) optimizing/calculating the preventive maintenance interval by balancing availability, reliability, and cost; (3) ranking preventive maintenance tasks; (4) accessing preventive maintenance information from piping and instrumentation drawings (P&IDs); (5) accessing preventive maintenance and other maintenance data; (6) listing recurring failure modes/parts, including failure to start and failure to run; (7) calculating and monitoring SSC availability; (8) accessing preventive maintenance procedures, and (9) keeping track of preventive maintenance cost.

RELIABILITY, MAINTAINABILITY, AND AVAILABILITY PLANNING. Methodology, tools and techniques to effectively design, build and operate facility safety systems.

REMOVABLE CONTAMINATION. Radioactive material that can be removed from surfaces by nondestructive means, such as casual contact, wiping, brushing, or washing.

REPAIR. The restoration of failed or malfunctioning equipment, system, or facility to its intended function or design condition (see Corrective Maintenance).

REQUIRED MAINTENANCE COST. Current maintenance needs cost estimate.

RISK-INFORMED MAINTENANCE. A term used in the commercial nuclear industry which is regulated by the U.S. Nuclear Regulatory Commission that relies on insights obtained from Level III probabilistic risk assessments to identify, rank and prioritize nuclear facility SSCs important to safety and their need to be preserved or maintained in order to prevent accidents or to mitigate the consequences of accident with optimization of resources.

ROOT CAUSE. The determination of the causal factors preceding an SSC failure or malfunction - that is, discovery of the principal reason why the failure or malfunction happened leads to the identification of the root cause. The preceding failure or malfunction causal factors are always events or conditions that are necessary and sufficient to produce or contribute to the unwanted results (failure or malfunction). The types of causal factors are (1) direct causes, (2) contributing causes, and (3) root causes. The direct cause is the immediate event or condition that caused the failure or malfunction. Contributing causes are conditions or events that collectively increase the likelihood of the failure or malfunction, but that individually do not cause them. Thus, root causes are events or conditions that, if corrected or eliminated, would prevent the recurrence of the failure or malfunction by identifying and correcting faults (often hidden) before an SSC fails or malfunctions.

RUN-TO-FAILURE. A maintenance strategy to allow selected components to operate until failure without performing preventive maintenance on the components.

SAFETY-CLASS STRUCTURES, SYSTEMS, AND COMPONENTS (SAFETY-CLASS SSCs). Systems, structures, or components including primary environmental monitors and portions of process systems, whose failure could adversely affect the environment, or safety and health of the public as identified by safety analyses.

SAFETY REVIEW. A review performed by a technically competent engineer to determine whether a proposed change to any SSC may have any adverse impact on facility safety.

SAFETY-SIGNIFICANT STRUCTURES, SYSTEMS, AND COMPONENTS (SAFETY-SIGNIFICANT SSCs). Structures, systems, and components not designated as safety-class SSCs but whose preventive or mitigative function is a major contributor to defense in depth (i.e., prevention of uncontrolled material releases) and/or worker safety as determined from hazard analysis.

SAFETY STRUCTURES, SYSTEMS, AND COMPONENTS (SAFETY SSCs). The set of safety-related structures, systems, and components, and safety-significant structures, systems, and components for a given facility.

SECONDARY STANDARDS. Calibrated by comparison with a primary standard of the same measurement modes. It should be used by laboratory personnel and stored in the standards laboratory. Use by other than standards laboratory personnel should be limited to that approved by the applicable manager.

SHELF LIFE. A specific period or interval of time after which a stored item may not meet its original design specifications, quality, or manufacture requirements.

SITE. A geographic entity comprising leased or owned land, buildings, and other structures required to perform program activities.

SKILL OF THE CRAFT. A defined level of technical proficiency for a worker performing a particular job that is verifiable through some form of qualification or supervisory knowledge.

SOLE SOURCE ITEMS. Any procurement action in which the requesting personnel restrict the procurement organization to one source of supply.

STAGING AREAS. Area designated and approved by the maintenance supervisor, for staging parts, materials, and supplies until a maintenance job is ready to work.

STANDARDS LABORATORY. A standards laboratory is a central on-site facility that maintains, calibrates, and certifies most of the facility portable instrumentation and test equipment.

STORAGE CONTROLS. Controls applied during purchasing, receiving, packaging, and storing of items to ensure that they are maintained properly.

STOREROOM. Any facility designed or used for receiving, storing, and issuing items.

STRUCTURES, SYSTEMS, AND COMPONENTS (SSCs). Physical items designed, built, or installed to support the operation of the facility. A structure is an element or a collection of elements to provide support or enclosure such as a building, free standing tank, basin, dike, or stack. A system is a collection of components assembled to perform a function such as piping; cable trays; conduits; or heating, ventilation, and air conditioning. A component is an item of equipment such as a pump, valve, or relay or an element of a larger array such as a length of pipe, elbow, or reducer.

SURVEILLANCE TEST. Functional tests of installed equipment and/or systems to satisfy technical safety requirements.

SURVEILLANCE AND MAINTENANCE. Activities conducted throughout the facility life-cycle phase including when a facility is not operating and is not expected to operate again and continuing until phased out during decommissioning. Activities include providing in a cost effective manner periodic inspections and maintenance of structures, systems and equipment necessary for the satisfactory containment of contamination and protection of workers, the public and the environment.

SYSTEM STATIONS. A location where two or more instruments are used as a unit to make certification measurements.

TECHNICAL SUPPORT. The engineering, design, computer support, training, warehousing, fabrication, procurement, operations, quality assurance, material and parts control and availability, specialized inspections, planning, or other such support needed to develop and implement a successful maintenance management program that provides an efficient and continuous operating DOE nuclear facility.

TICKLER FILE. A file that serves as a reminder and is arranged to bring matters to timely attention.

TOOL STORAGE AREAS. Area authorized and controlled for the issuance and storage of tools and equipment designated for use in a facility.

TOOLS AND EQUIPMENT. All noninstalled items commonly used to perform or assist in maintenance work functions within a facility. These items are not normally designed to perform highly specialized tasks and include such items as hand tools, power tools, electric cords, hoses, chain falls, scaffolding, ladders, and calibrated test equipment

TORNADO WATCH. Meteorological conditions are favorable for the formation of a tornado. These watches are usually for a period of time not exceeding 4 hours.

TORNADO WARNING. Issued when a tornado has been sighted in the area.

TRANSITION OF FACILITIES. The process of transferring programmatic and financial responsibility of land and/or facilities from one Program Office to another.

TRENDING. A systematic analysis of an SSC or facility performance to categorize and establish operating history that enables graphic depiction and simulation of results in measurable terms such as cause and effect, failures, production output or capacity, cost or other subjects of interest.

TROUBLESHOOTING. The process of locating and identifying SSC malfunctions through deductive and inductive reasoning and/or testing. The process may include (but is not limited to) activities such as taking readings, pulling fuses, stroking valves, changing electronic modules, partial or complete disassembly of a component, etc.

UTILITY. A system, or any of its components, that generates and/or distributes (via pipelines, wires, buses, or electromagnetic waves) a commodity or service to itself and/or to other facilities.

UTILITY SERVICE. A service, such as the furnishing of electricity, natural gas, steam, water, and sewer service and the furnishing of appurtenant facilities and systems. Telecommunication services or the removal and disposal of garbage, rubbish, and trash are not included.

VALUE-ADDED. A decision-making process that leads to an improvement in an operation or process, based on effectiveness, efficiency, cost-effectiveness safety, etc.

WEAROUT. The normal degradation process that is a function of operating time.

WORK-CONTROL DOCUMENT. A proceduralized document used by facility personnel to perform activities such as maintenance, inspections, testing, or other work.

WORK REQUEST AND/OR WORK ORDER (WR/WO). The WR/WO is a means of obtaining maintenance services available on both paper and electronic mediums and initiated by maintenance customers. Issued to Maintenance Planners and Estimators and used to define, plan, and execute maintenance activities. Documentation of a deficient equipment condition, requires detailed documentation of work performed, spare parts, procedures, or testing to verify maintenance was performed correctly. The WR/WO may also serve as documentation for completion of minor maintenance activities such as lubrication, light bulb replacement, etc.(It could also be called a maintenance job request.)

WORKING STANDARDS. Calibrated in the facility with a primary or secondary standard of the same measurement mode, or calibrated using other measurement modes. It generally should be used in day-to-day activities, (mainly in direct field applications where direct/ready access is required or when ALARA considerations exist), to certify product certification equipment and instruments in the maintenance recall program using approved procedures.

1.2 ACRONYMS

The following are acronyms commonly used in maintenance handbooks.

ALARA	as low as reasonably achievable
ASME	American Society of Mechanical Engineers
BIO	Basis for Interim Operation
CFAR	component failure analysis report
DOE	Department of Energy

EPRI	Electric Power Research Institute
EQ	environmental qualification
ES&H	environment, safety, and health
FCE	functionally critical equipment
FIMS	Facility Information Management System
FMEA	failure mode and effects analysis
FSAR	final safety analysis report
HVAC	heating, ventilating, and air-conditioning
ISI	in-service inspection
ISMS	Integrated Safety Management System
IST	in-service testing
LCO	limiting condition for operation
LTA	logic tree analysis
M&TE	measuring and test equipment
MEL	master equipment list
MIP	maintenance implementation plan
MSDS	Material Safety Data Sheet
MTBF	mean time between failures
NEPA	National Environmental Policy Act
NIST	National Institute of Standards and Technology
OJT	on-the-job training
ORPS	Occurrence Reporting and Processing System
P&ID	piping and instrumentation drawing
PCB	polychlorinated biphenyl
PM	preventive maintenance
PMT	postmaintenance test

PRA	probabilistic risk assessment
QA	quality assurance
QAP	quality assurance program
QC	quality control
RWP	Radiation Work Permit
SAR	safety analysis report
SSCs	structures, systems, and components
TSR	Technical Safety Requirements
UDOL	Unplanned Days Off-Line
USQ	unreviewed safety question
WR/WO	Work Request/Work Order

1.3 REFERENCES

Applicable laws, regulations, and directives referred to in this Guide appear in Section IV, "References." The superscript numbers appearing in the text of this Guide are keyed to the numbers in the reference list for easy access. As the basis for these guidelines, the referenced laws, regulations, and directives are the final authority and should be referred to for all questions.

2. GRADED APPROACH [1, 39]

2.1 CRITERIA

DOE nuclear facility contractors should use knowledge of their nuclear facility and sound engineering judgment to determine the depth of detail and magnitude of resources required for a particular maintenance management element described in Section 4. The level of safety analysis rigor, documentation, and controls [e.g., TSR/preventive maintenance (PM) inspection, testing developed for safety-related SSCs and safety-significant SSCs] should be more stringent than those developed for nonsafety items. Likewise, the safety-related SSC designation carries with it more stringent controls than the safety-significant SSC designation. Specific criteria used in the SAR[48] include those important to the following categories:

a. safety, safeguards, and security;
b. magnitude of any hazard involved;
c. life-cycle stage of a facility;
d. programmatic mission of a facility;
e. particular characteristics of a facility; and
f. relative importance of radiological and nonradiological hazards.

2.2 DEVIATIONS OR NONAPPLICABILITY

At those DOE nuclear facilities where deviations from the maintenance management element(s) identified in Section 4 are considered necessary and appropriate or any maintenance management element is nonapplicable, such deviations or nonapplicability should be identified and formally documented with supporting justification within the MIP.

2.3 FACILITY-RELATED NONSAFETY EQUIPMENT

DOE nuclear facility contractors may choose to include nonsafety equipment (see Sections 3.2 and 4.4.3.4.11).

3. MAINTENANCE IMPLEMENTATION PLAN

3.1 FORMAT AND CONTENT

In coordination with the appropriate field element, each DOE contractor should develop, implement, and document a program in conformance with the policy and objectives of DOE O 433.1 in a site maintenance plan and/or a MIP. The format and content of the MIP should include appropriate elements of Section 4 of this Guide, using a graded approach for each nuclear facility. Each of the 18 major elements of Section 4 of this Guide should be addressed. If an element is not included in a facility's maintenance program, an explanation should be provided justifying why the element is not applicable to the facility.

Section 4 frequently uses the word "should" indicating discretionary guidance to one acceptable method for inclusion in the MIP/maintenance management program. However, when a contractor adopts one or more of this Guide's acceptable methods for inclusion in the MIP/maintenance management program, the word "should" will need to be replaced with a word such as "will" or "shall" for the MIP to be acceptable to DOE.

3.2 BOUNDARIES

DOE contractors should develop a MIP for each nuclear facility under their cognizance. Where one contractor has more than one facility on a site, the contractor may develop a consolidated plan that can accommodate the facility differences without losing effectiveness. DOE contractors may include facility-related, nonsafety equipment within the MIP. The MIP should clearly identify and define the following minimum elements.

1. All SSCs included in the maintenance program (typically all those SSCs identified in the nuclear facility safety basis as documented in the SAR/BIO/TSR); SSCs that are critical to mission objectives or facility operations; or SSCs that may be desirable for inclusion in the maintenance program for other reasons. Contractors should develop a detailed master list of equipment/SSCs to be included in the maintenance program to help in selecting and scheduling PM and to evaluate the effectiveness of the maintenance program. The list normally is developed and controlled by or with assistance from engineering support organizations and can be used for other purposes, such as determining the safety or code classification of components. The MIP should include both safety-related and non-safety-related SSCs in the maintenance program. Failures of non-safety-related SSCs can lead to challenges, failure or undesirable consequences to safety-related SSCs. Special tools or equipment should also be included in the MIP. This list could be used effectively to help establish the maintenance history program and to determine the necessary parts required to maintain equipment (see Sections 4.4.2 and 4.4.3.1).

2. Management systems used to control maintenance activities associated with the defined SSCs (these include work control, postmaintenance testing, material procurement, handling and disposal, control and calibration of M&TE).

3. Assignment of organizational roles and responsibilities and appropriate maintenance-related training and qualification requirements.

4. Interfaces between the maintenance organization and other organizations (e.g., operations, engineering, quality, training, industrial health).

5. Facility/site mission.

6. System for assessing maintenance status.

7. Planned major activities.

8. Summary of maintenance backlog.

9. Performance indicators.

10. Self-assessment program.

11. Schedule for periodic inspection of SSCs, and equipment to determine whether deterioration or technical obsolescence that threatens performance and/or safety is taking place.

The MIP should establish maintenance priorities based on mission needs, and the priorities should be tracked directly to maintenance budget requests. This provides a forum on maintenance priorities between DOE and the contractor operating a nuclear facility. The maintenance priorities should be derived from or based on the SAR/BIO/TSR to preserve the facility's safety envelope so that the SSCs covered by the MIP are maintained in a condition suitable for their intended use.

The MIP should describe in detail the integration of the MIP with the QAP and the safety management system [see 10 CFR 830.122a; DOE G 450.4-1B; ISMS Principles 1 and 2; and ISMS Function l].

The MIP should establish a configuration management process to ensure the integrity of the identified nuclear facility SSCs using a graded approach [see DOE-STD-1073-93 and 10 CFR 830.122(d) and (e)].

The MIP should establish how an accurately documented, computerized maintenance history engineering database will be maintained locally and how certain data fields will be incorporated into the DOE corporate Facility Information Management System (FIMS). The MIP will facilitate DOE maintenance planning, performance evaluation, and prioritizing in a way that balances safety requirements, the maintenance backlog, and facility availability so that resources can be effectively allocated to address safety, programmatic, and operational considerations [see 48 CFR 45.509; 10 CFR 830.122(d); 41 CFR 101-3; and DOE P 450.4].

The MIP should establish how performance requirements for those infrastructure elements identified as part of the nuclear safety basis will be enforced (see DOE G 450.4-1B).

3.3 APPROVAL

Contractors operating DOE nuclear facilities should submit MIPs to the DOE heads of field organizations for review and approval.[12] MIPs should be reviewed every 2 years and necessary changes submitted to DOE heads of field organizations for approval.

4. MAINTENANCE MANAGEMENT PROGRAM ELEMENTS

4.1 MAINTENANCE ORGANIZATION AND ADMINISTRATION (Replaces DOE-STD-1051-93)

4.1.1 Introduction

The organization and administration of the maintenance function should ensure that a high level of performance in maintenance is achieved through effective implementation and control of maintenance activities. DOE operations office, contractor, and facility policies should reflect a striving for excellence in facility maintenance and operation. Effective implementation and control of maintenance activities are achieved primarily by management establishing and enforcing written policies, procedures, and standards for maintenance; periodically observing and assessing performance; and holding personnel accountable for their performance.[4, 9, 12, 56]

This section discusses the policy resources, goals and objectives, and accountability needed in facility maintenance.

4.1.2 Discussion

Senior management can achieve a high level of performance in facility maintenance by establishing high standards, by communicating these standards to personnel who perform maintenance, by selecting and training high-quality personnel, by providing sufficient resources to the maintenance organization, by setting goals and objectives, by closely observing and assessing performance, by effectively coordinating maintenance activities with operations and other facility organizations, and by holding workers and their supervisors accountable for their performance.[4, 9, 27, 56, 122] Another key to obtaining and maintaining high-quality maintenance performance is the establishment of an organization to provide time for and emphasize long-range planning, as discussed in Section 4.1.3.2.

Sufficient staff, equipment, and funding should be allocated to the maintenance organization so that its functions can be effectively performed. Resources can be allocated on a case-by-case basis, depending on the organization used. One indication that sufficient resources have been allocated is how well the maintenance goals are met.[18, 19, 20] Maintenance goals and objectives are discussed in Section 4.1.3.4.[9, 22, 32]

Contractors should establish maintenance standards, considering input from maintenance staff and crafts workers, who will more eagerly support standards they have helped to develop. These standards should establish expected performance levels and clearly define maintenance objectives, responsibilities, and accountabilities. Standards for maintenance activities should be integrated into maintenance procedures and programs. They should also be communicated to the workers by training them in good work practices and by making sure that supervisors observe and guide work activities [16, 75]. Performance in maintenance should be closely monitored by operations office personnel and facility managers through direct observation and development of maintenance reports. Progress toward achieving goals should be examined to measure the performance of the maintenance organization effectively.[22] Maintenance personnel should be held accountable for their performance through supervisor counseling, performance appraisals, and, when necessary, disciplinary measures. Remedial training should be provided when appropriate.

4.1.3 Guidelines

4.1.3.1 Maintenance Organization Policies

It is a primary responsibility of the maintenance manager* to ensure implementation of contractor management and facility policies that affect the maintenance organization. Maintenance organization procedures should support contractor management and facility maintenance policies. Responsibilities for implementing these policies, including the responsibilities of maintenance personnel,** should be clearly defined. Maintenance personnel should clearly understand their authority, responsibility, accountability, and interfaces with other groups. Procedures or other definitive documentation should specify policies used to guide maintenance organization activities. These documents should also specify the types of controls necessary to implement new maintenance policies.

4.1.3.2 Maintenance Strategy

Working Relationships. Each facility should develop an integrated approach to maintenance that encourages working relationships among all organizational units that support the maintenance function [e.g., operations, health physics, stores, quality control (QC), engineering, procurement, and modifications].[1, 17, 30, 49, 76]

The maintenance strategy should chart the relationship among these supporting groups, as related to overall plant maintenance, by defining responsibility, authority, and accountability. This will entail identification of the following:

- personnel interfaces;
- periodic self-assessments of work activities;
- procedural interfaces
- indicators relating to overall maintenance performance (e.g., equipment availability); and
- indicators relating to the support of maintenance tracked by each supporting group [e.g., number of plant Work Orders (WOs) on hold because of a lack of spare parts].

Long-Range Planning.[18, 19, 20, 28, 32] Effective management of the maintenance program requires long-range planning. Establishing a scope of long-range major activities shows how funding and staff resources can be managed to meet the needs of the maintenance program. Issues such as the following should be part of long-range planning:[9, 12, 18, 19, 27, 31, 38, 40, 57, 60]

- recurring major maintenance items such as component overhaul, inspections, and rebuilds;
- timing of planned maintenance and facility or equipment outages;

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*The term “maintenance manager” is used throughout the Guide to denote the manager responsible and hence accountable for the maintenance functions.

**The term “maintenance personnel” denotes any individual performing a maintenance function.

- major projects and modifications requiring maintenance organization involvement;
- future organizational structure and staffing changes aimed at continuing improvements in the maintenance program and the plant as a whole;
- planning for equipment replacement as components reach the ends of their service lives;
- timing of outages for other plants in the system when reliance on them for resources is part of the maintenance plan;
- periodic conduct of value-impact assessments of maintenance methods, processes, and approaches/alternatives to performing work;
- government and industry issues and events that will impact the maintenance program;
- budget changes or projects that may divert large amounts of money from maintenance activities; and
- contractor and corporate long-range support.

4.1.3.3 Staffing Resources [18, 19, 57, 60, 101]

The maintenance manager is responsible for helping to select high-quality personnel, for effectively using available resources, for assessing resource adequacy, and for making recommendations to the appropriate manager regarding needed change. He/she should be involved in defining entry-level criteria and in screening new personnel. High-quality personnel should be selected to establish a staff of supervisory, engineering, planning, technical (crafts workers), warehousing, and other personnel needed to support the maintenance program. Entry-level criteria should ensure that maintenance personnel have the requisite background and experience to be trainable for work in nuclear facilities.[27, 44, 45] A written or practical test could be used to demonstrate this minimum level of competence. If engineering personnel are not directly assigned to the maintenance organization, the maintenance manager should ensure the ready availability of adequate engineering support (e.g., system engineers who are actively involved with such daily maintenance activities as troubleshooting and evaluating unusual conditions). Additionally, during temporary increases in staff to support planned outages or other activities, high-quality personnel should be selected.

The maintenance staff should have sufficient personnel and time to conduct training activities. A training and qualification program should be developed for maintenance supervisors, planners, crafts workers, and warehouse personnel, to ensure that high-quality performance is achieved and maintained. Career progression plans should be developed to help ensure that future maintenance staff vacancies can be filled with qualified personnel. These progression plans include providing training and opportunities for experience to potential candidates for specific positions. All maintenance management and supervisory positions should be filled with permanent contractor personnel.[1, 45, 107]

4.1.3.4 Goals and Objectives [1, 2, 3, 4, 9, 10, 11, 22, 23, 27, 28, 29, 30, 31, 33, 40, 41, 42, 60, 67, 68, 72, 73, 76, 77]

Maintenance goals should be used as a management tool for involving cognizant facility groups in improving maintenance performance and for measuring maintenance effectiveness. Maintenance goals such as the following should be established.

- Reduce the impact of planned outages by planning and completing maintenance activities promptly.
- Reduce the number of unplanned outages.
- Minimize unplanned challenges to safety systems.
- Reduce the lost-time accident rate.
- Reduce station and equipment downtime.
- Reduce personnel errors.
- Reduce radiological exposure.
- Control and reduce contaminated areas.
- Reduce repeat maintenance Work Requests (WRs) (rework).
- Complete scheduled surveillance and PM activities promptly.
- Manage the corrective maintenance backlog to minimize it and the completion time of resolving outstanding deficiencies.
- Control overtime.
- Staff and train the maintenance organization.
- Complete outage and no outage work on schedule.

To establish goals, it is necessary to determine the current value and estimate the expected value of the parameter for which a goal will be established. Based on this, a challenging but achievable goal should be established. Meeting goals generally requires a definite set of actions. Action plans should be developed by the maintenance manager, with input from personnel involved in conducting maintenance activities, and reviewed and approved by the facility manager. Guidance is provided in Section 4.14 on measuring the effectiveness of goals and objectives and providing feedback for periodic review and adjustment of goals and objectives. If realistic, challenging, and measurable goals are established, maintenance effectiveness can be monitored and improvements achieved.

The purpose of maintenance goals is not simply to meet a numerical milestone; rather, the purpose is to improve performance. Goals for routine tasks or goals that are easy to meet with little action should not be used.

4.1.3.5 Accountability [9, 23, 28, 101]

Managers, supervisors, engineers, planners, crafts workers, warehouse personnel, and other personnel who support maintenance should be recognized for their performance. Rewards and other forms of positive recognition should be given for superior performance. Personnel involved in significant or frequent violations of maintenance requirements should be encouraged to improve through counseling, remedial training, or disciplinary measures, as appropriate. A performance feedback program, such as performance appraisals, should be used to evaluate the performance of facility maintenance personnel. This program should include or be augmented by routine managerial or supervisory discussions and feedback to each individual. With this continuing feedback, each employee should understand his/her accountability for the performance of activities and know what areas need improvement. Another valuable benefit of these sessions is the feedback provided by the employee to his/her manager or supervisor.

4.1.3.6 Quantitative Indicators [9, 19, 20, 22, 78]

A program should be in place to regularly provide management with accurate information regarding key maintenance performance indicators. Such information should be measurable and used to assess maintenance performance and identify areas requiring management attention. Overall indicators relevant to maintenance performance, indicators to measure progress in achieving goals and objectives, and specific indicators for monitoring current performance problems and performance in specific functional areas should be selected. Information should be presented in a systematic way that provides ready recognition of trends and comparison of actual versus expected results and, where appropriate, clearly indicates corrective action and the results of these actions.

For most quantitative indicators, a graphic format is preferable to show comparisons between actual results, facility goals, and overall industry progress over a period of time. Quantitative indicators should be presented in a way that shows a significant time period, such as 12 to 36 months, to support more meaningful analysis of performance trends. Where data are subject to wide variations over time, averaging techniques may be used to smooth the data and facilitate the identification of trends. A computerized database is the most effective way to compile data and analyze them for performance trends. Maintenance related computerized data should be part of an integrated operation and available for use by every member of the maintenance organization, as well as other facility personnel. It should tie together maintenance, warehousing, purchasing, accounting, engineering and production in such a way that all parties work together and share current information.

Monitoring reports based on quantitative indicators should be issued on a periodic basis. In most cases, updating quantitative indicator reports monthly has been found to be most effective. Quantitative indicators should be trended to permit early identification of trends requiring corrective action. A management summary that highlights trends and explains reasons for undesirable trends, including problem areas, needed improvements, and actions taken to cause improvement, enhances the usefulness of the reports.

Responsibilities should be assigned for collection and analysis of data for each indicator. A coordinator should be assigned overall responsibility for development, production, and distribution of the report.

Reports tailored to the needs and desires of responsible company management, including the facility manager and appropriate division managers, should be distributed.

Guidelines should be developed for determining what quantitative indicators are provided to each level of management. For example, the facility manager's report could provide overall performance indicators and other selected indicators along with an executive summary section noting unusual results and significant trends. A brief explanation of the cause of negative trends and corrective actions to be taken should be provided. Reports to other division managers should provide all the information in the facility manager's report and other selected indicators applicable to their areas of responsibility.

4.1.3.7 Status Reports to Managers [1, 5, 6, 7, 8, 9, 19, 20, 21, 22, 67, 71]

Managers should receive periodic reports on the status of various programs and on the status of action items. An integrated management information system is often used to provide this information. When independent reporting or action tracking systems are used, care should be taken to minimize redundant reports. Items that are nearing the completion date should be monitored to verify that due dates will be met. When items become overdue, they should be reviewed, appropriate actions should be taken, and the item should be rescheduled. Closeout methods should be streamlined to prevent an excessive number of completed items from being carried forward.

Follow-up on the effectiveness of corrective actions for deficient conditions should be scheduled as part of the management monitoring program. Follow-up monitoring should determine whether the immediate condition has been corrected and the root causes eliminated. In some cases, this will require monitoring of the immediate corrective actions and subsequent monitoring to determine whether recurrence of the condition is minimized. For the latter, sufficient time will need to be allowed to permit the completion of all corrective actions. Based on the results of the follow-up monitoring, the item can be closed or new corrective actions formulated.

Undesirable performance trends noted in quantitative indicators or as a result of management performance monitoring should be assessed to determine the root causes of this performance. Corrective actions should be developed and implemented to correct undesirable conditions.

4.1.3.8 Determination of Root Cause of Problems [1, 24, 25, 26, 28, 29, 43, 45, 50, 53, 54, 55,56, 79, 80, 105, 118, 119]

Problems that are identified by management assessment or by outside organizations should be analyzed to determine underlying root causes so effective corrective actions can be developed and implemented. The root causes can be defined as those causal factors (including management system factors) that, when corrected, will preclude a recurrence of a deficiency. Particular emphasis should be placed on deficiencies or causal factors identified as having generic implications.

Root-cause determination methods should be applied to event investigations, undesirable trends in quantitative indicators, and performance deficiencies noted in monitoring reports. For example, if a deficient condition exists because of personnel performance, the root cause may be one or more of the following:

- erroneous, incomplete, or unusable procedures;
- insufficient or incorrect training;
- insufficient supervision caused by lack of monitoring, accountability, or improper standards; and/or
- system or equipment design deficiencies.

Corrective Actions. Corrective actions should address the root causes rather than the symptoms of the problem. The objective of root-cause determinations should be to identify failures at a sufficient level to prevent not merely a reoccurrence, but also all other occurrences stemming from the same root cause. Corrective actions should be developed with input from appropriate facility and staff members, including those tasked with implementing the actions, to achieve ownership of the corrective actions. Facility line management should approve corrective actions and ensure the actions are implemented in a timely manner. Input from organizations such as QA or corporate support/oversight groups should be considered when determining actions in response to deficient conditions identified by these organizations. Management should track corrective actions until completion.

Responsible managers and supervisors should be held accountable for the timely and effective implementation of corrective actions. Delays in the completion of approved corrective actions should be brought to the attention of the responsible manager who assigned the corrective actions. An escalation process should provide higher levels of management attention to problem areas for which corrective action continues to be ineffective.[17, 28, 56, 80, 106, 125]

Use of Operating Experience. Programs should be in place to ensure the timely review of operating experience to incorporate lessons learned into maintenance programs and practices. Reviews should include in-house and external industry events. Management should use industry operating experience and in-house events as mechanisms for assessing performance to determine the root causes of problems. Mechanisms should also be in place to ensure that significant in-house events are promptly provided to the industry for use by other facilities.

Another aspect of operating experience involves visits to or communications with other facilities. Maintenance division managers, supervisors, and workers should take opportunities to visit and communicate with other facilities both to help solve specific problems and to learn different approaches to the routine business of operating facilities.[96]

4.1.3.9 Management Control of Plant Configuration [83, 84, 93, 99, 108, 109, 110, 116, 117]

Management should ensure that plant configuration, including the manner in which the facility is maintained, conforms to the established design basis requirements. Many routine activities, if carried out improperly, can have an adverse impact on facility configuration and cause eventual equipment damage or increase the probability or consequences of a significant event. Effective control of facility configuration requires rigorous attention to detail as well as the understanding and commitment of every member of the maintenance organization to observe and report/record material condition and status.

Configuration Management Policy. The maintenance policy regarding the control of plant configuration should be clearly defined and communicated to all levels of the organization. The policy should address the scope of configuration management controls, the responsibilities of the maintenance organization, and the principal interfaces between the facility and maintenance organization that directly control material condition assessments and facility design basis requirements. In addition, the policy should identify each maintenance line manager's responsibility for implementing the necessary controls to ensure effective implementation of the configuration management policy.[116, 117]

Availability of Design Basis Requirements. The current facility design basis requirements should be readily available to the maintenance staff. These requirements should be used in the preparation, review, and approval of proposed changes to plant design and maintenance procedures. In addition, these requirements should be used in troubleshooting problems and validating material condition assessment when questions arise. The organization responsible for controlling the design basis requirements and ensuring facility design integrity (i.e., the design authority) should be assigned the responsibility for interpreting design basis requirements as needed.[47, 48]

Control of Interfaces. The interfaces among facility maintenance and nonfacility organizations should be clearly defined to ensure the complete and accurate communication of facility configuration-related information. For example, a change to a vendor manual may result in changes to maintenance procedures, training materials, equipment lists, repair parts, and design base documents such as specifications and drawings. In addition, information may flow in both directions across organizational interfaces. For example, information related to a design change may be needed by operations, maintenance, and/or training to update procedures to conform with the facility design basis requirements. Conversely a procedure change initiated by maintenance personnel that affects an operating parameter may necessitate validation by design engineering personnel to verify expected operating conditions fall within the design basis requirements.

Controls should be established to ensure the necessary source information that initiates a configuration change is sent to all affected organizations and to ensure that the appropriate reviews, actions, and document updates are accomplished in a timely manner.[11, 41, 46]

Change Control. Management should ensure proposed changes to the facility configuration are warranted and properly controlled. As noted in "Control of Interfaces" above, many activities performed during day-to-day maintenance operations of the facility can have an adverse impact on plant configuration, material condition, and plant design basis if planned or performed improperly. Management should routinely review the conduct of these activities to ensure inadvertent and uncontrolled changes to the facility are not made.[4, 46]

Document Control. Management should ensure documents are the current, approved versions before use. Discrepancies between actual facility configuration and controlled documents should be identified, tracked, evaluated, and expeditiously resolved. Because information describing facility configuration is frequently duplicated in documents controlled by different organizations, a method of cross-referencing documents should be established to aid in the identification of documents affected by change. [1, 4, 46, 54, 78]

The maintenance document control program should ensure technically correct and readily accessible information is provided to support maintenance activities. Technically accurate and approved information written in a clear and concise format is needed to support safe and reliable maintenance operations. A document control system should be established to ensure that only authorized technical information is available for the performance of maintenance activities. Controlled information should include maintenance procedures, maintenance records and documentation, drawings, vendor technical manuals, and maintenance correspondence.

A formal process should be in place for the preparation, periodic review, and approval of maintenance procedures and procedure revisions to ensure continued accuracy and usability.

The document control system should also ensure maintenance documentation, including incoming and outgoing mail, maintenance records and reports, is properly stored and easily retrievable.

4.1.3.10 Document Control Administration [21, 28, 78]

A document control system should provide for the timely receipt, processing, distribution, retention, storage, and retrieval of documents originating both within and outside the maintenance organization. The responsibility for document control may be shared by more than one department. For example, one department may be responsible for the control, updating, and distribution of drawings. Another department may be responsible for maintaining maintenance procedures and retention and storage of maintenance documents. In either case, controls should be established outlining the responsibilities and authorities of individuals or groups associated with document control. A master control file of maintenance documents should be maintained, with access limited to designated personnel. Satellite files of controlled maintenance documents such as procedures, drawings, and technical manuals should be established as necessary to support maintenance operations. Responsibility for maintaining satellite files should be clearly defined.

4.1.3.11 Procedures [27, 83]

Controls should be established for the preparation, review, approval, distribution, and revision of maintenance procedures. A systematic program should be used to ensure the review and updating of maintenance procedures at regular intervals that are not to exceed a specified period (normally 2 years). Guidelines for procedure review should address the scope and depth of the review in areas such as technical and administrative content and human factors. DOE-STD-1029-92, *Writer's Guide for Technical Procedures* may be of assistance in this area.

A uniform procedure format should be used for all maintenance procedures. A maintenance administrative procedure should be developed that provides guidance in the prescribed methods of format, content, and numbering. Departmental procedures should provide the detailed guidance regarding the conduct of maintenance activities (see 10 CFR 830 Subpart A Work Processes).

4.1.3.12 Drawing Control [1, 28, 29]

Only controlled drawings reflecting as-built conditions should be used for maintenance operations. Drawings should be stamped or otherwise marked to clearly indicate that the drawing is controlled. Drawing indexes should be readily available and maintained current to allow quick verification of drawings for use. Satellite files of controlled drawings should be established as necessary to support maintenance activities. If satellite files are used, they should be periodically checked to ensure drawings are maintained up-to-date.

Controls should be established for distribution and updating of drawing files. Responsibility for maintaining satellite files should be clearly established. If document control personnel are not responsible for maintenance of satellite files, some means of positive verification should be used, such as return of outdated drawings. Drawings that are posted at various locations in the plant should also be controlled.

Drawings that are not part of the controlled drawing system should be considered uncontrolled and clearly identified as such. Maintenance procedures should indicate how controlled and uncontrolled drawings are identified so that personnel can readily determine the status of drawings. Uncontrolled drawings should not be used for the performance or planning of maintenance work activities [see 10 CFR 830.122(d), Documents and Records].

4.1.3.13 Vendor Information [1, 28, 29]

The receipt, processing, and distribution of vendor technical information relating to the systems or components installed at the facility should be controlled to the same level as facility documentation applicable to the same SSC. The proper performance of maintenance activities is strongly dependent upon the availability and use of accurate vendor technical information.

The application of controls on vendor manuals depends on the intended use of the manual. If detailed procedures have been developed for use in the conduct of maintenance, then vendor manuals should be used only as reference source material and so marked. If vendor manuals are intended as replacements, substitutes, or supplements for maintenance procedures, then their use should be controlled in the same manner as maintenance procedures. In both cases, vendor manuals should be reviewed for completeness, accuracy, and applicability before initial use. Vendor manuals should be treated as maintenance documents, with maintenance management retaining responsibility for maintaining the manuals current. Local changes should be approved and used as necessary to reflect equipment modifications and other relevant technical information.

Indexes listing all vendor manuals should be developed. Controlled manuals should be readily identifiable with a means provided to allow verification that each manual is complete and current. Manuals not included in the document control system should be considered uncontrolled and should not be used as guidance to perform maintenance on facility equipment. Maintenance procedures should indicate how controlled or uncontrolled manuals are identified.

Control mechanisms should be developed to ensure that changes required in vendor technical manuals (whether generated by external means, such as vendor technical bulletins, or changes resulting from plant modifications) are incorporated. Changes to all manuals should receive the same review and approval as the manual itself.

4.1.4 Maintenance Organization and Administration Performance Objectives [9, 22, 23]

The maintenance organization and administration should ensure effective implementation and control of maintenance activities.

CRITERIA

A. Organizational structure is clearly defined.

B. Staffing and resources are sufficient to accomplish assigned tasks.

C. Responsibilities and authority for each management, supervisory, professional and craft position are clearly defined and understood.

D. Interfaces with supporting groups are clearly defined and understood.

E. Administrative controls are used in the conduct of maintenance activities that affect safe and reliable plant operation. (Examples of such activities include scheduling PM, use of special tools and lifting equipment, and use of M&TE.)

F. Performance appraisals are effectively used to enhance individual performance.

G. Temporary and other nonfacility personnel use the same (or equivalent) facility- approved policies, procedures, and controls and the same workmanship standards as plant maintenance personnel.

H. Personnel are actively encouraged to develop methods to improve safety, reliability, quality, and productivity.

I. Performance indicators are reviewed and used to improve maintenance performance.

4.2 TRAINING AND QUALIFICATION OF MAINTENANCE PERSONNEL[27, 44, 81, 119, 121, 122, 123]

4.2.1 Introduction

A maintenance training and qualification program should be implemented to develop and maintain the knowledge and skills needed by maintenance personnel to perform maintenance activities effectively. The program should be designed so that the maximum potential of maintenance personnel is fulfilled.

This section describes the implementation of training and qualification programs for maintenance personnel. Guidance is also provided for training program evaluation and record keeping.

Maintenance managers and supervisors should be directly involved in training maintenance personnel. Their involvement should, at a minimum, include close coordination with the contractor’s training organization to establish and maintain course content and emphasis, determine and support training schedules, accomplish on-the-job training (OJT), and provide feedback to adjust course content and emphasis, as necessary.

4.2.2 Discussion

The training organization should maintain maintenance training programs that meet the intent of established industrial guidelines and that address specific company and facility needs. These training programs are supported and guided by the maintenance organization. This support and guidance normally includes all or a portion of the following tasks.

- Defining the jobs, tasks, skill levels, and responsibilities of individuals in maintenance positions.
- Defining training programs for each position.
- Determining the content and emphasis of the training needed.
- Determining and supporting training schedules.
- Determining the training needs of and tailoring the training program for each individual, based on his/her previous education, training, experience, and skill level.
- Providing instructors and trainers.
- Establishing qualification criteria, with emphasis on successful performance in the field.

- Coordinating the conduct and instruction of OJT.
- Qualifying individuals as they complete their training programs.
- Providing training-effectiveness feedback to the training organization to enhance and, where necessary, adjust course teaching methods, content, and emphasis.

Facilities to support maintenance training are key factors in obtaining safe, efficient, and high-quality maintenance. The maintenance manager should be involved in construction of new maintenance training facilities and in renovations to existing facilities. The maintenance training program should be used as the basis for determining the space and equipment needed for training facilities. Considerations for these facilities and equipment should include the following.

- Size of training class.
- Type of training (e.g., classroom, laboratory, and OJT).
- Use of mockups.
- Presence of environmental controls.
- Availability of services (e.g., electricity, air, water, and gas).
- Access to training equipment (e.g., lecture boards, projectors and screens, and simulators).
- Provision of equipment similar to that installed in the plant to be used for practical training.

4.2.3 Guidelines

4.2.3.1 Responsibilities

Responsibilities for establishing, implementing, and maintaining the maintenance training programs should be clearly defined and understood. The key element for success is close coordination between the managers and supervisors of the maintenance and training organizations (see Section 4.1).

4.2.3.2 Maintenance Training Programs

Training should be defined and should include managerial, supervisory, planning, engineering, warehousing, craft, and contractor personnel, and other positions, as deemed necessary. Courses should then be obtained or developed. Detailed guidance for accomplishing this is available in established industrial guidelines.

4.2.3.3 Training Schedules and Support

The following scheduling and support activities should be accomplished.

- Prepare schedules that reflect instructor, training facility, and trainee availability and that include (as appropriate) self-study, classroom instruction, practical training, vendor or other noncontractor employee training, and OJT.

- Review each trainee's previous education, experience, and skill level to determine which portions of the training program he/she can be exempt from. One method to accomplish this is to require that a prospective employee pass a written test as part of the interview process. Based on the test results, a training program and milestones for the individual can be established.

- Ensure that qualified instructors are available to teach specific courses.

4.2.3.4 On-the-Job Training [81]

OJT is practical, hands-on training in which employees achieve learning objectives through training conducted within the job environment. OJT is a formal part of the maintenance training program. This aspect of an individual's training is normally conducted in the facility as part of his/her day-to-day work activities. Accordingly, maintenance department supervisors and selected experienced craft personnel are directly involved in OJT. Key elements of OJT include the following.

- Program Adherence. OJT should be conducted in accordance with formally defined training programs that specifically identify items the trainee must accomplish. Knowledge requirements for each item, as well as the action a trainee must do (perform, simulate, observe, or discuss), should be defined. Both the trainer and the trainee should understand what is required for each training item.

- Trainer Qualification. OJT should be conducted by personnel who have qualified as OJT trainers. Personnel in the training department who have maintenance experience, as well as personnel in the maintenance department itself, may be used as OJT trainers. They should have good verbal communication skills and technical knowledge and should have the ability to provide trainees with effective hands-on experience.

- Trainee Supervision and Control. When trainees perform maintenance on installed equipment, a qualified OJT instructor should observe the work so that the trainee properly accomplishes the activity and understands how to avoid errors that could affect personnel safety or adversely impact the station. Before performing maintenance on equipment, trainees should discuss the procedure with the OJT trainer and talk through required actions by pointing to the control switch, valve breaker, or other component that will be manipulated. Incorrect actions should be discussed, particularly if they could result in a plant transient such as an equipment trip. The trainee should also demonstrate industrial safety and radiological protection aspects of the job (e.g., the equipment to be maintained is properly tagged and isolated, and an RWP is used).

  The trainer should review any information recorded by the trainee on official work and data sheets and should stress to the trainee the importance of maintaining accurate training and nuclear facility records. In addition, the instructor should discuss with the trainee out-of-specification values and their consequences and the required reporting of such issues.

- Number of Trainees. To determine the number of trainees allowed to participate simultaneously in any particular training evolution, the trainer should consider training effectiveness and the effect on the equipment being maintained. Limiting the trainee/trainer ratio will help each trainee receive the most effective instruction and will help ensure that the trainer is not overwhelmed by having too many trainees at once. For example, a trainer may be able to handle several trainees for disassembly and assembly of a pump or motor or a practical demonstration on stainless-steel tube fitting. It may be prudent, however, to have only one trainee at a time for work involving a live, high-voltage circuit or for conducting a reactor protection system surveillance test.

- Trainee Conduct of Maintenance. The maintenance manager should establish a policy that allows trainees to perform independent maintenance only on equipment for which they are qualified. This policy should specify how supervisors are to ensure that a trainee has completed needed training before he/she is independently assigned to perform a task on particular equipment. The trainee's need to make progress in training should be considered when maintenance tasks are scheduled for him/her.

4.2.3.5 Qualification

In conjunction with the training organization, maintenance management should review an individual's training accomplishments before qualifying him/her for a given task. Similarly, qualifications of contractor personnel should be reviewed. This review should include the following.

- Verifying completion of all required prerequisite training.
- Conducting or evaluating the results of a final written, oral, or practical demonstration examination and evaluating the recommendations of the individual's supervisors.
- Interviewing the individual regarding the knowledge and skill he/she has acquired (not as a verification of total expertise and proficiency but as an indicator of competence upon which to build).
- Formally approving and documenting qualification.

4.2.3.6 Training in Root-Cause Analysis [54, 80]

In addition to being trained in technical maintenance functions as described above, a select group or team should be schooled in principles and methods of root-cause analysis. This group should include individuals with demonstrated expertise in human performance, systems, failure analysis, facility operations, and relevant technical disciplines (e.g., stress analysis and corrosion). Group leadership should be placed with individuals who are experienced in root-cause analysis and who can function impartially, with no particular allegiance to any facility organization. Group members should be trained in various approaches to cause-and-effect analysis and should be provided the necessary background to select and implement an approach that is suitable for a particular situation.

4.2.3.7 Training Program Approval, Effectiveness, and Feedback [1, 27, 28]

The maintenance manager should be directly involved in approving and periodically reviewing the maintenance training program. The performance of maintenance personnel should be monitored to identify enhancements and emphases for the initial- and continuing-training program. (Sections 4.14, 4.15, and 4.16 provide guidance on monitoring maintenance performance.) The trainee's feedback on his/her perception of and suggestions for improving the training program should be obtained. Any performance trends indicating maintenance knowledge or skills that need improvement should be considered during review of the maintenance training programs. The training organization should consider recommendations from the maintenance manager for changes to training programs.

4.2.3.8 Management and Supervisory Training [27, 122]

There should be a formalized training program that addresses and provides the necessary training to develop and maintain managerial and supervisory skills. The program's training should include, but not be limited to, managerial and supervisory skills, accountability, assessment and observation of routine activities, communication skills, teamwork, and company management styles and philosophies. It should also include position-specific technical areas that enable these individuals to communicate properly with their workers and to carry out their responsibilities. This is especially important to aid first-line supervisors in managing maintenance activities. Career progression planning should be used to help customize the training program for personnel being considered for specific supervisory and managerial positions.

4.2.4 Maintenance Personnel Knowledge and Performance Objectives [22, 23, 27]

Maintenance personnel knowledge and performance should support safe and reliable facility operation.

CRITERIA

A. Maintenance is performed by or under the direct supervision of personnel who have completed applicable formal qualification associated with the tasks to be performed.

B. Maintenance personnel knowledge is evidenced by an appropriate understanding of areas such as the following:

- maintenance policies, processes, and procedures;
- general plant layout;[28, 50, 116]
- purpose and importance of facility/systems and equipment;[32, 48]
- effect of work on facility systems;
- industrial safety, including hazards associated with work on specific equipment/ systems;[2, 3, 32, 41, 42, 43, 48, 49, 52, 58, 59, 67, 68, 69, 70, 72, 74, 76]
- radiological protection and as-low-as-reasonably-achievable (ALARA) principles;[59, 60, 122]
- job-specific work practices;[1, 67] and
- cleanliness and housekeeping practices.[116]

C. Maintenance personnel are capable of troubleshooting equipment problems in an efficient manner.

D. Maintenance personnel, including temporary and nonfacility personnel, are knowledgeable of changes to plant policies, procedures, systems, and equipment that affect their activities.

E. Maintenance personnel are knowledgeable of appropriate lessons learned from industry and in-house operating experiences (including actual events) applicable to their craft.

4.3 MAINTENANCE FACILITIES, EQUIPMENT, AND TOOLS (Replaces DOE-STD-1067-94)[28, 29, 31, 32, 58, 111]

4.3.1 Introduction

Maintenance facilities, equipment, and tools should efficiently support the facility maintenance and maintenance training functions. Maintenance facilities directly affect the training of maintenance personnel and the ability to maintain the facility in an optimum state of readiness. Maintenance facilities include storage areas for equipment, tools, supplies, and parts (see Section 4.12, and Section 4.13).

This section provides guidance in determining needs for the facilities, tools, and equipment necessary to support maintenance.

4.3.2 Discussion

A program for evaluating the adequacy of maintenance facilities is needed to help ensure that maintenance activities can be effectively accomplished. Industrial safety, location, access, communication, environmental controls, radiological controls, power sources, and the type of activity to be performed are examples of items to be considered in providing adequate maintenance facilities. Maintenance training facilities, shops, satellite work areas, laydown and staging areas, storage facilities, mockups, temporary facilities, decontamination facilities, shower and toilet facilities, lunch areas, conference areas, and offices are examples of maintenance facilities that need evaluation. In addition, adequate office equipment should be provided to support efficient and effective work. The objective is to create and maintain a safe and productive workplace where high-quality work can be performed. (References 3, 11, 12, 15, 30, 33, 34, 35, 36, 48, 59, 68, 69, 70, 71, 72, 72, and 75.)

A program for evaluating the adequacy of tools and equipment to support maintenance activities is also needed. The types and quantities of tools and equipment needed to accomplish effective maintenance depend on such variables as facility purpose, design, and layout; installed equipment; and composition of the work force. The process of providing and developing tools and equipment should include considerations of cost, control, and storage. Tool and equipment control is addressed in Section 4.12. Although the development of new or special tools should be controlled for safety, cost-effectiveness, and future use, control of the development of new or special tools should not be so strict that employee innovation is discouraged.

Use of maintenance facilities, tools, and equipment should be periodically reviewed and adjustments made to support effective maintenance. Increased staff size, special equipment needs resulting from facility modifications, and the increasing sophistication of maintenance activities can overload existing maintenance facilities. Managers should be responsible for optimizing use of existing maintenance facilities and for recognizing areas where performance could be enhanced by additional or improved facilities. Planning for new or expanded facilities should be long range and should not be done to address an immediate need.

Increased staff size, special equipment and tool needs as a result of facility modifications, planned outage workload, and the increased sophistication of maintenance activities may overload existing maintenance facilities. Each maintenance facility, tool, and equipment use should be reviewed periodically, and appropriate adjustments should be made to support safe and effective maintenance. Managers should recognize that the pace of work and a “can do” spirit by the maintenance organization may disguise inadequate facilities. Managers are responsible for optimizing use of existing maintenance facilities, equipment, and tools and also for recognizing areas where performance may be enhanced by additional or improved facilities.

Maintenance should develop and implement comprehensive seasonal transition, freeze protection, and energy conservation plans developed to address the specific needs and action schedules to sustain critical areas, buildings, and individual items, as appropriate. Snow and ice control plans should be implemented as the need arises (see Section 4.18).[31, 39, 117]

4.3.3 Guidelines

4.3.3.1 Shops and Satellite Work Areas [29, 67, 68, 69, 70, 72]

The layout of shop and satellite work areas should be designed with a high priority on industrial safety and efficiency. As shops are modified and satellite work areas are changed throughout the life of the facility, safety and efficiency should remain foremost considerations.

Location and type of work performed should be considered in determining the types and level of environmental controls and services to be included in each maintenance shop and satellite work area. Examples of some environmental controls and services include the following.

- Fume removal.
- Temperature, humidity, and dust control.
- Equipment space considerations.
- Lighting.
- Demineralized water.
- Noise control.
- Facility service and instrument air.
- Electric power supplies.
- Radiological controls.

Environmental conditions often have a significant impact on personnel performance. Supervisors need to be responsive to maintaining workplace environmental controls conducive to increased maintenance quality and work efficiency.

Each shop and satellite work area should have storage that is convenient and that encourages craft personnel to keep the area neat and clean. Shelves, cabinets, lockers, and toolboxes are examples of storage facilities that could be provided for items such as tools, parts, reference materials, and personal effects (see Section 4.7.3.13).

4.3.3.2 Laydown and Staging Areas

A plan for identification and use of maintenance laydown and staging areas should be developed and kept current. This plan should define outage support requirements, use, and responsibility for area upkeep and control and should include items such as the following.

- Authorization for access, with provisions for security and fire protection.[54]
- Radiological control.
- Labeling of facilities to designate responsibility and entry authorization.[84, 90, 91, 92, 93, 98]
- Contingency plans for situations (such as unanticipated radioactive airborne contamination) that could render a facility unusable for its intended purpose.

Planned outages should have assigned staging and laydown areas for equipment, special tools, rigs, and parts. Personnel movement into and out of areas should be planned and understood by all concerned (see Sections 4.11 and 4.12).

4.3.3.3 Storage Facilities [4]

Storage facilities for supplies and parts are an important consideration in providing for safe, efficient, and high-quality maintenance. The evaluation performed to determine storage facility needs should address items such as the following.

- Environmental controls, considering such issues as isolation/segregation of chemicals, flammability of lubricants and paint, qualification of parts/components, damage to elastomers and polypropylene parts because of exposure to light, and control of radioactive materials.

- Storage activity controls, considering such subjects as material receipt, inspection, handling, storage, retrieval, and issuance (Section 4.10); and tool and equipment control (Section 4.12).

- Inventory level of spare parts, supplies, and equipment to support safe and reliable operation of the facility (Section 4.9 and Section 4.10).

4.3.3.4 Temporary Facilities [111]

Temporary facilities are required for activities involving contractor support during outages and control of airborne radioactivity and contamination. Planning and coordinating temporary facilities with other groups, such as radiological protection and operations, result in more efficient use of space. Such necessary services as electric power, compressed air, water, environmental controls, and lighting should be provided at temporary-outage support facilities. ALARA should be considered when designing and locating temporary facilities. Glove boxes or temporary containments should be considered for work on contaminated equipment to prevent spread of contamination. Design of major temporary facilities should be controlled through the plant's design change programs to ensure that additional building services (such as electricity, compressed air, and water) do not overload plant systems.

4.3.3.5 Decontamination Facilities [13, 32, 33, 38, 42, 111, 121]

Decontamination facilities and methods should be used to reduce the volume of radioactive solid waste, to clean up contaminated equipment, and to reduce contamination on reusable tools and equipment. Examples of decontamination facilities and methods include a washdown area, solvent rinse, ultrasonic bath, acid bath, electropolishing, hydroblasting, and sandblasting. Use of these facilities and methods can reduce exposure, repair time, and solid radioactive waste volume and provide better tool management.

4.3.3.6 Tool and Equipment Storage [111]

Storage facilities should be central to shops and normal work areas to improve maintenance efficiency. They should store tools and equipment needed daily by craft personnel; special tools, special equipment and test rigs; and mockups; all should be readily retrievable when needed. These facilities should have controls for temperature, humidity, dust, and radioactive contamination, as needed. They should also meet manufacturers' special material handling or storage requirements. Facilities should be provided for segregation, calibration, and repair of maintenance and test equipment. Design considerations such as heavy loads and seismic criteria should be considered for in-plant storage areas for tools. (See Section 4.12 for additional information on tool and equipment control.)

4.3.3.7 Office Equipment [111]

Maintenance facilities should include office equipment that supports the maintenance organization in efficiently completing its work in a high-quality manner. Adequate communication, calculation, reproduction, and other equipment should be accessible and maintained in reliable working condition. When computerized databases are used, convenient access to computer terminals should be provided. During outages or other high-activity periods, additional office equipment should be provided as needed.

4.3.4 Maintenance Facilities and Equipment Performance Objectives [23]

Facilities and equipment should effectively support the performance of maintenance activities.

CRITERIA

A. Maintenance facilities size and arrangement promote the safe and effective completion of work.[111, 166] Facilities should be provided for work on contaminated components.[100]

B. Work area lighting and other environmental conditions promote safe and effective working conditions.[16, 116]

C. Work areas are maintained in a clean and orderly condition.[166]

D. Proper tools, equipment, and consumable supplies are available to support work requirements.[111]

E. Suitable storage is provided for tools, supplies, and equipment. Special tools, jigs, and fixtures are identified and stored to permit retrieval when needed.[111]

F. Contaminated tools are segregated from clean tools to prevent cross-contamination. Reuse is stressed, when feasible.[59, 121]

G. Scaffolding and rigging equipment is identified, tested, and properly stored.[121]

H. Facilities, equipment, and tools are maintained in good repair.

I. M&TE is calibrated and controlled to provide accuracy and traceability. Out-of-tolerance test equipment is removed from service. Plant equipment calibrated with out-of-tolerance test equipment is evaluated in a timely manner for operability and is recalibrated as necessary.

J. Fixed local area hosts and work platforms are provided, as needed, to facilitate maintenance access to facility equipment.[111]

4.4 TYPES OF MAINTENANCE (Replaces DOE-STD-1052-93)[4, 9, 17, 19, 20, 30, 39, 117]

4.4.1 Introduction

A proper balance of corrective maintenance and PM should be used to provide a high degree of confidence that degradation of facility equipment is identified and corrected, that life of equipment is optimized, and that the maintenance program is cost-effective. The maintenance program includes preventive, predictive, and corrective maintenance.

This section provides guidelines for establishing the proper relationship of the types of maintenance in the maintenance program. It does not address TSR or operational safety requirements; however, operations maintenance surveillance and inspections, as well as ISIs, should be considered essential source data in establishing the scope of the predictive and preventive maintenance program.

4.4.2 Discussion

Many factors should be considered in establishing an effective and efficient balance of the various types of maintenance. On important systems and equipment, a thorough technical analysis using methods such as reliability-centered maintenance (RCM) will be needed to establish this balance (see Sections 4.4.3.3 through 4.4.3.6). Additional guidance in this area is provided in the draft report “Reliability, Availability and Maintainability (RAM) Guidelines” developed in support of DOE Order 420.1.[30] On less important systems, the amount of PM to be performed may be determined through use of a more basic judgmental engineering analysis.

A proper balance of the types of maintenance may include, at one extreme, no PM for equipment that is allowed to run until it fails, if the failure would not adversely affect facility operations. At the other extreme, for equipment whose failure can limit safe or reliable operation or result in unplanned outages, extensive PM may be required. The purpose of PM is to eliminate or minimize the latter type of failure.

Costs associated with PM should be offset by improved facility reliability and availability and by reduced corrective maintenance.[9, 17, 19, 20, 67] However, excessive or unnecessary PM can consume resources that could otherwise be used to extend the scope of the PM program and may also increase maintenance errors, rework, and personnel radiation exposure.

For the purposes of this Guide, the following types of maintenance are defined in Section 1:

- corrective maintenance,
- PM,
- surveillance,
- predictive maintenance,
- environment, safety, and health (ES&H) maintenance, and
- general maintenance.

The elements needed to successfully implement the maintenance program discussed above include the following.

- A master equipment list (MEL) to help in selecting and scheduling PM and in evaluating the effectiveness of the maintenance program.

- A method that determines how each of the different types of maintenance is to be used to maintain each system and piece of equipment. This method should address the PM actions required and the frequency needed for performing each PM action (see 48 CFR 45.509-1).[9]

- Scheduling each PM action in a manner that allows consideration for performing related maintenance at the same time (see Section 4.6).

- Review and approval by the maintenance manager of PM actions that are deferred past a grace period (normally, 25 percent of the established interval) or are missed entirely; such actions should also be reported periodically to the facility manager.

- Periodic review of the maintenance program to determine its effectiveness on overall facility reliability. Changes should be considered during this review to optimize the maintenance program (see Section 4.14).

4.4.3 Guidelines

4.4.3.1 Master Equipment List

A detailed master list of both safety and nonsafety equipment, components, and structures to be included in the maintenance program should be developed. Special tools and equipment should be included in this master list. It can be used effectively in establishing the maintenance history program (see Section 4.15).

4.4.3.2 Preventive Maintenance (See 48 CFR 45.509-1)[9]

PM consists of all those systematically planned and scheduled actions performed to prevent equipment failure. The PM program should define the required activities and the frequency with which they should be performed. Selection of required PM actions should be based on manufacturers' recommendations, plant experience, and good engineering practice. PM frequency should be based on adequately implementing the entire program, considering such elements as predictive maintenance results, vendor recommendations, ALARA considerations[121], and monitoring of performance. A documented basis for the planned actions should be provided. Further, any deferral of planned tasks should have a technical basis.

4.4.3.2.1 Component Wearout Degradation

It is reasonable to consider implementing PM activities for components that demonstrate failure modes caused by degradation or wear due to application, use, time, age, etc.

4.4.3.2.2 The Preventive Maintenance Process

A good PM program should be an evolutionary process. It should start with the scheduling of routine tasks done based on such items as regulatory requirements, TSR, codes and standards, vendor recommendations, facility and industry experience with similar equipment, engineering analysis of equipment performance, systematic analysis through predictive maintenance, history records of equipment performance, cost/benefit analysis, capacity need, and schedule use. It should be revised as additional history and trends indicate.

4.4.3.2.3 Interval of Preventive Maintenance Tasks

The initial interval for PM tasks should be established to maximize equipment reliability. The objective of a maintenance program is to increase the availability of SSCs by eliminating hidden faults before equipment is disabled. Unfortunately, maintenance actions sometimes introduce new failures because of factors such as human error. Because an effective PM program should reduce the overall failure rate of the SSCs involved while minimizing the downtime of the SSCs and the possibility of introducing new failures, the best method to determine PM frequency is to make it an optimization problem. This means on the one hand, that the availability increases because of a decrease in failure rate (by eliminating hidden faults) and, on the other hand, that availability decreases because of an increase in downtime. Therefore, there is an interval (or frequency of maintenance) that yields the maximum achievable availability. Those risk-significant SSCs for which an increase in their availability can most reduce facility risk should be selected for an optimized PM.

Optimization of maintenance intervals involves the following general activities:

- reporting PM activities, plans, and schedules;
- calculating the PM interval by balancing availability, reliability, and cost;
- ranking PM tasks;
- accessing PM information from piping and instrumentation drawings (P&IDs);
- accessing PM and other maintenance data;
- listing recurring failure modes/parts including failure to start and failure to run;
- calculating and monitoring SSC availability;
- accessing PM procedures; and
- keeping track of PM cost.

4.4.3.2.4 Scheduling and Tracking Preventive Maintenance Performance

1. A master schedule should be prepared based on the assigned interval determined per Section 4.4.3.4. The master schedule should include PM tasks intervals throughout the year.

2. PM work-control documents (see Section 4.6 and Section 4.7) should be prepared for each task. They may be either hard-copy duplicates or computer-generated copies.

3. PM tasks should be capable of being quickly sorted and listed by system and system operational condition required to perform the task. (System operational condition is not really a major item of concern at research facilities.) This should aid in planning work items, especially when being performed during forced outages and changes in operating conditions, and also aid in scheduling PM tasks by system/subsystem to increase overall equipment capacity.

4. PM should be scheduled at appropriate intervals and, where practical, with corrective maintenance and surveillance, ISI/IST test activities, and other related maintenance on the same equipment.

5. Grace periods should be specified in the PM program.

6. Delays in the performance of scheduled PM tasks beyond the defined grace period should require escalating approval. For example, approval should be obtained from department supervisors, operations managers, maintenance and maintenance engineering managers, and the facility manager, depending on the length of time that the task is to be delayed and the potential risk involved.

7. Appropriate craft supervision should be encouraged to recommend changes in PM task interval based on real-time observations and conditions. These changes should be approved by the operations, maintenance, and maintenance engineering managers.

8. The maintenance manager should report monthly to the operations manager any associated problems with scheduled PM tasks, including the number exceeding the grace period.

4.4.3.2.5 Performance of Preventive Maintenance Tasks

PM tasks should be performed using procedures or instructions and controlled by methods such as task cards or detailed PM job requests. Coordination should be established in advance among other maintenance groups and facility departments (e.g., operations, radiological protection, and QA/QC). Good work practices, such as prejob briefings, quality craftsmanship, observations, data recordings, cleanliness, correct tool use, and history update are essential to the PM task.

4.4.3.2.6 Preventive Maintenance Program Evaluation [See 10 CFR 830.122(i)[1]]

An evaluation of the PM program should be conducted annually by the maintenance manager with assistance from the applicable/affected operations, technical support, and engineering groups. This evaluation should address the overall effectiveness of the program in improving facility and/or equipment availability, as well as reducing the cost of maintenance. This evaluation should consider PMs that are being performed unnecessarily or excessively, thereby consuming valuable and limited resources that may otherwise be used to upgrade other maintenance programs. Additionally, excessive PM may increase item deterioration, radiation exposures, maintenance errors, and rework. Items to be considered in the evaluation should include, but not be limited to the following:

- adequacy of PM procedures as deemed by craftsperson feedback (Figure 4.4-C provides an example of a craftsperson feedback form.);
- QA audit reports and self assessment findings;
- failure trend reports for facility and industry equipment;
- occurrence reports;
- nonconformance reports;
- material deficiency reports; and
- causes for deferrals.

4.4.3.2.7 Preventive Maintenance Program Improvement

Using the results of the PM program evaluation presented in Section 4.4.3.7, the following improvements should be addressed and implemented as appropriate:

- adjustment of PM task interval;
- redefinition of PM activities;
- addition or deletion of PM activities;
- adjustment of spare parts stocking levels;
- propose design changes;
- identification of special tools;
- revised PM program and/or PM task procedures;
- replacement of cost/labor intensive items; and
- the need for personal protective equipment (e.g., whose use generates hazardous waste) in performing PM tasks.

4.4.3.2.8 Preventive Maintenance Program Enhancement [See 10 CFR 830.122(c)[1]]

The purpose of the following sections is to provide guidance that may be used to enhance an existing PM program by improving the reliability of facility components and systems while optimizing resources. The implementation of this guidance should help ensure that PM tasks for important components are applicable for the types of expected failures and are effective in controlling the failures.

Before the enhancement effort is started, the objectives to be achieved should be clearly established by management. In establishing the objectives, the status of the existing PM program should be considered. For example, objectives a facility may establish to enhance a weak PM program may focus more on equipment reliability and documentation of the basis for existing tasks, while a facility with a well-established PM program may have an objective to improve use of resources and optimize selected TSR for PM activities.

It is important that all groups involved in the development or performance of PM tasks become familiar with the stated objectives and participate in some portion of the analysis effort. This should produce more comprehensive results, enhance ownership of the program, and facilitate implementation of changes to the existing PM program.

The PM program enhancement method provides two analytical processes, problem components analysis and system analysis. Each process is followed by PM task selection and implementation. The final element of the enhancement method is establishment of a living PM program that is continually updated, based on actual equipment performance, to maintain its effectiveness.

Problem component analysis is described in Section 4.4.3.3. This analysis focuses on improving reliability of problem components by determining failure modes and implementing any needed PM tasks or design changes.

System analysis is described in Section 4.4.3.4. This analysis focuses on improving overall reliability of facility systems by determining failure modes and implementing PM tasks or design changes. This analysis improves the use of resources by identifying existing PM tasks and TSR that may be redundant or unnecessary. Additionally, this analysis identifies noncritical components that may be evaluated to determine whether assigned PM tasks are cost-effective with respect to resources and radiation exposure or consequences of failure. The review of noncritical components often provides the greatest opportunity to optimize the use of available resources.

Following completion of the analysis techniques in the PM program enhancement process (Sections 4.4.3.3 or 4.4.3.4), selection and implementation of applicable and effective PM tasks are performed as described in Section 4.4.3.4.14. Selection of condition monitoring (predictive maintenance) tasks is emphasized before selection of time-directed PM tasks. If an applicable and effective PM task cannot be determined, the process involves an evaluation to determine the feasibility of a design change or other corrective actions.

Maintaining an effective PM program is described in Section 4.4.3.6. Experience gained from facility operations, maintenance, and the installation of design changes dictates frequent review of the enhancement analysis and revision of the PM program to maintain program effectiveness.

4.4.3.3 Problem Component Analysis

This section describes a process that may be used to analyze problem components and identify any PM activities that may improve component reliability. The type and level of maintenance performed on a component should be based on its importance to the facility with respect to nuclear safety and reliability. The effort to enhance a PM program should start by focusing on these components. Although several analytical techniques may be used, the technique described in this section is a functional failure analysis that is commonly used in reliability-centered maintenance programs. The analysis described in this section includes the following:

- problem component selection,
- component boundary determination,
- component history review,

- selection of analysis technique,
- determination of functional failures, and
- determination of failure modes and effects.

After the problem component analysis is complete, selection and implementation of applicable and effective PM tasks may be performed as described in Section 4.4.3.4.14.

4.4.3.3.1 Problem Component Selection

Problem components are usually known and acknowledged as facility problems.

They may be identified as those components whose past failures have caused significant adverse impact on safety system availability or maintenance cost, or those components with a high rate of initiating facility or process shutdowns, or unplanned days of nonproduction. It is important to start the enhancement effort by focusing on these components so that timely improvements in component reliability may be realized.

An unacceptable failure rate is a factor in determining problem components; however, the consequences of the component's unreliability are more important factors. Problem components should usually be determined through existing programs for engineering analysis of facility performance. These analyses would include review of facility availability and event reports, limiting conditions for operation (LCOs) logs, outage reports, maintenance history, and component failure analysis reports (CFARs). The components identified using this process should be confirmed by interviews with various managers and key operations and maintenance personnel.

The components identified should be prioritized according to their impact on the facility. Impact on resources may also provide valuable input to prioritization. Any method acceptable to facility management may be used to quantify the component's impact on the facility. Facility management should review and concur with the priorities before the detailed analysis is initiated.

Efficiency may be gained if similar components are grouped together for the analysis. The criteria for grouping components should be that the components have similar functions, failure effects, and operating environments. Although it may be helpful to review failure history of all components with the same manufacturer and model number, selection and assignment of the same PM tasks to all of those components may lead to unnecessary tasks being assigned.

4.4.3.3.2 Component Boundary Determination

A boundary for the selected components should be established to ensure that associated devices are appropriately considered in the analysis. The boundary for a component should be a logical grouping of devices or components based on the function of the component. All attendant devices necessary for the component to perform its system function should be included within the boundary. For example, if a spray valve is identified as a problem component, then the valve operator, valve positioner, and current-to-pressure converter should be included in the boundary. Accurate and inclusive boundary determination is important because the unreliability of the valve may be caused by seemingly unrelated failures of these devices or it may be determined that the unreliability is primarily due to only one of the devices, in which case, the boundary may be redrawn to focus the analysis on that device.

For a larger component, such as a main feedwater pump, is selected, the boundary for the pump, which may be considered a subsystem of the feedwater system, may be established as described in Section 4.4.3.4.5, "Subsystem Boundary Determination," and analyzed using the guidance described in Section 4.4.3.4, "System Analysis."

When establishing the component boundary, also consider the devices associated with an equipment identifier since maintenance and operating history is usually most easily retrievable using those identifiers.

4.4.3.3.3 Component History Review

All appropriate operating characteristics, requirements, vendor maintenance recommendations, and history records of a component should be identified and considered in analysis of the component. History review and data collection may be time-consuming depending on individual facilities. These are efforts that should be performed throughout the analysis process. The information collected should be compiled into a data package to facilitate future use, reference, and ready access. All documentation developed during the analysis of components should be retained for use in the analysis described in Section 4.4.3.4, "System Analysis."

The data sources listed in Figure 4.4-A should provide the design and operating information needed to determine component functions and to perform the component analysis. The information needed includes the following:

- design specifications,
- operating requirements,
- theory of operation and operating limitations,
- maintenance and surveillance requirements, and
- internal and external commitments.

Component functions, requirements, and commitments should be listed on a form similar to Figure 4.4-B.

After the function and requirements of the component are established, its history and all the activities routinely scheduled for the component should be reviewed. At least 2 operating years of corrective, PM, and surveillance data should be evaluated. History for components performing identical functions in similar environments for multi-facility sites should be included. Data older than two years may be of limited value since it may not reveal any new failure modes or the cause of the failure may have been subsequently resolved. When reviewing the history of the components, the analyst should attempt to identify the following:

- failure modes;
- failure causes and mechanisms; and
- failure rates as compared to the industry, if easily retrievable and available.

Much of the information collected may be validated and additional perspective gained from interviews with key operating, maintenance, engineering, and vendor personnel. Information gained by interviews should be compared with the history data to ensure all known failures and reliability problems are identified for analysis.

4.4.3.3.4 Selection and Analysis Technique

Several analytical techniques may be used to determine the root causes and corrective actions for component performance problems. Each technique has its advantages and should be used when the circumstances best fit those advantages. Existing facility programs for root-cause analysis should be considered and used appropriately in resolving component performance problems. Unacceptable levels of corrective maintenance noted on a component may indicate a problem with maintenance work practices, inadequate procedures, spare parts, or inappropriate design. Corrective actions for the causes of these problems should be addressed on a case-by-case basis rather than considering additional PM tasks.

4.4.3.3.5 Determination of Functional Failures

This section describes the method for determining component functions and how the component may fail.

From the data collected during the component history review, the functions of the component should be determined and recorded. Functions are actions or requirements the component should accomplish to support its overall system function. It is important that all functions of the component be identified since preserving these functions is the primary objective of the PM tasks that should be selected.

After the component functions are determined, the next step is to identify the likely failures that may cause loss of one or more component functions. These are called functional failures. A functional failure exists when a component ceases to provide a required function whether the function is active or passive, evident or hidden. Some functional failures may be considered to be implausible. Examples of implausible failures are those that result from a rare or unexpected external occurrence or from an unexpected or unlikely failure mechanism. Although they are noted, implausible failures may not considered for further analysis in some cases.

4.4.3.3.6 Failure Mechanism and Consequences

The failure modes of the selected component and the effects or consequences of failures need to be determined. Performing the failure mode and effects analysis (FMEA) is a significant element of the problem component analysis [this may be referred to as physics maintenance (see Section 4.4.3.4.12)].

4.4.3.4 System Analysis

This section describes a process that may be used to analyze facility systems to improve system reliability and optimize use of resources. The purpose of a system analysis is to identify critical components whose failures should be controlled or eliminated to preserve important system functions. Additionally, this section provides a strategy for analyzing noncritical components. The steps of the analysis to determine necessary PM tasks are described in the following sections.

Before the enhancement effort is started, the objectives to be achieved should be clearly established by management. In establishing the objectives, the status of the existing PM program should be considered. For example, objectives a facility may establish to enhance a weak PM program may focus more on equipment reliability and documentation of the basis for existing tasks. A facility with a well-established PM program may have an objective to improve utilization of resources and optimization of selected TSR for PM activities.

It is important that all groups involved in the development or performance of PM tasks become familiar with the stated objectives and participate in some portion of the analysis effort. This should produce more comprehensive results, enhance ownership of the program, and facilitate implementation of changes to the existing PM program.

The PM program enhancement method provides two analytical processes, problem components analysis and system analysis. Each process is followed by PM task selection and implementation. The final element of the enhancement method is establishment of a living PM program that is continually updated, based on actual equipment performance, to maintain its effectiveness.

Problem component analysis is described in this section. This analysis focuses on improving reliability of problem components by determining failure modes and implementing any needed PM tasks or design changes.

System analysis is described in this section. This analysis focuses on improving overall reliability of facility systems by determining failure modes and implementing PM tasks or design changes. This analysis improves the use of resources by identifying existing PM tasks and TSR that may be redundant or unnecessary. Additionally, this analysis identifies noncritical components that may be evaluated to determine if assigned PM tasks are cost-effective with respect to resources and radiation exposure or consequences of failure. The review of noncritical components often provides the greatest opportunity to optimize the use of available resources.

Following completion of Sections 4.4.3.3 or 4.4.3.4, selection and implementation of applicable and effective PM tasks are performed as described in Section 4.4.3.4.14. Selection of condition monitoring (predictive maintenance) tasks is emphasized before selection of time-directed PM tasks. If an applicable and effective PM task cannot be determined, the process involves an evaluation to determine the feasibility of a design change or other corrective actions.

Maintaining an effective PM program is described in Section 4.4.3.6. Experience gained from facility operations, maintenance, and the installation of design changes dictates frequent review of the enhancement analysis and revision of the PM program to maintain program effectiveness.

Before the enhancement effort is started, the objectives to be achieved should be clearly established by management. In establishing the objectives, the status of the existing PM program should be considered. For example, objectives a facility may establish to enhance a weak PM program may focus more on equipment reliability and documentation of the basis for existing tasks. A facility with a well-established PM program may have an objective to improve utilization of resources and optimization of selected TSR for PM activities.

It is important that all groups involved in the development or performance of PM tasks become familiar with the stated objectives and participate in some portion of the analysis effort. This should produce more comprehensive results, enhance ownership of the program, and facilitate implementation of changes to the existing PM program.

4.4.3.4.1 System Selection and Prioritization

This section describes selection and prioritization of facility systems based on importance to nuclear safety, reliability, and cost. While two methods for selecting and prioritizing facility systems to be analyzed are discussed, there are many methods that have been used effectively. Each facility should establish criteria and select a method that best meets its specific objectives. The method selected is not critical to the enhancement effort; choosing a method, documenting the method and its results, and proceeding with the system analysis are more important.

Systems should be selected and prioritized using input from facility personnel and management. The selection and prioritization process should include representatives from operations, maintenance, and technical support, including managers, supervisors, and appropriate craft personnel. During the process, the following factors should be considered:

- importance to nuclear safety,
- potential for improved system or facility availability,
- regulatory concerns,

- historical and potential maintenance costs, and
- personnel and resource requirements.

Sources of information that may be helpful in the selection and prioritization of facility systems include the following:

- probabilistic risk assessments (PRAs);
- SARs;
- individual facility examinations;
- equipment failure trending data;
- radiation exposure histories;
- maintenance histories;
- facility life extension and aging studies; and
- job task analyses, process safety analyses, and worker safety requirements.

4.4.3.4.2 Methods Used to Select and Prioritize Facility Systems

The following are two methods that may be used to select and prioritize facility systems.

1. A system prioritization survey may be performed by developing a list of important criteria. Select and request managers, supervisors, engineers, and knowledgeable craftspersons to complete the survey for each system considered for enhancement. Each system should be evaluated by assigning weighting factors from 1 to 10 to each criterion (i.e., 1 = lowest, 10 = highest) and then determining an overall importance value for each system by summing the factors.

   The importance values provided by all personnel performing the evaluations should be summed for each system, and each system should be ranked in descending order. The systems with the highest ranking should be the ones considered when selecting the system to be evaluated first.

2. Method 2 is directed at improving nuclear facility safety through improvement to overall facility performance by focusing on system availability data (i.e., unplanned shutdown days and unplanned outage extension days) and the results of system prioritization surveys as they are described in Section 4.4.3.4.1. The survey and unavailability data are then scaled to reflect their relative magnitude. Next, the scaled values are multiplied by a weighting coefficient and summed to yield a composite score. These scores are then ranked in descending order.

   Some suggested weighting coefficients are shown below.

System Data	Weighting Factor
Unplanned days off-line	1.00
Surveillance unavailability hours	0.04 (Mode 1)
In-facility survey	0.10

Unplanned days off-line (UDOL) include unexpected facility shutdowns, forced outages, and outage extension days. The time spent in maintenance surveillance testing and corrective maintenance that place SSCs in an LCO action statement should be included in surveillance unavailability hours.

The following formula may be used to determine system ranking for a facility.

***NOTE*: LCOs hours for multifacility sites may be considered as shown in the formula.**

System score: 1.0 * [UDOL]
+ 0.04 * [LCO (F1) + LCO (F2)]
+ 0.1 * [Survey results]

Where: F1 = Facility 1
F2 = Facility 2
* = multiply.

***NOTE*: The formula may be modified for a specific PM program enhancement objective by changing or adding additional factors along with appropriate weighting coefficients. For example, a facility with a well-established PM program and a strong performance record may have an objective to optimize resources by selecting systems with a large number of PM tasks for possible reduction while not affecting safe and reliable operation of the system. To consider the impact of the existing PM effort, a factor may be added to the formula that represents the number of existing PM tasks per system or cost to perform the tasks. The weighting coefficient selected should be representative of the importance placed by management on that factor of the formula.**

4.4.3.4.3 System Evaluation

The system selection and prioritization process should be used for the facility systems deemed most important for nuclear safety, reliability, or economics. Facility management should review and approve the systems selected and their ranking. If two or more systems have equal ranking, facility management should decide the final ranking that establishes the sequence in which the systems should be evaluated.

It may be advisable to begin the enhancement effort by conducting a pilot study of one system. If a pilot study is to be conducted, it may be best to start with a system that has an unacceptable failure rate. Another criteria that may be used for the pilot study is that a relatively simple system containing mechanical, electrical, and electronic components be selected so all major technical disciplines may gain experience from the study. The primary objective of the pilot study is to refine techniques and establish guidelines for analysis of future systems. It should be recognized that the number of systems selected for detailed evaluation determines overall scope of the PM program enhancement effort and the resources needed.

4.4.3.4.4 Data Collection

Once systems are selected, the analyst should collect design, operational, and maintenance information to develop a data package for the system and components. This ensures the operating characteristics, requirements, and history of the system and associated components are known and considered in the analysis. The data package should provide the analyst with the information needed to determine system functions, equipment failure modes, failure causes, and failure rates. Various sources and types of data should be collected to perform the analysis. The information for the data package may be obtained from sources such as those shown in Figure 4.4-A. The information needed includes the following:

- design specification,
- operating requirements,
- theory of operation and operating limitations,
- maintenance and surveillance requirements,
- internal and external commitments, and
- routinely scheduled PM and surveillance activities.

Although the data collected may have many uses, collecting and assimilating the information is a time-consuming effort and is performed continuously throughout the process. To facilitate retrieving, using, and updating the data collected, a computer database may be used. If a computer program is not available for electronic approvals of analysis documentation, computer-generated forms may be used to obtain the necessary reviews and approvals.

4.4.3.4.5 System Boundary Determination

The next step in the enhancement process is to define the system boundaries and interfaces of selected systems and subsystems. The boundary of a system should include everything necessary for the system to accomplish its function(s). Defining system boundaries is an important step, and once established, boundaries should be documented and maintained throughout the remainder of the process. To assist in defining system boundaries, the analyst should refer to the boundary or system interfaces identified during a design basis review, if one is available. Using information already developed provides an opportunity to minimize the cost and resources needed.

Using a copy of the single-line schematic drawings and P&IDs of the selected system, define the system boundaries as follows.

- Draw boundary lines such that controlled components and their associated controllers and instrumentation are within the system boundary.
- Process boundaries for a system should be drawn at a valve, with the valve included if its function is for isolation of the system.
- For air-operated valves, include the instrumentation air system back to the first isolation valve off the instrument air header and the local instrumentation (e.g., positioners, current-to-pneumatic converter and solenoid valves). For the instrument air system, the valves, regulators, and piping serve the same function and should be analyzed as part of the instrument air system.
- Include multiple trains or redundant components in a system within the same system boundary.
- When a system contains a heat exchanger, include the heat exchanger with the system that is being cooled.
- Include specific components that are dedicated to a particular system within that system boundary. For example, the level and flow instrumentation in a main steam system that provides signals only to the feedwater control logic should be included in the feedwater system and not in the main steam system.
- Where system drawings are not sufficient to show instrumentation logic and electrical boundaries, special boundary points may need to be established. For example, to define functions where control logic is involved, the analyst may find it convenient to extend a system boundary beyond that shown on a given drawing to include instrument sensors that drive the system logic.
- It may be helpful to color code the P&IDs to show the boundaries and each component that should be addressed in the enhancement effort. In addition, it also may be helpful to develop a list of components within the boundary to track their analysis.
- Include a copy of the marked-up system drawings in the final documentation package.
- Review and compare major drawings to ensure all components in the selected systems were included in the process and important components were not excluded when system boundaries were established.

4.4.3.4.6 Subsystem Boundary Determination

This section provides a method to determine subsystem boundaries by partitioning the selected system. The boundary for a subsystem should be established as a logical grouping of devices based on the functions of the system being analyzed. All instruments and components that are necessary for the subsystem to perform its system function should be included within the subsystem boundary. These new boundaries partition the system under analysis into subsystems. Some of the guidance for defining system boundaries as described in Section 4.4.3.4.5 is also applicable to the subsystem boundary determination process. For example, redundant trains of components should be included in the same subsystem. The subsystem should be further partitioned into separate trains for analysis to consider the possibility that one train may perform a function(s) the other train does not perform. This step of partitioning into subsystems should be completed for all functionally significant components within a selected system.

Subsystem boundary interfaces also should be identified. These interfaces include significant mechanical, electrical, and pneumatic inputs/outputs and/or control signals such as the following:

- Inputs cross the boundaries moving into a component of the subsystem. Examples of inputs include fluids, gases (e.g., air), electrical power, instrument signals, and steam. These inputs are necessary for the component to function properly. In this process, inputs are always assumed to be present and available when needed.

***NOTE*: The assumption that these inputs are present and available when needed precludes the need for using a fault tree analysis to analyze multiple failures. For example, if the supply breaker is included in a subsystem, a fault tree analysis would be appropriate to analyze failures of the breaker along with failures of other subsystem components. If a fault tree is not used, the breaker should be analyzed as a separate subsystem or when the distribution system is analyzed.**

- Outputs cross the boundaries moving out of the component into other components or systems. These outputs are directly related to the functions that should be preserved.

- A component interface block diagram may be used to illustrate inputs and outputs.

4.4.3.4.7 Determination of System and Subsystem Functions

This section describes a method to determine the primary and auxiliary functions of a system and subsystem and the ways these functions may fail. Determining functions is an important step in this method since preserving these functions is the objective of the PM task that should be selected.

Function definitions describe what the system or subsystem should accomplish. Functions may be determined from the following:

- stem and subsystem interfaces that should be supported,
- internal interfaces that the system or subsystem should provide as input to another subsystem, and
- internal interfaces that the system or subsystem provides to support itself.

Examples of primary functions include the following:

- normal and emergency cooling flow;
- auto-start signal to another system;
- compressed air at a sufficient pressure for downstream components to operate properly; and
- control room alarms, indications, and recordings.

Determine the function(s) of each system and subsystem by reviewing facility system descriptions, SARs, P&IDs, TSR, operating procedures and instructions, abnormal operating procedures, emergency operating procedures, and design basis documentation. If functions, such as providing a vent or drain path, are determined not to be important to the overall purpose of the system or subsystem, then these functions may be omitted. Omission of specific functions (or other assumptions) should be noted in the data package along with the technical basis for the omission. System or subsystem function(s) should be listed on a tabulation form.

When determining system and subsystem functions to analyze, the analyst should consider that a system and subsystem typically perform a number of auxiliary functions in addition to their primary function(s). The analyst should carefully review the auxiliary functions of systems and subsystems to identify those functions that should be preserved. Auxiliary functions may include the following:

- maintaining pressure boundary integrity,
- providing indications required by TSR,
- shutting down components automatically,
- providing input signals for local instrumentation, and
- providing miniflow protection for pumps.

4.4.3.4.8 Determination of Functional Failures

This section describes a method for determining likely component failures that may cause the loss of system or subsystem function(s). A functional failure exists when a component ceases to provide a required function whether the function is active or passive, evident or hidden. Some functional failures identified may be judged to be implausible. Examples of implausible failures are those manufacturing defects that escaped detection during installation and operational testing, the result of an unexpected failure mechanism, or a failure that requires a rare or unexpected external occurrence.

The definition of what constitutes a failure is of primary importance. A clear distinction should be made between degraded performance and functional failure. Whenever a failure is defined by some level of performance, condition, or dimension, the appropriate standards should be stated to provide the basis for establishing whether a failure has occurred. For example, heat exchanger tube fouling may cause water temperature to exceed an allowable temperature. This would be considered a failure. Any temperature below the allowable value, but above the normal operating temperature, would be considered degraded operation. Component performance standards are determined from descriptive and operating information sources such as facility TSR, operating procedures, and design requirements.

4.4.3.4.9 Functionally Critical Equipment Selection

This section provides guidance for determining critical components and instrumentation that may cause important system functions to fail. After functional failures are identified, functionally critical equipment (FCE) is identified by analyzing the functional failures. Components within a system or a subsystem that meet the following criteria are FCE.

- Components whose failure results in a system functional failure
- Components whose failure frequency and severity have an adverse impact on facility operation
- Selection of FCE may be performed by analyzing the effects of a failure of the component on the system functions. If failure of the component may cause a loss of system function, the component is considered FCE. In addition, the results of a PRA or other model may indicate that a component is functionally critical. The following items also should be considered in the selection and prioritization of FCE:

  —individual facility examination,
  —importance to nuclear safety,
  —safety system functional inspections,
  —operating and maintenance history,
  —facility operating experience,
  —CFAR,
  —radiation exposure attributed to maintenance on the component,
  —commitments associated with the component,
  —cost of repair,
  —mean time between failures, and
  —input from vendors and other supplier programs (e.g., technical bulletins and notices).

A list of all FCE should be compiled, this list should be useful in assigning priorities and should provide a mechanism for tracking and documenting the status of subsequent analysis.

4.4.3.4.10 Instrument Matrix

This section describes a method of identifying functionally critical instruments. A system may contain hundreds of instruments and the analysis of these instruments may be a formidable task. Many instruments perform important system functions that should be preserved by a PM task. However, some of these functions may not be identified during an analysis of system functions or during development of an FMEA on FCE that has associated instruments. To assist in identifying functionally critical instruments, a matrix should be developed and used to identify the functions of the instrument and their importance in maintaining system functions. This technique of using a matrix has proved to be successful for evaluating instruments and provides a good checklist to ensure that all functions of the instrument are identified for analysis.

All instruments contained in the system should be listed on a matrix containing an instrument function. The functions to be listed on the matrix are as follows.

Function Identifier	**Function Description**
F1	Provides a component, system, or facility trip function
F2	Provides automatic control or interlock
F3	Safety-related display instrumentation (e.g., as defined in TSR and SAR)
F4	Supports TSR
F5	Provides alarm, indication, or recorder information to the control room
F6	Instrument monitored on operator rounds
F7	Provides computer input

Note: Explanation of the types or uses of the input should be noted on the matrix.

F8	Instrumentation that is used to continuously monitor system, component, or facility performance or design parameters (e.g., accumulator pressure indication)
F9	Used for manual system operation.
F10	Required for general indication
F11	No required function

Note: The functions of the instrument should be clarified during an interview to ensure the classification is correct.

Instruments that should be listed on the matrix are those process devices that sense, switch, convert, indicate, and transmit such parameters as flow, level, pressure, temperature, PH, and conductivity.

The matrix should be distributed to appropriate operations, technical support, and maintenance personnel. Each individual should complete the matrix by placing an “X” in the designated column if the instrument performs that function. Other characters may be used to provide additional information on the instrument’s function. For example, it may be helpful to use a “C”, “S”, or “P” to denote a component, system, or facility function. An asterisk (*) may be used if the instrument is found to provide a significant system function.

After each instrument has been analyzed, the matrix should be returned to the analyst. The results of all the responses are combined into a master matrix. Based on the collective responses, the analyst determines the importance of each instrument. The first three functions (F1, F2, and F3) listed on the matrix are important system functions. Instruments that implement these functions are typically associated with other FCE. Instruments that perform functions F4 through F9 of Section 4.4.3.4.12 should be considered for an FMEA based on the instrument’s use, its required accuracy, and consequence of its failure.

4.4.3.4.11 Analysis Strategy for Critical and Noncritical Components

This section describes the analytical method for determining component failure modes, causes, and failure consequences of the functionally critical components and discusses run-to-failure strategy for noncritical components. Two analysis strategies are presented to analyze failure modes of (1) critical and (2) noncritical components.

The strategy for noncritical components is to evaluate existing PM tasks and the components, considering the consequences of deleting the tasks. The analysis of noncritical components often provides the greatest opportunity to optimize use of resources by identifying unnecessary or inappropriate PM tasks.

After the list of FCE has been identified and analyzed, the noncritical components should be reviewed and evaluated. An analysis of the PM programs for noncritical components may justify the deletion or modification of existing tasks or provide an economic basis that should allow the component to run-to-failure. The analysis of noncritical components may also result in a reduction of maintenance worker hours, spare part inventories, and radiation exposure. In addition, this should allow maintenance personnel to concentrate their efforts on components that are important to facility operation and safety.

A minimum review of noncritical components should consist of a review of the maintenance history, total PM tasks, and vendor information for the component. This review should identify recurring or highly probable failure modes. If the failure rate of the noncritical component is high and its repeated failures are not cost-effective, then effective PM tasks or design changes may be used to control the failure rate. Noncritical components with an acceptable failure rate and whose failure consequences are economically tolerable should be considered for run-to-failure operation.

The strategy for critical components is to identify significant failure modes by using an FMEA. Significant failure modes are failure modes that have a high likelihood of occurrence and that also have an adverse effect on a system or the facility.

4.4.3.4.12 Determination of Failure Modes and Effects

This section discusses how to determine the failure modes and effects of FCE failures. Performing the FMEA is a significant element of the system analysis. After the FMEA is completed, the significance of each failure mode is established to determine which modes should be evaluated for PM tasks or design changes.

Failure modes are the types of failure or ways a component may fail. They may be determined by reviewing the component's operating characteristics and how it functions in the system. Each failure mode should be recorded on a tabulation form.

The plausible causes of each failure mode should be determined. Facility history may provide additional information to determine the causes. The failure causes should be recorded on the FMEA tabulation form.

The effects of the failure modes should be determined. Failure modes should be evaluated at the local, system, and facility level to determine their effects. When evaluating components with redundant trains, consider the consequences of the failure mode as if the redundant train was not available.

NOTE: A conservative assumption is that the consequences of a failure of redundant equipment are not known. This should result in failures of most redundant safety components being classified as single failures of safety system functions. As such, these failures should be evaluated because they meet the criteria of loss of safety system function. There are analytical techniques used to determine the consequences of failures of redundant components. These techniques are typically used in PRAs that quantify risk and reliability. Although usually manpower-intensive, these techniques may reduce the number of redundant components that require an FMEA or change the priority of the components to be evaluated.

Local effects are those that may be noted in the general vicinity of the failure. System effects are problems that inhibit system functions or operations. Facility effects are problems that impact more than one system, constrain facility operation, or limit power generation.

If a failure mode has only a local effect, then no other analysis is needed for that failure mode. Failure modes that have a facility effect and a high likelihood of failure are considered significant and should be evaluated for PM tasks or design changes. Failure modes that have a system effect are evaluated to determine their likelihood of failure and the significance of the failure effects. The following questions may be used to determine whether the failure modes with a system effect are significant.

***NOTE*: Probability of occurrence of a failure is a consideration used in several elements of the analysis. Specific probabilities or the criteria to be used should be established by the facility.**

1. Does the failure mode cause loss of a safety or system function?
2. Is the failure likely to occur?
3. Does the failure mode adversely affect facility availability or result in a loss of production?
4. Could the failure mode result in personnel injury or significant component damage?
5. Does the failure mode result in high maintenance costs?
6. Does the failure mode result in significant radiation exposure to accomplish repair?
7. Considering a reasonable repair time, does the failure mode impose excessive demand on other components (e.g., on-off cycling, uneven load distribution, or exceeding capacity ratings) that may shorten the service life of other components?

Input and interviews from the operations staff and training materials may be used to identify possible failure effects. The effects of each failure mode should be recorded on the FMEA tabulation form.

If the answer to any of the above questions is "yes," the failure mode should be addressed by a PM task or be evaluated for a possible design change to eliminate or control the failure mode. If the answers to the questions are "no" and the likelihood for failure is also low, then the failure mode is considered to be insignificant because the consequences may be tolerated. If a failure mode may be tolerated, it is not essential to perform a PM task to mitigate the failure. If all failure modes may be tolerated, the component was incorrectly selected as FCE and the component should be considered for run-to-failure operation. Existing PM tasks for the component should be considered for possible deletion.

If the failure mode should be addressed by a PM task, indicate "yes" in the column marked "significant mode" of the FMEA tabulation form and select a PM task as described in Section 4.4.3.4.14.

Before the FMEA is approved, it should be reviewed by knowledgeable technical support and maintenance personnel to ensure the analysis was comprehensive and technically accurate. FMEA reviews may be performed in meetings with the appropriate personnel to expedite the review and gain insight for future analysis.

4.4.3.4.13 History Review

The history review plays a vital role in the PM program enhancement effort. For the system analysis process, the review should be conducted after the FMEA to avoid biasing the outcome of the analysis, which could result in overlooking some failure modes or inadequately addressing some components.

After the FMEA is completed, the history and all the activities routinely scheduled for the component should be reviewed. At least two operating cycles (about 3 years) of corrective and preventive maintenance data along with any surveillance data should be evaluated. History for components performing identical functions in similar environments for multifacility sites should be included. Data older than 2 years may be of limited value since it may not reveal any new failure modes or the cause of the failure may have been subsequently resolved. When reviewing the component's history, the analyst should attempt to identify failure modes, failure causes and mechanisms, and failure rates as compared to the industry if easily retrievable and available.

Although facility data are weighed more heavily, failure data from other sources should also be used. Newer facilities may have to rely more on industry experience. This data should be reviewed closely to determine that failure modes and causes are plausible and coded correctly. DOE Notices and Bulletins are valuable sources of failure information. CFARs should be used and failure rate data may be helpful in evaluating failure history. Unacceptable levels of corrective maintenance noted on a component may indicate problems with maintenance work practices, inadequate procedures, spare parts, or inappropriate design. Corrective actions for these causes of problems should be addressed on a case-by-case basis rather than considering additional PM tasks.

Much of the information collected may be validated and additional perspective gained from interviews with key operating, maintenance, engineering, and vendor personnel. Information gained by interviews should be compared with the history data to ensure all known failures and reliability problems are identified for analysis.

4.4.3.4.14 Preventive Maintenance Task Selection and Implementation

This section discusses the selection and implementation of applicable and effective PM tasks. To accomplish this effort, significant failure modes identified from the FMEA are evaluated using a logic tree analysis (LTA) to classify the importance of the failure modes. This information is then used to recommend applicable and effective PM tasks or design changes. The recommended PM tasks are compared to the existing PM tasks to determine if the new tasks should be implemented or if the existing tasks should be modified or deleted. This section also discusses development of an integrated project plan to implement the recommended PM tasks.

4.4.3.4.15 Logic Tree Analysis

A decision tree analysis or LTA process may be used to determine the importance of each significant failure mode and aid in the selection of applicable and effective PM tasks. The logic tree requires the analyst to answer “yes” or “no” to a series of questions. These answers should determine the decision path. The analyst starts by evaluating whether the failure mode is visible or evident to the operating crew. The analyst then determines the consequence and importance of the component functional failure. After determining the consequences and importance of the failure, an applicable and effective PM task is selected or a design change may be necessary. Table 4.4-A illustrates the LTA process.

Using LTA, categorize each failure mode according to its consequence and importance to the operation of the facility. The categories are described below.

Class A (Safety). Failure modes that affect personnel and/or facility safety. Scheduled maintenance is required and should reduce the likelihood and severity of the failure to an acceptable level; otherwise, the component/system should be redesigned.

Class Bl (Shutdown Initiators). Failure modes that may cause facility shutdowns. Scheduled maintenance or a design modification is required to reduce operational costs and limit challenges to safety systems.

Class B2 (Operational Impact). Failure modes that result in forced outages, production losses less than 10 percent, or other operational impacts. Scheduled maintenance or a design modification is necessary to reduce operational and corrective maintenance cost.

Class C (Economics). Failure modes that affect support functions and do not cause production losses greater than 20 percent. Scheduled maintenance or a design modification is necessary to reduce the corrective maintenance cost.

Class D (Hidden Failures). Failure modes of standby or infrequently used components that do not affect personnel and/or facility safety and are not evident to the operating crew. Scheduled maintenance is necessary to reduce the likelihood of multiple failures to an acceptable level. Hidden failures are reclassified using LTA as B1, B2, or C to establish priority of task selection.

Significant failure modes should be addressed in the following order: A, B1, B2, and C. This information should be used in the selection of applicable and effective PM tasks.

Table 4.4-A. Logic Tree Analysis Process

Questions	Responses	
	YES	**NO**
Is the occurrence of a failure evident or visible to the operating crew while performing their duties? (This question divides failures into two groups, evident and hidden.)	Failures obvious to the operators during their normal day-to-day activities. It is not necessary that the operators know precisely what is wrong, only that something is wrong and that they may take the steps required to repair the component.	Failures discovered when operation of infrequently used equipment is attempted or when protective, standby, or backup systems fail to operate on demand. These failures are called hidden failures and may be especially critical to safe and efficient operation.
Does the failure cause a loss of function or secondary damage that has a direct and adverse effect on the safety of the facility?[a] (This question divides functional failures into two groups, safety and nonsafety.)	Failures that directly affect operating safety. Safety relates to essential functions needed to protect the health and safety of the public. These should be direct threats, not improbable combinations of events that have minor impacts on operating safety or are highly unlikely.	Failures that do not impact the operating safety as described above. These failures have economic or operational impacts that restrict the operator from using installed equipment.
Does the failure cause a loss of production greater than 10 percent or result in a forced outage?[b] (This question divides non-safety-related failures into two groups, operational and economic.)	Failures that directly impact operations and production. These failures affect the ability of an operations-critical system to perform its primary function.	Failures that impact support functions, result in production losses less than 10 percent, or have purely economic impacts.
Does the failure cause a facility shutdown? (This question divides failures that impact operations into two groups, shutdown initiators and operations impactors.)	Failures that result in a facility shutdown.	Failures that result in forced outages, production losses less than 10 percent, or other operational impacts.

[a]*Note:* Considering the consequences of a failure of safety system components as if redundant equipment is not available is a conservative assumption that may result in many components being classified as having a safety consequence. Analytical techniques to determine the significance of failures of redundant components are available. Typically these techniques are used in probabilistic risk assessments that quantify risk and reliability. Although usually manpower-intensive, these techniques may reduce the number of components that require failure mode and effects analysis or change the priority of the components being evaluated.

[b]*Note:* The amount of power reduction or other operational impact should be established by facility management.

4.4.3.5 Preventive Maintenance Task Selection

This section describes the method for selecting applicable and effective PM tasks to control the failures of significant failure modes. The PM task selection portion of the LTA is used in this method.

Four basic categories of PM tasks are described below. Special emphasis should be placed on selecting condition-monitoring tasks when they are applicable. If a failure mode provides any indicators of degradation of a component, baseline values should be set for the degradation and a regular monitoring program established for the component. When scheduling permits, multiple tasks should be combined into single activities. PM task categories are described in the following paragraphs.

Time-Directed Tasks. Tasks performed solely on the basis of a fixed time schedule, safe life limits, or economic life limits (e.g., change the air filters in the instrument air system every 30 days). The scheduled replacement of a component at the end of its life is a time-directed replacement task. Time-directed tasks may be ineffective if not performed at appropriate intervals. For example, a premature overhaul not only wastes resources but also increases the risk of human error during the removal, overhaul, and reinstallation process. In addition, premature overhauls may result in unnecessary radiation exposure and excessive equipment unavailability.

Condition-Monitoring Tasks. Tasks that are used to gather data so that component condition or performance may be monitored and evaluated in order to perform planned maintenance or condition-directed tasks, before equipment failure. Condition monitoring tasks are selected according to the parameters required to describe equipment performance.

Condition-Directed Tasks. Tasks performed on an as-needed basis when the condition or performance of a component has reached a predefined limit or standard. This is normally a restorative task that is performed before failure, such as changing a pump seal when leakage reaches 5 gallons per minute. In some cases, the component's performance should be baselined. Baselining involves measuring specific parameters during routine operation so they may be compared to established values, levels, and limits of performance that are indicative of normal, abnormal, or unacceptable conditions.

Failure-Finding Tasks. Tasks performed to discover hidden failures. The intent of these tasks is not to monitor and anticipate failure as with condition-monitoring tasks, but rather to find failures after they have occurred, at which time corrective maintenance may be performed. An example of this is a surveillance test that starts and runs the diesel-generators every 30 days. If the test results in the discovery of a failure, then corrective action should be taken. In addition to the above, the LTA process described in the previous section uses a series of questions to identify applicable and effective PM tasks for preventing or detecting failures.

NOTE: **Because many existing tasks are based on TSR, the surveillance test program should be used when practical to gather condition-monitoring data.**

Identify, describe, and record the recommended PM tasks and record the bases for the recommended tasks.

All PM tasks recommended from LTA should be evaluated to ensure they meet applicability and effectiveness requirements. Each PM task should be evaluated considering the failure it prevents. The applicability of a task depends on its ability to change the way a component fails and its failure rate. Applicability requirements are different for condition-monitoring and time-directed tasks. The requirements condition-monitoring tasks must meet include the following.

- The task should be able to detect a component's degraded condition or performance.
- The failure should be plausible and capable of being detected using condition-monitoring techniques.
- The failure should be predictable as it progresses from a potential failure to a functional failure.

The requirements time-directed tasks must meet include the following.

- The failure does not have detectable parameters or the parameters cannot be measured.
- The component should be in operation for the specified period of time.
- The task should restore the component's condition and reduce the likelihood of failure to an acceptable level.

Effectiveness requirements for a task depend on the consequences and cost of the failure (i.e., operational, safety, or economic). To be effective, a task selected for a failure mode with safety consequences should reduce the likelihood of failure within cost and implementation considerations. An example of an implementation consideration is the impact of performing a task online, thereby increasing the time a system is unavailable (i.e., LCO time), or performing it during an outage with the associated impact on outage workload and duration. A task to identify hidden failures with safety consequences, a failure-finding task, should reduce the likelihood of a multiple failure, also within identified constraints. The hidden failure should be discovered before another failure occurs that would result in loss of a system function or a safety system challenge.

***NOTE*: The effectiveness of a new PM task should be dependent on the existing material condition of the component. If a component is in a degraded material condition (e.g., a safety-related motor operating with excessive vibration), it may fail before the new PM task is able to prevent the failure as designed because much of the service life of the component has been expended. The component may need to be repaired, overhauled, or replaced to establish an acceptable material condition baseline. The new PM should then be effective in controlling the expected failure mode.**

For failure modes that have operational or economic consequences, the selected task should be cost-effective (i.e., the cost of PM should be less than the cost of the operational loss and/or cost of repair). Cost-effectiveness is evaluated by performing an economic trade-off study. This study should compare the cost of performing the proposed task (e.g., labor, materials, and spare parts) with the cost of the consequences of not performing the task. The present-value cost of the PM should be less than the present-value cost of not doing the task. The cost-effectiveness of a recommended PM task should be evaluated before the task is implemented.

4.4.3.5.1 Task Interval Determination

This section discusses considerations for establishing the intervals for PM task performance. Although the LTA is rigorous in selecting maintenance tasks, it does not address task intervals. The interval for each maintenance task is evaluated on the basis of the failure mode it prevents. The interval for a condition-monitoring task depends on its ability to measure and detect a reduction in the component's condition or performance before a failure occurs. The same is also true of failure-finding tasks assigned to components with potential hidden failures.

The requirement for the first interval for condition-monitoring tasks or inspection is that the interval be long enough that some physical evidence of deterioration may be detected. Subsequent intervals should be short enough to ensure that further degradation is detected before failure occurs so that planned or condition-directed maintenance may be performed to prevent failure.

After the applicability and effectiveness of the conditioning-monitoring task is established, a condition-directed task restoring the degraded condition-detected by the condition-monitoring task may be determined and prepared.

The initial intervals for time-directed tasks are conservatively selected based on operating and/or vendor information. These intervals should be adjusted according to the component's reliability and as-found condition based on review of PM task results and the component's maintenance history.

The following questions may be of assistance in determining the appropriate task interval for time-directed and condition-monitoring tasks.

- How frequently does the failure mode occur that the task is designed to prevent?
- How much time elapses between initiation of degradation and functional failure?
- Can the failure progression or component degradation be measured adequately?

4.4.3.5.2 Preventive Maintenance Task Comparison

Once the PM task selection process is complete, a task-by-task comparison of the selected, applicable, and effective tasks is made with existing activities and vendor recommendations. The comparison should include all existing PM activities/programs, surveillance tests, ISI tests, performance tests, and calibrations for the component being analyzed. Operator rounds or other routine inspections are often overlooked as recognized tasks, but they also should be recorded. After they are recorded, these tasks and activities may be compared to vendor-recommended activities, inspections, and tests.

It is important to establish the basis of the vendor PM recommendations to help resolve any differences between the recommendations and PM tasks. For example, were the vendor recommendations based on continuous or intermittent operation of the equipment? The source or requirement for each PM task should be determined and listed. Assistance from the groups responsible for tracking commitments may be helpful in identifying these requirements. Examples of sources include the following:

- TSR,
- vendor technical manuals and bulletins,
- DOE technical documents,
- insurance requirements,
- ISI requirements, and
- facility operating and maintenance experience.

The contents of newly defined PM tasks are compared with existing tasks. Any newly selected task not addressed by an existing task should be proposed as a new PM task. Any existing task not supported by the analyses should be considered for deletion as an unnecessary task. Caution should be exercised before deletion of any task. Before deletion, a review should be performed to ensure the deletion does not invalidate a commitment or an assumption made in the analysis process. If a commitment may be impacted by deletion of the task, then consideration should be given to requesting a change to the commitment.

Similarity of task content may indicate the need to combine activities. Frequency of task performance should be compared and adjustments to the frequency recommended if a review of the component's history indicates a change is warranted. Some of the selected tasks may be different in content or frequency from TSR. For these situations, collection of operating data and the bases developed during the analysis process may be of use in supporting a change request to the TSR.

Proposed deletions should be reviewed by personnel responsible for tracking commitments before the task is approved for deletion.

All data that have been used to determine the recommended PM task should be properly recorded and stored so that they may be easily retrieved, used, and referenced for future selections.

4.4.3.5.3 Task Review and Approval

The next step is to review and approve the recommended PM tasks and associated implementing actions. Before approval, each PM task should be thoroughly reviewed to validate the results of the LTA and to ensure the task may be properly and economically performed. This review should involve operations, maintenance, technical support, and other personnel who are familiar with the PM program goals, objectives of the enhancement effort, the analysis techniques, and the specific component. The review also should determine all actions needed to put the task into effect. Examples of these actions may include the following:

- adjusting PM task schedules,
- revising PM instructions,
- ordering new spare parts or adjusting inventory levels,
- purchasing or leasing diagnostic equipment,
- requesting deviation from commitments,
- updating vendor manuals,
- revising operation and maintenance procedures, and
- training personnel.

The task should be approved by the appropriate manager after it is verified to be technically sound and implementable. Approval of the task also should include approval of the actions needed to implement it. Often, approval of an implementing action is at a higher management level than approval of the specific PM task (e.g., request to deviate from a commitment). For these cases, the implementing action should be approved and completed before the task may be performed.

4.4.3.5.4 Task Implementation

The implementation process should begin as PM tasks are approved. Implementation includes completing all the actions each organization should take to put the approved tasks into effect.

Experience has shown that implementation of the analysis results often requires more effort and management involvement than that needed to actually perform the analysis. Therefore, an integrated project plan should be developed that assigns responsibilities, resource requirements, commitment dates, and status reporting requirements. The plan is needed to ensure all efforts are coordinated and completed within the desired time frame. The project plan should be monitored periodically by management to ensure milestones are met and the enhancement objectives are being achieved.

In addition, follow-up interviews should be conducted with operations, maintenance, and technical support personnel to ensure all responsible individuals understand and support the implementation and results of the analysis. Problems identified by these interviews should be expeditiously resolved and reviewed for generic consequences to maintain effective use of resources and timely progress.

4.4.3.6 Preventive Maintenance Living Program

After a PM enhancement effort has been implemented, appropriate adjustments need to be made periodically to the program because of changes in facility design, operating conditions, regulatory commitments, and as-found component conditions. This “living program” concept should ensure that components critical to facility safety and operation remain reliable. The primary objectives of the living program are to minimize future component failures, optimize PM tasks and use of resources, identify program expansion needs, and satisfy regulatory and industry concerns.

4.4.3.7 Task and Program Review

To gain the maximum benefit from the enhancement effort, appropriate review, feedback, and update processes need to be incorporated into the PM program to ensure that the program effectively addresses changing facility and equipment conditions. These processes should be routine functions of appropriate organizations.

Evaluation of data from the following sources and implementation of appropriate adjustments need to be performed to maintain the effectiveness of the PM program.

- Equipment failure trending.
- Root-cause analysis of component failures resulting in facility events.
- Craft feedback reports.
- Predictive maintenance analysis.
- Facility and system performance monitoring.
- Preventive and corrective maintenance history.
- Surveillance test optimization studies.
- Radiation exposure history of PM performances.
- Equipment design modifications.

During the evaluation of the data from the sources listed above, the following items should be considered:

- equipment failure characteristics (e.g., failure rates, causes, and mechanisms) to validate FMEAs;
- as-found equipment conditions and task intervals;

- installation of new equipment for program scope changes;
- operating and maintenance procedure changes for PM task content changes; and
- facility effects caused by failure of noncritical components.

Results of the evaluations should be used as the basis for appropriate adjustments to PM task content and frequency. Other actions that also may be needed to keep the PM program current include the following:

- revising the program scope,
- revising the analysis,
- updating documentation,
- performing a new analysis,
- selecting a different task,
- providing training,
- deleting tasks, and
- revising procedures.

An example of an adjustment to the PM program is replacing time-directed PM tasks with condition-monitoring tasks when the as-found condition of the components indicates that the intervals of the PM task may be increased and that a condition-monitoring task is applicable. This is a typical change that may result in improved use of facility resources. Also, PM tasks for components with commitment- or regulatory-specified intervals, along with the corrective maintenance history of the components, should be reviewed periodically to determine if the performance or frequency of the PM tasks is detrimental to the reliability of the components.

4.4.3.8 Task Frequency Optimization

This section describes one method for optimizing PM task frequency. PM task frequencies need to occasionally be adjusted to achieve optimal results. One method effectively used to change frequencies for non-safety-related components involves direct observation of the as-found condition of equipment during PM activities. The use of this process may result in an increase or a decrease in PM task frequency. The following method to optimize task frequency may be implemented without a substantial increase in craft or supervisory hours.

1. The as-found condition of equipment is recorded on a scale from 1 to 9 (where 1 is the lowest score possible and 9 the highest) during routine PM activities. This score is determined by the supervisor or in conjunction with the craftsperson who performed the job. A score of 1 for a PM task means that the condition of the component is very close to failure. A score of 9 indicates that the component is in excellent condition.

2. The overall general condition of the component is not evaluated. Only the condition with regard to the specific work performed by the PM is used in determining the score. For example, the description on a WR/WO is “Valve Packing Change-Out.” The score is

determined by evaluating the condition of the packing and whether it is close to failure or in very good condition. The score is always related to a specific component and should only be assigned while performing work under a PM WR/WO. For example, if a mechanic found that the valve packing was already leaking before performing the PM task, then no score should be assigned.

3. When performing a PM, a failure not related to the task and not previously discovered may be uncovered. In this case, the minimum score of 1 should be assigned and corrective maintenance initiated to repair the component.

4. This method facilitates initiation of an evaluation to determine whether adjustments to PM task frequencies are warranted. The following are typical criteria that may be used to initiate a review of past PM performance to establish the basis to adjust the interval of the task.

    - At least two consecutive high scores, as established by the facility, may indicate the need to increase the interval between PM task performances provided that no corrective maintenance was performed between the two periods.

    - A low score, as established by the facility, may indicate the need to decrease the interval between PM tasks performances.

5. The "as-found" scoring should be performed each time the PM is performed, during power operations as well as outages.

6. Reports containing PM task scoring and proposed frequency changes should be periodically provided to management.

To implement this method, it should be emphasized to crafts persons that a good, detailed description of the "as-found" condition of the component and the work performed should be recorded on all PM WRs/WOs. This allows engineering personnel to evaluate and trend the data to optimize task intervals and determine effectiveness of the tasks.

4.4.3.9 Component Failure Trending [1, 21, 50, 79, 80]

A PM program is designed to maintain the inherent reliability of equipment. This reliability may be determined by analyzing the failure or performance history of the component. Therefore, failures should be graphically trended to produce a record of component performance and provide indicators to facilitate changes in the component's design or existing PM tasks. The trending program should-include selected critical components so that the most effective adjustments to the PM program may be made.

Much of the data needed to establish a trending program are collected during the initial enhancement effort. Some of the data include failure times/dates, failure modes/causes, and statistically derived data such as failure rates. These parameters may be determined from facility-specific data or from industry sources.

Adverse trends in failure data are cause to initiate an evaluation or investigation to determine and correct the causes of the problems. The following method may be used to determine whether the results of component failure trend analysis warrant changes to the PM program.

1. If a PM task exists but the trend analysis shows an increase in failures, a review of the component analysis may be necessary to determine whether an additional failure mode should be considered or the adverse trend is caused by programmatic deficiencies. Additionally, consideration should be given to decreasing the existing PM task interval.

2. If a PM task exists and there are no failures over a significant period of time, then consideration should be given to increasing the task interval. In this case, it may be advantageous to use a condition monitoring task to determine the optimum task frequency and to determine whether the task is applicable and may effectively detect degradation before a failure occurs.

The timely collection and analysis of failure data are essential to improve component performance. Incomplete failure and repair descriptions on WRs/WOs often hinder timely analysis. One method that has proved to be effective in obtaining trending information on job requests is to initiate use of failure and repair codes. Codes established by the facility should be easily sorted by computers for trend analysis.

Other sources of data that should be used to make adjustments to the PM program are the facility's performance-monitoring and predictive-monitoring programs. Results of these programs may provide indications of adverse trends and may help identify components with performance or reliability problems.

To be effective in maintaining facility equipment design conditions with high levels of availability, the PM program should contain appropriate tasks, be properly executed, and be routinely reviewed and updated. These activities should be integral responsibilities of the appropriate groups and receive commensurate priority and attention. These actions, effectively implemented, may make a significant contribution to safe and reliable facility operation.

4.4.3.10 Predictive Maintenance [9]

Predictive maintenance should be integrated into the overall PM program so that "proactive repair" planned maintenance may be performed before equipment failure. Not all equipment conditions and failure modes can be monitored; therefore, predictive maintenance should be selectively applied. Reliable predictive maintenance is normally preferable to periodic internal, inspection or equipment overhauls. In addition, corrective maintenance efficiency may be improved by directing repair efforts (manpower, tooling, parts) at problems detected using predictive maintenance techniques.

Predictive maintenance should be limited to components and systems that are significantly important to the safe and reliable operation of the facility. The program should collect, trend, and analyze data and initiate planned actions for degrading equipment. The effectiveness of the program is dependent on the accuracy of equipment degradation rate and time to failure assessment.

Management commitment, control, and overview are essential for the success of a predictive maintenance program. The following sections contain a summary of key principles and program elements for a predictive maintenance program. The example programs are provided to assist facility personnel in developing and implementing predictive maintenance programs. Although the key elements of the program are applicable to all facilities, some of the details may need to be modified to reflect individual facility conditions and needs.

4.4.3.11 Selection of Predictive Maintenance Techniques

Many different predictive maintenance techniques are used throughout the industry (see Table 4.4-B). The following paragraphs describe some of the predictive maintenance techniques that may be used.

Vibration monitoring and diagnostics is a technique used for monitoring and analyzing facility rotating equipment. This technique is used to analyze displacement, velocity, and acceleration parameters to predict the need to correct problems such as bad bearings, poor alignments, or improper balance.

Lubricating oil analysis, ferrography, and grease analysis are techniques used for the early detection of lubricant breakdown and abnormal wear.

- Lubricating oil analysis monitors the actual condition of the oil itself. Parameters measured include viscosity, moisture, additive package, and the presence of other contaminants.

- Ferrography is a technique used to analyze oil for metal wear products and other particulates. Trending and analyzing the amount and type of wear particles in a machine’s lubrication system may pinpoint where degradation is occurring.

- Grease analyses are techniques used to detect changes in the lubricating properties of grease. Sensory tests such as color, odor, and consistency are most often applied to greases. A penetration test is sometimes used to quantify grease consistency. Grease analyses are often performed on samples obtained from motor-operated valves.

Bearing temperature trending/analysis is a technique used to measure and trend temperatures of critical machinery bearings to predict failure - Changes in bearing temperature may indicate wear due to loss of lubrication, excessive vibration, or intrusion of foreign material into the rotating assemblies. Bearing temperature analysis is often performed in conjunction with the vibration monitoring and lubricating oil analysis/ferrography programs.

Infrared thermography is a technique based on the fact that the infrared radiation emitted by a source varies with its surface temperature. Infrared surveys may be performed on heat-producing equipment such as motors, circuit breakers, batteries, load centers, and insulated areas to monitor for high resistance, loose connections, or insulation breakdown. Additionally, this technique may be applied to pinpoint condenser air in-leakage locations and valve leaks.

In addition to the predictive maintenance techniques already described, various other methods, including the following, may be used as a predictive approach to monitoring facility performance.

- Eddy current testing is used to monitor heat exchanger tube wall thickness.
- Temperature differential is used as a means of monitoring heat exchanger performance.
- Flow measurement is used to monitor heat exchanger and pump performance.
- Unit heat rate is used to measure facility steam cycle efficiency.

4.4.3.12 Example Vibration Monitoring Procedure

4.4.3.12.1 Identifying Monitored Equipment

The predictive maintenance coordinator should maintain a list of facility equipment included in the predictive maintenance vibration monitoring program. This list should contain the following information on each piece of equipment:

- component tag number and description,
- priority, and
- interval of monitoring.

***NOTE*: For purposes of this good practice, Table 4.4-C illustrates only a small portion of the equipment included in the vibration monitoring program.**

The predictive maintenance coordinator should designate the specific points to be monitored on each machine. Each point should be marked on the machine in a conspicuous manner (e.g., by using a paint or ink-marking device) to help ensure that data are taken in a consistent manner. Permanently mounted pick-up pads also are an effective method for ensuring consistent data. Upon request from members of facility management or in support of other maintenance activities, data may be taken on equipment other than that listed in Table 4.4-C.

4.4.3.12.2 Scheduling Vibration Surveys

Equipment should be scheduled for vibration testing at the frequency indicated in Section 4.4.3.16. Readings may be taken more frequently at the discretion of the predictive maintenance coordinator or as requested by facility staff. Vibration baseline readings should be taken after any maintenance affecting the rotating components of the machinery, such as bearing replacements. In addition, vibration data on selected facility equipment may be useful before securing the equipment for a planned outage to allow for repairs.

Equipment not in operation at the time of a scheduled test should not be started for the sole purpose of obtaining vibration readings unless justified. Such vibration tests should be rescheduled to a time consistent with normal facility and equipment operations, but within vibration test interval. Surveys should be scheduled to coincide with in-service testing (IST) for equipment that is normally not operated except for testing.

4.4.3.12.3 Collecting Data

The predictive maintenance coordinator should designate the format for the data tracked on each machine and measurement point (e.g., filtered, unfiltered, velocity, displacement). Any instrument capable of reading the desired vibration parameters may be used to obtain data. If possible, the same type of test equipment should be used on any given component.

Each set of readings on a particular machine should be made with the machine running under the same operating conditions (load, flow, head, etc.) as previous readings. On major equipment, the operating conditions may be determined by observing local instruments and/or by contacting operations.

Vibration readings should be taken at all measurement points included in each vibration survey route. If readings cannot be taken because of operating or environmental conditions, the readings should be rescheduled. Corrective actions, such as increased radiation shielding, should be taken to enable readings.

4.4.3.12.4 Examination and Evaluation of Trend Data[50]

After taking each set of vibration data, the data should be reviewed to identify any excessively high readings or undesirable trends indicating a degradation of equipment condition.

Vibration monitoring/analysis is not an exact science; greater emphasis should be placed on observed trends than on actual vibration levels at any time. The severity of an individual vibration reading should be determined by a subjective evaluation of all observed symptoms that should include factors such as prior experience with the same or similar equipment, industry standards, regulatory requirements, and vendor recommendations.

As an aid to rapid identification of potential problems, nominal alarm limits for each monitored machine should be established by the predictive maintenance coordinator. Comparable limits should be used for machines that are similar in design or are known to have similar vibration characteristics. Limits should be established by examining historical data for machines of the same type that have a good operating history.

When degraded equipment condition is indicated, the predictive maintenance coordinator should take action to ascertain the validity of the data. The predictive maintenance coordinator should notify the responsible maintenance organization when the suspected deficient condition has been verified.

4.4.3.12.5 Preparing and Distributing Reports

The predictive maintenance coordinator or designee should notify responsible operations and maintenance personnel when any deficiency is noted that may jeopardize equipment operation. Written reports should be prepared periodically to furnish necessary information to facility management. Written reports should ordinarily be limited to exception reports describing problems that have been identified and directly related information.

4.4.3.12.6 Corrective Actions and Follow-up

Equipment that has been found to have a known or suspected vibration problem should be scheduled for monitoring at more frequent intervals until the problem is resolved. Following notification of completed corrective action, vibration readings should be taken to establish a new baseline.

4.4.3.12.7 Instrument Calibration

Test equipment used in support of the vibration monitoring program should be incorporated into the M&TE program in accordance with the facility procedure that governs the control of M&TE.

4.4.3.12.8 Upgrading the Program

The predictive maintenance coordinator should continually seek to refine and improve the vibration monitoring program by the following:

- being alert and responsive to actual and suspected equipment operating problems as reported by members of facility staff,
- coordinating the collection of vibration data on infrequently operated equipment to coincide with normal facility operation, and
- evaluating readings taken to identify methods by which more appropriate or meaningful data may be taken.

Upgrading the program may entail increasing or reducing requirements in terms of machines to be monitored, type and number of measurements per machine, and time interval between readings. In addition, vibration monitoring equipment, including software, should be periodically evaluated and consideration made for upgrading based on changing technology.

Failures of equipment included in the vibration monitoring program should have detailed root-cause investigations to determine why the program did not detect degradation before the failures occurred.

4.4.3.13 Example Lubrication Oil Analysis Procedure

4.4.3.13.1 Identification of Included Equipment

The predictive maintenance coordinator should maintain a list of equipment included in the oil analysis program. Samples may be taken from equipment not included in Table 4.4-D, as requested by facility staff.

***NOTE*: For purposes of this good practice, Table 4.4-D illustrates only a small portion of the equipment included in the lubrication oil analysis program.**

4.4.3.13.2 Scheduling Sampling

Oil samples should be scheduled per the intervals indicated in Table 4.4-D. Scheduled sampling dates and/or intervals may be adjusted according to recommendations from the analysis laboratory or facility management. Samples may be taken more frequently at the discretion of the predictive maintenance coordinator or as requested by facility staff. For example, oil samples on selected facility equipment may be useful before securing the equipment for a planned outage to allow for repairs.

4.4.3.13.3 Collecting Samples

Collection of oil samples may be initiated by WR/WO or procedure. Oil samples should be representative. Whenever possible, samples should be drawn when the oil is still hot and well mixed. Samples should normally be collected by withdrawing oil directly from oil sumps/reservoirs with suction tubes into clean, new sample bottles. After collection, oil samples that are not radioactively contaminated should be delivered to the predictive maintenance coordinator for processing.

4.4.3.13.4 Processing Samples

The predictive maintenance coordinator or designee should ensure that any information forms or other documents required by the laboratory are completed and the samples are packaged for shipment to the laboratory. Personnel preparing information forms should use clear, consistent terminology so that the analysis laboratory can relate their reports to the correct reservoirs. The means of shipment of samples to the oil analysis laboratory should be selected on the basis of urgency of need.

4.4.3.13.5 Handling Sample Analysis Reports

Following analysis of samples by the laboratory, analysis reports for each sample should normally be forwarded from the laboratory to the predictive maintenance coordinator or designee. Preliminary reports may be made by telephone from the laboratory when tests indicate a deficient condition exists or if "rush" handling is requested for specific samples. The predictive maintenance coordinator or designee should review the data from each report, with any recommendations from the laboratory, comparing the current data to previous report data. If a need for corrective action is indicated, the predictive maintenance coordinator or designee should initiate or request that action be taken by appropriate facility groups. An example lubrication analysis report form is provided in Figure 4.4-D. Table 4.4-E lists metallic elements typically found in lubricating oils and their sources.

4.4.3.13.6 Preparing Reports

The predictive maintenance coordinator or other persons cognizant of the lubricating oil sampling program should notify responsible facility management when a deficiency is noted that may jeopardize facility equipment and/or operations. The predictive maintenance coordinator should prepare written periodic reports or furnish needed information to facility management to describe any identified problems, unsatisfactory trends, or trends following corrective actions or to recommend oil change frequencies based on analysis results and trends.

4.4.3.13.7 Corrective Actions and Follow-Up

Equipment that has been found to have a known or suspected lubricant problem may be sampled at more frequent intervals as recommended by the laboratory or as requested by the predictive maintenance coordinator until the suspected problem has been resolved or corrective action has been taken. Following any corrective action, a follow-up sample should be taken promptly to reestablish the "baseline" for the equipment in question and to ensure that the action taken was adequate.

4.4.3.13.8 Upgrading the Program

The predictive maintenance coordinator should continually seek to refine and improve the lubricating oil analysis program by the following:

- maintaining an awareness of actual and suspected equipment operating problems,
- evaluating the potential for oil sampling and analysis methods to aid in detecting and identifying equipment problems, and
- revising the program as appropriate to take advantage of improved sampling and analysis techniques as they become available.

Upgrading the program may entail increasing or reducing the requirements in terms of equipment included in the program and time interval between samples. Failures of equipment included in the lubricating oil analysis program should have detailed root-cause investigations to determine why the program did not detect degradation before the failures occurred. As a means of performing preliminary evaluation of equipment being considered for possible inclusion in the program and establishing measurement parameters for equipment to be added, thermographic data may be taken on equipment other than that listed in Table 4.4-F.

4.4.3.14 Example Thermography Program Procedure

4.4.3.14.1 Identifying Monitored Equipment

The predictive maintenance coordinator should maintain a list of facility equipment included in the infrared thermography program. This list should contain the following information on each piece of equipment:

- component tag number and description,
- priority, and
- interval of monitoring.

***NOTE:* For purposes of this good practice, Table 4.4-F illustrates only a small portion of the equipment included in the thermography program.**

Specific points to be monitored on each piece of equipment should be clearly identified in route descriptions, etc. Route descriptions may include the use of simple diagrams or sketches as a field aid to help ensure that data are taken in a consistent manner. These diagrams or sketches also may be used for note-taking to aid in the development of written reports concerning specific surveys.

4.4.3.14.2 Scheduling Thermal Surveys

Equipment should be scheduled for thermographic monitoring at the interval indicated on Table 4.4-F. Data may be taken more frequently at the discretion of the predictive maintenance coordinator or as requested by facility staff. For example, thermal surveys on selected facility equipment may be useful before securing the equipment for a planned outage to allow for repairs and postmaintenance activity. Equipment not in operation at the time of scheduled monitoring should not be started for the sole purpose of obtaining thermographic data unless justified. Such monitoring should be rescheduled to a time consistent with normal facility operations and within the nominal thermographic monitoring frequency, if possible. Thermographic monitoring should be scheduled to coincide with IST or other facility tests for equipment that is normally not operated except for testing, if applicable.

4.4.3.14.3 Collecting Data

The predictive maintenance coordinator or designee should designate the format in which data should be taken for each piece of equipment and measurement point (e.g., temperature scale, range, emissivity setting).

Any instrument capable of reading the desired data may be used to obtain the data needed; however, all such instruments should be incorporated into the M&TE program to establish and maintain calibration certification. If possible, the same type of test equipment should be used on any given component.

Each set of data taken on a particular piece of equipment for trending purposes should be taken with the equipment operating under the same conditions (load, flow, head, etc.) as previous readings. On major equipment, the operating conditions may be determined by observing local instruments and/or by contacting operations.

Thermographic data should be taken at all measurement points included in each thermal survey route. If readings cannot be taken because of operating or environmental conditions, the readings should be rescheduled.

4.4.3.14.4 Examining and Evaluating Trend Data

Thermographic data should be reviewed to identify any excessively high readings or undesirable trends indicating a degradation of equipment condition.

Infrared thermal monitoring/analysis is not an exact science. Emphasis should be placed on observed trends as well as actual temperature differentials indicated at any time. The severity of an individual temperature indication should be determined by a subjective evaluation of all observed symptoms and prior experience with the same or similar equipment.

When a degraded equipment condition is indicated, the predictive maintenance coordinator or designee should take action to ascertain the validity of the data and should notify the responsible maintenance organization when the suspected deficient condition has been verified.

4.4.3.14.5 Preparing and Distributing Reports

The predictive maintenance coordinator or designee should notify responsible operations and maintenance personnel when any deficiency is noted that may jeopardize facility operation.

The predictive maintenance coordinator or designee should prepare written reports periodically to furnish necessary information to facility management. Written reports should ordinarily be limited to exception reports describing problems that have been identified and directly related information.

4.4.3.14.6 Corrective Actions and Follow-up

Equipment that has been found to have a known or suspected temperature anomaly should be scheduled for monitoring at more frequent intervals until the problem is resolved. Following notification of corrective action, additional thermographic data should be taken to establish a new baseline.

4.4.3.14.7 Instrument Calibration

Equipment used to gather actual thermal data for the infrared thermography program should be incorporated into the M&TE program in accordance with facility procedures that govern the control of M&TE.

4.4.3.14.8 Upgrading the Program

The predictive maintenance coordinator should continually seek to refine and improve the infrared thermography program by the following:

- being alert and responsive to actual and suspected equipment operating problems as reported by members of facility staff,
- coordinating the taking of thermographic data on infrequently operated equipment to coincide with normal facility operation, as far as possible, and
- evaluating readings taken to identify methods by which more appropriate or meaningful data may be taken.

Upgrading the program may entail increasing or reducing the requirements in terms of machines to be monitored, type and number of measurements per machine, and time interval between readings. In addition, thermography equipment should be periodically evaluated and consideration should be given to upgrading, based on specific needs and changing technology.

If equipment included in the infrared thermography program fails, the predictive maintenance coordinator or designee should conduct detailed root-cause investigations to determine why the program did not detect degradation before the failure occurred.

As a means of performing preliminary evaluation of equipment being considered for possible inclusion in the program and establishing measurement parameters for equipment to be added, thermographic data may be taken on equipment other than that listed in Table 4.4-F.

4.4.3.15 Data Review, Trending, and Analysis

The predictive maintenance coordinator should compare recently acquired data with previous history data to detect any indicated change in equipment condition trends. If degradation indicates integrity of operating equipment may be endangered or if action criteria are being approached, the predictive maintenance coordinator should initiate one or more of the following actions.

- Coordinate with the data originator to determine whether corrective action has been initiated.
- Validate the trend analysis/conclusion.
- Request additional testing or monitoring be performed to confirm the suspected deficient condition. (Any of the various predictive maintenance techniques available may be used to obtain additional confirmatory information, if appropriate.)
- Initiate action (via a WR/WO) to have the defective equipment scheduled for repair.
- Recommend revisions to PM procedures and/or schedules, if appropriate.
- Acquire new equipment baseline data to verify correction of problems and to establish new reference points.

4.4.3.16 Scheduling Predictive Maintenance

The interval during which predictive maintenance tasks are performed may vary depending on factors such as those listed in Section 4.4.3.5. In addition, the relative importance of the equipment to overall facility operations may be factored into determining an appropriate interval. It should be recognized that predictive maintenance tasks should be managed and scheduled as part of the overall facility PM program. Example priorities for taking action based on predictive maintenance results are as follows.

- Safety-related (Priority A)—Designation of equipment whose failure would compromise safety and/or impose LCOs.
- Capacity Threatening–Not Spared (Priority B)—Designation of equipment whose failure would result in total or partial capacity loss.
- Capacity Threatening–Spared (Priority C)—Designation of equipment whose failure would result in partial or total loss of capacity if backup equipment is unavailable or fails.
- Support Equipment (Priority D)—Designation of equipment whose failure would result in eventual reduction of unit efficiency, safety, or reliability.
- High-maintenance Items (Priority E)—Designation of equipment that has a high incidence of failure.

A master schedule should be prepared based on the assigned interval dictated by Section 4.4.3.5.1 and the priorities denoted above.

Work-control documents should be prepared for each predictive maintenance task.

Grace periods should be specified in the predictive maintenance program (normally 25 percent of the scheduled interval); however, tasks should normally be performed as scheduled, and grace periods should be used only when approved, unavoidable conflicts arise. If the performance of scheduled, predictive maintenance has the potential for exceeding the grace period, the operations manager and the maintenance manager, or their designees, should be informed and be directly involved in the decision process.

Only operating equipment or equipment in standby should be placed in predictive maintenance monitoring. Such monitoring should be rescheduled at a time consistent with normal facility and equipment operations.

4.4.3.17 Evaluating and Upgrading the Program

Predictive maintenance managers or their designees should conduct detailed root-cause investigations of equipment included in the predictive maintenance program that fails to determine why the program did not detect degradation before the failures occurred. All personnel should be alert for possible inputs to the predictive maintenance program that may be beneficial in improving facility reliability and performance. These comments may result from work performed by corrective maintenance or modification activities. Inputs should be forwarded to the predictive maintenance coordinator.

Proposed techniques, additions, or modifications for/to the predictive maintenance program should be evaluated for applicability, potential benefit, and cost-effectiveness. Table 4.4-B provides an example form for evaluating proposed predictive maintenance program changes.

The predictive maintenance coordinator should provide periodic summary reports (e.g., monthly) to operations and maintenance management describing the current status of the predictive maintenance program and summarizing problems recently identified or corrected. These reports are useful for management to assess program effectiveness.

The maintenance manager should conduct an overall evaluation of the predictive maintenance program annually. This evaluation should address the overall effectiveness of the program, including procedure adequacy, in-facility and industry operating experience, QA audit reports and self assessment findings, failure trends, licensee event reports, nonconformance reports, material and deficiency reports.

Based on the results of evaluations and other input, the following examples of predictive maintenance program changes should be considered:

- adding or deleting equipment in the program;
- adding or deleting predictive maintenance activities on a particular piece of equipment;
- identifying the need for new, upgraded, or additional monitoring equipment and software;
- proposing facility design changes; and
- adjusting task intervals.

The predictive maintenance program evaluation and upgrade also may be integrated into the overall PM program review.

The following steps should be used to evaluate new methods or techniques for the predictive maintenance program.

- Provide a brief general description of the proposed technique. Include acceptance criteria, alarm points, frequency, and any other appropriate information.
- Determine the systems or equipment types that would be monitored by the proposed method.
- If the proposed method been used at the facility before, describe the application where it was used.
- List any additional special test equipment required (not already available). Include a cost estimate, if possible.
- Determine whether any special skills or training is required to implement the proposed method.
- Determine whether other facilities are known to be using or have used the proposed method, and, if so, whether reviews of their experiences are available.
- Determine whether there are other test or inspection methods to monitor the same parameters, and compare them to the proposed method or technique.
- Determine what information would be provided by the proposed technique that is not provided by test or inspection methods already in effect?
- Determine whether past equipment failures might have been prevented if the proposed technique had been in effect (be as specific as possible).
- Provide any additional information that might be helpful in evaluating the benefits to be derived from implementing the proposed method or possible consequences of not implementing it.

4.4.4 Corrective Maintenance

Corrective maintenance consists of all those actions performed to restore failed or malfunctioning equipment to service per the current authorization basis. Corrective maintenance activities should ensure that the condition that caused the failure is identified, corrected, and documented. Analysis should be performed to determine the root cause of failure and the corrective action that should be taken, including feedback into the preventive and predictive maintenance programs and maintenance training and qualification programs. The establishment of priorities for corrective maintenance should be based on plant objectives and the relative importance of the equipment.

Corrective maintenance is performed to accomplish timely repair of failed or malfunctioning equipment, systems or facilities in order to restore their intended function or design condition. A program for identification and timely repair of improperly operating or failed equipment, systems or facilities should be established based on a detailed master list of both safety-related and non-safety-related facility features. There should be established criteria and responsibilities in use to review and approve maintenance WRs, and only approved procedures should be used to perform routine or emergency maintenance actions.

The SAR, BIO, or other documentation that represents the authorization basis for a nuclear facility should be used to form the basis for designating maintenance as safety-related or non-safety-related. Once a corrective maintenance action has been identified, its planning, scheduling, and special training needs should be implemented in accordance with administrative controls, which require that the following records be prepared, assembled, and reviewed for completeness:

- corrective maintenance request approval;
- personnel performing the work;
- personnel inspecting the work;
- malfunction/failure cause, including generic implications;
- corrective action description;
- postmaintenance testing performed, test data, and personnel performing the testing;
- replacement parts, if pertinent; and
- M&TE used, if any.

This documentation should be maintained for an appropriate length of time, and a program should be established to review completed corrective maintenance records to assess the adequacy of the PM program and identify repetitive failures of parts and components resulting from design or generic equipment deficiencies. A reliable method should be in place to confirm that all material deficiencies are identified and entered into the work-control system. Periodic reviews of the maintenance program should be conducted and documented to indicate whether it is responding effectively to equipment failures, out-of-service equipment, alarms, and indicators showing failed equipment or instrumentation. This review should illustrate a comparison of overall operating status versus shutdown time of a facility due to maintenance related problems.

Inspection criteria, including a process to measure the degradation of standby safety-related systems should be in place, and inspection tours should be conducted to identify any exceptions or deviations from the following.

- Mechanical systems and equipment are in good working order.
- Good equipment lubrication practices are being followed.
- Fluid system leaks are minimized, monitored, appropriately corrected or controlled, and assessed for impact on safe operations.

- Instrumentation, controls, and associated indicators are operable and calibrated as required.
- Electrical and electronic equipment are operable and appropriately protected from adverse environmental conditions.
- Mechanical operators, fasteners, and supports are in place and operable.
- Components, systems, and structures are preserved and insulated.

4.4.5 Maintenance at Facilities in Transition and Production Readiness (See DOE-STD-1120-98)[31, 40, 117, 118]

Many DOE nuclear facilities are in a transition phase rather than an operational or standby mode.[50] Some of the transition phase facilities are large and complex, geographically widespread, and contain potentially hazardous chemical, nuclear, or radiological materials.[4, 121, 2, 3, 34, 76, 82] Their disposition phase should include deactivation, decommissioning, and surveillance and maintenance (S&M) activities. A pretransfer review should be conducted to provide the safety basis and physical and administrative characteristics of the facilities following cessation of operations but before the disposition phase.[40, 118] The objective of the review should be to identify and evaluate, using a graded approach, the explicit boundaries of the facility being transferred; its physical condition; the extent, nature, and level of contamination; inventories/estimates of types and quantities of special nuclear, fissionable, and toxic, hazardous, and radioactive materials; and S&M requirements.[82, 121]

Throughout a facility's transition phase, S&M activities should be performed to monitor and document the presence, status, and/or condition of SSCs and hazards associated with the facility. S&M should be adjusted as either deactivation or decommissioning activities are completed. Continuing S&M throughout the disposition phase should ensure, at a minimum, adequate containment of any contamination and potential hazards to workers, the public, and the environment are minimized.[2, 3, 34, 35, 60, 68, 72, 82, 121]

As remediation occurs at a facility in transition and the hazard profile changes or becomes uncertain because of remediation activities, the relationship between S&M and authorization basis should also change to be commensurate with the hazards and impacts to workers, the public and the environment posed by the facility.[16, 28, 30, 47, 48, 51, 52, 82, 117] The S&M activities should consistently be appropriate to ensure that the facility's safety envelope is maintained and the authorization basis is revised and approved accordingly. DOE-STD-1120-98 provides guidance for integrating ES&H into facility disposition activities. It also provides guidance that addresses authorization basis and its changes during facility disposition. DOE Guide 430.1-2, *Implementation Guide for Surveillance and Maintenance During Facility Transition and Disposition,* provides guidance details pertaining to maintenance activities.

Maintenance action is often scheduled routinely (e.g., by calendar hours or run time) on equipment to prevent breakdown and involves servicing, such as lubrication, filter changes, cleaning, testing, adjustments, calibration, and inspections. Planned maintenance is conducted before equipment failure and can be initiated by predictive or periodic maintenance results, by vendor recommendation, or by experience. Planned maintenance includes items such as the following.

- Scheduled valve repacking.
- Replacement of bearings as indicated from vibration analysis.
- Major or minor overhauls, based on experience factors or vendor recommendations.
- Replacement of known-lifespan components.

Planned maintenance is typically conducted during outages or on spare or redundant equipment that is available during facility operation.

Seasonal facility preservation measurements should be in place to preserve equipment and structures based on experience factors and vendor recommendations that include items such as the following.

- A program should be in place to prevent equipment and building damage due to cold weather at any nuclear facility that may be at risk. This program is necessary at DOE facilities because of the varied locations of Department facilities, the seasonal variations in temperature that they are subjected to, and other predictable weather conditions which may exist at their location.

- The program should include the preparation of a freeze protection plan that includes details on inspections, PM, and corrective maintenance imposed on nuclear facility safety equipment and buildings to assure continued safe facility operations. Inspections and self-assessments of freeze protection programs should be appropriately scheduled to ensure correction of deficiencies or preparation of other compensatory measures to protect DOE nuclear facilities before the beginning of cold weather conditions. The elements of DOE 5480.19 should be used to provide a formal and disciplined approach for consistent onsite application.

- A freeze protection plan should be prepared for each DOE nuclear facility. The plan will detail the actions and requirements to be imposed on the facility to assure protection of the safety equipment/facility from cold weather or freezing. The plan will ensure that, in all cases, the actions and requirements imposed to provide cold weather/freeze protection, particularly before those taken to restrict or cut off nuclear systems coolant, will be reviewed by facility operations and safety personnel to ensure the facility will be maintained in a safe condition to protect the health and safety of the public. As a minimum, this plan should ensure the following.

  —Heating systems in all nuclear facilities will be cleaned, serviced, and functionally tested.

  —Antifreeze used in cooling systems will be checked and replace as necessary.

—Heating system power and temperature controls will be protected against inadvertent deactivation by unauthorized personnel.

—Operations or maintenance staff have specific responsibility for monitoring the temperatures in facilities' on and off shifts, including weekends and holidays.

—All air intakes, windows, doors, and other access ways that could provide abnormal inflows of cold air be secured. Automatically controlled systems of this type will be functionally tested.

—Plans exist for alerting personnel and providing increased surveillance in periods of extreme, unusual, or extended cold. Operations or maintenance personnel will be on call to respond to such events.

—Systems requiring or deserving special protection due to hazards or costs associated with freeze damage will have temperature alarms and/or automatic backup heat sources.

—Facility personnel will inspect, test, and stage portable auxiliary heaters and have identified sources to obtain more, if needed. Personnel will be trained in the safe use of portable heaters.

—The main water supply cutoffs for each nuclear facility will be identified, tested, and readily accessible to emergency personnel responding to a freeze/thaw incident.

—Outside storage pads and unheated storage areas will be inspected to ensure that there are no materials susceptible to freeze damage.

—Employees will be aware of the need to identify and report any suspected problem with heating or other cold weather protection equipment.

—Cold weather gear will be available for emergency and operations personnel.

—Procedures will be developed for implementation and suspension of cold weather protection measures to ensure proper approval and review.

—Provisions are made to remove cold weather protection features after the cold weather season or freezing period is over with appropriate verification and documentation of removal through the facilities configuration management system.

—Wet-pipe sprinkler systems will be reviewed for areas susceptible to freezing, and appropriate actions planned, such as provisions for auxiliary heat; draining and posting a fire watch; etc.

—Contingency plans are prepared and available for temporarily curtailing operations in those nuclear facilities which are likely to sustain freeze damage when unusually sever weather is expected.

4.4.6 Conduct of Maintenance Performance Objectives [23]

Maintenance should be conducted in a safe and efficient manner to support facility operation.

CRITERIA

A. Personnel exhibit professionalism and competency in performing assigned tasks that results in quality workmanship.

B. Maintenance personnel are attentive to identifying and are responsive to correcting facility deficiencies with a goal of maintaining equipment/systems in an optimum material condition.

C. Managers and supervisors routinely observe maintenance activities to identify and correct problems and to ensure adherence to facility policies and procedures including industrial safety and radiation protection.

D. Maintenance managers, supervisors, and craftsmen actively use ALARA [121] concepts to minimize personnel exposure.

E. Support groups such as operations, engineering, QC, and radiological protection are appropriately involved in maintenance activities. Participation of these groups is coordinated to effectively support the maintenance effort.

F. Maintenance work is properly authorized, controlled, and documented.[54]

G. Prejob and postjob briefings are effectively used.

H. Work activities are performed in accordance with controlled procedures, instructions, and drawings as required by facility policy. Craftspersons and other maintenance personnel identify and provide feedback to correct procedural problems.

I. Good maintenance practices such as those listed below are followed:

- Proper tools and equipment are used.
- Good industrial safety radiological protection, and ALARA practices are followed.
- Foreign materials and contaminants are excluded from open systems and equipment.
- Work sites are clean and orderly.

J. Appropriate personnel (e.g., operations, engineering, and maintenance) are aware of and perform postmaintenance testing, review results, and take corrective action, as necessary.

K. Maintenance rework is identified and documented. Corrective actions, including periodic reviews for generic implications, are taken to minimize rework.

L. Temporary and other nonfacility personnel are properly supervised and work under the same controls and procedures, and to the same standards as plant maintenance personnel.

4.4.7 Preventive Maintenance Performance Objectives [23]

PM should contribute to optimum performance and reliability of facility systems and equipment.

CRITERIA

A. A PM program is effectively implemented and includes systems and equipment that affect safe and reliable facility operation. PM includes equipment layup protective measures, where applicable.

B. PM, including predictive maintenance activities, is performed at appropriate intervals. These intervals maximize equipment availability. Considerations such as operational experience, vendor recommendations, engineering analysis, and cost/benefit analysis are used as a basis to establish preventive maintenance tasks and intervals. [9]

C. PM activities are scheduled and performed within established intervals. PM is waived or deferred only with management approval.[9]

D. PM documentation provides a record of activities performed, data collected, and, where appropriate, the “as-found” and “as-left” condition of the equipment.[9, 78]

E. PM techniques and results are used to assess equipment performance. Program adjustments are made and other corrective actions are taken where needed.[9]

F. The effectiveness of the PM program is periodically evaluated at an appropriate level of management, and the results are used to make program improvements.[9]

Data Package Checklist

System: ____________________ Component: ____________________

Manufacturer: ____________________ Equipment ID: ____________________

Design Information

1. Design Basis Descriptions
2. Technical Safety Requirements
3. SAR
4. PRA Report
5. Individual Facility Examination
6. Design Drawings
   —P&IDs
   —Schematic
   —Logic/Loops
7. Vendor Catalogs/Manuals
8. Vendor Drawings
9. System Descriptions
10. Environmental Qualification Requirements

Operation Information

1. Operating Procedures
2. Operating Logs
3. ISI/IST Requirements
4. Surveillance Requirements
5. Facility Availability Reports
6. Training Lesson Plans

Maintenance Information

1. Maintenance Procedures
2. Vendor Technical Manuals and Bulletins
3. Corrective Maintenance History
4. Preventive Maintenance History/Tasks

Operating Experience

1. Commitment Tracking Database
2. Lessons Learned
3. Occurrence Reporting and Processing System

Figure 4.4-A. Data Package Checklist.

System: Instrument Air **Component:** Instrument Air Dryer

Originator: ________ **Reviewed:** ________

Approved by: ________ **Date:** ________

Function Number	Function	Source Document
1	Provides water vapor temperature	Operating Procedures
2	Cools compressed air	Training Manual
3	Removes liquids from an air system	Training Manual
4	Removes water and oil aerosols from the air system	Maintenance Procedure
5	Removes heat from the air between stages of compressors	Maintenance Procedure

Figure 4.4-B. Component Functions Example.

Preventive Maintenance (PM) Document Validation and Feedback Form

PM Task Number: ________________ Work Request/Work Order No.: ________________

Component Tag Number: ____________ Component Description: ________________________

Safety Class (SR, QR, NNS): ________ Environmental Qualification: __________ Procedure Number: ______________

Craftsperson: ______________________________ Discipline: ________________________

Evaluation Factors	**YES**	**NO**	**NA**
1. Materials and tools equipment list complete and adequate?			
2. Can PM task be performed as written?			
3. Procedure reflects current as-built facility configuration?			
4. Referenced parts/equipment correctly identified and easily located?			
5. Graphic illustrations accurate, legible, and easy to understand?			
Indicate enough illustrative detail to adequately perform the PM task?			
6. Data sheets follow sequentially with the procedure book?			
7. Prerequisites, precautions, and limitations clearly identified?			
8. Tag numbers, nomenclature, and units/symbols identical to those on the components or instruments?			
9. PM frequency adequate?			
10. Step, caution, and note statements easily understandable?			
11. Changes to Work Request/Work Order required?			
12. Human resource allocations/requirements adequate?			
13. Concurrent maintenance correctly identified?			
14. Editorial/grammatical errors identified?			

Recommended changes to format, flow, or technical content:

Additional Comments:

Resolution/justification:

RESOLVED BY:	SIGNATURE	DATE

Figure 4.4-C. Sample Preventive Maintenance Document Validation and Feedback Form.

Table 4.4-B. Examples of Uses of Predictive Maintenance Techniques

Equipment Type	Predictive Maintenance Technique
Generators	Radio-frequency monitoring Infrared thermography
Turbines	Vibration Monitoring Lubricating oil analysis and ferrography Bearing temperatures In-leakage detection
Pumps	Vibration monitoring Acoustic emission Lubricating oil analysis and ferrography Bearing temperatures In-leakage detection Infrared thermography
Electric motors	Vibration monitoring Infrared thermography Lubricating oil analysis and ferrography Bearing temperatures Insulation resistance
Diesel generators	Vibration monitoring Lubricating oil analysis and ferrography Bearing temperatures Insulation resistance
Condensers	In-leakage detection Infrared thermography
Circuit breakers	Infrared thermography
Valves	Infrared thermography Acoustic emission In-leakage detection
Heat exchangers	Acoustic emission Eddy current In-leakage detection Infrared thermography
Electrical equipment	Infrared thermography Insulation resistance Polarization Index Electric circuit monitoring

Table 4.4-C. Examples of Equipment Included in the Vibration Monitoring Program

Component Tag Number	Component Description	Priority (Ref. 6.4.1)	Nominal Frequency
3CENTSEP	Lube oil separator number 3	D	Semiannually
3F1A	Traveling screen 3A1 drive	D	Monthly
3K2	Turbine/generator /exciter	B	Monthly
3P1	Amertap BS inducer pump P1	D	Quarterly
3P1A	Generator feed pump 3A	B	Monthly
3P1B	Generator feed pump 3B	B	Monthly
3P3	Amertap BS recirc pump P3	D	Quarterly
3P3A	Heater pump 3A	C	Monthly
3P38	Heater pump 3B	C	Monthly
3P6A	Condensate pump 3A	C	Monthly
3P6B	Condensate pump 3B	C	Monthly
3P6C	Condensate pump 3C	C	Monthly
3P7A	Circulating water pump 3A1	C	Monthly
3P7B	Circulating water pump 3A2	C	Monthly
3P9A	Intake cooling water pump 3A	A	Monthly
3P9B	Intake cooling water pump 3B	A	Monthly
3P200A	Coolant pump 3A	A	Monthly
3P200B	Coolant pump 3B	A	Monthly
3P201A	Charging pump 3A	A	Monthly
3P201B	Charging pump 3B	A	Monthly
4V19A	Isophase bus/fan motor 4A	D	Semiannually
4V19B	Isophase bus/fan motor 4B	D	Semiannually
P10A	Diesel fuel transfer pump A	A	Quarterly
P10B	Diesel fuel transfer pump B	A	Quarterly

Table 4.4-C. Examples of Equipment Included in the Vibration Monitoring Program (continued)

Component Tag Number	Component Description	Priority (Ref. 6.4.1)	Nominal Frequency
P39	Fire pump—motor driven	A	Semiannually
4P15	Turbine lube oil filter pump	D	Quarterly
4P16A	Primary water makeup Pp4A	D	Quarterly
4P16B	Primary water makeup Pp4B	D	Quarterly
4P31	Turning gear oil pump number 4	D	Annually
4P32	Auxiliary oil pump number 4	D	Annually
4P36	Air side seal oil pump	D	Quarterly
4P37	Hydrogen side seal oil pump	D	Quarterly
4P40	Bearing oil lift pump unit 4	D	Annually
4P49	Gland steam cond drain pump	D	Quarterly
4P86A	Demineralizer hold pump 4A	D	Quarterly
4P86B	Demineralizer hold pump 4B	D	Quarterly

Table 4.4-D. Examples of Equipment Included in the Lubricating Oil Sample Analysis Program

Component Tag Number	Component/Reservoir Description	Priority	Nominal Frequency
K4A Diesel	Emergency diesel generator A—engine crankcase	A	Monthly
K4A/GOV	Emergency diesel generator A—governor	A	Quarterly
K4B Diesel	Emergency diesel generator B—engine crankcase	A	Monthly
K4B/GOV	Emergency diesel generator B—governor	A	Quarterly
P2A	Auxiliary feed pump/turbine A	A	Quarterly
L3A	Auxiliary feed pump/turbine A—governor	A	Quarterly

Table 4.4-D. Examples of Equipment Included in the Lubricating Oil Sample Analysis Program (continued)

Component Tag Number	Component/Reservoir Description	Priority	Nominal Frequency
P2B	Auxiliary feed pump/turbine B	A	Quarterly
K3B	Auxiliary feed pump/turbine B—governor	A	Quarterly
P82A	Standby steam generator feed pump A—motor inboard	D	Semiannually
P82A	Standby steam generator feed pump A—motor outboard	D	Semiannually
3P3B	Heater drain pump 3B—motor lower bearing	C	Quarterly
3P3B	Heater drain pump 3B—motor upper bearing	C	Quarterly
3P6A	Condensate pump 3A—motor lower bearing	C	Quarterly
3P6A	Condensate pump 3A—motor upper bearing	C	Quarterly
3P6B	Condensate pump 3B—motor lower bearing	C	Quarterly
3P6B	Condensate pump 3B—motor upper bearing	C	Quarterly
3P7A	Circulating water pump 3A1—motor lower bearing	C	Quarterly
3P7A	Circulating water pump 3A1—motor upper bearing	C	Quarterly
4P11B	Turbine facility cooling water pump 4B—pump inboard	C	Quarterly
4P11B	Turbine facility cooling water pump 4B—pump outboard	C	Quarterly
4P200A	Reactor coolant pump A—motor lower bearing	A	18 months
4P200A	Reactor coolant pump A—motor upper bearing	A	18 months
4P200B	Reactor coolant pump B—motor lower bearing	A	18 months
4P200B	Reactor coolant pump B—motor upper bearing	A	18 months
4P201A	Charging pump 4A crankcase or gearcase—inboard end	A	Quarterly
4P201A	Charging pump 4A—fluid drive	A	Quarterly
4P201B	Charging pump 4B crankcase or gearcase—inboard end	A	Quarterly
3P214A	Containment spray pump 3A	A	Semiannually
3P214B	Containment spray pump 3B	A	Semiannually

Table 4.4-E. Typical Sources of Metallic Elements in Lubricating Oils

Element (symbol)	Typical Source
Aluminum (Al)	Pistons, bearings, dirt, additives
Barium (BA)	Additives, water, greases
Boron (B)	Coolants, additives, sea water
Calcium (Ca)	Additives, water, grease
Chromium (Cr)	Cylinders, rings, crankshafts, gears, coolants
Copper (Cu)	Bearings, coolers, bushings
Iron (Fe)	Cylinders, crankshafts, water, rust
Lead (Pb)	Bearings, greases, gasoline, paints
Magnesium (Mg)	Bearings, additives, sea water
Manganese (Mn)	Valves, fuel, steel shafts
Molybdenum (Mo)	Additives, rings
Nickel (Ni)	Shafts, gears, rings, turbine components
Phosphorus (P)	Additives, coolants, gears
Silicon (Si)	Defoamants, dirt
Silver (Ag)	Bearings, solders
Sodium (Na)	Coolants, additives, sea water
Tin (Sn)	Bearings, solders, coolants
Zinc (Zn)	Additives, bearings, platings

LUBRICATION ANALYSIS DATA FORM

Component Tag Number: ______________________________

Oil Type: ______________________________

Reservoir: ______________________________

Sample Number: ______________________________

Sample Date/Time: ______________________________

PHYSICAL DATA

Water Volume __________

Solids Volume __________

Fuel Dilution (% Volume) __________

Fuel Soot (ABS) __________

Glycol (Coolant) __________

Total Acid Number __________

Total Base Number __________

Viscosity __________

SPECTROCHEMICAL ANALYSIS IN PARTS PER MILLION BY WEIGHT

Silicon: __________	Iron: __________	Chromium: __________
Aluminum: __________	Copper: __________	Lead: __________
Tin: __________	Nickel: __________	Silver: __________
Molybdenum: __________	Magnesium: __________	Sodium: __________
Boron: __________	Barium: __________	Calcium: __________
Phosphorus: __________	Zinc: __________	

Figure 4.4-D. Lubrication Analysis Data Form.

Table 4.4-F. Examples of Equipment Included in the Infrared Thermography Program

Component Tag Number	Component Description	Priority (Ref. 6.4.1)	Nominal Frequency
3F1A	Traveling screen 3A1 drive	D	Quarterly
3F1C	Traveling screen 3B1 drive	D	Quarterly
3K2	Turbine/generator/exciter	B	Quarterly
3P6A	Condensate pump 3A	C	Quarterly
3P6B	Condensate pump 3B	C	Quarterly
3P6C	Condensate pump 3C	C	Quarterly
3P7A	Circulating water pump 3A1	C	Quarterly
3P7C	Circulating water pump 3B1	C	Quarterly
3P37	Hydrogen side seal oil pump	D	Semiannually
3P40	Bearing oil lift pump, Unit 3	D	Annually
3P201A	Charging pump 3A	A	Quarterly
3P201B	Charging pump 3B	A	Quarterly
3P203A	Boric acid transfer pump 3A	A	Quarterly
3P203B	Boric acid transfer pump 3B	A	Quarterly
3P211A	Component cooling pump 3A	A	Quarterly
3P211B	Component cooling pump 3B	A	Quarterly
3V31A	Main steam penetration cooling fan/motor 3A	D	Semiannually
3V31B	Main steam penetration cooling fan/motor 3B	D	Semiannually
3XO1	Main transformer	B	Quarterly
3XO2	Station auxiliary transformer	B	Quarterly
3XO3	Start-up transformer	A	Quarterly
3DO2	Battery charger 3A	A	Semiannually
3025	Battery charger 3B	A	Semiannually
3YO1	Static inverter 3A	A	Semiannually
3YO2	Static inverter 3B	A	Semiannually

4.5 MAINTENANCE PROCEDURES (See DOE-STD-1029-92)[83]

4.5.1 Introduction

Maintenance procedures and other work-related documents (e.g., drawings and instructions) should be prepared and used to provide appropriate work direction and to ensure that maintenance is performed safely and efficiently. A key element in performing maintenance in a safe, efficient, and consistent manner is the proper use of written procedures. A balanced combination of written guidance, skilled employees, and work-site supervision is required to achieve the quality work essential to safe and reliable facility operation.[1]

This section describes important concepts for preparation, verification, validation, approval, control, use, and periodic review and revision of maintenance procedures.

4.5.2 Discussion

Maintenance procedures should provide technical guidance to craft personnel to help ensure that they accomplish their work in a systematic, correct manner. This guidance must be technically accurate, complete, up to date, and presented in a clear, concise, and consistent manner that minimizes human error. Experience has shown that deficient procedures and failure to follow procedures are major contributors to many significant, undesirable events. The probability of craft personnel error increases with the use of poorly written procedures (see Section 4.7.3.13).

Guidance should be provided for the issuance of maintenance procedures, including development and writing, verification and validation, approval, use, change control, periodic review, and revision. Other factors, such as control of reference material, procedure identification and storage, and the requirement to maintain accurate procedures, must also be considered.

4.5.3 Guidelines

4.5.3.1 Procedure Development and Writing [83]

Procedures should be written for and used in all work that could result in a significant process transient, a condition of degraded facility reliability, or a personnel or equipment hazard. Work complexity is also an indicator of the need for a procedure. Procedures should be written for each PM action or written generically for similar PM actions (including applicable equipment lists). Because procedures are used repeatedly, they should include information such as personnel and skill levels required; time needed to accomplish the action; special tools and materials needed; facility or system conditions needed; and clearance, RWP, and other safety requirements and precautions needed to perform the PM.[51] Workers should be involved in procedure development and verification whenever possible.

Information provided in procedures should be clear and concise, minimizing the need for interpretation and the possibility of misinterpretation. Experienced craft personnel and engineers can be trained to write maintenance procedures, or procedure writers can be used, with craft personnel or engineers providing technical input. Maintenance procedures must be written with the users (crafts workers) in mind and should include the following.

- Procedure identification and status (titling or numbering, location, and page and revision identification).
- Procedure purpose and scope.
- Consistent organization, presentation and designation of instruction steps, caution and note style, and page style.
- Clearly understood text, using correct grammar and punctuation; appropriate level of detail; concise instruction steps in logical sequence; specific nomenclature; quantitative and compatible values; referencing and branching methods; coordination of multiple actions; warning and caution location; effective formatting; and clear table, graph, and data sheet layout.
- Consistent presentation of illustrations (e.g., preparation, compatibility, views, level of detail, and legibility when reproduced).
- Clear indication of steps that could initiate an equipment trip or transient or the initiation or interruption of any process action.
- Clear indication of hold points, independent verification requirements, or data to be recorded.
- Systematic nuclear facility and system prerequisites, precautions and limitations, required special tools and materials, and required personnel.
- Clear indication of acceptance criteria, follow-on steps, and restoration instructions.
- Steps that inform operations personnel of expected alarms or equipment operations.
- Guidance to craft personnel to notify the operations organization of maintenance that cannot be completed as originally planned or that will be delayed and extended past the anticipated due date and/or across shift changes.
- Development and preparation using personal computer, desktop-publishing, and computer-aided writing programs; this also aids in providing easy-to-read text and clear illustrations.

4.5.3.2 Procedure Verification

Verification is review of a new or revised procedure to determine whether it is technically accurate and properly arranged. This review should ensure that the procedure incorporates human factors principles and appropriate administrative policies. The technical accuracy review should also include a review of the procedure against the design requirement for the system or component it concerns. This may be accomplished by comparing the vendor manual and design specifications to the procedures.

Verification should be conducted by one or more reviewers from the facility producing the procedure who were not involved in writing the procedure. Reviewers from other disciplines, such as health physics, engineering, and operations, should also be considered for involvement in the process.

4.5.3.3 Procedure Validation

Validation is review of a procedure to determine its usability and correctness. This review evaluates whether the procedure provides sufficient and understandable guidance and direction to the craft personnel and that it is compatible with the equipment or system being maintained. Validation may be conducted in a shop, in a training environment, or on a mockup or simulator.

4.5.3.4 Procedure Approval

Approval should be consistent with facility TSR or their equivalents and with administrative procedures. At a minimum, the maintenance manager or his/her designee should approve maintenance procedures.

4.5.3.5 Procedure Use

A procedure should be readily available and clearly identified to ensure that the user can determine its purpose, applicability, physical completeness, and proper approval. Identification markings should also be sufficient for the user to be able to compare a procedure to some centralized, controlling record to verify that the procedure in use is the most current version. Procedures should be checked before they are used to ensure that they are the most current and correct revision.

Procedure compliance requirements should be clearly stated in the procedure itself or provided as general administrative guidance and should be thoroughly understood by each plant craft personnel and contractor. Compliance requirements may vary considerably, depending on the proficiency of the craft personnel and the potential impact of the maintenance being performed on station safety, reliability, and continuity of power generation. Managers and supervisors should require and enforce procedural compliance requirements established by facility administrative controls. Normally, two levels of compliance are defined:

- step-by-step compliance without deviation (normally expected for maintenance on safety equipment, for maintenance on equipment important to facility reliability, and for any activity that could result in a transient or facility shutdown) and

- general-intent compliance (the experienced judgment of the craft personnel or his/her supervisor is exercised to carry out the maintenance).

Other compliance categories and definitions may be used, such as identifying a group of steps that may be performed out of sequence. Whole procedures or portions of procedures required to be in hand and reviewed step by step when performing maintenance should be clearly identified.

Procedure users should understand the need to use procedures with forethought and good judgment, even when step-by-step compliance is not required. They should question and seek resolution of any situation that in their judgment warrants supervisory assistance. Supervisors or managers should resolve such inquiries promptly.

Maintenance and, if appropriate, operations supervisors should be notified immediately when a procedure cannot be followed as written or when a procedure is followed and unexpected results occur. In these instances, work should be stopped and the equipment or system restored to a safe condition. As described elsewhere in this section, procedures may need to be changed or revised before restarting.

4.5.3.6 Procedure Change Control, Periodic Review, and Revision [4, 46]

Responsibilities for procedure program administration should be clearly defined. Procedures should be controlled in accordance with facility administrative requirements. All procedures should be periodically reviewed (e.g., every 2 years or before use for infrequently used procedures) for changes affecting content (such as revisions of reference material, permanent incorporation of changes, and incorporation of industry and in-house experience) and for philosophy and format enhancements and human factors considerations. Reviewers should use checklists to ensure that the scope and depth of the review are consistent and adequate. Revisions of procedures should receive the same review and approval as new procedures, as described in Sections 4.5.3.2 through 4.5.3.4, with the extent of these reviews varying depending on the extent of the revision. A method should exist to ensure that TSR and other commitments are not inadvertently changed or deleted in the process of revising procedures.

Controls are needed to allow for procedure changes (temporary alterations so that work can be safely continued) and revisions (permanent alterations that incorporate outstanding temporary changes and other needed updates). Changes and revisions are necessary to correct errors and to ensure that procedures reflect current maintenance practices and requirements. Procedure changes do not normally involve retyping or reissuing an entire procedure. Procedure change information should be inserted neatly in the body of the procedure so the changes are not missed when the procedure is used. At a minimum, these changes should be reviewed and approved by technically competent supervisors, even though the changes may not become permanent. For example, a typical procedure change may require a review by an engineer for technical content; by a maintenance supervisor for good maintenance practice and human factors principles; and by an operations supervisor for regulatory compliance, unit operations, and approval. Changes needed beyond their original intent should receive the same review and approval as a revision (i.e., as soon as feasible, normally within 2 weeks).

A procedure revision should be initiated when a change has been outstanding for an extended period (normally, longer than 6 months), when a procedure has been affected by several changes, or when a single change becomes so extensive that the procedure becomes difficult to follow. When the procedure is revised, all effective changes should normally be incorporated into the revision.

A system should also be in place to ensure that facility safety, system, and component changes or modifications adequately identify procedures affected by the change and provide for their revision as required.

Copies of each procedure should be controlled so that only the currently approved revision with any applicable changes is available for use by craft personnel.

Vendor manuals or the portions of a vendor manual and other reference materials used in support of maintenance should be technically accurate, up to date, and controlled. Reference material (e.g., an instruction section of a vendor manual and vendor or contractor drawings) used in lieu of facility-prepared maintenance procedures should receive the same review and approval as facility maintenance procedures. When vendor recommendations conflict with maintenance experience, a documented engineering evaluation may be required.

4.5.4 Maintenance Procedures and Documentation Performance Objectives [23]

Maintenance procedures and other work-related documents should provide appropriate directions for work and should be used to ensure that maintenance is performed safely and efficiently.

CRITERIA

A. The preparation, review, approval, and revision of procedures and other work-related documents are properly controlled.

B. Documents used in lieu of procedures (such as excerpts from vendor manuals) receive the same review and approval as procedures.

C. Procedures and other work-related documents such as vendor manuals, drawings, reference materials, and posted job performance aids used in support of maintenance are technically accurate and up-to-date.

D. Procedures are readily available and clearly identified.

E. New and revised procedures are reviewed for technical accuracy before use, and are checked to ensure usability before or during initial use.

F. Procedures are clear, concise, and contain adequate information for users to understand and perform their activities effectively.

- Portions or steps of other documents that are used or referred to when performing a procedure are specifically identified in the procedure.
- Technical details such as setpoints, control logic, and equipment numbers are consistent among procedures, drawings, valve lineup sheets, and system descriptions.
- Human factors considerations are incorporated into procedures to promote error-free performance.

G. Hold points, such as quality and radiological protection checks, are included in procedures, as needed.

H. A policy governing the use of procedures is implemented. The policy includes the following:

- Portions or steps of other documents that are used or referred to when performing a procedure are specifically identified in the procedure.
- Action to be taken when procedures conflict, are inadequate for the intended tasks, or when unexpected results occur.

I. Temporary changes to procedures, if used, are effectively controlled, including ensuring appropriate review and authorization before use and ensuring user awareness of applicable temporary changes

J. A formal program exists to periodically review procedures for technical accuracy, human factors considerations, and the inclusion of in-house and industry operating experience.

4.6 PLANNING, SCHEDULING, AND COORDINATING MAINTENANCE (Replaces DOE-STD-1050-93)[1, 4, 9, 10, 11, 18, 19, 29, 31, 36, 38, 39, 40, 42, 57, 59, 60, 67, 68, 69, 70, 72, 73, 74, 75, 76 83, 84, 116, 117, 119, 121]

4.6.1 Introduction

An effective system for planning, scheduling, and coordinating maintenance activities should be implemented to ensure maintenance is accomplished in a timely manner, ensure worker safety, improve maintenance efficiency, reduce radiation exposure, and increase equipment availability. Planning and scheduling involves assigning priorities that reflect the importance of maintenance work relative to safe and reliable facility operation; personnel safety; identification of logistics, personnel support; and other preparation; and minimizing any adverse impact that the maintenance activity has on facility operation. Coordination of work ensures that needed support (e.g., lockouts/tagouts, RWPs, QC) is available.[1 2, 3, 4, 5, 6, 7, 8, 9, 10, 11]

The processes of planning, scheduling, and coordinating work are discrete tasks that are closely related and that are usually delegated to one of several functional groups. Planning, scheduling, and coordinating work usually involves a planning group, a scheduling system (work-control system), a scheduling group (which may be a part of the planning group), and a coordination group (which may also be a part of the planning group). Outage planning, scheduling, and coordination are usually managed by a dedicated group of individuals in order to control this significant effort.[1, 28]

This section describes a system for effectively planning, scheduling, and coordinating routine maintenance activities as well as unplanned and planned outages.

4.6.2 Discussion

Planning for work is an important part of the maintenance process. In-depth work planning identifies the required support and detailed scoping necessary to schedule daily maintenance accurately. Defining the work to be performed and providing appropriate procedures or instructions can reduce maintenance errors and risk of injury to personnel. Assigning work priorities that reflect the relative importance of each job to facility operation maximizes the effect of maintenance in upgrading safety and reliability. Planning also reduces delays in accomplishing work by ensuring support items such as special tools, personnel protection equipment, and other equipment, and repair parts and materials required to accomplish the work are available when needed. This in turn results in increased efficiency and contributes to maintaining a higher level of facility condition as well as assuring worker safety. [30, 68]

Scheduling corrective and preventive maintenance and planned and unplanned outage work is necessary to ensure that maintenance is conducted efficiently and within prescribed time limits. Scheduling daily activities based on accurate planning estimates will improve use of time on the job and help reduce radiological exposure. Scheduling planned outages is important to support the return of the facility to service on schedule (and within the approved budget) and results in improved availability and capacity factors. A contingency work schedule (shutdown file) should be maintained so that if an unplanned outage occurs, the duration is minimized and effectively used and so that needed maintenance is performed before restart.[49]

Coordinating maintenance activities is necessary to help ensure that work can be effectively accomplished. Examples of areas where interdepartmental coordination is necessary include preparing and using safe work permits, RWPs, and fire or burn permits; entering confined spaces; equipment lockouts/tagouts; and QC verifications. Intradepartmental coordination is also needed among the mechanical, electrical, instrumentation and control, and contractor groups for many work activities. A planner, supervisor, or designated individual within the maintenance organization or within the group responsible for the major portion of the job should be assigned the lead in identifying and coordinating needed support.[54]

4.6.3 Guidelines

4.6.3.1 Planning for Maintenance Activities

4.6.3.1.1 Planning-Group Organization

Planning in an integrated management system is a function designed to be principally concerned with future activity, except in actual emergency situations. The planning function is primarily for providing job plans and procedures, job estimates, drawings, specifications, manuals, vendor information, special tools or equipment, job materials, production coordination, weekly work schedules, overhaul schedules, and equipment histories and records. The planning function should also be used to support the maintenance budgeting process, provide details on job costs, and identify and coordinate training needs. Planning maintenance activities can be accomplished by a dedicated planning staff or by maintenance supervisors at facilities with smaller staffs. If a dedicated group is used, it may be established as a central planning group or it may be decentralized, with planners for each discipline working within their respective groups.[11, 76]

A centralized planning group offers the benefit of improving the coordination among the various facility groups and providing a central point to supply planning and scheduling information. A decentralized planning group facilitates a closer working relationship between each planner and the individual shop craft personnel and can lead to increased planner credibility. However, this approach can diminish coordination among the planners.

The planning effort can be enhanced in two ways: by assigning maintenance personnel to the planning group and by assigning to the planning group knowledgeable and experienced personnel from such other disciplines as safety, operations, QC, and radiological protection. The alternative of assigning maintenance supervisors the responsibility for planning work has the advantage of having the most knowledgeable individuals perform the planning, but their workload must be adjusted to allow them to carry out all their assigned responsibilities properly.

A small facility may function well with maintenance supervisors being responsible for all planning. A larger facility may gain by having a dedicated planning group to relieve the first-line supervisor of most planning duties, allowing him/her adequate time for other supervisory duties, such as observing and directing ongoing maintenance activities at the work sites.

4.6.3.2 Planning-Group Responsibilities

All WRs or work packages should be reviewed by a planner. However, different levels of planning attention should be applied to different jobs; for example, correcting a packing leak on a manual valve does not normally need the same level of planning effort as does the overhaul of a major pump. The review should address the following items.

- Definition of the problem and identification of the work scope (e.g., by work-site inspection, by review of PM activities, and by other corrective maintenance that should or could be performed within the lockout/tagout boundary for the equipment).
- Identification of personnel hazards expected to be encountered during the maintenance activity, and safe work practices to be used to mitigate and eliminate such hazards;
- Identification and review of necessary procedures, drawings, vendor manuals, and maintenance history.
- Identification of needed and available data for use in analysis of maintenance problems (see Section 4.16).
- Procurement of necessary repair parts, materials, tools, and equipment.
- Assessment of labor and skill requirements for nuclear facility, nonnuclear facility, and subcontractor personnel.
- Identification and review of resources, including other tasks scheduled to occur in the immediate area during the same period.
- Prejob ALARA planning.[59, 121]
- Identification of initial conditions and prerequisites, including applicable TSR and LCOs.
- Identification of QC inspection requirements, code requirements, and TSR.
- Establishment of equipment restoration and postmaintenance inspection or testing requirements.
- Review of work instructions or work packages for completeness.

Once the work is completed, the review should address the following items.

- Review of completed work packages for proper documentation, adequate postmaintenance testing, industrial safety hazards encountered, and possible changes to the PM program (see Section 4.4).
- Equipment history update (see Section 4.15).

4.6.3.3 Craft Skills

To correctly and efficiently perform the planning function, management should provide adequate guidance on the level of control necessary to ensure consistent quality DOE nuclear facility maintenance. The requirements to provide procedures to maintain SSCs important to facility safety are defined in DOE Order 433.1, *Maintenance Management Program for Nuclear Facilities,* DOE Order 5480.19 [44], *Conduct of Operations Requirements for DOE Facilities,* 10 CFR 830 and facility TSR.[47] However, there may be large disparities between DOE nuclear facilities in the level of expertise of personnel performing maintenance activities. Many facilities rely heavily on what is known as “skill of the craft” (see definitions in Section 1.1) but have not assessed the actual skill levels of their personnel. For example, it is commonly accepted that an electrician possesses the necessary skills to install wiring and terminal lugs; however, certain electrical products for nuclear facilities require specialized training and skills to install electrical wires, cables, and conduits (e.g., termination and sealing of various types of medium voltage, 5–15 kV, cables; environmental sealing of connections of cables to busbars rated up to 15 kV in accordance with ANSI C37.20; and sealing connections to medium voltage motors).

Skill-of-the-craft expertise should be credited in Maintenance Work Packages when it is known that the work required is routine to the individuals performing the work. However, where this is not known and new or specific vendor instructions exist, additional training and work instructions should be provided to ensure worker qualifications. For example, work instructions for nonfacility contractors may need to include more details, inspection, or supervisory guidance. To reduce the potential for inadequate instructions to personnel, maintenance managers should establish minimum levels of craft proficiency and implement training programs to ensure that the expected craft skill levels are developed and maintained.[120] Deficiencies identified through daily activities, industry experience, or root-cause analysis may result in the identification of additional training needs to maintain this skill level. For work beyond expected skills, detailed work instructions should be provided to the craft persons. Skills of the craft are work skills that are documented and common knowledge to individuals involved in maintenance planning and execution. Facility maintenance personnel should be formally trained, by means of an accredited OJT program [81, 127], and qualified and verified to possess the knowledge and expertise to be sufficiently skillful in the work they are assigned and expected to perform under the supervision of an individual qualified to judge the proficiency of their work.

Some examples of maintenance craft skills include the following:

- tightening or replacing fittings;
- replacing gaskets, bolting, valve packing, and stationary seals;
- valve lapping;
- standard testing, such as insulation resistance, voltage, etc.;
- replacing fuses and lamps;
- lubricating equipment;
- removing corrosion from surfaces;
- trimming refrigerant charge;
- removing oil from refrigeration facilities;

- cleaning threads by mechanical means;
- cutting fasteners to length;
- insulating cables (except on printed circuit boards);
- soldering (except on printed circuit boards);
- crimping lugs and splices;
- tubing installation; and
- tube-fitting makeup.

Skill-of-the-craft expertise is considered to be standard DOE nuclear facility practice and does not usually require job steps, instructions, or an approved procedure in hand. However, if a job requires a work-authorizing document such as a Work Request/Work Order (Figure 4.6-A), the inclusion of skill-of-the-craft expertise does not alter this requirement. The use of skill of the craft in the performance of a job is not considered to be a change of work scope, providing it is confined to the job covered by the Work Request/Work Order and that all other work performed is in accordance with approved facility procedures. In all cases, however, all work should be documented on the WR/WO.

The “traditional” craft role of maintenance personnel was to respond and repair failed items rather than to provide care and cleaning to prevent failures. They were fixers rather than preventers. When applied to machinery this usually meant the equipment would run until failure. In a traditional organization the supervisor reviewed work tickets, and after considering craft skills, personalities, and equipment knowledge, handed the work tickets to each craft person at the start of the work period.

The craft person was relied on to review the needed repairs, get the materials and tools, and independently coordinate the task. This resulted in less hands-on time spent on equipment and more time spent preparing (planning and scheduling, obtaining parts, etc.) the work.

The new craft role of much of today’s work requires increased control because of the hazards at nuclear facilities and the need for increased efficiencies caused by reduced budgets. Elements that must be considered include hazard recognition and control, schedule completions, and increased work documentation to satisfy stakeholder interests. During the transition from the traditional to the new craft role, various interpretations of the requirements have resulted in procedures and work packages containing a very high level of rigor and over-regulation of craft performance, with little recognition of supervisory or craft contributions.

The organization and administration of the maintenance function should ensure that a high level of performance in maintenance is achieved through effective implementation and control of maintenance activities. A maintenance organization prevents equipment failure through preservation (preventive or predictive maintenance) and restoration (corrective maintenance), particularly failures affecting SSCs important to safe and reliable operation. What are the key maintenance roles and where does the craft worker fit into the new picture?

DOE contracts with individual companies to manage, operate, and maintain the facilities and sites in a safe, efficient manner. Senior management ensures the obligations and schedules defined in the contract are met. The first-line supervisor and/or team leader is responsible for executing these obligations in the field.

The first-line supervisor/team leader is accountable to senior management for the quality of work performed in the following areas:

- understanding and ensuring the correct use of appropriate DOE, site, facility, and department policies and procedures;
- selecting qualified people to perform work;
- identifying and controlling job hazards;
- following an integrated work schedule to manage time and resources effectively;
- periodically observing work-in-progress, while providing job-site coordination and supervision;
- ensuring proper return to service of equipment, including job-site cleanliness and postmaintenance testing; and
- maintaining the quality of the completed work packages to adequately record the work actions performed.

Craft persons provide specialized hands-on skills. At the direction of first-line supervisors/team leaders, the crafts perform those tasks necessary to preserve or restore the equipment. Craft responsibilities are in these general areas:

- maintaining appropriate skill levels;
- using and following procedures and work instructions properly;
- recording information accurately;
- performing work using good quality and ES&H work practices; and
- identifying and controlling job hazards.

The balanced combination of skilled worker, clearly written guidance, and supervision that is in today’s work environment in the new craft role is not suitable for all maintenance tasks. There are situations and tasks where the traditional craft role is an appropriate and viable approach. It is to these tasks that the term “skill of the craft” applies.

A balanced combination of written guidance, craft skills, and work-site supervision is required to achieve the quality workmanship essential to safe and reliable facility operation.

This statement sums up work management and identifies three primary elements for focus:

- written guidance—instruction(s) provided to the worker to accomplish a task;
- craft skills—the level of technical proficiency of the worker verifiable by some form of qualification or supervisory knowledge; and
- work-site supervision—the level of field supervision of the task, including prejob briefing, job site observations, job site coordination, and postjob review.

A balanced combination of these three elements produces the appropriate rigor to complete the task safely and efficiently. Rigor is the amount of supervision and written direction based on the risk and complexity of the task and the known skills of the craft person. The relationship of all three elements must be considered during task planning and personnel assignment.

Management, first-line supervisors, and planners may use the Balanced Combination Matrix, explained below and on the following pages, to evaluate maintenance tasks for a balanced combination. It must be understood that the task risk/complexity relationships shown are not fixed values, but simply demonstrate a range based on the balanced combination.

Balanced Combination Matrix

High Risk/Complex Task	**High Risk/Simple Task**
C Detailed written instructions C Maximum supervisor involvement C Craft qualified for task	C Guideline written instructions C Normal supervisor involvement C Craft qualified for task
Low Risk/Complex Task	**Low Risk/Simple Task**
C Guideline written instructions C Normal supervisor involvement C Craft skill sufficient for task	C Verbal instructions C Minimum supervisor involvement C Craft skill sufficient for task

<u>High Risk/Complex Tasks</u> (upper left quadrant of matrix). As an example, assume that an air compressor installed in a plant safety class system, in a radiological area (RA), requires a complete overhaul. The process piping may have internal contamination that poses an obvious health hazard. Management identifies the task as a high risk/complex task. Here, the balanced combination would be as follows.

- Written guidance—a detailed, continuous use procedure to ensure work quality and repeatability and worker safety. A detailed RWP would also be required. A second craft person is also required (about 75 percent of the job balance).
- Craft skills—a previously qualified journeyman or technician that has additional specific qualifications for radiological work (about 5 percent of the job balance).
- Work-site supervision—a prejob briefing, job safety review, work site visitation, and postmaintenance and postjob critiques would normally be expected (about 20 percent of the job balance).

Low Risk/Complex Tasks (lower left quadrant of the matrix). Assume that the same compressor is installed in a vehicle support building and requires a complete overhaul. Management identifies the task as a low risk/complex task. Here, the balanced combination would be as follows.

- Written guidance—a detailed, continuous use procedure or approved vendor overhaul manual to ensure work quality, repeatability, and worker safety (about 70 percent of the job balance).
- Craft skills—a previously qualified journeyman or technician (about 25 percent of the job balance).
- Work-site supervision—a prejob briefing, job safety review, work site visitation, and postmaintenance and postjob critiques would normally be expected (about 5 percent of the job balance).

High Risk/Simple Tasks (upper right quadrant of the matrix). For example, assume a gate valve with body-to-bonnet leaks is installed in a chemical processing system. The leaking fluid is a carcinogenic chemical. Management identifies the task as a high risk/simple task. Here, the balanced combination would be as follows.

- Written guidance—a detailed continuous use procedure to ensure work quality repeatability and worker safety (about 33 1/3 percent of the job balance).
- Craft skills—a previously qualified journeyman or technician that has additional specific qualifications for that particular process system (about 33 1/3 percent of the job balance).
- Work-site supervision—a prejob briefing, job safety review, work site visitation, and postmaintenance and postjob critiques would normally be expected (about 33 1/3 percent of the job balance).

Low Risk/Simple Tasks (lower right quadrant of the matrix). Assume the same gate valve is installed in an irrigation water system in the “north forty.” Here, the leak is just a nuisance.

Management identifies the task as a low risk/simple task. The balanced combination in this case would be as follows.

- Written guidance—a piece of paper that states something like “Using appropriate safety precautions, replace or repair as necessary,” may be acceptable (about 5 percent of the job balance).
- Craft skills—a qualified journeyman or technician with suitable skills would be the normal requirement (about 70 percent of the job balance).
- Work-site supervision—minor supervisory instruction, optional work site visits, and discretionary supervisory QC would be appropriate (about 25 percent of the job balance).

A maintenance training and qualification program should be implemented to develop and maintain the knowledge and skills needed by maintenance personnel to effectively perform maintenance activities.

The training program includes available initial training for qualified new hires or promoted craft personnel, continuing training in a classroom setting to improve or update job skills and knowledge, and OJT, where practical hands-on training is performed in the job environment. Several work management systems at Hanford have implemented the skill-of-the-craft concept differently. Two are summarized below. Both methods are acceptable.

At K Basins, 14 types of activities are authorized for skill-of-the-craft task assignment. A job hazard analysis matrix to match commonly identified hazards to the 14 maintenance types is also provided. The current K Basins organizational structure follows the traditional vertical alignment.

PUREX organizational structure has recently been reengineered to reflect a project management and area team structure rather than the traditional vertical tree alignment. The makeup of the lower tier area teams provides a composite group that can authorize skill-of-the-craft work. PUREX has developed a computerized job hazard analysis tool to match commonly identified hazards to the skill-of-the-craft activities.

The primary objective of work planning is to identify all technical and administrative requirements to complete a work activity and to provide the materials, tools, and support activities needed to perform the work. These items should be provided to maintenance personnel in an easy-to-use, complete work package. Effective planning should help ensure that consistent quality maintenance activities are conducted safely and correctly. Also, planning coupled with an effective scheduling and coordination methodology, will help ensure delays in performing nuclear facility maintenance are kept to a minimum.

Work planning is an evolutionary process that should be periodically assessed through field observation of work being performed and direct feedback from maintenance personnel to maintenance planners. An effective planning program should contain the following key elements:

- management commitment, overview, and support to ensure success of the program;
- management direction to ensure the appropriate level of detailed work instruction is developed and provided so that schedulers and other affected organizations can carry out the activities as planned;
- proper coordination of integrated discipline review and required Maintenance Work Package sign-off for consistency in planning and execution between disciplines to ensure involvement of the appropriate persons and the proper sequence of carrying out the work;
- thorough review and coordination by experienced individuals of products produced by the planning group to facilitate effective scheduling and to minimize or eliminate errors;
- feedback from craft persons and supervisors to facilitate improved future planning activities; and
- use of job history for establishing standard job duration, parts, and consumables for repetitive jobs.

The planning function should also coordinate between facilities to determine scheduled shutdowns (planned outages) and replanning requirements. A planning control system should determine when maintenance is to be accomplished and record that it has been accomplished. The planning system should be responsible for the maintenance activity required to achieve a balanced flow of preventive vs. corrective maintenance. When this balanced flow cannot be achieved, the planning system should identify and direct corrective actions as required. The planning system should include a tracking system addressing the following:

- reducing the impact of planned outages by planning and completing maintenance activities in a timely manner;
- reducing the number of forced outages;
- minimizing challenges to SSCs important to safety;
- reducing worker lost-time accident rate;
- reducing facility and equipment downtime;
- reducing human errors;
- reducing radiological and toxicological exposure to workers;
- controlling and reducing the number of contaminated areas;
- completing scheduled surveillances and PM activities in a timely manner;

- reducing repeat maintenance WRs (rework);
- managing the corrective maintenance backlog to minimize the backlog and completion time of outstanding deficiencies;
- controlling overtime;
- staffing and training the maintenance organization; and
- completing outage and nonoutage work on schedule.

4.6.3.4 Planning System

A system of planning, scheduling, and coordinating maintenance work activities should be clearly defined based upon the maintenance operations model, which consists of five interrelated processes applicable to each maintenance job. The processes are as follows.

1. Plan Maintenance Job. Identify the scope of a needed maintenance job. Produce a maintenance job plan. Determine maintenance job planning category, priority, and safety concerns. Identify and procure materials, and identify other maintenance task resources. Prepare the maintenance job package.

2. Schedule Maintenance Job. Calculate estimated start date and project resources for the maintenance job. Schedule and commit required resources and special tools/equipment items to allow performance of all maintenance tasks within the maintenance job.

3. Execute Maintenance Job. Initiate and perform a maintenance job and collect job information as defined in the maintenance job package.

4. Execute Postmaintenance Test (PMT). Verify facilities and equipment items fulfill their design functions when returned to service after execution of a maintenance job.

5. Complete Maintenance Job. Perform maintenance job closeout including completion of all documentation contained in the maintenance job package to ensure historical information is captured.

4.6.3.5 Work-Control Program [54]

A work-control program based on the requirements of DOE Order 433.1, *Maintenance Management Program for Nuclear Facilities,* should be integrated with the planning system. The implementation of this program should ensure that the maintenance activities in nuclear facilities are conducted in a manner that preserves and restores the availability and operability of the SSCs important to safe and reliable facility operation. The work-control program should include a WO system, job planning and estimating, time standards, a priority system, procedures and documentation, scheduling, postmaintenance testing, backlog work management, equipment repair history and vendor information, training and qualifications, an ISMS, lockouts/tagouts, work performance standards, human factors, and engineering (see Section 4.7.).

4.6.3.6 Maintenance Work Request/Work Order Processing [54]

The maintenance manager should have overall responsibility for the establishment, implementation, and performance of the planning, scheduling, and coordination maintenance activities through the planning function's processing of WR/WOs as described below.

NOTE: **Deficiency identification and control of work vary widely from facility to facility. This section provides the basic elements needed in the work-control system to provide the planner with adequate information to perform the planning function.**

A maintenance WR/WO should be initiated and a maintenance deficiency tag/sticker attached as soon as practical after discovery of a facility equipment deficiency (see Figure 4.6-A).

All WR/WOs for facility equipment should be delivered to the owner/operator designated representative for review and appropriate action to minimize further equipment damage. The owner/operator review should ensure the following:

- the WR/WO is not a duplicate of an existing WR/WO
- equipment name, identification number, and location are properly entered;
- originator information is included on the form and is legible;
- deficiency tag number and location are documented, if applicable;
- failure/problem description is accurate and clearly stated;
- special conditions necessary to remove equipment from service such as an LCO, a system outage, or a major facility outage are clearly identified; and
- priority is assigned, TSR are identified, and time limits for action are specified, if applicable.

Reviewed WR/WOs should be initialed by the owner/operator representative and forwarded to the maintenance planning department. The planning supervisor, or designated individual should review the WR/WO to determine whether the work on the WR/WO should be performed as a minor maintenance task and assign the WR/WO to the responsible craft planner. The craft planner should review the WR/WO and perform the following.

1. Verify that the WR/WO is not a duplicate of an existing WR/WO.

2. Walk down the identified deficiency using the walkdown checklist (Figure 4.6-B), as necessary, to assist with job planning.

3. Verify the identified deficiency accurately describes the equipment problem. For example, "waste disposal pump leaks," does not provide enough information to assess the urgency of needed repairs or to provide accurate direction in performing repairs on the pump. A more accurate and quantitative problem description would be, "The casing flange on the waste disposal pump leaks 10 drops per minute during pump operation at full load. The pump design does not permit any leakage from the casing flange. Continuation of the leakage will damage the pump and result in its inoperability."

4. Identify special equipment/conditions to be considered in planning the work such as scaffolding requirements, special tools, interference removal, special radiological considerations, etc.

5. If the activity should be performed as minor maintenance, forward the WR/WO to the appropriate craft supervisor or scheduler for accomplishment.

4.6.3.7 Maintenance Work Request/Work Order Planning

The planner should perform the following steps using the walkdown checklist in Figure 4.6-B.

1. Identify any other pending and/or appropriate maintenance tasks, such as PM, surveillance tests, or related corrective maintenance, that may be performed concurrently with the work being planned. Discussion with operations, scheduling, and engineering may be necessary to coordinate all associated work.

2. Identify and initiate appropriate requests as necessary for additional task and/or support needs such as scaffolding erection, electrical disconnection, piping removal, etc.

3. Review component history to determine when and what actions were previously taken for similar repairs. Consider repairs to similar equipment in other locations. Repetitive maintenance trends for problem equipment, components, and structures should be brought to the attention of engineering for resolution.

4. Obtain applicable detailed drawings of the components and associated systems to be repaired or affected by the repair.

5. Review vendor information for special requirements for component repair and parts that may be needed to perform repairs.

6. Provide a list of required special tools and parts for the job in the job package. If like-for-like replacement parts are not available, contact engineering for resolution.

7. Check for parts availability. Order/reserve parts as necessary to perform repair.

8. Determine procedure requirements based on equipment classification, ALARA considerations, and/or extent of repair needed to restore the equipment to operating condition (see DOE-STD-1029 *Writer's Guide for Technical Procedures*). Where preapproved procedures are available, work should be performed using these procedures. Typically the following types of repairs have approved procedures or work instructions, which should be reviewed before initiating work:

   - repairs to SSCs important to safety,
   - repairs to environmentally qualified equipment,
   - welding,
   - code repairs,
   - repairs that involve QC verification, and
   - repairs to configuration managed equipment.

9. If an approved procedure is not required as determined in Step 4.6.3.3, provide work instructions to the craftsperson in sufficient detail to correct the equipment deficiency. Vendor recommendations, engineering requirements, craft training/skills (skill of the craft), special tool needs, and hazards involved in performing the task should be considered when preparing these instructions. Engineering review of new work instructions should be performed to ensure adequacy. Work instructions to control troubleshooting should also be developed.

***NOTE:* Consideration should be given to maintaining a library of routine, recurring maintenance instructions to minimize planning time. Previous job histories should be reviewed to establish standard job durations, typical parts and consumables needed, and other job requirements listed in Figure 4.6-C (Planning Check Sheet).**

10. Working with craft supervision, review maintenance history records to determine time and coordination requirements to accomplish the task.

11. Initiate special permits necessary to perform the maintenance task. Flame permits, confined space permits, tagging requests, RWP requests, etc., should be included in the work package, if available.

12. When ALARA work planning is performed, special consideration should be given to providing adequate detail to assist the craftsperson in performing the task and reducing radiation exposure. Examples of items that should be considered include the following:

    - reviewing previous work packages for lessons learned and effective methods of performing the task;
    - reviewing area photographs, if available, to identify problems that may delay work;

- providing detailed tool lists;
- providing rigging and handling sketches;
- performing mockups or practice runs in nonradiation areas;
- using portable shielding to reduce radiation levels;
- dividing work into distinct tasks to be performed by different individuals;
- holding an in-depth prejob briefing to ensure crafts persons have a clear understanding of the tasks to be performed;
- improving access to the work through portable scaffolding or work platforms;
- flagging work areas to control access;
- including ALARA personnel in the planning process; and
- designing special tools that may reduce time to complete repair.

13. Work with the operations manager and engineers to determine the following:

    - operational impacts such as alarms, possible actuation, special system alignment, or operator actions, and
    - PMTs that should be performed to check the maintenance performed and to return the component to operation (Section 4.8 addresses postmaintenance testing).

14. Assemble the work package. Include items listed in Figure 4.6-C (Planning Check Sheet), as required. Facility document control procedures should be followed to ensure the most recent revision of a procedure is used by the craftsperson in performing the maintenance.

15. Place the work package in the appropriate file or forward it to scheduling for accomplishment. Files should indicate the following.

    - Ready to Work—All requirements are met; parts are available; support needs, such as scaffolding, are identified.
    - Hold for Parts—Repair parts are on order but have not been received or are not available.
    - Hold for Facility Conditions—All requirements have been met; however, special facility conditions, such as a component outage/LCO, are needed to perform the work.
    - Outage Item—Facility outage or major system outage is needed to perform task.

4.6.3.8 Scheduling Maintenance Activities

4.6.3.8.1 Control of Work Backlog [1, 9, 32, 54]

A computerized work-control system should be used to provide the maintenance manager and his/her supervisors with the means for identifying, recording, and tracking the status of all valid WRs. Computerized systems offer the following features that could be helpful in managing the work backlog:

- the ability to sort WRs by deficiency tag, priority, WR date, facility conditions required, and systems affected;

- the ability to indicate the status of all WRs on hold for planning, parts, material, or other constraints;

- the ability to track the status of in progress WRs; and

- the ability to track postmaintenance testing to ensure that all required PMTs are accomplished before a piece of equipment or a system is returned to service (especially important after outages, when many jobs may be performed on a system that is removed from service for an extended period or when several jobs are completed under one clearance; see Section 4.8).

The maintenance manager or his/her designee should add a WR to the system as part of the system backlog from the time the work is identified until all actions are complete, including postmaintenance testing and administrative reviews. The system should provide a serialized list of WRs with a brief description of work required, priority assigned, dates initiated, and plant conditions required to perform the work.

PM actions should be scheduled at appropriate intervals and, when appropriate, combined with corrective maintenance activities on the same equipment and with other related maintenance, based on equipment similarity or proximity. For example, corrective maintenance could be scheduled simultaneously with an upcoming PM action that requires the same or a similar lockout/tagout, PM routes could be established that allow crafts workers to lubricate all equipment on a particular elevation, and quarterly and annual PM could be scheduled simultaneously.

These principles also apply on an interdisciplinary basis. For example, operations, mechanical, electrical, instrumentation and control, and technical staff activities should be integrated.

A method should be established for advising all facility groups of the short-range and long-range PM schedules, either independent of or within the work-control scheduling system. Regardless of the method used, it is essential that all affected groups have adequate advance notification of each PM action to be accomplished.

Delays beyond the scheduled dates for PM actions should be approved by the maintenance manager. If the action has the potential to exceed the grace period (normally, 25 percent of the prescribed maintenance interval), the maintenance manager should be informed and be directly involved in the decision process.

The facility manager should approve delays in performing PM actions beyond the approved grace period. The maintenance manager should report this exception status periodically (e.g., quarterly) to the facility manager, indicating the reasons and intended actions.

The maintenance backlog should be monitored to ensure important jobs are not being delayed unnecessarily and control is maintained over the amount of work in the backlog.

4.6.3.8.2 Work Priority [1, 28, 54]

Each WR related to repairs of production equipment should be reviewed by the operations department to determine its impact on facility operations. Meaningful priorities that determine how soon a WR needs to be worked should be set based on operational and industrial safety and reliability. Communication among cognizant groups should be established to enable proper priorities to be set. A method should be established that avoids congesting the work-control system with jobs that are not important to safe and reliable operation.

The priority system should be kept simple to enhance its use and accuracy; typically, it is limited to about six categories. Corrective maintenance should be assigned a priority based on the maximum time allowed before corrective action must be taken, as well as on the importance of the system or equipment.

Items that should be considered when priorities are assigned to WRs include the following:

- personnel and radiological safety;
- equipment repair urgency;
- operability of redundant equipment;
- operating approval commitments (e.g., TSR, LCO);
- facility conditions required for equipment repair;

- status of repair or replacement parts;
- ALARA considerations such as exposure and contamination control;
- personnel availability; and
- minimization of the spread of contamination from leaks.

The following list illustrates a priority system.

1. Nonoutage work.

    - Priority 1—Emergency or severe adverse impact on personnel safety; limits facility operation (top priority: work today and provide special coverage if necessary).
    - Priority 2—Urgent; hinders facility operation (schedule within 24 hours).
    - Priority 3—Necessary; has potential to degrade or hinder facility operation (schedule within 7 days).
    - Priority 4—As time permits.

2. Outage work (subcategories for Priority 5 and 6 work as part of outage planning are also useful).[***]

    - Priority 5—Hot shutdown or hot standby.
    - Priority 6—Cold shutdown.

Scheduling corrective and preventive maintenance as well as planned and forced outage work is necessary to ensure that maintenance is conducted efficiently (e.g., within prescribed time limits). Scheduling daily activities based on accurate planning estimates improves facility production capacity through effective use of time on the job and helps to reduce hazardous worker exposures. Scheduling planned outages is important to support the return of the facility to service on schedule (and within the approved budget) and results in improved availability and capacity factors. In addition to the integrated maintenance schedule, a contingency schedule should be maintained so that if a forced outage occurs, the forced outage time is minimized and effectively used and so that all needed maintenance is performed before an anticipated facility restart.

An effective integrated maintenance schedule should assist management in controlling and directing maintenance activities and enhance management's ability to assess progress. The schedule should reflect the long-range plan and day-to-day activities. Effective scheduling should result in the most efficient use of resources by significantly decreasing duplication of

[***] Analogous conditions can be defined for nonreactor facilities.

work and technical support, decreasing personnel idle time and ensuring timely completion of planned tasks. The schedule should be the road map for reaching established facility maintenance goals.

Scheduling should be considered an integral part of the overall preparation for maintenance activities and should be performed consistent (simultaneously, where possible) with the planning activities covered in this handbook. The integrated maintenance schedule should be based upon such details as work scope, facility goals and objectives, prerequisites and interrelations, integrated design or modification reviews, parts procurement and personnel availability, resources, and constraints, all of which should be identified during the planning process.

A properly prepared and updated integrated maintenance schedule should be a primary tool to assist in managing maintenance activities. The successful completion of maintenance activities could be jeopardized if a schedule is not available to identify and properly sequence maintenance tasks. Sufficient detail should be included in the integrated maintenance schedule to coordinate activities and track progress. By grouping individual work items and integrating major tasks, more efficient use of technical support and scarce resources should be achieved.

The integrated maintenance schedule should form the basis for progress reporting. The schedule should remain useful if it is updated frequently based on the progress reports.

Effective daily schedules are needed to implement the maintenance activity plans represented by the integrated schedule. Management should track and periodically assess performance to the daily schedule. Effectiveness of the daily scheduling process during normal operation should be a good indicator of how effective the daily schedule may be during outages.

The integrated maintenance schedule should be reviewed by those responsible for its implementation. It should be accepted and widely used by personnel involved in maintenance activities. One purpose for preparing schedules for contingencies should be to decrease the time necessary to respond to problems if they occur and increase the information available for decision making.

A WR/WO priority coding system should be established to aid in scheduling maintenance activities. An example of such a coding system is as follows.

Critical (C). SSCs that should operate more than 90 percent of the time. Being out of service for more than 1 working day could result in imminent and significant worker and public health effects or environmental damage; a breach of security; or interruption of facility production or experiment.

Urgent (U). SSCs or experiments that should operate more than 80 percent of the time. They are important to facility goals, and being out of service may result in a significant interruption of facility production or experiments. Importance is great enough to justify diverting personnel from other assignments and to work overtime, based on real-time circumstances.

Priority (P). SSCs or experiments that should operate more than 70 percent of the time. They are important to facility goals but have backup or redundant hardware.

Routine (R). SSCs or experiments not meeting the criteria for any of the other categories and that may be worked in the most economical manner.

4.6.3.8.3 Schedule Requirements [1, 28, 54]

The schedule should be a management tool (particularly for first-line supervisors) to control and direct maintenance activities. It should be used by management to determine the critical path and explore alternatives when needed. The schedule should be a concise method for tracking completion of maintenance tasks, particularly critical path activities. The following are some of the attributes that should be included in the schedule.

The schedule should be an accurate, living document. The individuals expected to follow the schedule need to understand that it should make their tasks and the tasks of others easier. They also should understand the importance of their tasks in relation to the schedule as a whole.

The schedule report format should be appropriate for the user. The level of detail in the schedule needed by the facility manager should be different from the level of detail needed by a craft supervisor, but both needs should be accommodated.

The schedule should be proactive, predicting and leading activities, rather than reactive, merely recording what has transpired. It should be more than just an historical document.

The schedule should be credible. It should be based on the best information available and reviewed and accepted by those actually responsible for doing the work. The schedule should be up-to-date and reflect changing situations to maintain credibility. An out-of-date schedule often may have more adverse effects than having no schedule at all.

The schedule should be flexible, within the overall goals of the facility, to deal with unanticipated events and produce optimum results.

There should be one overall schedule. The overall schedule should be developed such that a hierarchy of schedules of varying detail may be obtained from a common database. (Note: It has generally proven difficult to keep two or more schedules consistent, even when significantly different in level of detail shown.)

4.6.3.8.4 Schedule Methods [5, 6, 7, 8, 21]

To be responsive to the needs of management, a computerized scheduling system should be used. Computerized scheduling offers the following advantages:

- rapid update capability,
- ease in exploring alternatives,
- resource determination and leveling capability,
- identification of work-site congestion, and
- reports tailored to users.

The success of a computerized planning and scheduling program is very dependent on the knowledge and experience of planning personnel and on the management support, training, and emphasis placed on its use. All supervisory personnel should have a basic understanding of the schedule program appropriate to their needs and uses. Frequent training sessions should be used to enhance understanding of the schedule and explain reporting, updating, and adherence policies.

4.6.3.8.5 Schedule Detail

The detail included in the overall schedule should be that required to ensure coordination of work and permit assessment of progress. It is particularly important to include details of tasks that have interfaces among the various crafts and support personnel. The following are some examples of the detail required.

- The operations manager should be able to anticipate tagout needs.

- Radiological protection personnel should be able to determine the need for and schedule in advance RWPs, technician support, and major radiological protection actions, such as installation of temporary shielding.

- QC personnel and other inspection groups should be able to anticipate the need for their presence at the job site.

- Critical resource needs, such as overhead cranes and scaffolding, should be described in sufficient detail to avoid interference, conflicts, and work delays.

For minor jobs, some facilities have been successful in identifying support requirements, such as tagging and RWP requirements, within the coding structure for activities in the schedule. When this is done, it is very important that sufficient training and familiarization be given to enable personnel to interpret the coding easily. It has generally been found necessary to explicitly schedule the support needed for major tasks rather than use only activity coding. A sufficient number of activities should be scheduled to ensure the short-term visibility needed for work coordination and progress tracking. Milestones should be defined for the completion of logical collections of tasks. Use of these intermediate milestones may provide an overall measure of the progress of maintenance activities and identify tasks significantly behind schedule.

Associating detailed work lists to a single activity in the schedule, rather than explicitly scheduling start dates for each job, has proven useful. This provides visibility of details but permits the individual tasks to be managed by the responsible departments and/or first-line supervisors. This is only successful, however, when tasks don't have to be completed in a particular sequence, the support and interface requirements are minor, and a strong daily schedule and good communications exist. Note that the completion of the individual jobs should be closely monitored and progress tracked or there is a risk that delays in completion of one or more of the jobs may result in major schedule delays.

4.6.3.8.6 Daily Schedules

Daily schedules are important to ensure that work is properly coordinated even when there may be last-minute schedule changes. A daily schedule is generally used as the basis for discussions at daily meetings. The daily schedule may be generated by the computerized scheduling program itself or developed separately from information contained in the scheduling program database.

A 3-day outlook schedule, updated and issued daily, has proven useful at many facilities. This schedule provides the detail necessary to control the present day's work and provides an opportunity for craft planning for the next few days without an unreasonable amount of data. Extending the outlook period further than about 5 days and/or not issuing the schedule on a daily basis increases the risk that data may not be current when needed.

A detailed review of the daily schedule should be an integral part of shift turnover activities to ensure that the oncoming shift is familiar with any short-term adjustments made to the schedule. This is particularly important for operator turnovers to ensure that operators know the status of the facility and are familiar with upcoming maintenance activities including tagging needs.

4.6.3.8.7 Schedule Preparation

The following items should be considered during the schedule preparation process.

- The schedule should be success oriented (i.e., contingency plans should not be included). If a contingency plan needs to be implemented, the schedule then should be revised to fit the particular situation.

- The schedule should be challenging but achievable. It should be consistent with the goals set by management.
- Work items should be coded to identify their discrete locations in the facility and reviewed together to assess the degree of area congestion and to minimize duplication of support work such as scaffolding and insulation removal.
- The schedule should be craft loaded and the sequence and timing of activities adjusted to ensure that resource requirements are consistent with resource availability.
- Tests, inspections, or other tasks that may identify additional work should be scheduled as early as possible to permit time for completion of the additional work within the established time frame.
- Significant as-found, postmaintenance, and postmodification testing should be explicitly scheduled. Time should be allotted for testing, line up, and other activities required for returning systems to service. System interactions and operator resources should be considered when scheduling system and facility start-up.

4.6.3.8.8 Schedule Integration

Integration of major tasks is a key to successful schedule development. There should be one overarching schedule that includes work to be done by both nonfacility contractors contributing support to the schedule and site personnel. The planning organization should involve nonfacility contractors as early as possible in the planning process to ensure their work is integrated and scheduled properly.

Details for specific tasks should be provided by those responsible for the tasks. The planning organization should integrate these details into the overall schedule.

Work force and support requirements should be included for maintenance activities. Work that should be integrated includes PM, corrective maintenance, modifications, surveillance testing, and ISIs.

4.6.3.8.9 Schedule Review

Schedule users, including nonfacility contractors, should be required to review and comment on the schedule. Several reviews during the preparation process frequently avoid last-minute problems during the final review. Comments should be resolved before the next revision of the schedule. Support of this activity by line managers is a key to the success of the schedule.

The rationale behind specific schedule decisions should be documented and explained to those who are responsible for implementing the schedule. The explanation also should include restraints on the activity, including the restraints the activity places on others.

Opportunities for schedule improvements should be explored during the review process. This should include review of TSR and other regulatory requirements to determine whether changes that may result in work efficiency or schedule improvements are possible without sacrificing safety.

The overall intent of the schedule review process, coupled with obtaining user input to the planning process, should be to provide a sense of ownership of the schedule to those who are expected to implement it.

4.6.3.8.10 Format, Progress Reporting, Updating, and Distributing

The schedule should be viewed as a tool by everyone involved in maintenance activities. The schedule information provided to users should be concise and understandable.
Detailed information should be limited to the needs of the recipient. For example, a machinist overhauling a valve may need only start and finish times. The supervisor, however, should know the work scheduled several days in advance so availability of needed tools, materials, and required support may be ensured. The discipline manager should require advance schedule information for all associated work so assignments may be planned.

Progress information should be summarized for management personnel, emphasizing problem areas and potential problem areas. Progress associated with the critical path or near-critical path should receive particular attention.

The fundamental principles of a progress reporting system should be simplicity, accuracy, and timeliness. The individuals responsible for the work also should be responsible for progress reporting. To be most effective, the reporting system should be structured to be useful to those reporting and doing the work. The information requested should be limited to the minimum required.

The individuals responsible for progress reporting should be selected, by name, in advance of the start of the maintenance activities. Training should be held for those selected to ensure they understand the reporting system, the information needed, and how the information may be used. The need to report problems should be emphasized. Reporting will be more accurate and timely if the need for the data is fully understood. Vendors and contractors should be included in the progress reporting system.

Progress may be reported in a number of ways, some of which depend on the particular scheduling system used. For some systems, reporting start date, time, and remaining duration has been effective. Another effective method is marking up daily schedules used by the work groups and returning them to the scheduling organization for input to the tracking system. Reporting progress relative to intermediate milestones has also been found to be useful.

As discussed above in Section 4.6.3.8.3, the schedule should be current. The schedule should be updated regularly, based on the progress reports. The interval of updating should depend on the rate of change. For major changes and changes affecting the critical path or near-critical path, daily updates may be necessary. The key is that the schedule is maintained credible and provides the guidance needed to those responsible for performing the work.

4.6.3.9 Coordinating Maintenance Activities [1, 11, 28]

The planning group or maintenance supervisors should maintain the status of all open WRs and PM items that are overdue or coming due and should recommend assignments from this list based on job priority. Meetings involving scheduling of routine jobs need to be held frequently to ensure proper communication concerning priorities, current problems, job interferences, and requests for support among facility organizations. These meetings should be chaired by a designated individual from the operations department. Supervisors or responsible spokespersons from all maintenance disciplines, safety, environmental protection, QC, radiological protection, technical support, and the warehouse should attend these meetings. Other personnel should be invited as needed.

Facility personnel should be apprised of scheduled maintenance activities that affect them to ensure proper activity coordination. This may be accomplished by publishing and updating a short-duration rolling schedule covering about 3 days. A schedule of this nature would identify scheduled activities for the next 1 to 2 days and planned activities for the remaining day. This schedule should be updated either daily or every other day after the routine planning meeting.

The responsible maintenance supervisor should be provided with work packages soon enough for adequate shop-level preparation and prejob instructions before starting the job. Each supervisor should have sufficient fill-in work assigned to maintain crew productivity. When feasible, this fill-in work should be independent of facility condition requirements and should be easily coordinated and initiated. If this is not the case, it should be identified on the rolling schedule so that all cognizant groups are aware of the jobs that may be initiated by maintenance supervisors.

The schedule should allow for unexpected or emergency work requirements. WRs that could be postponed or stopped should be identified or a similar method used to allow the work force to accomplish emergency work. Appropriate managers should approve such postponements and work stoppages.

After jobs have been scheduled and assigned on the rolling schedule, the responsibility for support coordination should be assumed by the lead group—the group responsible for the most significant portion of the job. The lead group should then be responsible for coordinating such activities as verifying that lockouts/tagouts are available as required, that QC inspectors are available as required, and that parts are available at the job site.

Facility maintenance activities may be complex projects involving large numbers of personnel. Resources to support the activities should be coordinated in a timely, controlled manner to ensure that they are ready to support the integrated maintenance schedule. The types of resources to be considered include personnel, material, expendable supplies, special tools, and services.

The quality of maintenance activities performed directly impacts a facility's reliability. Thus, management of the work force to achieve quality workmanship while maximizing productivity requires close control by maintenance managers and supervisors. Daily meetings with affected individuals, should be conducted to focus on the progress of key jobs and to provide short-range coordination of scheduled activities. Meetings should be managed to efficiently use the time of the managers and supervisors, to minimize redirection of work in progress, and to prevent delays to oncoming work shifts. Care should be taken to ensure that meetings focus on problems and their solutions and do not become a forum for exchange of status only.

Material availability is an important element to a successful maintenance program. Many items, particularly material needed for modifications and repair parts for older equipment, may be long-lead-time items. They should be identified and ordered well in advance and tracked to delivery to ensure that they will be available at the job site when needed.

Performance measures of the rate of activity completion, schedule adherence, productivity, and progress toward meeting facility maintenance goals, should be developed (see Section 4.14, "Management Involvement"). These measures should be periodically checked for validity and should be used by maintenance management to monitor performance.

This Guide addresses the elements considered essential for maintenance managers and direct-line supervisors to assign responsibilities and outline methods that may be used in the overall planning, scheduling, and coordination functions to accomplish the following:

- identifying and screening facility deficiencies;
- controlling minor maintenance work activities within the facility work control system;
- determining the level of detail necessary to accomplish maintenance tasks and troubleshooting;
- using maintenance history in planning preventive/corrective maintenance and repetitive job tasks (see Section 4.15, "Maintenance History");
- identifying support needed to perform maintenance; and
- preparing and assembling a maintenance work package.

Extensive involvement of managers and supervisors in maintenance activities ensures timely completion of work, quality of completed work, and safety of personnel and equipment. This level of involvement should facilitate timely corrective actions for performance deficiencies noted.

Supervisors should routinely monitor maintenance work in progress to ensure timely availability of support services and coordination with other activities and to ensure that activities are performed in accordance with facility policies and procedures. Particular emphasis should be given to the following areas in training supervisors:

- monitoring on-going work to control quality and progress;
- providing accurate and timely status reports;
- coordinating support and interface work activities;
- ensuring the timely availability of tools, supplies, and parts; and
- understanding schedule interpretation and use.

Supervisory controls (such as independent verification) should be applied to verification of tagouts before opening piping, valves, or mechanical equipment or working on electrical equipment. Additionally, specific precautions should be taken to exclude foreign material intrusion into open systems.

4.6.3.9.1 Prejob Coordination

Coordination of maintenance activities may involve detailed integration and timely implementation of many interrelated activities. Planners should be responsible for identifying and planning these interrelated activities, but the actions of managers and supervisors will determine how successfully the scheduled work is completed.

Specific coordination and integration activities that should be considered by the line supervisors in preparing for work include the following:

- effective integration of facility system operation and maintenance activities to ensure proper facility conditions, timely equipment or system tagouts, initiation and completion of maintenance or modifications, and timely performance of inspections;

- ALARA actions, including shielding installation and prejob briefings on ALARA precautions;

- support of maintenance activities by health physics and decontamination personnel, including support during the performance of tasks, identifying and posting work areas, and timely decontamination of tools, floors, and equipment;

- allocation of space and crane use;
- inspection of maintenance activities by QC personnel, including completion of associated documents; and
- continuous document processing, issuing, and closeout throughout the job.

The effectiveness of prejob coordination should be routinely assessed by managers and supervisors and corrective actions taken when required to improve work efficiency.

4.6.3.9.2 Material Staging and Availability

A clear definition of the responsibility for ensuring that adequate parts and material are on site and available for the performance of scheduled work activities is necessary to avoid problems during the performance of maintenance. Facility responsibilities regarding procurement of material required for maintenance and modifications should be included in the definition. Having one organization responsible for coordinating material needs and a single point of contact for expediting material has proven successful at other facilities and should be considered (see Section 4.10).

Parts and material required for maintenance activities should be identified and purchased in time to allow for receipt and inspection well before they are needed. After processing, these parts and material should be identified for specific work packages and segregated from other stock inventory. Standard stock items and consumables required for planned work should be allocated to ensure their availability (see Section 4.10).

Adequate storage and protection of parts and materials segregated for planned maintenance activities should be provided. This is particularly important for material staged at the job site and not within normal storage areas.

Periodic reports highlighting any material or parts problems should be distributed to appropriate management personnel. Problems with material availability should be identified early to permit contingency planning.

4.6.3.9.3 Daily Meetings

Well managed planning and scheduling meetings are necessary to keep facility personnel aware of significant maintenance activities that are in progress and to make corrections to schedules. Meetings should be effectively managed to limit the time personnel spend in the meetings. Participation in meetings should be limited to those personnel affected. Three types of meetings, discussed below, have been shown to be effective in improving communications among work groups and in enhancing job coordination.

A daily directional meeting may be held after the start of the primary work shift. This meeting should be attended by management personnel and representatives from all major work groups. The meeting should focus on major jobs and evolutions planned for the next 48 hours and identify any redirection necessary due to significant problems such as lack of materials, shortage of other support resources, delays in key support activities, or other problem areas. Care should be taken to not unnecessarily disturb work in progress. At many facilities, the planning organization prepares discussion material for this meeting including considerations for alternative paths. Results of the directional meeting affecting activities should be factored into the schedule at the daily planning meeting.

A planning meeting should be held each day following the directional meeting to review the near-term (next 3 to 5 days) schedule and verify that jobs may be worked as scheduled. Planners and representatives of the operations manager, radiological protection, and other support departments should attend. The participants at this meeting should ensure that the information contained in the next updated schedule is consistent with current plans and resource availability. The schedule then should be updated by incorporating information from the directional meeting and the planning meeting. Reprioritizing or rescheduling some work may be necessary for some support groups.

A shift work coordination meeting should be held shortly before the start of each shift. This meeting should be attended by oncoming shift supervision for each of the groups supporting the maintenance schedule, including maintenance, health physics, technical staff engineering, area coordinators, and task coordinators, for jobs requiring significant support. The operations supervisor for the oncoming shift should also attend. The shift work coordination meeting should address all scheduled work for the upcoming shift by exception and should modify the schedule as necessary to reflect last-minute changes. Reissue of the daily schedule to reflect these changes should not be necessary. Items requiring multidiscipline support should be identified to the respective support groups and an estimate of the quantity of resources and the time required should be provided. Each attendee should leave the meeting with a clear understanding of what their work group should do on the upcoming shift. The meeting should end in time for supervisors to return to their work groups before the shift starts.

Assignments for problem resolution should be made at meetings, but resolution should not be attempted during the meeting. The meetings should not be used as the primary method to determine the status of maintenance activities.

4.6.3.10 Planning, Scheduling, and Coordinating Outages [31, 40, 52, 117]

Responsibility should be assigned for the overall control of long-term (typically, 3 or more days) planned and unplanned outages and for adherence to the outage schedule. Revisions to the schedule should be made as required to ensure that the schedule reflects achievable goals and real-time progress. Activities on the critical path and near-critical paths should be monitored at least once per shift during the outage. The outage management system should be structured so that individuals responsible for areas of outage work present status reports directly to outage management staff as well as to their line managers.

A summary of outage status should be prepared at least once a week and should include the following types of information:

- time ahead of or behind schedule;
- completion status (expressed as a percentage) for long-duration activities (i.e., those that exceed 1 week);
- completion estimates for all critical-path and near-critical-path activities in progress;
- problems that are delaying or are expected to delay completion of scheduled major activities, with the intended course of action and individual(s) responsible for resolving each problem; and
- industrial safety issues that have arisen as a result of the nature of the outage.

Schedules of past outages (planned and unplanned) should be retained for reference in planning for future outages. They can be especially useful in preparing unplanned outage schedules.

4.6.3.10.1 Planned Outages

Preparations and scheduling for future long-term planned outage activities should begin no later than immediately after a unit's completion of the current outage. Preparation for and scheduling of major maintenance activities and modifications may have to begin several years in advance, depending on the complexity of the effort. A designated outage manager or coordinator should be assigned to direct preparations for and management of the outage.

Shortly after a major planned outage is completed, a critique of it should be held to ensure that lessons learned during that outage are factored into the preparations for the next one. Outage jobs held over should be assessed and factored into the following outage or deleted with appropriate justification.

Engineering work should be completed as early as possible. Adequate time should be allowed for review of work packages, resolution of comments, budgeting, contracting, procurement, and other long-lead-time planning functions.

A current list of proposed outage activities should be maintained. It should include all demands for resources (such as nonnuclear facility contractor and subcontractor resources) and activities (such as corrective maintenance, PM, surveillance, in-service tests and inspections, and modifications). Outage planning meetings should be held periodically to refine and update this list.

An initial milestone list that identifies cutoff dates for major activities required to support outage planning should be prepared. This list should include items such as the following:

- identification of major jobs;
- letting of bids for contracts and materials;
- identification of corrective maintenance, PM, surveillance, and in-service test requirements;
- identification of major modifications and dates for design work, work package preparation, and procurement of materials, parts, and services;
- identification of preoutage work that can and should be performed to reduce the demand for resources during the outage (such as pipe prefabrication, cable pulling, conduit runs, raceway installation, fabrication of supports, and scaffold erection);
- identification of facilities required for outage support and milestones for their construction;
- identification of temporary services that may be provided to craft personnel when lockout/tagout of equipment related to the maintenance activity disrupts normal services (e.g., electricity, lighting, air, and water);
- staging of special tools and equipment and preparation of work areas; and
- development of schedules.

An overall outage schedule should be developed as soon as all major outage activities are identified. Periodic revisions to this schedule should be issued throughout the outage planning process. The schedule should be approved and issued at least 90 days before the scheduled outage start date. Issuance should represent a cutoff date for addition of new outage work. This should include all modification work and all major maintenance to be accomplished. The schedule should identify and allocate such critical resources as labor, shop facilities, cranes, equipment accessibility, personnel radiation dosage, and availability and scheduling of outside subcontractors and nonfacility contractor groups.

Based on the overall schedule, a detailed outage schedule should be issued at least 30 days before the scheduled outage start date. This schedule should be a commitment by all affected groups. Addition of unanticipated work to the outage schedule should require a formal review and approval process. Depending on the severity of impact on outage resources or critical-path time, successively higher management levels should approve the changes. Schedule-change constraints are mandatory for the successful and timely management of an outage.

4.6.3.10.2 Unplanned Outages or Other Limitations to Facility Operations

Management of unplanned outages and other facility operating limitations is necessary to minimize the duration of these conditions and to use available time effectively. Facility management or the maintenance supervisors should maintain a prioritized list of corrective maintenance, modifications, surveillance, PM, special items, or commitments that must be performed under a system or facility outage or power reduction. Resource requirements, industrial safety considerations, and task completion time for each of the identified jobs should be estimated to aid in planning, scheduling, and coordination. To the extent possible, an up-to-date list of prioritized outage tasks and assembled work packages, including procedures, repair parts and materials, lockout/tagout requests, special tools, and personnel entry forms (such as RWPs or confined-space entry permits) should be prepared.

Potential short outage or facility capacity reduction work should be grouped by the required facility condition and approximate duration. Schedules of various lengths should be prepared. Activities should also be grouped to accomplish as much work as possible on one lockout/tagout. Other maintenance activities, such as surveillance or PM, should be reviewed to determine whether they should be performed while equipment or systems are out of service. A computerized maintenance request system can provide significant assistance in accomplishing the above tasks.

An unplanned outage work list should be prepared, and outage activities should be coordinated. Facility management should conduct planning meetings periodically to update the list (typically, once every 2 weeks). Copies of the proposed outage list, reflecting current planning, should be sent to all affected facility organizations after each planning meeting.

If an unplanned outage, power reduction, or other major limitation occurs, appropriate facility managers should initiate selected work from the outage list based on the estimated duration of the outage and resources available. For unplanned outages of longer duration (commonly, more than 3 days), preparations should be started for additional outage work while managerial decisions are being made to determine the actual length of the outage. In this case, each organization should review its current unplanned outage list and identify any additional significant work to be conducted during the outage. If an unplanned outage can be delayed, the outage manager should schedule and coordinate work for the expected duration of the outage.

Once the duration of the outage has been determined, facility management should conduct coordination meetings to determine the critical path and major milestones and to accept or reject any new or significant work to be accomplished. Support requirements should be verified and coordinated among cognizant departments. During the outage, a status should be obtained during each shift to measure progress and to make any required adjustments, such as coordinating special support needs. After completion of each outage, facility management should conduct a critique to determine how outage improvements could be made and designate personnel to implement these improvements.

4.6.3.11 Planning, Scheduling, and Coordinating Maintenance Performance Monitoring [1, 22, 23, 100]

Facility management should develop performance measures to monitor the progress toward meeting facility maintenance goals.[74] Progress toward meeting these goals should be evaluated frequently and reported to facility management. The following are typical performance measures:

- rate of activity completion;
- percent compliance to the daily schedule;
- progress against the schedule;
- amount and rate of bulk work (nonscheduled or listed work) completed;
- expended worker hours by craft or work group versus planned worker hours;
- number of accidental occurrences;
- expended man-rem versus planned man-rem;
- amount of radwaste generated; and
- number of skin and clothing contaminations.

The performance measures should be monitored frequently to ensure they are valid measures of facility maintenance status. Examples of areas that may be checked to ensure that the progress reported actually reflects real status include the following.

- The rate of activity completion is checked against the projected activity completion, the number of activities remaining, and the time remaining on the schedule to ensure that the current rate supports the scheduled completion date.

- Compliance to the daily schedule is maintained at a high level to ensure that scheduled work is being completed to support the overall facility maintenance goals.

- Progress against the overall schedule is tracked to identify areas where work completion does not support the schedule.

- Bulk work completions should be tracked against remaining resources and time to ensure that bulk work is being completed at a rate that supports the schedule.

- Actual expended worker hours are tracked against the earned value (original estimates) of completed jobs, planned worker hours, remaining scheduled work, and remaining time to ensure that sufficient resources and time exist to complete the maintenance activities as scheduled.

- Other performance measures, such as accidental occurrences, skin and clothing contaminations, and overall exposure, should be tracked to identify areas of concern where actual values are exceeding projections.

Deviations in the expected results identified in reviews of the performance measures, such as those listed previously, should be analyzed to identify their root causes and should be reported to facility management for appropriate corrective action.[23, 80]

Table 4.6-A. Examples of Minor Maintenance

Examples of Mechanical Minor Maintenance

A. The following are examples of work that may qualify as minor maintenance.

1. Manual Valve: Adjust packing on manual valves not subject to testing, repair or replace handwheel, lubricate valve stem.
2. Pumps: Adjust packing; adjust cooling water flow.
3. Flanges: Tighten to stop leakage (not to exceed recommended torque values).
4. Diaphragms: Seal against in-leakage.
5. Brackets/Hangers: Replace missing bolts (except safety-related/seismically qualified or material substitution).
6. Doors: Repair or replace knobs, hinges, bars, or closures.
7. Plumbing: Repair or replace commodes, water fountains, sinks.
8. Structures: Patch walls, roofs, etc. (except fire barrier seals).
9. Grating/Stair: Treads: Repair or replace grating, clips, or treads.

B. The following are examples of work that does not qualify as minor maintenance.

1. Manual Valves: Adjust packing on valves that require testing.
2. Motor-operated Valves: Adjust or replace packing.
3. Pumps: Replace packing or seals, replace casing bolts, replace gasket.
4. Flanges: Replace gasket or fasteners; install or remove blank flange.

Examples of Electrical Minor Maintenance

A. The following are examples of work that may qualify as minor maintenance.

1. Lamps or Bulbs: Replace.
2. Fuses: Replace where fuse is not required to be safety-related.
3. Junction Boxes (nonenvironmentally qualified): Replace covers or screws.
4. Conduit: Replace covers, screws, brackets.
5. Motors: Replace air filters, replace cover screws, replace screens.
6. Facility Paging System: Repair or replace handles, knobs, etc.
7. Portable Sump Pumps: Repair or replace motor or wiring.
8. Door Locks or Latches: Repair or replace (except fire and security doors).
9. Telephone Equipment: Install, replace, or repair.

B. The following are examples of work that does not qualify as minor maintenance.

1. Light Fixture: Repair or replace where tagout is required.
2. Fuses: Replace where fuse is safety-related.
3. Fire Alarm Panel: Repair.
4. Protection Relay Test Switches: Repair or replace.

Table 4.6-A. Examples of Minor Maintenance (continued)

Examples of Instrument Minor Maintenance
A. The following are examples of work that may qualify as minor maintenance. 1. Lamps or Bulbs: Replace. 2. Fuses: Replace where they do not perform a safety function. 3. Pressure Gauges: Replace gauge or glass. 4. Instrument tubing: Tighten. 5. Air Filters: Replace. 6. Knobs: Tighten, repair, or replace. B. The following are examples of work that does not qualify as minor maintenance. 1. Electro-pneumatic Equipment and Positioners: Clean or adjust. 2. Pneumatic Controllers: Clean, adjust, or calibrate. 3. Fuses: Replace when the fuse performs a safety function. 4. Transmitters: Vent or fill.

WORK REQUEST/WORK ORDER				UNCLASSIFIED PAGE 1 OF 2
Date Written:	Priority Code:	Work Order #	Account #	Job Number:

Badge:	Requester:	Phone:	Building:	Authorized By/Badge:

Deliver to:	Badge:	Name:	Building:	Room:	Phone:

Category Codes __ Corrective Maintenance __ Other
__ Preventive Maintenance __ Predictive Maintenance

Required Work Permits: __ None __ Safety __ Radiation
__ Electrical __ Other (Specify) __ ______

Required Completion Date:	Equip ID/Code /	Work Location:	Special QA Action: __ (Specify)

WORK REQUEST/WORK ORDER				UNCLASSIFIED PAGE 2 of 2
Date Written:	Priority Code:	Work Order #:	Account#:	Job Number:

Description of Work Requested
(Include specific location, drawing #, required tests, sketches, and inspections.)

WR/WO TEST DESCRIPTION:

PLEASE BE AS SPECIFIC AS POSSIBLE

Figure 4.6-A. Work Request/Work Order Form.

____ PROPERTY NUMBER	**WALKDOWN CHECKLIST**	**WR/WO NO.** ____

NAMEPLATE DATA INFORMATION

MANUFACTURER ____ HORSEPOWER ____ RPM ____

TYPE ____ SIZE ____ VOLTAGE ____ AMPS ____

FIGURE ____ MODEL ____ FRAME ____ TYPE ____

PRESSURE ____ TEMP ____ SERVICE FACTOR ____

DRAWING ____ ITEM ____ SERIAL NO. ____

ADDITIONAL NAMEPLATE INFORMATION ____

OUTAGE REQUIRED	☐ YES	☐ NO	**ADDITIONAL SUPPORT PERSONNEL REQUIRED:**
SCAFFOLDING	☐ YES	☐ NO	
INSULATION REMOVAL	☐ YES	☐ NO	____
BOLTING MATERIAL DEGRADED	☐ YES	☐ NO	____
MACHINING	☐ YES	☐ NO	____
WELDING/CUTTING	☐ YES	☐ NO	____
CRANE SERVICES	☐ YES	☐ NO	____
RIGGING	☐ YES	☐ NO	____

RIGGING REQUIRED ____ ____

____ ____

INSTALLATION TYPE: ☐ N / A

☐ FLANGED ☐ WELDED ☐ BRAZED ☐ SCREWED ☐ BOLTED ☐ ____ OTHER

EQUIPMENT TYPE:

☐ PUMP ☐ VALVE ☐ MOTOR ☐ FILTER ☐ DOOR ☐ ____ OTHER

FASTENER SIZE: ☐ N/A **APPLICATION:**

BOLT: ____ ____

STUD: ____ ____

NUT: ____ ____

OPERATIONS REQUIREMENTS

LOCK-OUT TAG-OUT REQUIREMENTS ☐ NONE REQUIRED

☐ MECHANICAL ☐ ELECTRICAL ☐ HIGH VOLTAGE

POWER SUPPLY: ____

OTHER COMPONENTS / EQUIPMENT AFFECTED BY HOLD-OFF:
____

OPERATIONS COMMENTS: ____

SPECIAL CONDITIONS / TIME RESTRICTIONS: ____

WALKDOWN PERFORMED BY: ____ **BADGE NO.** ____ **DATE** ____

Figure 4.6-B. Walkdown Checklist.

Table 4.6-B. Example Troubleshooting Guide

For work that requires troubleshooting for unknown conditions on energized, pressurized, or operating equipment, perform the following.

1. Before developing the troubleshooting methodology, review/consult with the following sources of information as necessary to understand the equipment/systems interactions.

   a. System engineers
   b. Owner/operator personnel (organization responsible for the equipment)
   c. Training
   d. Technical Safety Requirements
   e. Final safety analysis report
   f. Equipment vendor manuals
   g. Equipment manufacturers
   h. Applicable procedures
   i. Applicable system/circuit drawings
   j. Vendor drawings

2. Include the following, as applicable, in the work instructions to the craftsperson.

   a. Notes, precautions, and prerequisites for the specific task (e.g., “System contains live steam; do not vent”; “Do not exceed three motor starts in any one-hour period”; “Do not remove input/output signal cable before de-energizing power supply”).

   b. Steps to record and observe as-found/as-left conditions of the affected equipment.

   c. Steps to record any abnormalities observed during equipment operation (e.g., bearing noise, smoke, vibration)

   d. Steps to prevent further damage if any abnormal conditions are observed.

   e. Specific instructions for craftspersons/technicians to stop work when problems or conditions encountered were not anticipated or are not understood. They should be directed to consult with their supervisors or planners before taking action.

   f. Steps to record and verify lifted/landed leads. Lifted lead forms should be included in the work package as required.

   g. Steps to record the identification numbers and calibration due dates of measuring and test equipment used (see Section 4.11 “Control and Calibration of Measuring and Test Equipment (M&TE) at DOE Nuclear Facilities.”)

   h. Steps to tag and retain all parts removed during the troubleshooting process. These parts will be retained as appropriate for further investigation/analysis by maintenance or systems engineer.

Table 4.6-B. Example Troubleshooting Guide (continued)

3. For troubleshooting equipment important to safe and reliable facility operation, a troubleshooting impact statement should be included as part of the planning package. Include the following information on the statement: a. scope of the troubleshooting, b. required equipment status, c. work boundaries for the activity, d. potential facility upsets that may occur, and e. approval of owner/operator supervision before beginning troubleshooting activities.
4. Any follow-up corrective maintenance deemed necessary as a result of troubleshooting should be performed under a separate corrective maintenance work order or under an approved revision to the work plan.

PAGE 1 OF 2	JOB PLANNING CHECK SHEET	WR/WO NO. ____________

***** EQUIPMENT CATEGORIES *****

CATEGORY I	☐	**HIGH-RISK STRUCTURES, SYSTEMS, AND COMPONENTS (SSC)** **(Section A, B, and C SHALL be completed)**
CATEGORY II	☐	**MEDIUM-RISK STRUCTURES, SYSTEMS, AND COMPONENTS (SSC)** **(Section A and B SHALL be completed. Section C as required)**
CATEGORY III	☐	**HIGH-RISK STRUCTURES, SYSTEMS, AND COMPONENTS (SSC)** **(Section A SHALL be completed. Section B and C as required))**

******* SECTION A *******

NOTE: WHENEVER BLOCK IS CHECKED, PLANNER SHALL ADD EVALUATION DATE.

HEALTH AND SAFETY	**YES**	**NO**	**DATE /**	**COMMENTS (AS REQUIRED)**
JOB HAZARD ANALYSIS	☐	☐	____/	____________
CONFINED SPACE	☐	☐	____/	____________
LOCK OUT/TAG OUT	☐	☐	____/	____________
HIGH VOLTAGE HOLD-OFF	☐	☐	____/	____________
CONTAMINATION CONTROL *(ALARA)*	☐	☐	____/	____________
PERMITS				____________
OSWP	☐	☐	____/	____________
EXCAVATION	☐	☐	____/	____________
PENETRATION	☐	☐	____/	____________
ASBESTOS/CERAMIC FIBER	☐	☐	____/	____________
WASTE DISPOSAL	☐	☐	____/	____________
POTABLE WATER	☐	☐	____/	____________
STORM/SANITARY SEWER CONNECTION	☐	☐	____/	____________
OTHER ____________	☐	☐	____/	____________

NOTE: CHECK THIS BOX ONLY IF NO PERMITS OF ANY TYPE ARE REQUIRED

NO PERMITS REQUIRED ☐

JOB PACKAGE INCLUDES

WR/WO ■ **<u>WR/WO INCLUDED WITH ALL JOBS</u>**

OTHER REQUIREMENTS	**YES**	**NO**	**DATE /**	**COMMENTS (AS REQUIRED)**
NEPA ASSESSMENT REQUIRED	☐	☐	____/	____________
DAVIS-BACON ASSESSMENT REQUIRED	☐	☐	____/	____________

******* JOB PACKAGE APPROVAL *******

ESTIMATED CREW SIZE ____________ ESTIMATED NUMBER OF MANHOURS ____________

JOB PACKAGE INCLUDES NECESSARY INFORMATION, AND MATERIAL LOCATIONS

PLANNER ESTIMATOR ____________ BADGE NO. ____________ DATE ____________

FMO SUPERVISOR ____________ BADGE NO. ____________ DATE ____________

Figure 4.6-C. Example Job Planning Check Sheet.

PAGE 2 OF 2	JOB PLANNING CHECK SHEET	WR/WO NO. __________

******* SECTION B *******
WORK START APPROVAL

CUSTOMER ______________________________ BADGE NO. ______________________________

COMMENTS

NOTE: WHENEVER BLOCK IS CHECKED, PLANNER SHALL ADD EVALUATION DATE.

SPECIAL REQUIREMENTS	YES	NO	DATE /	COMMENTS (AS REQUIRED)
Cross WR/WOs Issued to Support SSCs	☐	☐	______/	
Special Tools/Materials	☐	☐	______/	
Certification Requirements (Specify)	☐	☐	______/	
Previous Repair History Required	☐	☐	______/	
POST-MAINTENANCE TESTING				
Documented Formal	☐	☐	______/	
Checkout/verification	☐	☐	______/	
JOB-SITE INSPECTION				
Security Department	☐	☐	______/	
Fire Department	☐	☐	______/	
Health Physics	☐	☐	______/	
Industrial Hygiene	☐	☐	______/	
Criticality Safety	☐	☐	______/	
Planner Estimator	☐	☐	______/	
Other ______________________	☐	☐	______/	
JOB PACKAGE INCLUDES				
WR/WO Cont. Sheet with Work Instructions (Required for Category I & II)	☐	☐	______/	
Repair History Form (Required for Category I & II)	☐	☐	______/	
Bill of Materials	☐	☐	______/	
Procedures (Required for Category 1)	☐	☐	______/	
CFC Drawings (Required for Category 1 Mods)	☐	☐	______/	
Technical Manuals	☐	☐	______/	
Job Plan (Required for Category 1)	☐	☐	______/	
QA/QC Requirements	☐	☐	______/	
Vendor Data	☐	☐	______/	
Other ______________________	☐	☐	______/	

****** SECTION C ******

JOB-SITE INSPECTION COMPLETE

CUSTOMER (REQUIRED FOR CATEGORY 1)	☐	☐	______/	
FMO SUPERVISOR (REQUIRED FOR CATEGORY 1)	☐	☐	______/	

Figure 4.6-C. Example Job Planning Check Sheet (continued).

4.7 CONTROL OF MAINTENANCE ACTIVITIES (Replaces DOE-STD-1053-93)[1, 4, 11, 12, 27, 28, 29, 36, 54, 83, 84, 101, 102, 103, 104, 105, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117]

4.7.1 Introduction

Management involvement in control of maintenance activities should ensure that maintenance practices are effective in maintaining safe and reliable facility operation. This control should extend to all facility, contractor, and subcontractor personnel involved in maintenance activities. Rigorous control of maintenance activities should be directed toward achieving high-quality work performance, personnel safety (including radiological protection), equipment and system protection, and facility safety and reliability.[11, 54]

The work-control program should be based on administrative procedures that address identification of needed work, planning and preparation for work, establishment of conditions to perform work, conduct of work activities, documentation of completed work, postmaintenance acceptance of work, return-to-service procedures, review of completed work records, control of temporary repairs, and control of nonfacility contractor and subcontractor personnel working in the facility. The program should also make provisions for collecting and storing equipment maintenance data (see Section 4.15).

This section describes the attributes of an effective program for controlling facility maintenance activities.

4.7.2 Discussion

A work-control program is an administrative method by which maintenance activities are identified, initiated, planned, approved, scheduled, coordinated, performed, and reviewed for adequacy and completeness. The program should address the following areas.

- Developing administrative procedures to describe the control of work from identification and planning through completion, review, and storage of historical data. Personnel (including key nonfacility contractor and subcontractor personnel) involved in the conduct and support of maintenance should be trained in using these procedures.

- Identifying the individuals/job titles responsible for performing various types of work (such as packing adjustments, equipment lubrication, and maintenance of health physics portable instrumentation).

- Using WR forms to control maintenance activities. A WR form (and/or work package) should be prepared and used to direct and document maintenance activities. This form should provide for documented review at the appropriate level. WR forms control maintenance activities by ensuring correct equipment energy isolation (e.g., personal locking devices in addition to operational control of lockout/tagout procedures), personnel safety, and the proper conduct of maintenance and PMTs.

- Controlling troubleshooting to prevent unplanned repairs and unauthorized modifications.

- Reviewing requested work to ensure unauthorized modifications are not accomplished by the maintenance request.

- Setting goals for high-quality workmanship, safe work practices, and improved radiological protection and obtaining the support for them from maintenance personnel. A key factor in achieving these goals is work-site guidance and overview provided by maintenance supervisors. Monitoring to identify rework (maintenance that has to be repeated) can be effectively used to identify programmatic or qualification deficiencies.

- Documenting work accomplished and the results of PMTs, including the satisfactory return to service of the equipment or system.

- Reviewing WRs after the completion of maintenance to verify that the activity was satisfactorily completed in accordance with facility procedures and standards and to capture maintenance history data.

- Performing temporary repairs under the facility's temporary modification program to provide engineering review of the adequacy of the temporary repair and a means for identifying required permanent repairs.

- Establishing and maintaining the same policies and procedures for nonfacility contractor and subcontractor personnel conducting maintenance on the site as facility personnel.

The work-control system should provide the data necessary to properly plan and schedule maintenance activities (see Section 4.6). The work-control system also provides a means of collecting facility maintenance data to be used for failure analysis (see Section 4.16) and maintenance history (see Section 4.15). The system used should be comprehensive enough to fulfill these functions, yet simple enough to function efficiently.[28, 93, 100, 112]

The maintenance organization should establish high standards for all maintenance personnel engaged in supervising and performing maintenance activities (see Section 4.14). These standards should ensure that work is conducted in accordance with DOE, contractor, and facility policies and procedures.[28, 82, 105, 107]

Operational control of facility maintenance is facilitated by the proper use of system status and lockout/tagout procedures and by communications between operations, maintenance, and other functional groups at the work site. Lockout/tagout procedures should be operationally controlled to maintain the safety envelope of configuration controlled equipment and systems. Personal lockout/tagout devices should be controlled by the maintenance organization for individual personal safety while working on equipment under operational configuration control.[28, 44, 84, 93, 117]

Configuration control is maintained by ensuring that systems and equipment are restored to their original condition following maintenance.[117]

4.7.3 Guidelines

4.7.3.1 Work-Control Procedure [28, 54, 82, 86, 101, 104, 105, 109, 110]

Each facility or group of facilities should have an administrative procedure describing the work-control system. Administrative requirements may be contained in separate documents covering individual areas or in one overall procedure that describes the administrative control of maintenance activities. The work-control procedure helps all personnel understand the requirements and controls required for performing work. The basic intent of the work-control system is to identify all facility deficiencies and work needed, avoid redundant identification of deficiencies, and guide the safe accomplishment of work and subsequent postmaintenance activities. If the work-control system does not include modifications, in-service tests, surveillance, and PM actions, the systems controlling these activities should interface with the work control system.

The work-control procedures should describe the WR form, including applicable attachments, and should, at a minimum, address the following:

- personnel responsibilities for identifying and tagging deficiencies and initiating WRs that adequately describe the symptoms or problems;
- supervisory responsibility for controlling the safe conduct of maintenance activities and processing WRs;
- descriptions of the process for initiating and processing WRs, including the prejob review, approval cycle, and postjob review;
- descriptions of the priorities used to schedule work;
- determinations of the impact of maintenance activities on facility operations;
- work planning and scheduling (see Section 4.6);
- conduct of routine maintenance planning meetings (see Section 4.6);

- requirements for personnel and equipment safety and radiological protection (e.g., confined-space entry permits, welding and burning permits, lockouts/tagouts, RWPs, and personal safety equipment);
- postmaintenance testing (see Section 4.8); and
- collecting data for maintenance history files (see Section 4.15).

The work-control procedure may cross-reference or include outage scheduling and control procedures (see Sections 4.5 and 4.6.3.10).

4.7.3.2 Work Request/Work Order

Maintenance performed on nuclear facility systems should be controlled by the facility WR or by another approved work-control document. The document should clearly define the work to be performed and should include the following items:

- equipment identification;
- name of the person initiating the WR;
- date WR was initiated;
- description of the symptom, problem, or work requested;
- location of equipment and deficiency tag;
- job priority;
- personnel safety and radiation protection requirements or permits (e.g., confined-space entry permit, welding and burning permit, lockout/tagout, isolation, draining, depressurization of the component, and RWPs);
- applicable TSR,[47] time constraints, and associated LCOs;
- qualification requirements (such as environmental and seismic qualifications);
- applicable work instructions and references;
- inspection, safety, or ALARA hold points associated with the work;[2, 3, 14, 30, 42, 59, 60, 100, 121]
- required postmaintenance testing, inspections, and acceptance criteria;

- authorization by the appropriate operations shift supervisor and maintenance supervisor to commence work;
- narrative description of conditions found by the craft personnel;
- documentation of actual work performed with postmaintenance testing and inspection results;
- acceptance of the equipment by operations; and
- final reviews and signoffs by maintenance, QC, and other groups in the WR review cycle.

The WR should be reviewed by affected groups or their representatives (such as maintenance, operations, technical support, QC, safety, and radiation protection personnel) during the planning process. This review can be simple or extensive, depending on various factors, such as the complexity of the job and its relation to facility safety and reliability.

4.7.3.3 Supervision of Maintenance Activities [39, 107, 122]

First-line supervisors should spend the majority of their time in the field. They should routinely monitor work in progress to help ensure that maintenance activities are conducted safely in accordance with DOE and facility policies and procedures. Good work practices should be recognized and encouraged; poor work practices should be corrected on the spot. Causes of poor work practices should be identified and corrected, and generic corrective actions should be initiated as needed. Work-site supervisors and good industrial safety practices are interrelated. Success in safety is achieved by the consistency of policies and procedures applied by supervisors. This is an integral part of the supervisor's total responsibility. Examples of work practices that should be checked include the following.

- Prejob briefings and applicable training (e.g., mockup training).
- Industrial safety and radiological protection practices (e.g., appropriate use of safety equipment, adherence to lockout/tagout requirements, proper handling of hazardous chemicals, proper use of ALARA concepts, and minimizing spread of contamination).
- Quality of workmanship, materials, and parts.
- Procedure use, including adherence to step-by-step requirements, signoffs, and work hold points.
- Open system and component protection.

- Accountability of tools, chemicals, and materials.

- Correct tool use for the job (e.g., short, nonsparking tools for batteries; prybars, chisels, or punches used as intended rather than as substituting screwdrivers; and test instruments used on correct ranges).

- Clean and orderly work sites.

- Work progress and time required to perform the job, especially if an LCO exists.

- Work being performed on the correct component, system, or unit.

- Adequate documentation of actual work performed.

- Proper use of postjob reporting and, when applicable, postjob critiques.

4.7.3.4 Review of Completed Work Requests [1, 28, 37, 103, 104, 116]

The operations shift supervisor should compare the work accomplished to the postmaintenance testing or inspection performed to determine that all work is acceptable before returning the equipment or system to normal service.

Maintenance supervisors should review completed WRs for adequacy of repair, complete documentation, notation of generic corrective actions, and identification of rework. A post-job review should be held with the craft personnel involved. This review could be a brief discussion or an involved critique. The purpose of this review is to determine whether any unexpected problems or unsafe conditions occurred and/or how the activity can be accomplished more efficiently and safely the next time. Other reviews should be accomplished by technical support, QC, safety, radiation protection, and other organizations, as appropriate and in accordance with facility instructions. Feedback should be provided to planning, scheduling, and maintenance personnel to highlight areas that were exemplary and areas that needed improvement.

4.7.3.5 Temporary Repairs [1, 28, 83, 84, 110, 117]

For temporary repairs or modifications to the facility, see Section 4.17.

4.7.3.6 Control of Nonfacility Contractor and Subcontractor Personnel

Nonfacility contractor and subcontractor personnel (workers not directly employed by the facility operating contractor) who perform maintenance or modifications on facility systems should be trained and qualified for that work they are to perform. These personnel should also receive general employee training and specific training in appropriate facility administration, safety, QC, and radiation protection procedures and practices. Adequate time should be provided for this training. Recognition should be given to individual needs and previous training and experience. Experienced personnel could be allowed to bypass training by proving proficiency through examination and demonstration. Nonfacility contractor and subcontractor personnel who are not fully trained and qualified for the job to be performed should be continuously supervised by qualified personnel.

Nonfacility contractor and subcontractor personnel should perform maintenance under the same controls as and to the same high work standards as are expected of facility maintenance personnel. Nonfacility contractor and subcontractor managers and supervisors should be held accountable for the work performance of their personnel. Facility supervisors should review the work of these personnel during preparation for work, at the job site, and during postmaintenance testing and acceptance inspections to the extent needed to enforce these requirements.

Use of subcontractor personnel to perform routine facility maintenance should not be relied upon to the extent that it deters the development of expertise of permanent staff.

4.7.3.7 Equipment

Equipment should be selected for special attention under this program based on the criteria below. The selection of certain equipment for special attention under this program does not imply that other equipment is to be ignored; normal care and application of sound technical and management controls are needed for all equipment, as well as for all activities associated with the equipment.

Equipment with a record of frequent operational failures that either have caused or have significant potential for causing loss of production capacity or negative impact on safety (failure information considered should include in-house records as well as information on other facilities available through vendor technical information) should be given special attention.

Equipment whose failure to operate as designed would likely cause significant loss of production capacity because of its importance to the facility should be given special attention.

Equipment with a record of frequent maintenance or rework that has caused inordinate use of maintenance resources or that has caused significant loss of production capacity or actuation of nuclear safety systems should be given special attention.

Equipment that maintains environmental conditions for important operating components should be given special attention.

4.7.3.8 Equipment Analysis

The maintenance engineers, with assistance from other technical personnel as necessary, should perform detailed failure analyses for equipment failures that either cause or have a significant potential for causing a loss of production capacity or adverse impact on safety, whether or not the equipment has been selected for special attention covered under this program.[28, 80, 112, 117, 125] Analyses should also be performed for repetitive minor failures that have a potential to cause lost production capacity, adverse impact to safety or require excessive use of maintenance resources. The purpose of the failure analysis is to identify the basic and contributing causes of the failure and to develop corrective recommendations. Failure analyses should examine, as necessary, all functional areas that might have contributed to a failure. Results of failure analyses and intended corrective actions should be reported in writing to the facility manager, cognizant owner/operators, and department managers. Possible addition of equipment or activities for coverage under this program should be considered in the development of corrective action. Corrective actions resulting from the analyses should be tracked to completion.

For equipment performance deviating significantly from normal, prefailure analysis should be performed. This should attempt to determine the cause(s) for deteriorating performance and whether the equipment should be repaired or replaced to preclude further degradation of performance (see Section 4.16).

4.7.3.9 Control of Maintenance Activities Performance Monitoring [1, 22, 23, 26, 28, 39, 46, 50, 103, 104, 109, 116, 125]

In addition to regular monitoring by operators, equipment performance should be regularly evaluated by performance tests and analysis of operating and maintenance data.

The performance test program should be structured so that tests are performed often enough to detect and correct degrading equipment performance before failures result in lost production or forced facility shutdowns. Performance tests should also be used to evaluate equipment performance after maintenance work as part of postmaintenance testing. These tests should be based upon manufacturer’s recommendations and operational experience with specific equipment, both at the facility and elsewhere in the industry. These tests should be performed by qualified personnel in accordance with approved facility procedures. The procedures should state the desired test interval and should include provisions for recording test results. The following are examples of performance tests that may be included:

- pump speed control system performance,
- flow instrument loop calibration,
- pump performance,
- lube oil system performance,
- trip valve performance,
- control building air conditioning system performance,
- instrument air compressor performance,
- instrument air dryer performance,
- voltage control system test,

- air ejector/vacuum pump performance,
- rotating equipment vibration tests, and
- valve leakage tests.

Performance test results should be analyzed by a performance engineer. The performance engineer should report significant analysis results and trends to cognizant owner/operators, department managers, and the facility manager, along with recommended corrective actions based on the analyses. When analyzing trends and developing corrective recommendations, the performance engineer should consult with other cognizant technical personnel and analyze performance information and trend data maintained by other departments.

Analysis and trending of selected routine operational data such as calibration results, and maintenance history should be performed by the cognizant departments. Selection of the data to be trended is the responsibility of the department manager. Corrective action for adverse trends or unacceptable performance should be taken promptly by the cognizant department.

4.7.3.10 Configuration Management

Configuration management is a discipline that applies technical and administrative direction and surveillance to identify and document the physical characteristics of a facility. It is a method of doing business that maintains consistency among design requirements, physical configuration, and facility documentation. It audits to verify conformance to specifications and related documentation. Basically, it boils down to doing all those things you know you should have been doing all along to properly manage and control physical and functional items at a facility. Such a program can be broken down into five basic programmatic elements.

- Program management
- Design requirements
- Document control
- Change control
- Assessments

An important aspect of a configuration management program is the assurance that the design basis of a DOE nuclear facility is established, documented, and maintained. The facility SSCs, and computer software should conform to approved design requirements, and any changes to them must be minimized through an integrated management review process, with established approval criteria. This will help to establish that the operations of the facility are reliable if personnel operating the facility are knowledgeable about changes through timely review and training. Proposed changes should be thoroughly evaluated to determine their impact on other hardware and documents. Such changes should be reviewed and approved by appropriate, responsible managers before implementation. This way, the program maintains a consistency between the documents of all departments and organizations (i.e., design, inspection, operations, maintenance, testing, or training). Safety, mission, economic impact, and benefit can be fully analyzed through the full range of review and approval contained in the program (see DOE-STD-1039-93 and DOE-STD-1073-93).

4.7.3.11 Conduct of Operations Lockout/Tagout

Because of the complex nature of operations and maintenance at DOE nuclear facilities and the interdependence of job activities, the way workers perform day-to-day activities to meet facility mission objectives should be formalized by established rules governing their work. For every operation, whether it be routine, infrequent, abnormal, emergency or casualty, a procedure should be in place so workers know how the operation should be conducted. Good procedures should produce good products. Verbatim compliance with procedures should be mandated policy. Compliance with procedures that are wrong or simply nonexistent could lead to failure. Knowing what to do when things go wrong is the fundamental key to understanding formal conduct of operations. Conduct of operations is the formality needed to ensure that workers know the status and configuration of systems and equipment at the facility during all phases of operations and maintenance (see DOE 5480.19, DOE-STD-1029-92, DOE-STD-1030-92, DOE-STD-1031-92, DOE-STD-1032-92, DOE-STD-1033-92, DOE-STD-1034-93, DOE-STD-1035-93, DOE-STD-1036-93, DOE-STD-1037-93, DOE-STD-1038-93, DOE-STD-1039-93, DOE-STD-1040-93, DOE-STD-1041-93, DOE-STD-1042-93, DOE-STD-1043-93, DOE-STD-1044-93, and DOE-STD-1045-93).

4.7.3.12 Integrated Safety Management System

An ISMS is based on the concept that safety requires the involvement of the workers and hands-on contractor line managers—they should determine safe work practices and other hazard mitigating requirements. Primarily, the goal of ISMS is to make safety planning an integral part of overall site strategic planning. It uses the concept that safety management should not be an add-on to strategic planning, but a central part of that planning. It is a high-level program that endeavors to integrate ES&H considerations with the programmatic requirement setting, resource allocation, and budgeting process. It aims to incorporate safety into management and work practices at all levels, addressing all types of work and all types of hazards to ensure safety of workers, the public, and the environment. ISMS should be the foundation of the budget formulation and allocation process, and a primary factor in establishing expectations and accountability. The seven ISMS management principles are as follows.

1. Line management responsibility for safety.

2. Clear roles and responsibilities.

3. Competence commensurate with responsibilities.

4. Balanced priorities.

5. Identification of safety standards and requirements.

6. Hazard controls tailored to the work being performed.

7. Operations authorization.

NOTE: **Worker involvement is evolving as the eighth ISMS management principle.**

Under an ISMS format, contractor safety responsibilities and accountability should be clearly established within the contract. In addition, certain high hazard facilities (such as nuclear facilities) require an explicit authorization agreement, based on a DOE reviewed and approved authorization basis. The ISMS framework has functions that—

- define the scope of work,
- analyze the hazards,
- develop and implement hazard controls,
- define performance of work within controls, and
- provide feedback and continuous improvement.

This framework is only a minimum set of activities. For nuclear facilities, the SAR requires several additional activities; most notably, the conduct of an accident consequence analysis after the identification and analysis of hazards. Maintenance is necessary to ensure that the conditions specified in authorization agreements are maintained. SARs, TSR, and other safety documentation establish the conditions for safe operation; facilities maintenance assists in maintaining the safe operating conditions. The SAR is a nuclear facility's most important living document. It substantiates the basis for assumptions made in environmental impact statements and environmental assessments mandated by the National Environmental Policy Act. A SAR should also include analysis of highly hazardous chemicals under normal and accident conditions per 29 CFR 1910.119, "Process Safety Management for Highly Hazardous Chemicals." SARs and TSR are part of a nuclear facility's authorization basis. The SAR describes the hazard analysis and accident consequence analysis that was conducted to define the conditions under which the facility can be safely operated, and specifies safe operating conditions and parameters. TSR are individual operational requirements that must be met to ensure safe operation.

Poor maintenance practices can potentially violate the conditions of the SAR or TSR and result in an unreviewed safety question (USQ). A USQ is a situation in which the safety of operations/maintenance at a facility is in question. For example, if TSR required that a backup pump for an automated fire-control system be tested every 18 months and that pump has not been tested for 10 years, the facility is in violation of the TSR, the facility would be placed in an unauthorized state, and a potential USQ may result regarding the operational status of that pump. Would it actually work as a backup if the primary pump failed in an emergency? Thus, the dependence of a facility's authorization basis on periodic maintenance of safety-related systems can be a strong justification for maintenance budget requests (see DOE P 450.4; DOE 5480.21; DOE 5480.22 and DOE 5480.23).

4.7.3.13 Human Factors Engineering

The industrialized world went through two technical revolutions before the one we are currently in. One was the shift from water-powered industrial production to steam; the other was the shift from steam-powered industrial production to electromechanical production. As machines and automation became more sophisticated, it was necessary to design increasingly user-friendly tools, machinery, and equipment for production processes. This has resulted in recent concerted efforts in human factors engineering and the development of systems for specific purposes and objectives based on human/machine interfaces. To execute successful operation of production processes, such systems require the input of information from a variety of sources, sensing of information, information processing and decision making, action and control through communication, and output to maximize both human and machine performance and prevent system failures and other undesired consequences.

Human beings are quite inventive in the kinds of mistakes they can make in any simple or complex system. They may err and cause a chain of events in a system to be broken through failure to perceive a stimulus, failure to discriminate among various stimuli, failure to respond in the correct sequence, misinterpretation of the meaning of stimuli, or physical inability to make a required response. To an equal extent, a given system task is also influenced by hardware performance. Hardware system performance depends on original design intent and industrial engineering reliability that is established by empirical data and failure probabilities.

Human activities in the workplace range from strictly mental to predominantly physical and can vary both in type and level of effort or intensity. The output from human activity in the workplace can produce the desired result; however, an individual's response to work or personal relationships, to training or the lack of it, or to physical or mental impediments can produce shortcomings in an entire industrial process. For example, sleep experts recommend 8 hours of sleep per night for good health, safety, and optimum performance (National Sleep Foundation, 2001). Even if this basic human need is ignored because of the demands of work or an individual's personal life, the human body still retains the need for sleep. Lack of sleep can cause workers to fail to complete assigned tasks properly.

To prevent human failures from occurring in maintenance activities at DOE nuclear facilities, human factors engineering concepts should be incorporated either as part of original design or as required design modifications are made. Human reactions to unforeseen events are extremely difficult to assess before the events take place. A thorough review of lessons learned from previous events and necessary corrective measures lays a foundation for such an assessment. Some workers become frustrated or excited by the circumstances of events, and they may ignore strict control measures or consider them not applicable to the situation. Posing hypothetical situations provides insights on how people may respond (confidently without hesitation) under normal conditions. However, when procedures, lighting, communications, physical limitations, physiological or psychological demands, stressful mental activity, unreasonable expectations, physical arrangement of displays and controls, or other regular/irregular environmental conditions frustrate or strain them, people, seeking relief, become innovative in ways that can have extremely negative impacts. For example, under the stress of deadlines, maintenance workers might be tempted to disable or override important safety features or interlocks to speed repair work. Situations such as this should be anticipated and specifically controlled through SSC design, training, and procedure compliance. Measures should also be implemented to overcome worker's ambivalence to training and failure to adhere to procedures.

Human factors should be accounted for both in the design and operation of DOE nuclear facilities to ensure that SSCs contribute to their maintainability by accommodating proactive PM and reactive corrective maintenance. These maintenance actions include inspecting, checking, troubleshooting, adjusting, replacing, repairing, and service activities.

Other factors that influence maintainability include repair and maintenance support facilities, hot shops, maintenance information, and various aspects of the environment. Human factors efforts are oriented toward improving maintenance activities by—

- reducing the need for and frequency of design-dictated maintenance;
- reducing system/equipment downtime;
- reducing design-dictated maintenance support costs;
- limiting maintenance personnel requirements; and
- reducing the potential for maintenance error.

To realize the overall goal of DOE nuclear facility SSC maintainability, one should prevent system failure, or once failure occurs, restore an SSC to operational effectiveness promptly, easily, and cost effectively. Maintainability and the associated human factors contributions should be integrated into total systems design, operations, and the maintenance process. Maintainability should be designed into SSCs at the beginning stage of development to ensure that costly maintenance and/or redesign are avoided. Maintainability should complement operational requirements of a system. SSC design for maintainability should also be an evolutionary process throughout the life of SSCs, including their dismantlement, deactivation, and complete removal from service.

Human factors engineering in maintenance at DOE nuclear facilities should start with the data generated by the SSC reliability program and the FMEA to identify the maintenance tasks that must be performed by maintenance personnel. Design specifics should be dictated by good human factors design principles, but engineers should also consider how the job should be done, including factors such as the following:

- unitization, modularization, and standardization;

- unit layout, configuration and mounting;
- labeling, marking, and coding;
- accessibility;
- controls, displays, and protective devices;
- lockout/tagout considerations; and
- other factors that influence ease of maintenance and reduce human error.

The data generated by the human factors SSC development process can then feed directly into the work-control process, providing information for the work-control system, including work planning; procedures, and job aides; maintenance support equipment; workspace; storage and workshop design; and PM scheduling (see DOE-STD-1029-92, DOE UCRL-15673, and EPRI 4350).

4.7.4 Work-Control System Performance Objectives [22]

The control of maintenance work should support the completion of tasks in a safe, timely, and efficient manner such that safe and reliable facility operation is optimized.

CRITERIA

A. The work-control system provides management with an accurate status of maintenance planning and outstanding maintenance work.

B. Control of work is accomplished through the effective use of a priority system. The backlog of work is effectively managed.

C. Work planning includes considerations such as material, tool, and manpower requirements; interdepartmental coordination; safety considerations; radiological protection requirements; and QC requirements. Maintenance history records are considered where appropriate.

D. The work to be accomplished is clearly defined by a work document that identifies or includes applicable procedures and/or instructions. Troubleshooting activities are controlled by applicable work documents.

E. Advance planning is performed and routinely updated for scheduled and unscheduled outages. Considerations such as work priority, work procedures and instructions, facility/system conditions, length of outage required, prestaging of documents and material, and coordination of support activities are included.

F. ALARA concepts are used in work planning to minimize man-rem exposure.

G. Scheduling and coordination of maintenance activities avoids unnecessary removal of equipment and systems from service and uses manpower effectively.

H. Postmaintenance testing requirements are clearly defined and include the following:

- clearly written test instructions,
- test scope sufficient to verify the adequacy of work accomplished, and
- test acceptance criteria.

I. PMT results are documented and reviewed to ensure proper system/equipment performance before returning the system to service.

J. Completed work-control documents are reviewed in a timely manner to check proper completion of maintenance work and to verify that corrective action resolved the problem.

4.8 POSTMAINTENANCE TESTING (Replaces DOE-STD-1065-94)[1, 28, 109, 112]

4.8.1 Introduction

Postmaintenance testing [see 10 CFR 830.122(h)] should be performed to verify that components will fulfill their current, authorized design function when returned to service after maintenance. Postmaintenance testing includes all testing performed after maintenance activities. An effective postmaintenance testing program should apply to all maintenance activities and should address each organization’s responsibilities, equipment to be included, degree and type of testing, procedure needs, acceptance requirements, testing control, and results documentation. Postmaintenance testing could be as simple as checking a manual valve for leaks at normal operating pressure after packing adjustment or as detailed as an in-depth diesel generator performance test (see Section 4.15 “Maintenance History,”[78] and DOE 5480.19, *Conduct of Operations Requirements for DOE Facilities*).

The objective of postmaintenance testing is to verify that SSCs are capable of performing their intended function when returned to service following maintenance and to ensure that the original deficiency is corrected. Postmaintenance testing requires close coordination among various facility groups and contract personnel. Postmaintenance testing integrates with the work-control system and the health and safety permit system. An effective PMT may be directly related to facility reliability. This Guide does not specifically address the postmodification testing process; however, most of the methods described may be directly used for postmodification testing as well.

Postmaintenance testing involves the following key elements.

- Responsibilities of each group are clearly defined.
- Scope of equipment tested includes all facility equipment.
- Specifying appropriate tests includes inputs from maintenance, owner/operator, and technical support groups.

- Guidance is available to planners for identifying appropriate tests.
- Testing is conducted with owner/operator's authorization, uses approved procedures or instructions, and is performed and reviewed by qualified personnel.
- Tests are conducted under the appropriate system operating parameters.
- A form is used to authorize, document, and review the results of PMT.
- Posttest system restoration is formally controlled (restoring system to normal and/or standby modes following completion of postmaintenance testing).

This section describes a program for specifying, performing, documenting, and accepting postmaintenance testing.

4.8.2 Discussion

Postmaintenance testing is used to determine whether maintenance was performed properly and the equipment operates correctly and performs its desired functions. A PMT should be performed after corrective maintenance and after some PM activities. The test should be commensurate with the maintenance work performed and the importance of the equipment to facility safety and reliability. In some cases, this may include testing additional equipment to verify system performance.

A postmaintenance testing program should include the following elements:

- Assigning responsibility for determining PMT requirements using functional groups such as operations, maintenance, and technical support.
- Determining the scope of the postmaintenance testing program to help ensure that appropriate levels of testing are applied to facility equipment and that redundant testing is minimized.
- Tracking the status of equipment that has undergone maintenance to ensure that all testing is completed before work closeout.
- Conducting proper PMTs, documenting the results, and verifying that the resulting data meet acceptance criteria.

4.8.3 Guidelines

4.8.3.1 Postmaintenance Test Requirements

A program should be established to control and document postmaintenance testing. It may be a part of the facility work-control system and may use the facility WR or work package to specify testing, assign responsibility, and document acceptance of all PMTs. The WR should provide specific instructions or cross-reference a test procedure and should provide traceability to PMT data. This may be accomplished by recording the data directly on the WR or by referencing data recorded on PMT data sheets or documents.

When WRs are received for planning, a review should be conducted to determine PMT requirements and whether the proposed repair is to equipment covered by applicable codes or TSR. Tests of any equipment affected by code or TSR should be reviewed by cognizant personnel. These reviews should ensure incorporation of testing required by the applicable code or TSR and of any additional testing, data recording, or special documentation required. Technical support organization assistance is also normally required on tasks that are complex and require engineering assistance, even though no code or TSR apply. The WR should be reviewed by the operations organization to verify that the postmaintenance testing requirements listed will provide adequate verification that the equipment will be capable of performing its design functions.

A satisfactory test is one that verifies; the ability of a particular SSC to perform its intended function, the original deficiency has been corrected, and no new or related problems have been created by the maintenance activity. All WR/WOs should be reviewed to determine the need for documented PMTs.

PMTs should be performed following all corrective maintenance activities. In addition, testing should be done following PM and troubleshooting activities that might have affected normal functioning of the SSC. Tests should usually be conducted under conditions that represent normal operating parameters, such as flow, differential pressure, temperature, input signal values, and fluid type.

Tests should be conducted in accordance with written instructions or formal procedures, as appropriate. The instruction/procedures should measure performance versus criteria on key parameters and allow for documentation and review of test data for the SSC. An example PMT Control Form and PMT Data Sheet are shown in Figures 4.8-A and 4.8-B, respectively. The results should be documented and filed with the WR/WO or cross-referenced by the WR/WO to the applicable document.

4.8.3.2 Postmaintenance Test Program Scope

Because corrective maintenance is performed to correct a deficient condition, most corrective maintenance should have a retest associated with it to verify that the equipment functions properly. Some PM activities also require postmaintenance testing. The rigorousness of the testing performed should be based on the work done and the importance of the component to safe and reliable facility operation. Postmaintenance testing should be accomplished on both safety and nonsafety equipment, systems, or activities such as the following:

- Maintenance that affects integrity or operation of a liquid or gas system.
- Maintenance that affects mechanical strength of components or fittings.

- Equipment that is included in special programs, such as the ISI and environmental qualification programs.
- Maintenance that affects or removes design-approved radiation shielding.
- Electric distribution equipment, such as breakers, bus work, or high-voltage connections.
- Electric control circuitry, such as protection relays, limit switches, or permissive relays.
- Electronic components, such as controllers, circuit cards, and transmitters.
- Instrumentation and instrument loops.
- Health physics and chemistry instrumentation.
- M&TE.
- Temporary systems that have been installed as substitutes for systems or portions of systems that are normally operational.

The following activities are representative of common PMTs:

- visual or dimensional inspections and nondestructive tests specified by code;
- voltage, current, integrity or continuity checks;
- operational exercise of the component (including vibration, pressure, flow, temperature, distance of travel, and other measurements where applicable);
- calibration or alignment of a component or instrument loop;
- leak rate testing;
- closure and response times, strokes; and
- hydrostatic test if a pressure boundary was affected.

Combinations of the elements listed above may be specified as appropriate to provide a complete PMT. Examples of maintenance performed and associated PMTs are given in Table 4.8-A. The examples are provided as guidance only. The necessary testing should be tailored to the specific maintenance performed.

Control and documentation of PMT activities are a part of the facility's work-control and equipment status-control systems.

During the initial processing of an WR/WO, the maintenance planner should include predefined PMTs in job instructions based on consultation with the owner/operator.

A PMT control form like that shown in Figure 4.8-A should be filled out by the planner and attached to the WR/WO, as appropriate.

When a maintenance activity involves several different tests, a separate PMT control form may be used to document each test.

The maintenance planner should obtain assistance from the owner/operator, technical support, the responsible system engineer, or other groups as needed to ensure that all testing requirements and acceptance criteria are specified.

The maintenance supervisor responsible for the work should review the WR/WO before beginning work, including the PMT control form. During this review, the supervisor is responsible for understanding the specified testing for the intended work and providing feedback for inadequacies.

The owner/operator should approve the WR/WO before the start of maintenance work.

PMTs should be performed according to approved instructions provided in the planning and authorization process. If the scope of work expands beyond the original WR/WO, work should be stopped and the WR/WO should be returned to planning along with any PMT Control Forms for further direction.

If more than one group is involved in testing, the owner/operator should coordinate the performance of the PMTs.

Following maintenance, the owner/operator should give permission to begin any testing by signing the PMT control form.

At the completion of postmaintenance testing, the owner operator should review the test results and sign the PMT control form, indicating acceptability of the equipment based on satisfactory completion of all PMTs. The owner/operator should make the final determination of operability.

The owner/operator is responsible for restoring SSCs to a correct setpoint for operating or standby mode following testing. This may be accomplished by instructions in the test procedure, by conducting specific system lineups, or by other formal methods.

For troubleshooting WR/WOs, the test requirements normally cannot be determined until the troubleshooting is complete. A record should be kept of work performed during troubleshooting to ensure that postmaintenance testing covers the troubleshooting scope. The supervisor responsible for the troubleshooting should generate a new WR/WO for necessary work. Testing requirements should then be identified through the normal planning and review process.

If the test cannot be completed immediately after maintenance is performed, the WR/WO should be held as an open WR/WO until such time as testing may be completed. WR/WOs awaiting testing should be tracked in a central file for follow-up to closure.

As facility conditions allow, testing may be performed and the WR/WOs may be closed out. Examples of delayed testing would include steam system valves or flanges repaired during unit outage periods that cannot be tested until normal operating facility conditions exist.

If the test is unsatisfactory, deficiencies identified during testing should be documented and corrected by generating a WR/WO.

When the stop work conditions are corrected retest requirements should be evaluated to determine whether prior testing should be repeated.

If a test is unsatisfactory, the SSC should be tagged to indicate that a deficiency still exists. The owner/operator may tag the component out of service; declare it inoperable; or, depending on the test results and significance of the existing deficiency, return it to service with the documented deficiency.

Equipment that is important to safe and reliable facility operation should be tested in accordance with approved procedures. PMT procedures should contain acceptance criteria that aid in measuring the performance of repaired equipment. Baseline data should be provided, if applicable.

Various classifications of equipment will require different levels of procedure support for postmaintenance testing. Where applicable, existing surveillance test procedures can be used to evaluate the operational acceptability of the equipment. If only part of the procedure is to be performed, the applicable sections, including necessary prerequisites and precautions, should be identified. An engineering or system acceptance test procedure, alignment check procedure, generic test procedure, or special test procedure may also be used to provide test instructions. PMT procedures used for a range of generic equipment, such as manual valves or flow controllers, should include data sheets for specific equipment when acceptance specifications or performance data are required.

The various classifications of equipment required to ensure safe and reliable facility operation should require different levels of instruction/procedural support for PMT activities. Available sources of PMT instructions/procedures should include (but are not limited to) engineering test procedures, surveillance test procedures, maintenance procedures, calibration procedures, and activity-specific generated instructions.

If an applicable surveillance test procedure exists, then that procedure may be used to verify operability of the equipment. A surveillance test may be used for postmaintenance testing if it not only proves system operability, but also verifies operability of all components and features either directly or potentially affected by the maintenance activity, verifies that maintenance was performed properly, and ensures that the initial deficiency was corrected.

If only applicable sections of a procedure are used, caution should be used to ensure that previous sections are reviewed for system status, lineups, or prerequisites. Applicable sections with supplemental precautions or prerequisites should be specifically referenced on the modification request or supplemental document.

If a surveillance test, calibration, or special procedure does not exist to test particular equipment following maintenance, a special test procedure may be written, or the test may be performed in accordance with instructions written for the WR/WO. With any of these procedure methods, the required and actual testing performed should be described, data recorded, acceptance criteria specified, and appropriate reviews and approvals performed and documented. If special test procedures are written to perform PMTs, the appropriate safety and technical reviews should be performed in accordance with facility procedures.

Test instructions should include details such as initial conditions and prerequisites, hold points, cautions, personnel qualification requirements, personnel safety requirements, clear acceptance criteria, and posttest restoration.

Test instructions should be as specific as possible and should avoid using vague criteria such as “verify proper operation” or “check for excessive temperature.”

Test equipment should be specified and provision made for recording the equipment identification and calibration due date.

For troubleshooting WRs, it may not be feasible to fully determine the PMT requirements until the troubleshooting is complete. The responsible individual should add instructions to the troubleshooting WR stating that PMT instructions will be specified after completion of the work. Once the work is completed, the appropriate PMT should be specified, verified by the appropriate individuals, and performed.

The following are representative examples of PMTs.

- Hydrostatic or other pressure tests with visual inspection for leaks.
- Visual inspection or nondestructive examinations for loose fasteners and mechanical misalignment.
- Operational test of the component, including checks such as valve stroke time; measurement of vibration, flow, pressure, and temperature; operation of interlocks; and comparison against other applicable equipment.
- Calibration or alignment of an instrument or loop.
- Response time test of an instrument or instrument loop.
- Continuity, voltage, or current checks.
- System or component inspections for cleanliness.

A single test or a combination of tests such as those listed above should be specified to provide complete postmaintenance testing. The specific testing to be performed should be referenced on the WR or test procedure.

4.8.3.3 Postmaintenance Test Control [1, 84, 109]

A program should be established to control postmaintenance testing. When more than one group is involved in the PMT or when the test must be delayed until conditions permit, one organization, such as the operations department, should be responsible for coordinating test performance. The designated organization should review the total work scope to minimize redundant testing. The department performing or having the lead for performing the PMT should assign an individual with overall responsibility for conducting the test and an individual with responsibility for reviewing test data and determining the acceptability of equipment.

If facility conditions dictate that the postmaintenance testing cannot be completed immediately after maintenance is performed, the WR should be held open or some other tracking method used by the department having lead responsibility for testing until the equipment can be tested. Danger or caution tags may be required for the equipment until proper postmaintenance testing can be completed. Safety equipment should not be declared operative until postmaintenance testing has been satisfactorily completed. Operators should know the status of equipment on hold for postmaintenance testing and should minimize the amount of equipment in this condition. This status should be reviewed before any scheduled mode change. Equipment that can be tested during the upcoming mode change should be identified and the PMTs accomplished in that process or as soon as feasible after the new condition is reached.

4.8.3.4 Postmaintenance Test Performance, Documentation, and Acceptance [28, 44, 83]

The operations department should be assigned responsibility for the operational acceptability of all equipment and systems. Accordingly, operators should normally perform or be closely involved in postmaintenance testing. Maintenance, technical support, QC, and other personnel may also be involved in or called upon to perform postmaintenance testing. For tests involving participation of more than one group, an individual in the lead group should be assigned to coordinate testing activities. Postmaintenance testing of minor equipment may be performed by the operator returning the equipment to service, by the craft personnel performing the maintenance, by the engineer after maintenance, or by a combination of these and other needed individuals. The organization responsible for specifying the PMT should review the work performed to ensure that the test is appropriate. Any questions should be resolved with the organization that determined the postmaintenance testing requirements.

Operational acceptability of the equipment, based on satisfactory completion of PMTs, should be verified by the operations organization obtaining an appropriate signature on the WR or other reference document. This verification should be made from objective evidence, such as conducting or witnessing the PMT and reviewing completed procedures and documented test results. PMT data and their acceptability should be entered or cross-referenced to maintenance history with the WR (see Section 4.15).

Deficiencies identified during postmaintenance testing should be documented and corrected on the original WR and on a new WR or on another reporting system before the original WR is accepted as complete by operations. The original WR should reference any new WRs or other documents written to resolve these deficiencies.

If a PMT fails and the equipment or system cannot be repaired and tested satisfactorily in a short time (normally, before the next shift change), the degraded or inoperative status of the equipment should be documented such that operators understand its limitations. TSR should be consulted for safety equipment, and appropriate actions should be taken until the equipment is properly tested and returned to service.

Equipment ID No.	POSTMAINTENANCE TEST CONTROL FORM	WR/WO No.	
Description of Test:			
Test Instructions:			
Attachments: Pages			
Test Form Prepared By:	Name	Badge	Date
Test Start Approval:	Equipment Owner	Badge	Date
Test Results (Comments)			
Satisfactory Unsatisfactory			
Corrective Actions Taken:			
Test Performed By:	Name	Badge	Date
Test Accepted By:	Equipment Owner	Badge	Date
Test Accepted By:	Maintenance Supervisor	Badge	Date

Figure 4.8-A. Example Postmaintenance Test Control Form.

1. The Maintenance Supervisor should ensure that the Test Form Preparer (typically the planner estimator) has provided on the form the equipment identification, the WR/WO number, description of the test, the test instructions and attachments, signatures, badge numbers, and dates.

2. The Maintenance Supervisor should ensure that the Test-Start Approval signature, badge number, and date have been obtained from the Equipment Owner, (or designee) prior to starting test.

3. The Test Performer should fill in the Test Results (Comments) Section of form, indicating whether test was Satisfactory or Unsatisfactory and any Corrective Actions taken, if applicable.

4. Upon completion of test the Test Performer should sign, add badge number, and date.

5. The Maintenance Supervisor should obtain signature, badge number, and date from the Equipment Owner in the applicable Test Accepted By Section.

6. The Maintenance Supervisor should sign, add badge number and date to indicate test acceptance in the applicable Test Accepted By Section.

7. The Test Performer and Maintenance Supervisor should ensure that the PMT Control Form is kept together with the complete job package.

NOTE:

- **If an equipment-specific data sheet and a PMT procedure are available, they may be referenced instead of duplicating the test-result data.**
- **The location of the completed data sheets, if separate from the job package, should be identified.**
- **Appropriate signatures on this PMT Control Form are required and should be returned to the PE with the job package.**

Figure 4.8-A. Example Postmaintenance Test Control Form (continued).

RADIO UNIT POSTMAINTENANCE TEST DATA SHEET WR/WO#: _________

Operational Tests

Reference	Test	Pass	Fail	Condition
Section VII.A	Pretest Setup			
Step 6				All radio display LEDs are OFF
Step 8				Radio PTT LED lights
Section VII.B	Radio Unit Low Battery Alarm			
Step 2				COS printout occurs for group E point 3
Step 4				ALARM printout occurs for group E point 3
Section VII.C	Station and Radio Loss of AC Power			
Step 2a	Station Loss of AC Power			Radio LED 5 lights and an ALARM printout occurs for group A point 5
Step 2b	Radio Loss of AC Power			POWER FAIL printout occurs
Step 4a				All radio display LEDs are OFF
Step 4b				A COS printout occurs for group A point 5
Step 4c				A POWER RECOVERY printout occurs
Section VII.D	Fail-Fail Alarm			
Step 2				Radio LEDs 1, 6, and 7 are lit
Step 5a				All radio display LEDs are OFF
Step 5b				ALARM printout occurs for group A points 1, 6, and 7
Step 5c				COS printout occurs for group A points 1, 6, and 7
Section VII.E	Fail-High Alarm			
Step 3.				Radio LEDs 1, 3, and 6 are lit.
Step 7a				All radio display LEDs are OFF.
Step 7b				ALARM printout occurs for group A points 1, 3, and 6.
Step 7c				COS printout occurs for group A points 1, 3, and 6.

Figure 4.8-B. Example Postmaintenance Test Data Sheet.

RADIO UNIT POSTMAINTENANCE TEST DATA SHEET WR/WO#: __________

Operational Tests

Reference	Test	Pass	Fail	Condition
Section VII.F	High-Fail Alarm			
Step 3				Radio LEDs 1, 2, and 7 are lit
Step 7a				All radio display LEDs are OFF
Step 7b				ALARM printout occurs for group A points 1, 2, and 7
Step 7c				COS printout occurs for group A points 1, 2, and 7
Section VII.G	High-High Alarm			
Step 2				Radio LEDs 1, 2, and 3 are lit
Step 5a				All radio display LEDs are OFF
Step 5b				ALARM printout occurs for group A points 1, 2, and 3
Step 5c				COS printout occurs for group A points 1, 2, and 3

REMARKS:

____

____

____

Verifying Craft Worker: ____

Signature Badge Number

Figure 4.8-B. Example Postmaintenance Test Data Sheet (continued).

Table 4.8-A. Selected Maintenance Activities and Postmaintenance Tests

- This list of activities and tests is a guide only and is not meant to be all-inclusive. The testing selected should depend on the scope of completed maintenance and the requirements established by the owner/operator.
- An appropriate test for nearly all mechanical work would be a general leakage inspection and any testing required by American Society of Mechanical Engineers (ASME) codes or equipment-specific procedures.

Maintenance Activity	Recommended Test
Repair electric motor.	1. Perform the following checks: insulation resistance, winding resistance, polarization index, high potential. 2. Verify proper direction of rotation and proper phase relationships. 3. Operate the equipment and verify absence of abnormal noises. 4. Obtain baseline vibration-analysis data. 5. Measure the bearing temperatures. 6. Measure the starting and the running current for each phase. 7. Check oil levels. 8. Check air-filter cleanliness.
Repair circuit breaker.	1. Verify adjustment of circuit breaker trips. 2. Perform trip-shaft torque measurements if applicable. 3. Measure phase-to-phase and phase-to ground insulation resistances. 4. Measure microhms across each main contact. 5. Perform automatic-function test on the breaker (opens and closes on required signals). 6. Measure breaker-response time. 7. Verify operation of auxiliary trip devices and relays. 8. Perform manual operational checks on the breaker. 9. Check breaker parameters (e.g., breaker operating voltage, current, control power, status lights).
Adjust packing of or repack air-operated or motor-operated valve (MOV).	1. Using air or motor operator, verify full stroke of valve to ensure freedom of movement. **(NOTE: Valve stroke required may be different from operative capability.)** 2. Perform stroke timing test. 3. Check running current on motor. (If running current has increased by more than 8 percent of the baseline value, evaluate the need to perform diagnostic testing of the valve.) 4. Check for leakage at normal operating pressure. 5. Perform leak rate test if required.

Table 4.8-A. Selected Maintenance Activities and Postmaintenance Tests (continued)

Maintenance Activity	Recommended Test
Repair internals of air-operated or motor-operated valve.	1. Leak-test valve if required by technical safety specifications or surveillance procedures. 2. Perform retesting required for adjusting packing. 3. Verify position indications (remote and local). 4. Grease/lubricate MOV.
Repack manual valve or adjust packing.	1. Verify that valve stem moves freely without binding. 2. Check for leakage at operating pressure.
Repair (or replace) MOV.	1. Perform full-stroke exercising checks (two motor-operator strokes) done at normal system flow, pressure, temperature. 2. Test seat leakage. 3. Perform stroke timing test. 4. Measure the running and the starting current of motor. 5. Verify torque and limit-switch settings. 6. Test automatic functions. 7. Check position verification. 8. Check packing leakage, at operating pressure. 9. Grease/lubricate MOV. 10. Perform appropriate diagnostic tests to establish a new baseline.
Repair (or replace) air-operated valve.	1. Perform full-stroke exercise checks at normal system parameters. 2. Test seat leakage. 3. Perform stroke timing test. 4. Test automatic functions. 5. Check position verification. 6. Verify control-valve loop alignment. 7. Check packing leakage at operating pressure. 8. Check positioner and E/P or S/P converter calibration.
Repair solenoid valve.	1. Perform full-stroke exercise checks. 2. Test seat leakage. 3. Test automatic functions. 4. Check position-indication verification.
Repair (or replace) seat-tightness testing.	1. Perform any code-required strength or isolation valve. 2. Perform technical-specification-required leak-rate and operability testing. 3. Verify position indication.
Repair pressure-regulating valve.	1. Check set-point calibration. 2. Test valve-seat leakage.
Repair safety valve/ relief valve.	1. Test relief set-point (bench test or in-place test). 2. Test valve-seat leakage. 3. Check position indications proper; check for chatter and packing leakage.

Table 4.8-A. Selected Maintenance Activities and Postmaintenance Tests (continued)

Maintenance Activity	Recommended Test
Repair (or replace) safety-related pumps or non-safety-related pumps.	1. Test in accordance with ASME code, as required. 2. Perform appropriate surveillance test. 3. Check direction of rotation if motor leads were disconnected. 4. Inspect suction filters, oil level, cooling flows, suction and discharge pressures, bearing temperatures, packing or seal leakage. 5. Run baseline vibration analysis. 6. Measure applicable pump and motor performance data. 7. Perform automatic function tests. 8. Inspect base plate/foundation.
Perform maintenance on ventilation system fan/filter unit.	1. Perform function tests and manual start. 2. Check dynamic balance. 3. Check bearing temperatures, vibration levels, abnormal noise, airflows. 4. Measure running current. 5. Perform filter inspections and tests.
Repair (or replace) manual, motor- and air-operated dampers.	1. Check full stroke. 2. Check damper leakage. 3. Check automatic function and interlocks. 4. Check stroke timing. 5. Check position indication.
Rebuild (or repair) air compressor.	1. Check for leakage at operating pressures. 2. Measure bearing temperatures. 3. Measure baseline-vibration levels. 4. Check for unusual noise. 5. Check parameters (discharge pressure, cooling flow, oil level, air temperatures).
Perform turbine maintenance.	1. Test automatic start functions. 2. Check turbine (pump) performance (flow, speed, bearing temperature, and vibration amplitude). 3. Test turbine protective features. 4. Test manual start. 5. Check oil levels. 6. Check for fluid leakage at normal system parameters. 7. Measure baseline vibration data. 8. Check for rotor grounds. 9. Grease sliding plates at foundation and pedestal. 10. Check auxiliaries for heating and cooling.
Perform heat-exchanger maintenance.	1. Check heat-exchanger parameters (temperature, flow, external leakage, etc.). 2. Test heat-exchanger performance (heat balance). 3. Check hydrostatic or operational test for tube and tube-sheet leakage.

Table 4.8-A. Selected Maintenance Activities and Postmaintenance Tests (continued)

Maintenance Activity	Recommended Test
Perform maintenance of emergency diesel generator (EDG) and related components.	1. Test automatic-start function. 2. Check EDG fluid parameters (e.g., lube- oil level, cooling-water temperature and flow, governor-control oil system, fuel-oil sampling). 3. Test EDG automatic protective features (overspeed, generator differential, low lube-oil pressure, high crankcase pressure, etc.). 4. Test EDG synchronization and load. 5. Test EDG manual start. 6. Check diagnostic baseline parameters (e.g., vibration, cylinder compression). 7. Check voltage regulation and frequency.
Perform piping-system maintenance.	1. Flush system. 2. Check ASME code requirements. 3. Perform pressure/hydrostatic test. 4. Check integrity of mechanical joints. 5. Check cleanliness and verify system filled and vented. 6. Verify correct fluid-chemical parameters. 7. Verify that piping supports, heat tracing, and insulation are restored. 8. Review for unusual pipe displacement. 9. Ensure that instrumentation lines are attached to pipe and properly refilled.
Make new (or repair) weld.	Test in accordance with the ASME code (this is required for systems covered by the code). Facility guidelines are specific for applicable categories.
Replace component in instrument loop.	1. Calibrate replaced component. 2. Ensure that component is installed properly. 3. Inspect mechanical joints under normal operating or hydrostatic test pressure to verify no leakage. 4. Verify proper operation of instrument loop by comparing with— • Other readings of the same parameter on different instrument channels. • Readings between channels that monitor the <u>same</u> variables and bear a known relationship to each other. • Readings between channels that monitor <u>different</u> variables and bear a known relationship to one another. 5. Measure loop-response time if a time constant is associated with instrument response. 6. Perform operational checks on process.

Table 4.8-A. Selected Maintenance Activities and Postmaintenance Tests (continued)

Maintenance Activity	Recommended Test
Replace switch devices (pressure, flow, temperature, level).	1. Calibrate pressure switch and verify actuation and reset points. 2. Inspect mechanical joints under normal operating or hydrostatic test pressure to verify no leakage. 3. Verify, in accordance with technical manual and technical safety specifications, that environmental qualification requirements have not been degraded by installation or maintenance. 4. Ensure that switch is valved in after maintenance and that indication is as expected.
Perform instrumentation transmitter channel maintenance.	1. Perform channel checks. 2. Calibrate all channel components except sensor. 3. Calibrate sensor channel (complete channel). 4. Test operation of trip activation device. 5. Calibrate in-core detector channel (normalization). **NOTE: During channel calibration, verify that all automatic actuation interlock set points and resets function properly.**
Perform maintenance of radiation monitors.	1. Perform channel checks. 2. Perform source checks. 3. Test automatic functions. 4. Calibrate channel.
Perform transformer maintenance.	1. Check transformer parameters (oil temperature, oil level, oil pressure, tap settings, cooling-fan status). 2. Test transformer operability (primary/secondary voltage and current). 3. Check insulation resistance high-potential, polarization index.
Repair (or replace) static inverters.	1. Verify voltage and currents. 2. Check inverter load. 3. Perform transfer test, if applicable.
Perform electrical maintenance on load center and distribution panel.	1. Verify voltage and load current. 2. Visually check for fastener tightness, cleanliness.
Repair cranes and hoists.	1. Perform load test. 2. Check limit-switch operability. 3. Check brake/clutch operability.

Table 4.8-A. Selected Maintenance Activities and Postmaintenance Tests (continued)

Maintenance Activity	Recommended Test
Perform battery maintenance.	1. Check battery parameters (specific gravity, electrolyte level, cell voltage, electrolyte temperature, battery-terminal voltage). 2. Verify that battery cells, cell plates, terminals, and connectors are free of corrosion. 3. Perform battery service discharge test. 4. Perform battery performance discharge test.
Repair (or replace tank/pressure-vessels.	1. Check tank/vessel integrity for leakage. 2. Check tank parameters (proper level, pressure, temperature 3. Check tank-content parameters (e.g., boron concentration, radiation level, viscosity, particulate contamination, other). 4. Check tank cleanliness. 5. Check ASME code requirements, as appropriate. 6. Check condition of internal coatings.

4.9 PROCUREMENT OF PARTS, MATERIALS, AND SERVICES (Replaces DOE-STD-1071-94)[1, 11, 19, 20, 39, 74, 114]

4.9.1 Introduction

Proper parts, materials, and services required for maintenance activities should be available when needed [see 10 CFR 830.122(g)]. Proper parts and materials in good condition are necessary to maintain design requirements for maintenance activities during normal facility operation and to support both unplanned and planned outages. Services are periodically needed to provide unique or supplementary maintenance support. An effective procurement process should be developed in conjunction with QA requirements to ensure that parts, materials, and services are available when needed.

This section describes the procurement of parts, materials, and services to support facility maintenance. The receipt, inspection, handling, storage, retrieval, and issuance of parts and materials are described in Section 4.10.

4.9.2 Discussion

Having the correct part, material, or service available when needed to complete a maintenance activity should be the fundamental objective of an effective procurement program.[74] This is accomplished by establishing clearly defined policies and procedures and by implementing the program thus defined. Controls on and assessments of procurement activities are used to help ensure that proper parts, materials, and services are purchased to support maintenance activities and to meet the requirements for safe and reliable facility operation.

4.9.3 Guidelines

4.9.3.1 Procurement Policy and Procedures [1, 28]

Policies should be established for the procurement of parts, material, and services. These policies must be understood by stores and purchasing personnel and other personnel who interface with them, such as maintenance supervisors, planning personnel, and scheduling personnel.

Procedures should be prepared that describe the specific responsibilities of personnel involved in the procurement function. Specific procurement actions should be included in these procedures.

Procedures should be prepared to describe specific procurement actions and the specific responsibilities of personnel involved in the procurement of—

- safety-class items,
- safety-significant SSCs,
- critical spare parts,

- major project purchases,
- routine procurement purchases,
- contracted work and services, and
- hazardous materials.

Established procedures should provide for the update of spare part stocking levels and removal of outdated/obsolete items as part of the design change process.

A system should be established as part of the design change process to update spare parts needs and remove outdated/obsolete materials from the stock system.

4.9.3.2 Procurement Initiation [1, 28]

Timely procurement of parts, materials, and services for maintenance activities can be enhanced by considering items such as the following:

- identifying long-lead-time items early;
- selecting procurement sources based on approved vendors and past vendor performance;
- justifying single-source items;
- selecting vendors on the basis of performance, approved listings, and/or design mandate;
- identifying special receiving inspection needs and criteria;
- specifying vendor technical documentation and Material Safety Data Sheets (MSDSs), as applicable, as a deliverable;
- identifying appropriate quality, engineering, environmental, shelf life, PM, and vendor technical manual requirements;
- updating the spare parts inventory after design modifications; and
- participating in a spare parts system pooled with other facilities that share common or nearby sites.

4.9.4.3 Procurement Control [1, 28]

Controls should be developed and maintained throughout the procurement process to help obtain parts, materials, and services promptly. Controls such as the following should be provided.

- Segregation and status resolution of damaged, nonconforming, or otherwise deficient items. Technical reviews should be initiated promptly to aid in the resolution of these items.

- Special receiving inspection documentation to support future procurement.

- Ensuring initial deliverable quantities and spare part stocking levels are adequate.

- Emergency procurement process and practices that ensure that acquired items support safe and reliable application.

- The ability to track procurement status by the requester.

- The ability to track procurement status from receiving through delivery to issue-for-use.

- Assurance that procurement documents and controls prevent the delivery or use of suspect/counterfeit parts.

- Verification of the reliability of supplier performance. This can be accomplished by audits, inspections, or surveillances of supplier facilities.

- Prompt and effective resolution of deficiency or nonconformance of items. Technical reviews should be initiated promptly to aid in resolving these issues.

- Control and maintenance of QA records to provide documentation for qualified parts and materials and to ensure traceability of parts and materials.

- Provision of a means of qualifying nonqualified material. An effective upgrade process will result in improved availability of quality parts and materials.

- Provision of a method for acceptable substitution to obtain parts that are no longer available from the original supplier, that have new identification numbers, or that have different material specifications. Engineering and maintenance experience should be provided to support this process. Change approval documentation and substitution information should be maintained in a retrievable form.

- Review of design requirements by appropriate personnel to ensure that upgraded or substitute parts are consistent with the application of the part and component. Retrievable documentation should exist to support the identification of inspection and testing requirements necessary to ensure the qualification and acceptability of the part.

- Development of emergency procurement policies and an expediting process to obtain parts, materials, and services that are needed immediately to support safe and reliable facility operation. Acquisition deadlines should be clearly identified for parts, materials, and services that require emergency procurement.

- Establishment of a parts and materials reorder system that ensures material availability for anticipated usage while minimizing unnecessary inventory. For example, a minimum/maximum stock level can be established to determine when items should be reordered (the minimum level) and to limit the amount ordered (the maximum level). Changes to these levels should be controlled by review of usage history and maintenance experience.

- Identification of multiple applications of requested parts or materials; use of specific parts or materials in more than one system or piece of equipment should be considered as part of the procurement and stocking process.

- Ability of the procurement organization to track procurement progress and take necessary measures to meet maintenance and outage schedules.

4.9.3.4 Services [28, 58]

Identification of the need for specialized services from vendors should be made in time to provide for solicitation of bidders and for bidding on and awarding contracts. Provisions should be made when possible for general service agreements so that services can be supplied at short notice.

4.10 MATERIAL RECEIPT, INSPECTION, HANDLING, STORAGE, RETRIEVAL, AND ISSUANCE (Replaces DOE-STD-1071-94)[1, 28, 54, 74, 115]

4.10.1 Introduction

All phases of receiving, inspecting, handling, storing, retrieving, and issuing equipment, parts, and materials for maintenance should be covered by effectively implemented policies and procedures from the time an item is received until it is installed in the facility (see 10 CFR 830, Subpart A).

This section establishes the functions that a stores organization should perform in administering the stores program.

4.10.2 Discussion

Many personnel at a facility are involved in some portion of the stores operation. They should be aware of the correct process to receive, inspect, handle, and store facility material and equipment so that it is easily retrievable and usable when issued. Therefore, policies should be established that address these functions. These policies must be understood by stores personnel and other organizations that interface with them, such as purchasing, QA, QC, engineering, radiological protection, operations, safety, and maintenance. Procedures should be prepared that specifically describe the responsibilities and the techniques for receiving, inspecting, handling, storing, retrieving, and issuing material from stores. QA/QC aspects of the stores function should be incorporated into these procedures.

Procurement (see Section 4.9) is the first step in ensuring that the correct parts and materials are available, usable, and readily retrievable for issuance for maintenance activities.

4.10.3 Guidelines

4.10.3.1 Receipt and Inspection

When parts, materials, and equipment are received, stores personnel should inspect them before they are accepted for storage or are used. This inspection is conducted to verify that the items delivered agree with the approved purchase documentation, are packaged in accordance with purchase order specifications, have necessary product control requirements furnished by the vendor (such as special storage or shelf-life information), and appear to be in good condition. In the case of safety items and designated critical items important to reliable facility operations, stores personnel should inspect them to ensure that the vendor has supplied what was ordered, that the necessary formal documentation has accompanied the shipment or is otherwise on hand, and that items have been received in an acceptable condition. Technical staff and maintenance personnel may be needed to assist in the inspection of more complicated parts, materials, and equipment.

Technical staff and QC personnel should approve any deviation from design specifications of material or equipment received before the item is accepted into the stores system. They should also approve any upgrade of material or equipment from a nonsafety to a safety category. An acceptance tag or label placed on the received material may be used to signify that the receiving inspection was performed and that the applicable requirements have been met.[1]

A separate receiving and inspection area, as well as a separate holding area, should be provided. The latter area is used to hold material and equipment that has not been officially received into the stores system because of nonconformance.

Nonconforming material must also be clearly tagged or labeled to prevent its inadvertently being issued. A tracking or follow-up method should be established to ensure that problems with nonconforming items are promptly resolved.[1, 74]

During receipt inspection, the designated organization should ensure that special storage instructions have been addressed. Before final acceptance of an item, the designated organization should ensure that the necessary purchase order instructions and requirements are completed such as the following.[1]

- The tickler file has been updated as described in Section 4.10.3.3
- Appropriate items have been added to the PM program.
- Appropriate inspection instructions are clearly defined.

Inspection and test activities should be selectively and judiciously applied to new, repaired, and replacement items, on the basis of risk to safety and/or importance to reliable capacity, to ensure items will perform as expected.

Plant Engineering should develop a process for providing data sheets that form the basis for procurement of Safety Class Items and other major purchases (i.e., equipment and construction projects). These data sheets should provide—

- procurement information,
- critical parameters and their acceptance criteria,
- unique or special testing requirements/methods,
- reorder instructions, and
- suspect/counterfeit parts information.

Items or parameter values that do not satisfy established acceptance criteria should be rejected; Plant Engineering approval should be required for other disposition.

Nonconforming items should be—

- clearly identified;
- segregated from normal items to prevent inadvertent use;
- documented on a nonconformance report and/or a defective or substandard material report; and
- tracked and dispositioned as soon as practical by the applicable authority.

Routine inspections performed by appropriate personnel should include the following:

- ensuring that packaging is appropriate (as designated on the purchase order when specified), is undamaged, and/or has not deteriorated;
- ensuring color, count, shape, size, part number, model number, manufacturer/vendor name, etc., are as specified on the purchase order;
- ensuring shelf-life and other time-environment requirements have not been violated;
- ensuring date and time of receipt are logged for regular follow-up review during the storage period; and
- ensuring specified vendor documentation, in the quantities required by the purchase order, exists.

Special inspections should be performed on safety-class items, safety-significant SSCs, and other items when designated by the requisitioner.

- Special inspections should be performed by the organization specified on the requisition.
- Special inspection requirements for items not involving Engineering data sheets should be defined by the requisitioner.
- Special inspections normally require—

  —formal quality records of all measured data,
  —formal date inspection performed,

—identification of the individual and the organization performing the inspection,
—accept/reject status identification, and
—signature of the applicable authority to approve the status.

Items receiving special inspection (especially safety-class items and safety-significant SSCs) should be appropriately identified and segregated from normal stock to indicate status and ensure proper application.

Before becoming available for use or restock, materials and equipment that have been repaired and/or stored in the plant should require the same inspection defined for the original purchase and/or appropriate for its intended application as specified by engineering.

Stored items that are affected by time-environment should be regularly checked by designated personnel; expired or otherwise jeopardized items should be removed from normal storage until dispositioned by the proper authority.

An "acceptance tag" should be placed on the item after satisfactory receipt inspection. The tag should be legibly marked to indicate whether an item has any type of special storage requirements (see Figure 4.10-A for an example). This provides the user, requestor, or storeroom personnel with an easy method to ensure special storage control requirements are satisfied. The tag may cross-reference a particular entry in a file system (tickler file) for further instructions.

A method should be developed to accept material that has been repaired or reworked by the facility maintenance organization. Whenever materials or parts are repaired or reworked, suitable testing and inspection requirements should be specified by design engineering to ensure that the materials or parts perform acceptably when placed in service. This method should also address material that has been issued and is sent back to stores for reissuance.

Warehouse documents should be updated to reflect receipt of the material and any shelf-life or PM requirements.

4.10.3.2 Handling [4, 33, 115]

A procedure should be prepared for items requiring special handling. It should include information such as weight, size, chemical reactivity, radioactivity, and susceptibility to physical shock, damage, or electrostatic sensitivity. Sling location balance points, method of attachment to the load, and other pertinent factors in handling loads should be clearly identified. Sound handling practices should be followed whether a specific procedure is used or not.[33, 115]

Hoisting and lifting equipment should be certified by the manufacturer, indicating maximum loads to be handled, and the information marked on the equipment. The maximum load capability, as marked on the equipment, should not be violated when handling or moving items. Hoisting and lifting equipment should be regularly tested, inspected, and acceptance tagged to ensure integrity. The facility inspection program for hoisting and lifting equipment and rigging should be applied to items used in the stores operation. Personnel required to operate cranes, forklifts, and other lifting equipment should receive performance-based training and be appropriately licensed to verify their qualifications.

Clearly defined instructions or job plans, including unusual, unique, or deceptive weight, balance, or lift points and other critical information, should be communicated to the handler for items to be lifted or otherwise handled. Likewise, clearly defined instructions/job plans should be developed and communicated for items that require special handling such as vibration isolation, protection from the environment, specific orientation, etc., to ensure integrity. Calibrated/certified items should be handled in a manner that ensures their integrity is not jeopardized.

4.10.3.3 Storing Material and Equipment [1]

Material and equipment should be stored in a manner that provides maximum protection and ready availability. Material and equipment should also be stored with due consideration for environmental conditions. For example, PM should be performed on large pumps and motors (those having more than 25 horsepower) that are in storage. This includes periodically checking energized heaters, periodically changing desiccant, meggering motors, rotating shafts on pumps and motors, changing oil on rotating equipment, and performing other maintenance specified by the vendor.

***NOTE:* For large rotating equipment in storage, shafts should be rotated periodically and the end result should be that the shaft is rotated 90 degrees from the preceding storage set point.**

Also, a method should be developed that provides controlled access to storage areas. Controls should be established for field storage of such consumables as lubricants and solvents to ensure that they are properly stored, identified, and used.

A shelf-life control program should be provided for items in stores that are important to safe and reliable facility operation. Various items with finite storage lifetimes (such as paints, recorder paper, adhesives, sealants, valve diaphragms, and gasket material) should be tracked so that stock that has exceeded its shelf life is not issued. Any material reaching the end of its shelf life should receive proper engineering analysis with appropriate vendor input to extend its storage life. If storage life cannot be extended, the material should be disposed of and new material ordered. Reordering/restocking programs should incorporate appropriate lead times to ensure sufficient material with good shelf life is available for issuance.

Safety material and equipment should be segregated from non-safety-related material and equipment to prevent inadvertent use of the wrong category of item. If segregation is not practical, marking and tagging techniques should be developed to preclude use of the wrong material or equipment.

A system should be established to ensure the proper storage, segregation, and control of hazardous materials such as chemicals, radioactive/reactive organics, reagents, explosives, flammables/combustibles, corrosives, and pesticides/herbicides; specialty equipment and tools; and general materials, equipment, and tools.

Material and equipment subject to restricted use and distribution such as Safety Class Items, critical spare parts, Bill-of-Material items, certain sealants and compounds, precious metals, etc., should have clearly defined instructions that provide for—

- segregation from normal stock;
- access control;
- unique identification;
- issue only to those on authorized signature lists;
- stock records maintenance; and
- purchase order tracking and ready traceability from design drawing through purchasing, storage, and handling, to installation.

The quality of stored items should be maintained through the selective and judicious application of clearly defined protection and availability controls.

A system for the periodic general inspection of storage areas should exist. Typical storage control observations should verify the following:

- corrosive chemicals are segregated from sensitive equipment and metal items;
- flammables are in proper containers and marked;
- radioactive substances are properly shielded and marked;
- stainless steel and other "pedigree" metals are segregated from other metals (particularly carbon steel);
- motors, pumps, relief valves, and other items are stored on their bases;
- stacking of items, crates, boxes, barrels, etc. does not exceed stacking recommendations;
- packaging and seals have not been violated leaving contents exposed to degradation caused by the intrusion of foreign materials or environmental conditions;
- machined surfaces are left adequately protected;
- applicable insect and rodent controls are in effect;
- applicable shelf-life conditions are in effect;
- carcinogens are segregated from other materials and equipment; and
- reordering/restocking is clearly indicated.

A system should exist that ensures MSDSs are readily accessible to the user.

Policies, procedures, and processes governing the storage and disposal of materials should be verified regularly to ensure compliance with regulatory requirements.

When established, automatic reorder/restock criteria should be implemented. Reorder/restock quantities should be reviewed and adjusted on the basis of lead-time, usage (historical and projected), and value-added or other established criteria.

A shelf-life program should be developed that applies to items stored in warehouses and plants before end use. Shelf-life requirements should be specified for (but not limited to) the following types of items:

- rubber components;
- silicon sealants;
- some paints;
- photosensitive chart paper;
- photographic material;
- some prelubed bearings;
- capacitors;
- resins;
- complete assemblies containing items listed above; and
- chemicals, reagents, and organics.

Certain items, such as electric motors with heaters, may be required to be energized continuously or periodically when stored in an uncontrolled environment.

Heavy equipment such as motors, gearboxes, and other prime-movers should be rotated periodically to maintain a proper coating of lubrication and to prevent bearing or gear-face denting at point of contact.

In addition to the controls of the general storage areas, temperature and humidity controls should be considered for individual item groups. It may also be necessary to change or monitor desiccants or to provide heaters.

Certain items such as gearboxes may be required to be filled with fluid.

It may be necessary to seal or cap components to the extent possible to prevent entry of foreign material, dust, or contaminants. Reinforced packing or barriers between items may be required to prevent damage or prevent mixing of chemicals due to leakage or breakage.

A monthly inspection of storage facilities and items should be performed. Examples of things that should be checked for during these inspections include cleanliness, vermin control, lighting, labeling, flooding, fire protection, safety, and segregation of material, including segregation of reactive chemicals. The inspection should be performed and documented using a checklist that includes criteria appropriate to the inspection. Observed deficiencies should be noted and corrective action addressed before resolution of the checklist. (See Figure 4.10-B for an example of inspection checklist format.)

Items stored in the plant should be placed under the same type of controls used for the storeroom.

A tickler file system, organized by months of the year, is one method that may be used to ensure that specific storage control instructions are followed. The system may be either manual (similar to a card file) or computerized. Specific storage control instructions for individual items should be entered into the tickler file system by designated personnel. These instructions should be entered separately (either as a separate card or computer entry) and put in the appropriate month that the activity is to take place. As a minimum, additional information such as part number, purchase order number, item description, and MSDS identification number should be included. (See Figure 4.10-C for examples.)

Designated personnel should ensure that the particular storage control activities for the month are completed. (This may require assistance from other departments for activities such as rotating motors and functional tests.) Designated personnel also should review the tickler file entries on a monthly basis for upcoming activities (e.g., those within 60 to 90 days) to ensure proper planning and scheduling of assistance from other departments, when necessary. This review would be in addition to the review and completion of storage control instructions for the particular month.

A method should be established that identifies parts or materials that are designated for maintenance activities or modification. Staging, tagging, or other means of designation may be used.

The placement into or the removal of items from stores should be documented promptly so that the stores inventory record accurately reflects the current inventory. The stores record system should also indicate the location of items in the warehouse, stores issue room, or other designated storage areas.

Provisions should be made for minimum/maximum limits for parts, material, and equipment and for prompt reordering when the minimum limit has been reached. These limits should be reviewed periodically (e.g., annually or at the time of each reorder) and adjusted based on usage, maintenance experience, cost, and lead time.

Periodic (e.g., quarterly) general inspections of the stores issue rooms and warehouse areas should be performed. Storage issues that should be looked for during these inspections and addressed, if necessary, include the following:

- corrosive chemicals not segregated (i.e., near equipment and metal stock);
- flammable materials not properly stored;
- radioactive materials not properly stored;
- stainless-steel components not protected from direct contact with other metals, particularly carbon steel;
- relief valves, motors, and other equipment not stored on their bases;

- containers, boxes, and barrels stacked to unreasonable heights and not in accordance with vendor instructions;
- parts, materials, and equipment not repackaged or protective caps not reinstalled to seal items on which previous packaging or protective caps have deteriorated, been damaged, or been lost during storage;
- elastomers and polypropylene parts stored in areas exposed to light;
- machined surfaces not protected;
- equipment intervals not protected from intrusion of foreign materials; and
- proper rodent control to protect material and equipment in storage area not established.

4.10.3.4 Retrieval and Issuance

Parts, materials, or equipment removed from storage should receive the same care they received when placed into storage (see Section 4.10.3.2). A method should be established to control parts, materials, and equipment after issuance to ensure use in the correct application and to maintain the necessary traceability.[74, 115, 117]

All receipt documents and inspections should be satisfactorily completed before an item is issued. For items such as safety and environmentally qualified spare materials and parts, proper documentation should be retained to ensure traceability.

A system should exist to ensure that items are identified and stored to facilitate ready retrieval upon approved request.

Items should be selectively and judiciously controlled, on the basis of their risk to safety and/or importance to reliable operations, during the interval between stores issue and installation to ensure intended traceability and/or integrity is not violated before installation.

The appropriate control documents should clearly indicate that safety-class items, safety-significant SSCs, and other controlled items are to be issued ONLY to individuals on authorized requester lists.
Issuance documentation should be handled as quality records.

A system should exist that provides for current storage inventory status information to be maintained, to be made available to, and to be usable by authorized individuals upon request.

The following information should be included on storage inventory lists:

- stores catalog number;
- noun name;
- manufacturer/vendor part number;
- application and contact for controlled item disposition;

- reorder criteria, when applicable;
- quantity on-hand;
- MSDS information; and
- any special considerations for configuration managed items.

A catalog of parts, materials, and equipment should be developed, allowing facility personnel to check what is available for issuance. This catalog should provide a cross-reference listing that contains such information as manufacturer part number, facility part number, name, and component or system for which a part is used. This catalog could assist in more efficient planning and execution of maintenance activities.

4.10.4 Materials Management Performance Objectives [1, 22, 23]

Materials management should ensure that necessary parts and materials meeting quality and/or design requirements are available when needed.

CRITERIA

A. Programs are implemented to order, receive, and issue proper parts and materials for work activities. Stock levels are adjusted, as necessary, to meet facility needs.

B. Procurement documents provide clear and adequate technical and QA requirements consistent with design specifications. Areas such as storage, PM, and shelf-life requirements are addressed. Proper engineering control and approval are obtained on any deviation from design specifications for parts or materials.

C. Mechanisms are in place to provide for the expeditious procurement of parts and material on a high priority basis when needed.

D. Methods are established to acquire replacement parts not available from the original supplier.

E. Material is inspected to ensure conformance to purchasing requirements before release for use and storage. Documentation for received material is accounted for and retrievable. Nonconforming items are identified and controlled to prevent unauthorized use.

F. Effective material procurement status is provided including accurate stock records, tracking of purchase orders, and maintaining traceability of safety-related parts and material.

G. Materials are stored and identified in a manner that results in timely retrieval.

H. Safety-related parts and components are properly controlled, segregated, and identified in all material storage areas.

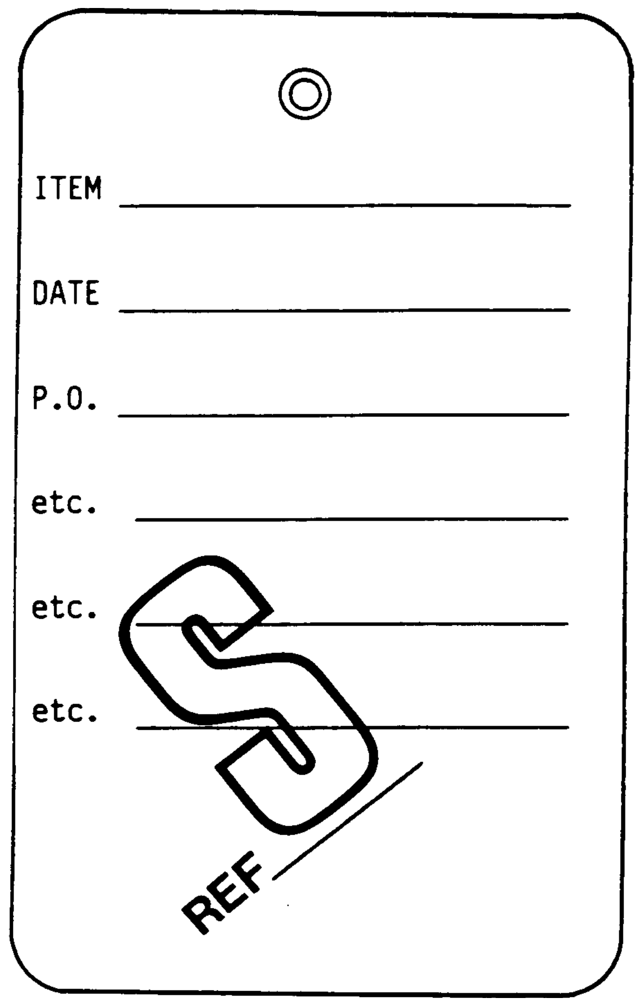
I. The quality of stored equipment, parts, and materials is maintained by appropriate means such as environmental and shelf-life controls, and PM.

J. Parts and materials issued for installation are properly controlled. Unused parts and materials are promptly returned to a controlled storage area. Safety-related parts are readily traceable from purchase to installation.

K. Flammable and hazardous materials are identified, segregated, and properly controlled during receipt inspection, storage, and issue.

L. Equipment and materials used by nonfacility personnel are subject to inspection, storage, and issuance controls equivalent to items received through normal facility processes.

M. Lessons learned from experience, such as lead times, parts usage, and supplier reliability, are factored into materials management.



If storage controls are necessary, the "acceptance" tag may be stamped "S" with a transparent colored stamp.

Figure 4.10-A. Example Acceptance Tag.

OUTSIDE WAREHOUSE			
Inspector Initials/ Date	**Inspection Criteria**	**Comments and Deficiencies**	**Corrective Action Completed; Initial/Date**
JB 3/9/82	1. FLOODING. Ensure water has not entered storage areas and caused damage.	OK	
JB 3/9/82	2. FIRE SPRINKLERS. Ensure storage of items does not reduce the effectiveness of the fire sprinklers.	OK	
JB 3/9/82	3. DISTORTION OF ITEMS. Ensure that items are not damaged or distorted because of crowding or excessive weight.	Insulation damaged because of new desks.	Moved Desks JB 3/15/82

Additional Criteria to Consider

- Cleanliness
- Safety hazards
- Fire extinguishers
- Vermin control
- Leaking roofs
- Climate controls
- Locks in place
- Temperature controls
- Protective covers
- Tags in place
- Corrosion
- Adequate room
- Colored wire protected from sunlight
- Dust and dirt
- Lifting equipment in proper operation
- Tickler file complete

Figure 4.10-B. Example Inspection Checklist.

COMPUTERIZED METHOD				
Month/ Task No. for Month	**P.O. No.**	**Part No.**	**Description**	**Task**
6-20	Q 207	EZ 12	F. D. Cylinder	Check gas pressure greater than 1000 psi every 6 months
6-27	Q 312	OH 17	R. H. Motor	Rotate Shaft XX degrees every 6 months
9-13	Q 12	Z-30	F. T. Gasket	Shelf life expires September 1989
12-2	Q 312	OH 17	R. H. Motor	Rotate Shaft XX degrees every 6 months
NOTE: Computer printout may be used as a check-off and filed with records with comments.				

Figure 4.10-C. Examples of Tickler File Information.

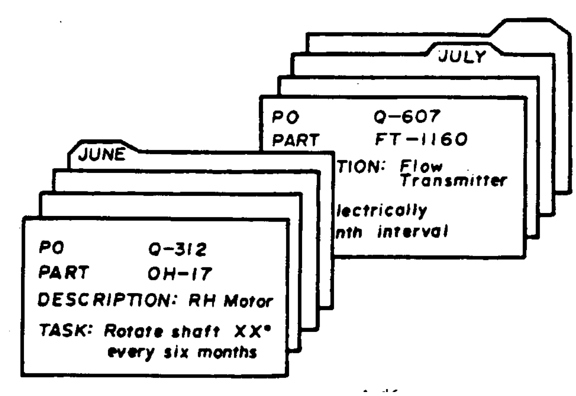


Figure 4.10-D. Example tickler cards for manual card file system. Card file should be organized by month. Appropriate personnel should check for tasks that are due for the particular month and in the next several months.

4.11 CONTROL AND CALIBRATION OF MEASURING AND TEST EQUIPMENT (Replaces DOE-STD-1054-93)[1, 104]

4.11.1 Introduction

The program for control and calibration of M&TE should be consistent with QA requirements of 10 CFR 830, Subpart A, and should ensure the accurate performance of facility instrumentation and equipment for testing, calibration, and repair [see 10 CFR 830.122(h)].[1] M&TE devices include all tools, gauges, instruments, devices, or systems used to inspect, test, calibrate, measure, or troubleshoot to control or acquire data for verifying the conformance of an instrument or piece of equipment to specified requirements. M&TE devices do not include permanently installed facility process or control instrumentation, nor does the category include test equipment used for preliminary checks where data obtained will not be used to determine acceptability or verify conformance to established criteria.

The M&TE selected for use should have the precision necessary to ensure that facility instrumentation and equipment will operate within design accuracy requirements and be durable enough for their intended applications. Control and calibration requirements for M&TE apply to both onsite and offsite calibration facilities and nonnuclear facility contractor or subcontractor groups that are engaged in maintenance activities.

This section describes the policies, actions, and records that form the basis of an effective M&TE control and calibration program.

4.11.2 Discussion

The control and calibration of M&TE used on safety-class items, safety-related SSCs, or SSCs that affect critical facility performance and reliability play an important role in maintenance and the safe operation of DOE nuclear facilities. Ensuring that properly calibrated measuring, tooling and test equipment performs as intended is essential to a comprehensive maintenance program, and is an important factor in enabling facilities to move from corrective maintenance to effective PM. A computer based system should be considered as necessary for the establishment of an M&TE program to allow for frequent updates of M&TE status and permit personnel access to current information as quickly as possible.

Operators depend on installed facility instrumentation for accurate indications, process control actions, and trip functions to operate the facility safely and reliably. The accuracy of the installed instrumentation is established and maintained through the M&TE control and calibration program. Such a comprehensive M&TE program should include the following elements.

- Unique identification numbers on all M&TE that accurately identify the specific devices and provide traceability.
- A current MEL identifying all M&TE.

- Calibration standards that are traceable to a national standard or that themselves are recognized as standards.
- Procedures for calibrating M&TE to help control the performance of calibration and to provide repeatable calibrations and acceptance criteria.
- Establishment of a calibration frequency that helps maintain M&TE accuracy and availability.
- Provision for checking the function of M&TE, when applicable.
- Provision of facilities to control storage, issue, and calibration of M&TE.
- Segregation and marking of M&TE devices with suspected or actual deficiencies to prohibit their use.
- Clear marking to indicate limitations of M&TE devices that are not fully calibrated or usable.
- Records for accountability and traceability of use. A recall system should be developed for recalibrations.
- A maintenance policy that minimizes contamination of M&TE.
- Timely evaluations of M&TE devices found out of calibration or defective to determine the validity of all measurements and/or calibrations for which they were used.
- Trending of M&TE reliability problems to determine if any corrective actions are needed.
- Periodic reviews to determine whether the control of M&TE is effective.

This section establishes guidance for a process to ensure that M&TE is properly controlled, calibrated, and certified with standards for calibration and certification. The certification data should be traceable to the National Institute of Standards and Technology (NIST) or analysis and design calculations should be performed to verify design and/or predict performance during a design effort (i.e., during the preconceptual activities, or to verify that evolving designs meet specified requirements).

4.11.3 Guidelines

4.11.3.1 Procurement

Copies of technical manuals with full schematics, troubleshooting sections, spare parts lists, tables of specifications, and calibration procedures should be obtained with each type of equipment. A certificate of calibration and tolerance should be included. Distribution of these manuals should be in accordance with document control procedures. Training aids furnished by manufacturers may be desirable for certain types of equipment, as determined by the M&TE requestor. Equipment selected should be the proper range, accuracy, and precision. Also, where practical, the equipment selected should be a type that minimizes the possibility of human error (e.g., direct digit readout, large mirror scale, null indicators, and direct temperature readout).

4.11.3.1.1 Receipt Inspection and Acceptance Test

Before acceptance, a receipt inspection and test should be conducted in accordance with Section 4.10 and applicable facility policies and procedures.

4.11.3.2 Identification

Each piece of M&TE should be assigned a unique identification number that is permanently marked on or attached to it (the identification number may consist of the manufacturer’s serial number). These numbers assist in identifying, tracing, and controlling M&TE. An MEL of all controlled M&TE should be maintained. If separate organizations control their own M&TE, each should maintain or have access to a list of its own equipment. Equipment lists should include the following at a minimum:

- generic description, trade or marketing name, manufacturer, model, and serial number;
- unique identification number;
- range(s) and accuracy;
- calibration procedure;
- calibration frequency;
- calibration interval;
- expiration date;
- date of last calibration;
- systems/stations number (this identifies a specific document which establishes parameters, range, precision, accuracy and other requirements for application of the individual item listed);
- responsible organization or person; and
- normal storage location(s).

4.11.3.2.1 Tagging

A calibration sticker should be attached to each M&TE device. This sticker should indicate (1) date calibration performed (month/day/year); (2) badge number of the individual who calibrated the device; and (3) expiration date (month/day/year). The expiration date is determined from the interval and the date last calibrated. The calibration sticker should be removed and replaced with a new sticker each time the equipment is calibrated.

A “restricted use” sticker should be placed on any equipment requiring special restrictions or precautions in its use. This sticker should be attached in addition to the calibration sticker and should include (1) equipment identification number, (2) a statement of the restrictions that apply, (3) badge number of the individual attaching the sticker, and expiration date, if applicable, and (4) the date the sticker is attached.

A "rejected" sticker should be placed on any equipment that fails to meet acceptance criteria or is suspected of being defective. This sticker should include (1) device identification number, (2) reason for rejection, (3) badge number of the individual attaching the sticker. A rejected sticker may also be used to identify devices that are not to be used due to the device exceeding the calibration due date.

4.11.3.3 Records

A maintenance history file should be kept for all M&TE. This file should include the following, as appropriate:

- manufacturers' data, including model serial numbers;
- facility-unique identification number;
- calibration interval and specifications;
- history of calibrations, repairs, restrictions on use, and other appropriate data;
- calibration nonconformance evaluations (Section 4.4.3.4);
- usage record; and
- nonscheduled actions.

Records for lost, destroyed, unavailable, or removed-from-use M&TE should be maintained in the history file.

Manufacturers' information manuals and supplemental bulletins should be filed in accordance with document control procedures.

4.11.3.4 Calibration

4.11.3.4.1. Calibration Standards

Only calibration standards traceable to NIST or other nationally recognized standards organizations should be used for calibration of M&TE. M&TE should be calibrated using reference standards (secondary or working) whose calibration has a known valid relationship to nationally recognized standards or accepted values of natural physical constants. If national standards do not exist, the basis for calibration should be documented. The reference standard used should have an accuracy at least four times greater than the device under test. If this accuracy ratio cannot be met, analysis of the errors should be estimated to provide a valid uncertainty of the calibration process. If repair or calibration of a standard is necessary, the recalibration must be traceable to NIST or to the standard of record for the M&TE. Calibration standards maintained at the facility should be kept in calibration facilities in designated storage locations. If calibration standards are issued for field use, the supervisor responsible for them should authorize and minimize the period of issuance. Issuance of laboratory standards for field use should be discouraged. Standards should be calibrated on a frequency consistent with vendor recommendations and facility experience. Calibration records for standards should be consistent with those of all other M&TE.

4.11.3.4.2 Calibration Procedures

Calibration of equipment should be performed by qualified technicians using approved procedures. (Note: The “ratio of accuracy” of the standard to the M&TE being calibrated should be as high as reasonably achievable and consistent with national standards.) These procedures should be written as described in Section 4.5 and should contain the following.

- Precautions or limitations.
- Calibration standards to be used and their accuracy.
- Calibration instructions and data sheets for as-found and as-left data.
- Acceptance criteria for each scale, expressed as a range and in the units that are being measured (e.g., represent 9.75 volts as 9.726-9.774 volts rather than as 9.75 volts ± 0.25 percent). Acceptance criteria should be rounded up on the - side and down on the + side to be within the range of accuracy of the instrument being read.

4.11.3.4.3 Calibration Frequency

Frequency of calibration should be determined based on the manufacturers’ recommendations, M&TE usage, and M&TE historical reliability. Consideration should be given to the amount and type of M&TE available for use compared with that needed to support periods of peak activity such as outages. This information can help determine calibration frequency and schedule requirements that result in adequate M&TE support for facility needs.

4.11.3.4.4 Measuring and Test Equipment Calibration Schedule and Interval

The standards laboratory, in conjunction with each department manager responsible for M&TE, should establish and maintain a calibration schedule for the M&TE (including primary, secondary, and working standards. Specific items may be calibrated on a prior-to-use basis rather than on a periodic basis. These devices should be controlled as specified in Sections 4.11.3.1 and 4.11.3.2.

The schedule should normally be divided by application departments. The M&TE assigned to a department should be listed in calibration due date order by the unique identification number (Section 4.11.3.2) and noun name. Calibration dates for similar M&TE should be staggered to ensure availability for day-to-day and peak needs. The established scheduling organization should normally update and distribute the schedule to the responsible department managers on a quarterly basis. Department managers should ensure that M&TE under their cognizance is calibrated in accordance with the master schedule.

The calibration intervals for M&TE should be established by the cognizant department managers. The initial interval should be based on the inherent stability characteristics of the device, the rate/level and purpose of expected use, manufacturer’s recommendation, and historical data for similar equipment. Calibration intervals may be revised, based on a review of previous calibration results and maintenance history. Revision of calibration intervals should require the approval of the cognizant department manager. Revisions should be documented on the Calibration Interval Change Authorization form which should be filed in the maintenance history.

4.11.3.4.5 Calibrating Measuring and Test Equipment On-Site

All M&TE on-site calibration should be done using facility-approved procedures. These procedures should include the following items:

- identity and exact location of the equipment to be calibrated;
- calibration equipment and reference standards to be used;
- precautions and limitations;
- checks, tests, measurements, acceptance tolerances, accuracy, precision, range, and specific parameters;
- step-by-step instructions regarding sequence, methods, data sheet completion details, etc. (including as-found and as-left conditions); and
- special instructions, such as environmental conditions, when appropriate.

The reference standard used should have an accuracy at least four times greater than the device under test. If this accuracy ratio cannot be met, analysis of the errors should be estimated to provide a valid uncertainty of the calibration process.

M&TE calibration data sheets should include provisions for recording as-found data before any adjustments or repairs are made. Completed data sheets should be reviewed, by the standards laboratory supervisor, before release of the equipment to service to verify that acceptance criteria are satisfied. When M&TE is found to be out of calibration (gross error), an evaluation should be performed as described in Section 4.11.3.6. Completed data sheets should be filed with the maintenance history.

4.11.3.4.6 Calibrating Measuring and Test Equipment Off Site

M&TE may be calibrated by off-site organizations that have been approved in accordance with on-site QA department procedures. Purchase orders or calibration requests to these organizations should reference or include the following information:

- tolerance requirements;
- calibration test data requirements;
- any special environmental, handling, and shipping requirements (see Section 4.11.3.5); and
- calibration data to be supplied with the calibrated equipment.

The off-site organization should also be required to provide immediate verbal notification if the as-found data for an M&TE device does not meet specified acceptance criteria. This notification is necessary to ensure that the evaluation required by Section 4.11.3.6 is initiated as soon as possible.

Upon return of the M&TE, the standards laboratory supervisor should ensure that the calibration data submitted is reviewed and an appropriate calibration sticker is attached.

4.11.3.4.7 Measuring and Test Equipment Repairs/Out of Calibration

M&TE found to exceed required calibration tolerance or that has been subjected to possible damage should be identified as rejected. When repairs are required to standards or other M&TE, they should be recalibrated to the original requirements before being returned to normal service. When calibration/certification is performed, the as-found condition and/or minor adjustments to the M&TE should be noted as part of the equipment history information.

When M&TE is suspected or actually found to be inoperable, unreliable, defective, or out of calibration, all data recorded since the previous calibration by affected equipment should be identified through the usage record described in Section 4.11.3.6. A prompt evaluation should be performed to determine the need for corrective action. This evaluation should be documented on a Gross Error Report. The appropriate owner/operator of the affected equipment should evaluate the validity of all applications and data derived since the previous calibration, determine their disposition, and establish the nature and timing of corrective actions, if necessary.

4.11.3.4.8 Functional Checks

When operational tests, functional checks, or battery checks of M&TE are performed, the desired response or acceptance criteria should be clearly specified or indicated on the equipment. These types of checks are intended to detect M&TE problems before and after an instrument is used in the field; they are not substitutes for calibration checks.

4.11.3.5 Control

The control process used for M&TE should be a well established recall program containing total inventory listing, weekly calibration due notices, individual automatic job opener and information cards, weekly calibration overdue notices, exception report for program errors, and scheduled and nonscheduled action history reporting.

Maintenance personnel should not use any standards not authorized by the accountable supervisors and then only under controlled conditions and time limitations.

The application readiness of M&TE should be regularly verified by applicable testing; where applicable, battery checks should be performed and pass/fail criteria for each item should be clearly indicated on each instrument. These readiness checks should not be a substitute for calibration activities.

Special-,limited-, or restricted-use M&TE should be clearly identified to describe its applicability.

M&TE integrity should be maintained during handling and shipping. Packaging for shipment to the standards laboratory should not conceal or destroy existing conditions of equipment. Packaging after calibration and certification should be in a manner that does not jeopardize equipment.

M&TE should be traceable from the field application to working standards, secondary standards, primary standards, and NIST or other nationally recognized standards. All calibration data should have both forward and reverse traceability between the specific item and NIST.

Storage. Department M&TE storage areas should be authorized by the maintenance manager. All equipment should be stored in a manner that assures integrity is maintained and unintended contamination is minimized. Equipment in these storage areas should be identified as to its current status, per Section 4.11.3.2.1 of this Guide. The M&TE storage areas should provide sufficient separation of the ready-to-use equipment (calibrated and restricted use) from other equipment (expired) to preclude inadvertent use.

The environment of M&TE storage areas should be controlled to preclude any adverse effect on equipment accuracy. Environmental factors that should be considered include, but are not limited to, temperature, humidity, vibration, radio frequency interference, electromagnetic interference, and fumes.

Security of the M&TE storage area should be maintained by designated individuals responsible for control of M&TE. In the absence of these individuals, the storage area should be locked with access controlled by the responsible department manager and/or supervisor.

Instruments used on systems that contain oil, brackish water, etc., should be cleaned thoroughly after each use.

As discussed in Section 4.3, proper facilities are needed to help ensure equipment is protected from damage in storage, is properly maintained, and is readily retrievable. M&TE devices that are relatively easy to damage during transport and handling should be provided more protection by being boxed or by being mounted in special rigs (e.g., test gauges mounted in portable frames). M&TE in the issue area should be in an area segregated from M&TE that is defective, out of calibration, or that requires investigation, ensuring that only calibrated M&TE is available for issuance. This should be a physically and distinctively marked separation.

Uncalibrated Measuring and Test Equipment. New M&TE devices should be calibrated before they are used to verify they meet acceptance criteria, are functional, and are safe to use.

Uncalibrated test equipment used only for troubleshooting should be clearly marked so that it is not used as M&TE for taking data. Test equipment used only for troubleshooting does not need to be fully calibrated, but it should be periodically checked for operability and safety. For example, a volt/ohmmeter might be checked for operability every 6 months.

Measuring and Test Equipment with Limited Use. M&TE devices that have special uses, limitations, or restrictions should be clearly labeled to describe these characteristics. The following are examples of information that should be reflected on M&TE tags or labels:

- scales or ranges that are inaccurate or inoperative, including some indication of the amount of inaccuracy;
- calibrations that do not include the full indicating range;
- internal radioactive contamination; and
- limited or restricted use such as oil, oxygen, saltwater, or demineralized water systems.

Department M&TE storage areas should be authorized by the maintenance manager. All equipment should be stored in a manner that assures integrity is maintained and unintended contamination is minimized. Equipment in these storage areas should be identified as to its current status, per Section 4.11.3.2.1 of this Guide. The M&TE storage areas should provide sufficient separation of the ready-to-use equipment (calibrated and restricted use) from other equipment (expired) to preclude inadvertent use.

The environment of M&TE storage areas should be controlled to preclude any adverse effect on equipment accuracy. Environmental factors that should be considered include, but are not limited to, temperature, humidity, vibration, radio frequency interference, electromagnetic interference, and fumes.

Security of the M&TE storage area should be maintained by designated individuals responsible for control of M&TE. In the absence of these individuals, the storage area should be locked with access controlled by the responsible department manager and/or supervisor.

Instruments used on systems that contain oil, brackish water, etc., should be cleaned thoroughly after each use.

Issuance and Recall. One or more controlled issue points should be provided to help ensure that only qualified persons are allowed access to M&TE. Traceability of M&TE should be provided to support a timely evaluation of instruments, systems, and other equipment associated with deficient M&TE. This can be accomplished by recording the M&TE user, when the equipment was used, what instrument or equipment it was used on and for what purpose (typically by referencing maintenance request or procedure number), and what ranges were used or values read. Maintenance history that can be readily sorted by specific M&TE used to perform maintenance is an alternative method for providing traceability.

A recall system should be implemented to ensure that M&TE devices are removed from service before or at expiration of their calibration. This recall system can be enhanced by the use of calibration stickers on each M&TE device. If used, such a sticker should be attached to the M&TE device, designating, at a minimum, the date recalibration is due. This information is normally needed for work documentation; calibration stickers, therefore, provide a convenient method for users to obtain this information and ensure that the M&TE is currently calibrated.

The recall system should stagger calibration due dates to meet M&TE needs for peak-use periods such as outages, as well as for day-to-day use.

Contaminated Measuring and Test Equipment. Equipment subject to contamination should be packaged and used in a manner that minimizes the possibility of external and internal contamination (e.g., being wrapped in clear plastic, being taped, and being isolated). This should be emphasized as part of the OJT program addressed in Section 4.2.3.4. These practices can help minimize the spread of contamination and the amount of M&TE kept only for use on contaminated systems and equipment. In addition, consideration should be given to establishing an area for storing and calibrating contaminated M&TE.

4.11.3.6 Evaluation

Out-of-Calibration and Defective Measuring and Test Equipment. When an M&TE device is found to be or suspected to be out of calibration, defective, or otherwise unreliable, an evaluation of the instruments and equipment it has measured or tested since it was last calibrated should be performed promptly to determine whether recalibration or rework is needed. Also, records of the field instruments calibrated by the M&TE should be reviewed to determine whether recalibration is necessary. M&TE devices in this status should be controlled as discussed in Section 4.11.3.3.

Performance Trending. Results of M&TE calibrations should be trended, and corrective actions should be determined for any M&TE reliability problems. This predictive maintenance technique can identify needed corrections or changes to the M&TE program, such as adding or deleting M&TE devices, adjusting calibration frequencies, correcting procedures, or upgrading M&TE quality.

4.12 MAINTENANCE TOOLS AND EQUIPMENT CONTROL (Replaces DOE-STD-1069-94)[113]

4.12.1 Introduction

Methods should be provided for storage, issuance, and maintenance of an adequate and readily available supply of tools and equipment and also for the development of special tools and equipment needed in the maintenance program.

This section is intended to assist facility maintenance organizations in the review of existing methods and in developing new methods for establishing maintenance tool and equipment control for all areas of the facility, including RAs. Tools and equipment of the proper type, quality, and quantity should be available for issue and use when needed by the maintenance craftspersons. Adequate tool and equipment control in the facility contributes to worker efficiency, and it also is needed to limit the number of tools introduced into potentially contaminated areas, to minimize the spread of radioactive contamination, and to reduce volumes of solid radioactive wastes. A dedicated supply of tools and equipment should be established for exclusive use within the facility’s RAs. A controlled supply of tools and equipment should be provided to ensure that an adequate quantity is available to avoid delays in maintenance work activities. Good tool control should minimize the risks of (1) personnel contaminations and (2) the inadvertent release to RAs of such potentially contaminated items. Personnel accountability is essential to an effective tool and equipment control program.

An adequate decontamination facility is needed to enable the facility to reuse a wide variety of contaminated tools and equipment and to minimize replacement expenditures. A versatile decontamination facility and program should be used to reduce levels of removable and fixed radioactive contamination on the surface of controlled tools and equipment. Decontamination of tools and equipment also should be used to minimize the contribution of contaminated tools and equipment to solid radioactive waste volumes.

This section addresses considerations for an effective control program for tools and equipment.

4.12.2 Discussion

A program for storing, issuing, and maintaining tools and equipment is needed to accomplish maintenance activities effectively and efficiently. The process of providing tools and equipment should include proper storage and issuance controls. Crafts persons should be readily able to obtain the tools and equipment they need to perform maintenance and then return them as soon as practicable after completing the work. Tools and equipment should be kept in a state of readiness, some by inclusion in the PM program. Proper PM can also result in improved personnel safety and extended life of tools and equipment.

A system should exist which provides for tool and equipment control within the maintenance organization. This system should include (1) unique identification of controlled items and (2) documentation of their issue and return. Also, the system should provide for storing, issuing, and maintaining tools and equipment in a manner so as to enhance efficient and effective maintenance activities.

Crafts persons should be provided an initial issue of tools of the trade for day-to-day use. On the basis of need, special tools should be drawn from controlled storage and returned as soon as reasonable after completion of the task.

All worn or damaged tools should be repaired or replaced. Tools should be regularly inspected and serviced, on the basis of recall program controls, to ensure they—

- remain safe to use,
- are in a high state of readiness for use, and
- do not prematurely require replacement.

The process should provide the supervisor with opportunities to exercise an active role in encouraging individual innovation when new and/or special tool and equipment needs exist.

A program for the development of new or special tools and equipment should specify formal criteria covering safety, identification, availability for future use, and cost-effectiveness. Supervisors should have an active role in identifying and approving tool and equipment improvements that make maintenance more effective and efficient. These improvements can result in improved safety for personnel and equipment, improved work quality, and improved facility reliability.

4.12.3 Guidelines

4.12.3.1 Storage and Issuance [1]

The maintenance organization should assign responsibility for the proper storage and issuance of both stationary and portable tools and equipment. Permanent issuance of tools to individuals or groups of crafts persons who use them daily and who are responsible for maintaining them contributes to worker efficiency. Tools and equipment used less often should be available on an as-needed basis. For these, proper storage facilities should be central to shops and normal work areas and should be readily accessible to crafts persons to promote efficiency. Controls, such as sign-out sheets and tool crib attendants, should be used in tool storage areas to provide accountability for and availability of tools. A policy should be established for the storage, issuance, decontamination, and reuse of contaminated tools and equipment.

Worn, defective, or otherwise unusable tools should be segregated so that only safe, usable tools are available. Unrepairable tools should be disposed of in a timely manner.

Special tools and equipment are sometimes obtained temporarily from other sources, such as a vendor or contractor. A method should exist to identify availability of and sources for these special tools and equipment so that they can be obtained and made ready for use when needed. When these special tools and equipment are at the facility, they should be controlled in the same manner as other tools and equipment.

Policies governing the control of tools and equipment should be clearly established. Policies and procedures should emphasize personnel accountability and item traceability. These policies should address all aspects of tool control including inventory, issue, tracking, use, and return.

An inventory system should be established for tools and equipment. This inventory should be computer-based, compatible with existing facility inventory systems, and adaptable to daily supply changes.

A computer-based issuance and tracking system should be established, using a bar-code identification attached to tools or to containers of equipment. Permanent laser-affixed codes should be used where possible to prevent inadvertent loss of identification. Items should be marked where possible with a unique identification number, to provide a specific tracking mechanism. Preinventoried containers of tools and equipment may be identified as single units if the contents are inventoried and restored after use.

All facility departments and contractors should be required to obtain tools and equipment for use in potentially contaminated RAs from the contaminated-tool storage areas.

The return of tools should be tracked against the expected return dates. Tool and equipment use should be recorded to establish use patterns and needed inventory quantities. The computer-based inventory system should be utilized to track the number and flow of stocked items used within the RA. When items are not returned, the user should be made to account for them.

Tools and equipment should be returned to their sources immediately upon completion of use. All issued tools and equipment should immediately undergo operability and radiological evaluations.

Worn, defective, or otherwise unusable tools should be removed from work areas as soon as possible, to prevent inadvertent use.

The replenishment of tool supplies should be performed only by the responsible coordinating department on the basis of past usage and expected needs. The uncontrolled introduction into the RA of tools and equipment, should be prohibited.

Tools and equipment that need inspection, calibration, or refurbishment by personnel in specific work groups or by vendors may require shipment to special locations elsewhere on site or off site. When those transfers are necessary, the control coordinator should have records of location and status.

Perform an inventory of all maintenance tools and equipment (1) at least annually and (2) after major planned outages. The quantities of tools and equipment should be compared to previous inventories and significant changes investigated. The inventory list should include equipment items such as chain falls, lifting rigs, and scaffolding, as well as all tools. This inventory should be maintained by a single organization which is also responsible for the storage, issuance, and control of tools and equipment.

The following items, as a minimum, should be addressed in the storage-and- issuance process.

- Both potentially contaminated and contaminated items should remain within the RA until verified by the appropriate authority to be clean and safe to remove.
- A job-planning process goal should be to ensure that the proper items are available in the quantities required to support scheduled maintenance requirements.
- Instrument/motor/pump pools should maintain a supply of critical items for designated applications.
- Reuse of repaired items should be encouraged on the basis of maintaining them in a high state of clean, safe, and reliable readiness.

- Specialty tools should be identified and stored for ready retrieval.
- Unusable items should be segregated from normal items for dispositioning and to prevent inadvertent issue for use.
- Instructions should be developed to define responsibility and accountability for the proper storage and issuance of controlled items.
- The system should provide for storage areas that segregate items to prevent cross-contamination or wrong selection for issue.
- The system should provide for designating and controlling storage, laydown, and staging areas.
- A method should be established which provides for inventory listings of specialty and controlled tools and equipment and which may be used to communicate applicable information to potential users.

4.12.3.2 Tool and Equipment Maintenance

Maintenance tools and other support equipment should be included in the PM program (see Section 4.4). Inclusion in the PM program enhances the availability and reliability of equipment such as cranes, portable lifting and rigging equipment, welding machines, weld rod ovens, shop machinery, and M&TE.

Worn, defective, or otherwise unusable tools should be segregated so that only safe, usable tools are available. Unrepairable tools should be disposed of in a timely manner.

Maintenance tools and other support equipment should be evaluated for inclusion in the PM program (see Section 4.4). Inclusion in the PM program should enhance the availability and reliability of equipment such as cranes, portable lifting and rigging equipment, welding machines, welding rod ovens, shop machinery, and M&TE.

The following items, as a minimum, should be included in the tool and equipment maintenance process.

- Regular-issue hand tools should be checked by the user to ensure safe, reliable use.
- A recall system should be established for the periodic inspection of welding, lifting, hoisting, and rigging equipment, as well as for safety devices and personnel safety equipment. The recall system should also provide for scheduled equipment and tool inspection (including some portable hand tools such as electrical drill motors) on the basis of risk to safety and importance to reliable use.
- When worn or defective items are identified, a method should be established to remove them from service and to segregate them from normal items to prevent unsafe use.

- Unrepairable tools and equipment should be disposed of as soon as practical.

- The system should provide for repair/replace decisions based upon established guidelines for worn/damaged/defective tools and equipment.

- Instructions should be developed which define responsibilities regarding deficiency-tagged equipment (see Section 4.13).[116]

4.12.3.3 Use of Special Tools and Equipment

Special tools, test rigs, special equipment, lifting and rigging equipment, and mockups should be suitable for their intended use and properly identified. To improve tool and equipment use and enhance job performance and efficiency, instructions should be provided for their use, especially for high-hazard or high-stress tasks. Maintenance supervisors should review proposed designs for special tools and equipment to determine cost justification, effectiveness, safety considerations, and the need for reviews by other organizations. These tools should be stored and controlled in accordance with the guidance provided above.

Specific instructions should be provided to control the use of lifting and rigging equipment. Subjects such as the following should be included in the instructions:

- locations where rigging equipment can be safely attached (e.g., pipes, beams, and structures) and the load limits for each;
- allowable lifting limits for different types of loads;
- safe load paths; and
- training and qualification requirements for craft personnel using lifting and rigging equipment.

Instructions should be provided for the use of special tools, test rigs, equipment, lifting and rigging equipment, welding equipment, safety devices, personnel protective equipment, and mock-ups. These instructions should be written so as to improve tool and equipment use and enhance job performance and efficiency. Maintenance supervisors should review proposed special tool and equipment designs to determine cost justification, effectiveness, safety considerations, and the need for reviews by other departments. These tools should be stored and controlled in accordance with the direction provided in this guideline.

Applicable training facilities and equipment (including simulators and mock-ups) should be provided, where warranted, to perform needed training in an environment and under conditions expected during normal use. Performance-based training and applicable licensing, when required, should be provided before authorized use of the following:

- cranes and hoists;
- forklifts, man-lifts, Verti-Lifts;

- vehicles;
- heavy equipment;
- welding equipment; and
- new technology and/or specialty items that require verified skill for safe, effective operation.

Written instructions should be provided for tools and equipment items when considered important to personnel safety and to encourage continued proper use through improved first-effort performance/efficiency/confidence by the user.[68, 69]

4.12.3.4 Tools and Equipment in Radiological Areas [2, 3, 42, 115]

An adequate supply of tools and equipment dedicated for exclusive use in RAs should minimize the number of unnecessarily contaminated tools used to perform work within the RA. The control of these tools, including issuance, decontamination, inventory, and repair, should be assigned to a single facility department manager, such as the Maintenance or Radioactive Materials Controls Department Manager. Although it may not be practical to store the total inventory of potentially contaminated tools in a single location, all satellite locations of RA tools and equipment should be under the control of the same facility department.

A sufficient supply of RA tools and equipment should be established for routine maintenance needs to prevent introduction of additional noncontaminated items. The input and the cooperation of all maintenance work groups are required during maintenance planning to determine the types and numbers of tools and equipment needed. Input should be obtained from maintenance, operations, planning, engineering, radiological protection, and contractor groups. The initiation of an RA tools and equipment supply system may require a major one-time input of nonradioactive tools from other tool control areas or from facility stores.

All RA tools and equipment should be stored in designated contaminated-tool control storage areas. Positive controls over all contaminated-tool storage areas should be provided, including checking items out and in and continually staffing each tool control storage area during periods of heavy demand. Locked storage, however, should be the minimum acceptable positive control for tool storage areas during low-demand periods. The use of temporary tool storage areas and mobile cabinets should be planned as an effective method for supporting work at specific locations during maintenance activities. The program should ensure facility control over the issue and inventory of RA tools and equipment.

Introduction into the RA of highly specialized tools previously used in other facility's RAs should be controlled. Allow access only when approved by the radiological protection manager or designee. Since these specialized items may contain radioactive contamination (including hot particles), thorough radiological surveys should be conducted before introducing items into the RA.

If required, tools and equipment should be forwarded for decontamination or repair before restocking for further use. Criteria should be established to control whether tools are returned to tool storage areas, decontamination facilities, or field attendants, depending on the radiological conditions of the job. Field attendants, for example, should be assigned to accept used tools from highly contaminated radiological work areas during major maintenance activities.

Control all RA tools and equipment as radioactive material. Controlling these items as radioactive material serves to make workers aware of the potential hazard associated with the use of these tools and to assist the facility in properly retaining each item within the RA. The following controls should be incorporated.

- Handle potentially contaminated tools and equipment in accordance with applicable facility procedures.

- Mark or label each potentially contaminated item as radioactive material. Small hand tools and minor equipment should be uniquely identified by permanent marking to clearly distinguish them from similar items intended for non-RAs of the facility.

- Label or mark all containers of temporarily stored RA tools and equipment such as barrels, toolboxes, “gang” boxes, crates, etc., as radioactive material, along with the identity of the contents, the levels of radioactive contamination, and the radiation dose rates, in accordance with applicable facility procedures.

- Designate storage areas for highly radioactive tools and equipment which may cause high-radiation areas. These areas may need to be shielded and locked and should be as remote as possible from traffic areas. High-radiation areas should be controlled as specified in applicable facility procedures.

When necessary to remove tools and equipment from the RA, adequate facility decontamination facilities are necessary to ensure that all tools and equipment are decontaminated and released in accordance with applicable facility procedures.

Facility policies should prohibit the release of RA tools and equipment to uncontrolled areas except where specifically authorized. The release of potentially contaminated tools to uncontrolled areas increases the risk of uncontrolled releases of radioactive materials.

The number of tools and equipment unconditionally released to uncontrolled facility areas should be limited. The need to unconditionally release large numbers of tools and equipment in a short time period at the end of major maintenance activities or outages should be prevented. Radiological surveys of large numbers of potentially contaminated tools that are generated during major maintenance activities or outages are time-consuming. Attempting to perform surveys rapidly may result in the release to uncontrolled areas of radioactive material above facility limits.

The facilities and equipment provided for the release of items to uncontrolled areas should be of sufficient size and layout to allow for the accurate assessment of radiological hazards, including radioactive hot particles. All radiological-release surveys of outgoing tools and equipment from the RA, should be recorded to document compliance with acceptable contamination and radioactive material control policies. Such items should be released only by qualified and authorized personnel and with the items tagged or marked as releasable to noncontrolled areas of the facility. The attached tag or marker should include written approval from both the responsible department and by authorized radiological protection personnel.

Dry radioactive-waste containers, as well as collection and sorting areas, should be monitored frequently (after establishing a tool control program) and periodically thereafter. This monitoring should include the recording of tools and equipment found in radioactive-waste receptacles, to determine the extent at which losses of these potentially contaminated items are occurring and to identify the source or reason for the losses. This information should be used to correct the problems as soon as possible. Problems experienced should be included in lessons learned to aid future planning.

4.13 FACILITY CONDITION INSPECTION (Replaces DOE-STD-1072-94)[116]

4.13.1 Introduction

Management should conduct periodic inspections of safety equipment and facilities to ensure excellent facility condition and housekeeping 10 CFR 830.122(h). The condition of a facility depends on many factors, including design, fabrication, modifications, ongoing maintenance, facility work-control programs, and day-to-day operation. After initial facility construction, ongoing maintenance and the control of modifications are prime contributors to keeping systems and equipment in optimum condition to support safe and reliable operation.

The involvement of facility managers and supervisors in periodic walkdowns and inspections clearly displays management standards to all personnel and can significantly improve the condition of the facility. Establishing a program for identification and dispositioning of condition deficiencies and housekeeping discrepancies is an important step in maintaining facilities and equipment in a condition of maximum safety, reliability, and availability.

This section describes the attributes of an effective inspection program for maintaining excellent facility condition and housekeeping.

4.13.2 Discussion

The appearance and proper functioning of facility systems and equipment are key indicators of a well-maintained and -operated facility. Good facility condition, cleanliness, and housekeeping can be established and maintained by knowledgeable individuals who are alert to onsite deficiencies and who take prompt corrective action. Additionally, there should be a periodic, focused inspection effort, by thoroughly trained personnel, to assist in effective identification and correction of facility deficiencies.

The maintenance of systems and equipment within design conditions produces such benefits as minimizing fluid leakage, minimizing control room alarms caused by malfunctioning equipment, and maintaining environmental integrity of equipment. Providing easier access for operations and maintenance activities by reducing the sources and spread of radioactive contamination constitutes another benefit of good facility condition and housekeeping.

Properly used, a facility condition and housekeeping inspection program is an effective means for identifying and correcting deficiencies. The following elements should be included in the inspection program.

- Facility managers should set high facility condition and housekeeping standards and communicate them to all personnel to promote a clear understanding of these standards.
- Appropriate personnel should receive training in inspection techniques.
- Facility managers and supervisors should personally participate in inspections.
- Inspection areas should be assigned to ensure that the entire facility is periodically inspected, including areas with difficult access (e.g., high-radiation areas and locked areas).
- An inspection coordinator should be assigned to implement, schedule, and monitor the effectiveness of the inspection program.
- Deficiencies identified should be reported and corrected promptly, thus allowing personnel to see the positive results of the inspection program.
- A condition assessment survey with assigned risk assessment code could be used to prioritize schedules for repair.
- Instructions could be prepared to establish the program and define responsibilities for conducting inspections, correcting deficiencies, and accomplishing other tasks associated with the program, such as on-the-spot correction of minor deficiencies. What are considered minor deficiencies, who is allowed to correct them, and the limitations and documentation associated with this type of work should be clearly defined.
- Inspection guidelines and criteria could be prepared to assist the assigned inspectors in performing their inspections.

4.13.3 Guidelines

4.13.3.1 Standards

Setting standards involves management establishing an atmosphere of proper work ethics; positive attitudes; and specific expectations that are realistic, that are within the capabilities of the staff, and that are consistent with sound engineering judgment and good economic practice. Standards must be communicated effectively to all personnel so that they are clearly understood. Facility managers and supervisors should conduct routine inspections to assess adherence to these standards. Indicators of good facility condition and housekeeping standards include the following.

- Rotating equipment operates in accordance with design specifications (e.g., bearing temperatures normal, vibration levels normal, and shaft seal leakage limited to that required to cool and lubricate the shaft seals).
- Equipment is properly serviced (e.g., lubrication, drive belts, and filters).
- Fluid system integrity is maintained (e.g., leaks that can be corrected during operation are promptly repaired; leakage that cannot be repaired under existing conditions is collected and routed to appropriate drains or collection facilities, particularly if the leakage could cause a further degradation of equipment, present a safety hazard, or cause the spread of radioactive contamination).
- Temporary repairs are recorded and controlled by the facility temporary modification program. Permanent repairs are scheduled when facility conditions permit.
- Instruments and gauges are operational, calibrated, on scale, and indicate values representative of the existing system and equipment conditions.
- Energized electrical and electronic equipment is operative, supplied from normal power sources, and protected from adverse environmental effects such as leaks and overheating.
- Protective cabinet doors and electrical enclosure covers are installed to maintain design integrity (e.g., all fasteners installed and tightened, filters clean).
- Equipment and systems are insulated to control heat transfer to or from the environment, to control ambient noise levels, and to promote personnel safety.
- Facility equipment and systems subject to corrosion are protected with a preservative to minimize corrosion.
- Temporary environmental protection is provided, where appropriate.
- Industrial safety and radiological hazards are minimized (e.g., chemicals, oils, and solvents properly stored; fire barriers maintained; trip hazards nonexistent; radiological postings current and in place; radiological barriers and step-off pads properly established; and sources of contamination identified).
- Walkway and equipment access is maintained.
- Equipment is clean (i.e., dirt, debris, tools, parts, and miscellaneous materials are not allowed to accumulate on equipment or inside electrical panels).
- Station areas, rooms, and grounds, including the storage areas for needed tools and materials, are maintained in a clean and orderly condition.
- Coatings or coverings used to seal walls and floors in potentially contaminated areas are in good condition and assist in controlling contamination.
- No unauthorized modifications or changes to the facility exist.
- Illumination of areas, rooms, and grounds is maintained in a manner that provides sufficient light to perform inspections and minor maintenance.

4.13.3.2 Facility Inspection Zones

The following process applies to inspection zones.

- The facility should be divided into inspection zones. Inspection zones should be numbered for identification.
- Inspection zones should be assigned to department managers by job title (e.g., zone 1 assigned to the maintenance administration manager).
- Periodically, each inspection zone should be assigned to a different department manager. This should help ensure consistency throughout the facility.

4.13.3.3 Scheduling

The following process applies to scheduling.

A schedule should be established that ensures each inspection zone is inspected approximately every 2 weeks. Schedules should specify the week in which the inspection should be accomplished and what general inspection category should be concentrated on. The day and time of inspection should be left to the department manager's discretion. At the beginning of the quarter, the inspection coordinator should notify each department manager of the inspection zones for which he/she is responsible by publishing a schedule matrix. This schedule should indicate the inspector, zone, and type of inspection for each week of the quarter. An example facility inspection quarterly schedule is illustrated in Table 4.13-E.

4.13.3.4 Types of Inspections

The following process applies to types of inspections.

Inspections should be separated into general categories and identified as follows:

- material condition, mechanical (M), electrical (E), roof/building (A), or grounds (G);
- industrial safety (S);
- cleanliness/housekeeping (H);
- radiological protection/control (R);
- mechanical inspections (2 weeks);
- general housekeeping (bimonthly);
- site drains (quarterly);
- electrical inspections (biannually); and
- roof inspections (biannually).

Each inspection should concentrate on one general category. This should allow an in-depth look at one specific aspect of facility performance. However, other deficiencies should not be overlooked.

All applicable general categories should be completed for each inspection zone by the end of each calendar quarter.

4.13.3.5 Conducting Inspections

The following process applies to the conduct of inspections.

Each department manager or his/her designated representative should conduct an inspection of his/her assigned inspection zone during the week scheduled. The inspection may be conducted as one evolution or as a series of smaller inspections during the week.

Each inspection should include detailed walk downs of the inspection zone. Key areas to consider are out-of-the-way and limited-access areas. The inspection should not only identify deficiencies; it should also identify corrective actions being taken to improve facility conditions. In this manner, the program serves as a positive feedback mechanism.

Subordinates should be included on inspections-periodically. This should provide a method to teach inspection techniques and convey high standards.

The owner/operator should accompany each department manager periodically to ensure his/her (owner/operator's) standards are adequately understood by other department managers.

4.13.3.6 Inspection Techniques

While inspections are performed, observe the following:

- safety practices,
- work habits,
- radiological control practices, and
- work-site orderliness and protection of open systems/components.

Tables 4.13-A through 4.13-D list many examples of deficiencies for each general inspection category. Table 4.13-F is an example of an inspection checklist that may be used. Typically, in-depth inspections include the following techniques:

- touching bearing housings, motors, and pumps to check for excessive heating or vibration;
- being alert for abnormal sounds or unusual odors;
- using a flashlight throughout the inspection for poor lighting conditions;
- tagging and documenting deficiencies found during the inspection to provide accurate description and location information for each problem; and
- referencing deficiencies to specific maintenance procedures or requirements.

4.13.3.7 Reporting and Follow-up

The inspection coordinator should provide blank inspection report forms (Figures 4.13-C and 4.13-D) to inspectors. Inspectors should submit an inspection report to the inspection coordinator within 3 working days of each inspection.

For some deficiencies, on-the-spot corrections may be possible. In those cases, corrective action should be initiated at the time of the inspection and noted on the report. Significant deficiencies in facility condition and safety should be reported immediately to the shift supervisor for appropriate near-term attention and so noted on the report.

The inspection coordinator should forward copies of each inspection report to the appropriate department managers for corrective actions. He/she should maintain the original inspection reports on file for tracking and evaluating program effectiveness. He/she should periodically review his/her files to identify repetitive problems and trend progress.

Department managers should note on the inspection report the corrective actions planned and conducted for each deficiency under their responsibility and return the inspection report to the inspection coordinator to clear deficiencies on file.

The inspection coordinator should keep the owner/operator informed of program progress. This may be done by written report or by verbal update and should include discussions of generic or specific performance deficiencies, as well as particularly good areas.

4.13.3.8 Material Deficiency Identification

An individual noting a facility material deficiency should clearly identify the problem as set forth below.

Deficiencies should be tagged using numbered, coded, duplex deficiency identification tags (Figure 4.13-A) to facilitate tracking. The tags do not have to be used in sequential order, nor is there to be accountability for blocks of numbered tags. Inspectors should enter a description of the deficiency in the "Note" section of the tag. The same tag should be used for multiple deficiencies of a similar nature, in close proximity to each other, that are to be included on the same WR/WO (e.g., 10 fasteners missing from a motor control center). The fact that the tag is for multiple deficiencies should be indicated in the note section of the tag. Entry of the date is particularly important. The date should be used in conjunction with the tag number to obtain the WR/WO number that corresponds to the identified deficiency (see Section 4.13.3.9).

The inspector should attach the hard copy of the tag to the equipment or component, as close as possible to the deficiency. The duplicate copy, which contains the information necessary for completing a WR/WO, should be retained until a WR/WO is initiated.

If the deficiency is inaccessible because of radiation or physical constraints, the hard copy of the deficiency tag should be hung in a clearly visible area as close as possible to the deficiency (e.g., at eye level, directly below a valve leak in the overhead, or on/near the access door to a high radiation area). For those situations in which the hanging of a deficiency tag may restrict the visibility of facility instrumentation or controls, a smaller deficiency identification sticker (Figure 4.13-A) should be used. This situation generally pertains to deficiencies within the control room or on facility control panels.

Blank deficiency identification tags and stickers should be kept in the control rooms and the maintenance shops for field completion at the time a deficiency is identified. Operations personnel, maintenance personnel, and engineers should be encouraged to carry a supply of tags with them while working in the facility.

4.13.3.9 Work Request/Work Order Initiation

The individual identifying a deficiency should initiate a WR/WO (see Section 4.6,) according to the following steps.

- Enter the deficiency identification tag or sticker number in the WR/WO index. Because the date on the deficiency tag is the date of the WR/WO, the index provides a cross-reference.
- Use the duplicate portion of the deficiency identification tag to enter key information on the WR/WO.

  —Record the tag or sticker serial number, date, and description of deficiency on the WR/WO.

  —Note whether it was possible to place the deficiency identification tag in close proximity to the deficiency. Such a notation should assist maintenance personnel in locating the tag before starting work and in removing the tag upon completion of work.

  The duplicate may be affixed to the WR/WO or discarded. The system now provides complete traceability from a deficiency, using the tag number and date, to the WR/WO index and then to the WR/WO, which contains the tag or sticker serial number and a copy of the original tag. The age of a deficiency may be determined in the field from the date on the tag and the status of its repair determined from the work-control system.

4.13.3.10 Removing Deficiency Tag Stickers

Maintenance personnel should ensure that deficiency tags and stickers are removed following the completion of corrective maintenance and after verification that the deficiency has been satisfactorily corrected.

The mechanic or technician actually performing the work should remove the tag or sticker when the job is complete. The tag may be destroyed. If the tag is lost, or cannot be located, the circumstances should be noted on the original WR/WO. As a part of their review of the completed WR/WO, the maintenance supervisor should verify that the tag or sticker has been removed.

4.13.3.11 Confirmation of Deficiency Identification Tag and Sticker Use

At least semiannually, the maintenance planning manager should initiate the following review to check the use of deficiency identification tags and stickers. This review should be a management tool only and should not be considered a permanent record.

- A representative sample of pending WR/WOs should be randomly removed from the files and the presence of the tag or sticker serial number verified.
- The fact that the original tag or sticker is in place in the facility should also be verified for the WR/WO removed from the files.
- A representative sample of completed WR/WOs should be randomly selected from the work-control index and removed from the files. Field locations should be checked to verify that the deficiency tag has been removed.
- A completed Deficiency Identification Review Form (Figure 4.13-E) should be submitted to the maintenance manager.

4.13.3.12 Training

Personnel involved in inspections should be knowledgeable of the standards expected by laboratory requirements and the techniques required to perform facility condition inspections. In addition, all personnel should be aware of the importance of good housekeeping and maintaining the facility in good condition. An effective method of imparting expected standards is for the facility manager to conduct some inspections with selected individuals, as discussed above in Section 4.13.3.4.

4.13.3.13 Procedures

Administrative procedures that describe the inspection program should define expected standards, provide for documentation of deficiencies, provide a means to follow up on deficiency corrective actions, assign responsibilities for program implementation, and establish a means to measure program effectiveness. Implementation procedures for facility inspection could be incorporated into the PM or surveillance program in a manner similar to other visual inspections, such as housekeeping inspections. Deficiencies identified during the inspection should be documented by the inspector (e.g., by initiation of a maintenance request or by use of an area inspection report). Checklists of equipment to be inspected and types of problems to look for could be useful as guides for inspectors.

4.13.3.14 Scope of Inspections

The inspection should include detailed walkdowns of assigned areas. Remote and limited-access areas should be included. The ALARA concept should be considered when assigning inspectors and inspection frequencies to radiation and high-radiation areas.

Key individuals should accompany the managers and supervisors during their inspections. Discussions during the inspection should center around ways to improve inspection techniques and should convey the expected standards for facility condition and housekeeping.

Inspections should include, but not be limited to, identification of such deficiencies as those discussed in Section 4.13.3.1. The facility manager may designate specific types of deficiencies that should be given special attention during the inspection based on his/her desire to emphasize and upgrade particular aspects of facility condition and housekeeping.

Although a variety of inspection techniques may be used, one important aspect of inspecting is to spend sufficient time in an area to search for deficiencies—not simply walk through the area. The inspector must look closely at individual components and notice deficiencies that usually would not be seen during a casual walk through an area. Once a deficiency is identified, the inspector should look closer and attempt to determine the source or cause, how long it has existed, and whether it has been previously identified. For example, steam venting from a valve in the overhead may actually be coming from a pipe flange on the other side; a control valve that has been cycling excessively for a long time may require engineering support to resolve.

4.13.3.15 Inspection Program Elements

Routine inspection programs should include the following elements.

- Inspection areas small enough to be thoroughly inspected within the time allotted.
- Each facility area scheduled for periodic inspection.
- Periodical rotation of inspectors to avoid familiarity with an inspection area, which can hinder deficiency identification.

4.13.3.16 Deficiency Follow-up

A list should be prepared of all deficiencies not included in the work-control system or some other corrective action system, with responsibility for correction or disposition of each. Personnel assigned corrective action should periodically report to the inspection coordinator the results of the actions planned or conducted, and deficiencies should be tracked to resolution—by personnel assigned corrective actions and the inspection coordinator, as a fail-safe mechanism.

Reported deficiencies should be monitored to identify recurring, generic, and long-term problems. Action taken to resolve these problems should include a failure or root-cause analysis and not merely a correction of symptoms. For example, frequent low oil levels in operating pumps could be due to leakage or to an improper lubrication schedule. Adjustment to the lubrication schedule or additional training of personnel might be needed to maintain correct oil levels. (Section 4.16 addresses the analysis of maintenance problems.)

Follow-up of selected corrective actions from previous inspections is necessary for evaluating the timeliness and effectiveness of corrective actions and for obtaining the maximum benefit from the inspection program. Several methods may be used to accomplish this follow-up. For example, the inspection coordinator may select some previously identified deficiencies to verify that they were corrected or are being corrected in a timely manner. This could be accomplished during each facility condition and housekeeping inspection.

The inspection coordinator or an assigned individual should periodically review inspection reports and facility conditions to evaluate the effectiveness of the inspection program. Inspection emphasis should be adjusted, as required. The review should also determine whether changes should be made to any program to reduce generic, recurring, or continuing deficiencies.

4.13.4 Facility Material Condition Performance Objectives

The material condition of the facility is maintained to support safe and reliable plant operation.

CRITERIA

A. Systems and equipment are in good working order; examples of this include the following.

- Fluid system leaks are minimized.
- Equipment is appropriately protected from adverse environmental conditions.
- Instruments, controls, and associated indicators are calibrated, as required.
- Good lubrication practices are evident.
- Fasteners, supports, and safety systems are properly installed.
- Equipment and SSCs are properly preserved and insulated.

B. Material deficiencies are identified and are in the work-control system.

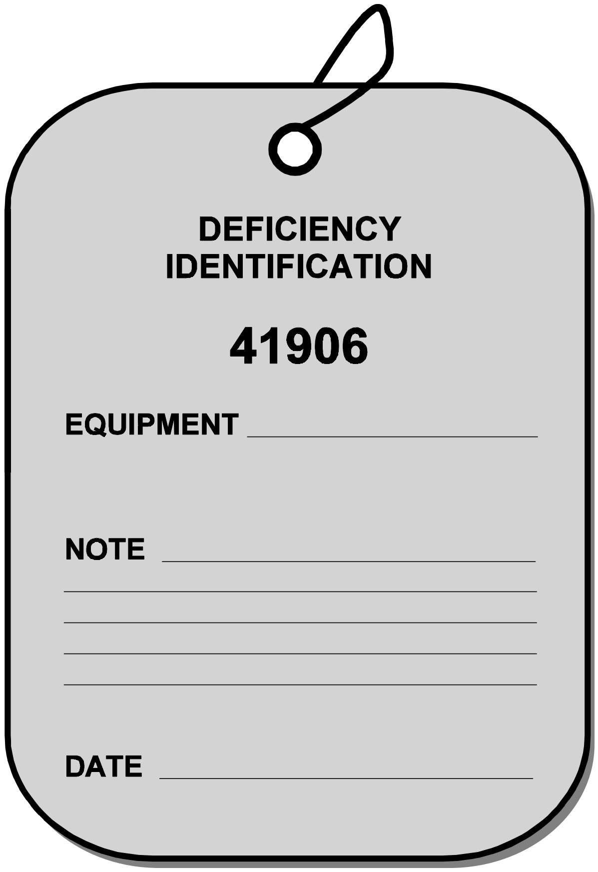
C. Temporary repairs are minimized and permanent repairs are made when conditions permit.

D. Temporary environmental protection (e.g., dust, humidity, freeze, shock) is provided for facility equipment when needed to support construction, outage, or maintenance activities.

E. Newly installed or modified systems/equipment are verified to be in good working order before operational acceptance by the facility staff.

EXAMPLE DEFICIENCY IDENTIFICATION TAG

(Two Parts — Hard Copy and Carbon)



EXAMPLE DEFICIENCY IDENTIFICATION STICKER

Figure 4.13-A. Example Deficiency Identification Tag and Sticker.

Table 4.13-A. Examples of Housekeeping/Cleanliness Deficiencies

1. Cluttered areas, dirt accumulation
2. Undisposed of packaging material
3. Cigarette butts on floors, equipment, or structures
4. Improper waste disposal (e.g., waste in wrong cans, lids missing)
5. Tool cribs in disarray
6. Tools or parts left unattended for prolonged periods of time
7. Caked dirt on equipment and bed plates
8. Signs and labeling in disarray
9. Storage areas disorderly
10. Shop areas cluttered; old parts lying about

Table 4.13-B. Examples of Industrial Safety Deficiencies

1. Ladders—no chain safety barrier across access, ladder rungs broken; poorly lighted, improperly positioned and secured

2. Catwalks or elevated work spaces—no safety rails installed, lack of a 4- to 6-inch toe board at bottom

3. Scaffolding—improperly installed or secured; in poor repair; not authorized

4. Compressed gas bottles—unsecured, caps missing, improper environment, unlabeled

5. Tripping/slipping hazards (e.g., temporary hoses, piping, holes in floor, oil or water on floor)

6. Water leakage in the immediate vicinity of energized equipment

7. Protrusions into aisleways without protection devices/warnings

8. Unsafe work habits

   a. Failing to wear hard hats, safety glasses, proper shoes, ear protection when needed
   b. Working on energized equipment without proper approval and protective equipment and clothing
   c. Handling chemicals without proper protection (e.g., no apron, face shield, gloves, respirator, boots)
   d. Lifting heavy objects improperly
   e. Lack of fire-watch for welding, cutting, and grinding operations
   f. Smoking in prohibited areas
   g. Working at heights without safety belt
   h. Improper hoisting and rigging
   i. Misused or missing safety devices (e.g., locks, limit switches, etc.)
   j. Using equipment improperly

9. Maintenance shop equipment does not have guards installed, safety signs, work space marked off around each piece of equipment

10. Fire hazards (e.g., untreated wood, packing boxes, flammables in unauthorized containers)

11. Fire protection equipment

   a. Hoses improperly racked and inspections not up-to-date

Table 4.13-B. Examples of Industrial Safety Deficiencies (continued)

   b. Fire extinguishers not in place, safety pins not sealed, and inspections not up-to-date
   c. Emergency cabinets improperly stocked or in disarray
   d. Access to safety equipment not clear
   e. Hose/equipment through fire doors

12. Posting and control of hazardous or confined areas

    a. Zones not clearly marked or posted; permits not posted
    b. Warning signs not posted or not understandable

13. Eyewash stations/showers

    a. Instructions not posted
    b. Not located near hazard; access restricted
    c. Not well maintained or tested

14. Noncompliance with facility safety policies and procedures

15. Heavy or vibrating equipment stored in elevated positions.

Table 4.13-C Examples of Material Condition Deficiencies

Note: For environmentally qualified components, the presence of any of these deficiencies may invalidate the environmental qualification.

1. Leaks (water, steam, oil, or air): packing, stem, seal, flange, body to bonnet, internal
2. Lubrication (oil, grease, or water): evidence of too little or too much as noted by sight glasses, bull’s eyes, flow indicators, dip sticks, grease cups, and grease (zirc) fittings
3. Handwheels/operators—missing, key or pin missing, identification label missing
4. Filters/screens/louvers clogged, dirty, missing
5. Gauges/instruments—not in calibration, inoperable, face broken, pointer missing/bent
6. Drains/drain holes clogged, full, plugged; screens or grating missing
7. Drain and vent hoses improperly stored or installed
8. Vent and drain caps improperly installed
9. Lines/pipes—loose, unbracketed, insulation missing, or sagging
10. Fasteners loose, stripped, missing
11. Indicating lamps missing, burned out; covers missing
12. Panels—covers missing, open, loose
13. Electrical box covers improperly installed and loose
14. Area lighting—burned out, bulbs missing
15. Packing—bottomed-out adjustment, dirty or rusted glands
16. Cables/leads—unsecured, worn or frayed insulation, improper terminations
17. Motors/generators—dirty, brush rigging pigtails broken, ground straps loose/missing, excessive noise/vibration
18. HVAC expansion/vibration, isolation seals cracked, split or hardened expansion joints

Table 4.13-C Examples of Material Condition Deficiencies (continued)

19. Metal equipment/parts—rust, corrosion
20. Labels—missing, unclear, inaccurate
21. Radiation/contamination areas not clearly identified
22. Fire doors open, fire barriers not intact, and fire hazards present
23. Safety tags not properly completed, adequately attached, or authorized
24. Equipment access unsatisfactory or hampered by scaffolding or other material
25. Noise and vibration levels abnormal
26. Insulation damaged or missing
27. Pipe hangers missing, loose, or misused
28. Area cleanliness unsatisfactory
29. Improper or misused electrical grounding devices

Table 4.13-D Examples of Radiological Protection Deficiencies

1. Postings—radiological protection signs not legible, understandable, or appropriate

2. Barriers

   a. Barriers (rope, fences, etc.) not properly positioned to require conscious action to cross them
   b. Purpose of all radiological protection barriers not easily determined

3. Poor personnel radiological protection practices

   a. personnel wearing or removing protective clothing improperly
   b. personnel monitoring (frisking) themselves incorrectly (too fast, incomplete, etc.)
   c. personnel smoking, eating, drinking, and/or chewing in radiological areas
   d. wearing dosimetry improperly (wrong location, separated)

4. Radiological protection equipment and instruments damaged or overdue for calibration

5. Radioactive material improperly identified or wrapped to control contamination

6. Protective clothing containers overflowing or protective clothing outside of contaminated areas

7. Items that should not be radioactive in radwaste containers (e.g. cardboard cartons, computer print-outs, newspapers, etc.)

8. Accumulation of radioactive materials, tools, drums in other than designated areas

9. Spills or leaks not redirected or contained to prevent spread to noncontaminated areas

10. Missing or incomplete bulletins (e.g., Right to Know, MSDS postings)

11. Improper storage: Markings/labeling, cleanliness, type of cabinets, improper logging of data (e.g., 90-day accumulation site), material compatibility, flammable materials

12. Missing or improper Emergency Response: spill response material, overpack drums, emergency notification data/means, drum/container closure equipment, personal protection equipment

13. Improper containment: Container integrity, Secondary containment

14. Improper or inadequate training: Spill response, hazard identification, employee responsibility

15. Improper decontamination: Procedures, materials/equipment, waste containers, worker practices, signage

Table 4.13-E Example of Facility Inspection Quarterly Schedule

Quarterly Inspection Schedule
For ____________________ Quarter: __________
(facility name)

	Week											
Inspector	1	2	3	4	5	6	7	8	9	10	11	12
Maintenance Administration	1M*	9R	2S	10H	3M	11R	4S	12H	5M	13R	6S	14H
Maintenance Training	2R	10S	3H	11M	4R	12S	5H	13M	6R	14S	7H	15M
Maintenance Engineering	3S	11H	4M	12R	5S	13H	6M	14R	7S	15H	8M	16R
General Maintenance	4H	12M	5R	13S	6H	14M	7R	15S	8H	16M	9R	1S
Facility Maintenance	5M	13R	6S	14H	7M	15R	8S	16H	9M	1R	10S	2H
Maintenance Planning Oversight	6R	14S	7H	15M	8R	16S	9H	1M	10R	2S	11H	3M
Electronic Maintenance	7S	15H	8M	16R	9S	1H	10M	2R	11S	3H	12M	4R
Utilities Maintenance	8H	16M	9R	1S	10H	2M	11R	3S	12H	4M	13R	5S

*****Key: Numbers (1 through 16) = various areas (zones)in the facility
M = material condition
R = radiological protection
S = industrial safety
H = housekeeping/cleanliness

MAINTENANCE INSPECTION CHECKLIST

Responsible person: ______________________ Zone: ______________

Inspector: ______________________ Building: ______________

Area: __________ Room: __________ Date performed: __________

Grade	Postmaintenance Test	Adjective	Description
4	Green	Outstanding	Creative or innovative activities
3	Green	Superior	Efforts significantly beyond what is normally expected as acceptable
2	Yellow	Satisfactory	Complies with what is normally expected as acceptable
1	Yellow	Marginal	Somewhat less than what is normally acceptable
0	Red	Unsatisfactory	Effort significantly below what is normally expected

Grades of 0 and 1 require action by the responsible person (e.g., WR/WO, memo to supervision, verbal reply)

Figure 4.13-B. Example Inspection Checklist Cover/Instruction Sheet.

Table 4.13-F. Example Inspection Checklist

Standard	**Grade**	**Required Action**
1. Aisleways clearly distinguished from work areas.		
2. Aisleways/doorways/ramps/stairs provide direct and clear egress from the shop		
3. Stairs and ramps have proper handrails		
4. Lighting adequate for all aisleways, stairs, workbenches, machines, and storage areas.		
5. Emergency lighting illuminates egress paths and exits are clearly identified.		
6. Shop is weather tight		
7. Physical enclosure of shop (i.e., ceiling, walls, support structure, floor) in serviceable condition		
8. Coatings and coverings for ceilings, walls, floors continuous, clean, and sound.		
9. Fire protection devices (e.g., sprinklers, extinguishers) adequate, properly charged, and not blocked or otherwise inhibited in their intent		
10. Insect and pest control effective.		
11. Signs in the area appropriate, visible, properly located and clearly communicate the intent		
12. Trash receptacles clearly indicate intended contents, conveniently located, regularly emptied		
13. Material Safety Data Sheets and other documents stored systematically and readily accessible		
14. Housekeeping— a. Aisleways free of debris/fluids b. Workbenches uncluttered c. Storage areas orderly; packing materials disposed of properly d. Machinery work area free of unnecessary/ excess debris and foreign objects e. General area orderly, uncluttered		
15. Fixed hoists, ladders, work platforms, etc., provided where needed		

Table 4.13-F. Example Inspection Checklist (continued)

Standard	Grade	Required Action
16. Special equipment labeled to encourage access and proper use		
17. File cabinets, storage cabinets, doors, and drawers closed when not in use		
18. Bulletin boards available, used for intended purpose, and clean when not in use		
19. Utility services such as electric power; heating, ventilating, and air-conditioning; water; drainage; and exhaust controlled, consistent with needs, and convenient to primary users		
20. Piping, valves, and electrical circuits visibly labeled to identify contents; no visible signs of deterioration; operating statuses clearly identified		
21. Electric power disconnects/panels/transformers not blocked		
22. Electric circuits not jeopardized by wet or contaminated conditions		
23. Proper personnel guarding/protective measures in place for specific hazards		
24. Adequate ear protection provided and used to properly suppress excessive noise		
25. Portable and hand tools and equipment returned to designated storage areas when not in use or at the end of shifts		
26. Communications equipment reliable; provides adequate coverage.		
27. Audible and visual alarms operational		
28. Equipment/tools ready for use; worn/defective items properly segregated for disposition and to inhibit use		

Table 4.13-F. Example Inspection Checklist (continued)

Standard	Grade	Required Action
29. Facilities sized, organized, and equipped for safe, effective work, consistent with the workload, work performed, crew size, and mission, and include— • equipment/machines • personal, portable tool boxes • diagnostic and verification tools/devices • layout space • staging areas • storage • temporary areas (e.g., gloveboxes, screening) • offices • restroom access • designated eating area		
30. Structural leaks not damaging materials or equipment		
31. No unauthorized storage		
32. Storage areas— a. Convenient to users b. Adequate physical/environmental protection for stored items c. Hazards of stored materials clearly identified d. Materials segregated by type and application/use (e.g., sheet metal, piping, conduit, lubricants; measuring and test equipment, defective awaiting disposition, shipping, receiving) e. Items not stored in excessive quantities f. Stored items do not exceed shelf/rack/stack/ storage limits		

TO: (Inspection Coordinator)
FROM: (Inspector)
SUBJECT: Inspection Report

On ________ , I made a tour of zone _________ . During this tour, I noted the deficiencies
(Date) (Number)
and/or conditions listed on the attached pages.

Signature Date

TO: (Responsible Manager)
FROM: (Inspection Coordinator)
SUBJECT: Inspection Report

Forwarded for action for each item as indicated on the attached page(s).

Signature Date

TO: (Inspection Coordinator)
FROM: (Responsible Manager)
SUBJECT: Inspection Report

Corrective action for each item assigned to me has been completed as noted on the attached page(s).

Signature Date

Figure 4.13-C. Example Inspection Report Transmittal Forms.

INSPECTION REPORT

Location[a]	**Description**[b]	**Corrective Action**[c]	**Date Initiated/Completed**[d]	**Responsible Organization**[e]

[a]Describe the exact location of deficiency, including system, elevation, etc.

[b]Include the magnitude of the problem in the description (e.g., “Packing leak of 1qt/min on FW-V-37").

[c]Include work order number, purchase order number, etc.

[d]Date initiated = date work order was written.

[e]Determined by inspection coordinator.

Figure 4.13-D. Example Inspection Report Form.

TO: Maintenance Manager

FROM: Maintenance Planning Manager

SUBJECT: Deficiency Identification Review

Pending Work: ______________________________

Number of job requests reviewed: ______ Number of job requests having tag serial numbers: ______

Number of tags/stickers posted at identified deficiencies: ______

Problems Noted: ______________________________

Completed Work: ______________________________

Number of job requests reviewed: ______ Number of tags/stickers remaining in facility: ______

Problems Noted: ______________________________

Comments: ______________________________

The functioning of the deficiency identification system is considered to be: ______________

Name	Signature	Date

Figure 4.13-E. Example Deficiency Identification Review Form.

4.14 MANAGEMENT INVOLVEMENT (Replaces DOE-STD-1055-93)[105]

4.14.1 Introduction

To ensure the safety of DOE facility operations, DOE and contractor corporate and facility managers should be technically informed and personally familiar with conditions at the operating facility 10 CFR 830.122(c).[1] Responsible DOE and contractor corporate managers should visit the facility, including visiting at irregular hours; assess selected activities and portions of the facility; and leave a written record of their observations. Additionally, DOE, contractor corporate, and facility managers should periodically review the maintenance programs to verify that they are effectively accomplishing their intended objectives and are upgraded as needed. This section addresses management involvement, performance indicators, goals and objectives, results, progress and feedback reviews, and maintenance program reviews needed for an effective and efficient maintenance program. Key features of programs that support maintenance management are described which if implemented should enhance safe, reliable, and efficient maintenance operations. They include—

- management involvement;
- performance indicators, goals, and objectives results;
- problem analysis;
- feedback; and
- program reviews.

4.14.2 Discussion

Excellence in maintenance begins with the commitment and initiative of DOE and contractor corporate and facility managers to be involved and know what is going on by touring the facility frequently. Personnel perform at a higher level when their activities are observed, appropriately recognized, and supported. Motivating first-line maintenance supervisors to observe the activities of crafts workers in the field requires that managers take the lead and set an example. A crafts worker's pride in his/her work may be bolstered by direct observation and immediate feedback, especially when it is provided by managers several levels above first-line supervisors. Fewer errors, higher standards, and improved morale can result.

Maintenance performance should be checked by observing people at work; by inspecting, monitoring, and checking equipment; and by following up promptly on corrective actions. Key assistants and selected supervisors should also be trained to perform these types of activities. If administered properly, management efforts will be multiplied to the point where personnel at all levels of the organization feel responsible for and are involved in the early identification of problems.

This high profile by management during frequent nonscheduled individual tours of work areas both on- and off-shift provides first-hand observation of actual conditions and an opportunity to communicate expected performance standards through appropriate and timely recognition/

feedback directly to individuals regarding either positive or negative observations. It also provides an opportunity to seek involvement in and to establish ownership of approved actions at the level closest to and directly involved in performance improvement. This promotes incentive for individuals at all levels to take pride in their accomplishments and encourages motivation for first-line supervisors and crafts workers to accept responsibility for the early detection of opportunities for improvement. This degree of management involvement also provides the means for timely escalation of significant problems/concerns to the level of management having resolution authority.

In addition to first-hand observations, maintenance managers ensure effective knowledge-based decisions using factual information derived from and substantiated by a variety of sources, including key performance indicator trend review, critical self-assessments, exception reports, problem and corrective action status tracking, lessons learned and alert system reviews, daily and weekly review of staff activities, customer feedback, crafts worker input, historical data, and regulatory (ES&H) requirements.

Follow-up actions assure all levels that management is interested in and acts upon individual input.

A work sampling program should be used to establish and update baseline effectiveness values and to assess the impact of imposed constraints and limitations such as radiation contamination control and historical repair time versus engineered time standards to provide for productivity improvements.

Maintenance workmanship standards used to gauge and ensure an appropriate level of performance are those consensus standards associated with specific maintenance activities such as—

- National Electric Code,
- Asbestos Abatement Standards,
- Occupational Safety and Health Administration (OSHA) regulations,
- national standards for calibration and certification,
- garage (vehicle) repair/service standards,
- warranty/guarantee stipulations,
- Federal Communications Commission telecommunications regulations,
- Davis-Bacon Act,
- waste stream management standards and regulations,
- ALARA contamination control,
- facility housekeeping standards, and
- environmental regulations.

A real-property cost collection system (using a series of blanket WOs for each building) may be used to assist in identifying cost drivers associated with facility buildings and structures.

Programmatic maintenance support should be identified by accounting WOs associated with specific programmatic activity.

Current cost drivers that use up maintenance resources normally allocated to facility maintenance and production/process equipment tasks include safety class items, OSHA and environmental compliance, and various upgrades.

A system for converting identified facility, personnel, or programmatic problems into corrective actions is needed to assure workers that management is interested in their inputs for improvement. Such a system should consider routine reporting of maintenance effectiveness trends and prompt elevation of significant problems to the attention of the level of management having resolution authority.

4.14.3 Guidelines

4.14.3.1 Manager Involvement

Managers should include time in their schedules for walking through the facility. This time should be directed at improving face-to-face communications and feedback at all levels of the maintenance organization. Maintenance management should establish the percentage of time that first-line supervisors are expected to spend supervising fieldwork. The workload of first-line supervisors should be monitored and adjusted to allow them sufficient time monitoring work in the field. Facility tours and personnel contacts should also be planned for irregular hours (including selected weekend or backshift inspections) and should cover selected facility areas and personnel activities. The results and observations of these tours should be documented and reviewed for action.

Rules, responsibilities and accountability between DOE and contractor and facility managers should be clearly delineated and communicated to all levels of the maintenance organization. DOE managers should be responsible and accountable for the management and maintenance of DOE assets in accordance with federal regulations, DOE directives, and contractual agreements. DOE contractors should be responsible for the operation, management, and maintenance of DOE nuclear facilities in accordance with commitments and agreements for satisfactory deliverables under the contract.

As prescribed in 48 CFR 970.2303-2(a) and 970.5204.2 (DEAR), contractors operating DOE nuclear facilities should integrate ES&H into maintenance work planning and execution. The contractors should ensure that ES&H functions and activities become an integral, but visible, part of the contractors work planning and execution process.

Managers should include time for nonscheduled walk-throughs of facility work areas as a regular management activity. These walk-throughs should be directed at improving dialogue with workers at all levels of the maintenance organization. Implementation of this method should be an on-going process. Facility and work-site tours should be conducted randomly for management visibility to and contact with weekend and second and third shift workers. These tours may also be selectively and judiciously accomplished based on concerns resulting from program reviews or other feedback. The results of management walk-through observations and contacts should be documented and communicated to affected organizations and individuals and followed to logical conclusion. Managers should demonstrate to all employees their commitment to excellence in all areas of maintenance.

DOE involvement in the oversight of nuclear facility maintenance programs should include reviews by the DOE facility representative, field and area offices, and Headquarters. Inspections, audits, reviews, investigations and continuous self-assessment are necessary ingredients to achieving excellence in maintenance activities. Whether DOE or contractor, senior managers should periodically review and assess elements of the maintenance program for effectiveness and to identify areas of needed improvement. Such assessments should be aimed at assisting line managers and supervisors to identify and correct deficiencies. A comprehensive assessment of maintenance program elements should be conducted at least every other year and should include input from managers and supervisors from maintenance and other groups such as operations, technical staff, and appropriate corporate departments.

Further guidance on some techniques that may be used to conduct facility inspections is given in Section 4.13.

4.14.3.2 Performance Indicators, Goals, and Objectives

The results of maintenance performance indicators, goals and objectives, and other related information should be developed, trended, and reported to provide feedback. This feedback should be used by senior management in the progress and feedback reviews discussed below. Section 4.14.2 discusses the development of performance indicators, goals, and objectives for maintenance. Reports should include trends of the performance indicators, goals, and objectives; a brief explanation for trends that appear unusual (positively or negatively); and intended corrective measures where warranted.

Accomplishments toward established performance indicators, goals, and objectives should be developed, trended, and reported to provide feedback to those affected.[70]

A well-structured formal quality management program should be developed within the maintenance organization. Various councils, task analysis teams, and engineering and technical support groups should continually review—

- significant program elements to determine and recommend opportunities for maintenance program improvement,
- critical work in progress,
- system and procedure applicability,
- real-time and history data,
- root-cause resolution,
- activity intervals and acceptance criteria,

- value-added new technology for acquisition potential,
- project status,
- nonfacility maintenance personnel performance, and
- site planning.

These groups should meet regularly with management to review and report progress, maintain management visibility and awareness, ensure management support for proposed actions and obtain management approvals.

Meetings with affected individuals/groups should be conducted on a regular schedule to provide for sharing information through interrogative/interactive participation. Reported accomplishments should be tracked and regularly evaluated for trends (both positive and negative) which provide timely visibility and opportunity for informed knowledge-based management decisions leading to continued improvement. Trends (both positive and negative) should be analyzed for root-cause determination (see DOE-NE-STD-1004-92). Action plans to correct deficiencies and reverse negative trends should be implemented, when appropriate. Positive indicators should be evaluated for stability, reliability, and the potential for broader application.

4.14.3.3 Problem Analysis

Root-cause analyses of unplanned, recurring, and persistent maintenance problems, incidents, and outages that impact safe and reliable operations, although historically performed, have only recently adopted formal methodologies to systematically and clearly lead to their effective resolution. The root cause is seldom a single factor.

Individuals at all levels should be trained in the use of one or more of a variety of formal problem analysis and solving methodologies, including—

- Kepnor-Tregoe,
- job hazard analysis,
- function analysis,
- total quality management—performance improvement process,
- reliability, availability, and maintainability analysis,
- single-failure analysis,
- root-cause analysis,
- facility safety analysis and review,
- risk assessment (including failure modes and effects analysis), and
- value engineering.

The interaction and effects of one or more of the following factors should be considered:

- design,
- drawings,

- procedures,
- training,
- qualification verification,
- tools,
- attitude,
- supervision,
- human error,
- management control, and
- communication.

When the nature of specific concerns warrants (based upon uniqueness, warranty, complexity, time-constraints, state-of-the-art technology, special skills/equipment/tools, etc.) outside expertise may need to be contracted to ensure the appropriate focus.

Root-cause categories should be established to facilitate future analyses, correlate proven corrective actions, and focus management action on the critical few.

These methods result in value-added and knowledge-based correction plans that should be followed to validated resolution and documented in the maintenance history files. Applicable information should be shared as lessons learned for broad-based benefit from local actions.

4.14.3.4 Information Collection

Problems should be coded and clearly defined to permit status tracking. In addition to maintenance history files, information pertinent to the most recent occurrence is valuable during problem analysis and may be obtained from—

- WRs/WOs,
- shop floor activity logs,
- strip-chart and other recording devices,
- operator statements (facts and symptoms),
- troubleshooting results,
- crafts worker statements, and/or
- industry experience.

Information and data gathered from the most recent occurrence should be recorded as maintenance history.

4.14.3.5 Information Analysis, Cause Determination, and Corrective Action

Problems should be analyzed by problem analysis teams composed of owners/operators and other informed/involved individuals; however, the responsibility and authority for performing the analysis, cause determination, and corrective action recommendations should be clearly defined. The problem analysis methodology suitable for the type problem, formality warranted, and application of the information available should be used. All information should be evaluated to establish a list of most probable or associated causes (care should be taken to go beyond simply addressing symptoms). Each probable cause should be analyzed until the combination of factors which, when corrected, should prevent recurrence of the problem is determined. That combination of factors is the actual root cause.

The criteria for acceptable root-cause resolution are as follows:

- implementation should prevent recurrence of the problem;
- the proposed action is feasible;
- implementation should not adversely impact safety, reliability, or operational goals;
- the proposed action results in long-term improvement, and
- generic applicability.

A plan defining the acceptable root-cause corrective action should be developed, documented, approved by applicable managers, implemented, and tracked to validated completion. Analyses and corrective action plans should include generic applicability to similar items, training and qualification programs, documentation revision, maintenance activities, and tool availability.

4.14.3.6 Corrective Action Follow-up

Following validated problem resolution, postmaintenance testing should be performed to ensure all critical parameters are within tolerance and the owner/operator considers the item acceptable for return to normal service.

4.14.3.7 Generic Follow-up

Management should be responsible for ensuring that generic applicability of validated resolutions is communicated through the lessons learned validator system. Generic applicability within the facility should be tracked until validated completion.

4.14.3.8 Feedback

A key element of management involvement is the establishment of a system where feedback and communication are encouraged. This system should include planners, engineers, crafts workers, warehouse personnel, appropriate line management, and others so that participation in improvement is promoted at all levels of the maintenance and management organizations. Project teams (for such purposes as discussing proposed modifications to the facility, prioritizing industrial safety actions, and improving facility condition) should include representatives from the affected crafts.

Management should actively solicit and encourage constructive feedback from all affected individuals and organizations including line, staff, support (crafts workers, planners, engineers, etc.), and customers regarding performance concerns and opportunities for improvement at all levels of the maintenance organization. A written and verbal means for interested individuals to identify concerns and to suggest actions for resolving deficiencies should be provided. Feedback should be evaluated and actions that result in improved maintenance services implemented. The individual identifying the concern or suggestion should receive feedback with a timely response from management that demonstrates management's interest in the input, explains the rationale for either no action or alternate action, and indicates status of the suggested action.

Concerns that involve broad areas of responsibility should be addressed by project teams consisting of representatives from all affected crafts and organizations. These project teams should be given the necessary time to provide effective action.

The ability to apply lessons learned from in-house maintenance experiences (and the experiences of others) is essential for long-term success. Management should use information about problems encountered during maintenance activities to improve performance. The maintenance group can also benefit by taking advantage of related experience at other facilities.

The maintenance manager, and sometimes the facility manager, may address specific groups on topics related to team integration, productivity, and motivation. Additionally, managers should set aside time for maintenance personnel to discuss problem areas and suggested improvements.

4.14.3.9 Program Reviews

Inspections, audits, reviews, investigations, and self-assessments are necessary parts of an effective maintenance program. Senior managers should periodically review and assess elements of the maintenance program. These assessments can assist line managers and supervisors in the identification and correction of program deficiencies. An evaluation of each maintenance program element should be conducted at least every other year and should include inputs from maintenance managers and supervisors and other groups, such as operations, technical staff, and appropriate corporate departments. This evaluation should address the overall effectiveness of the program element. It should also address interorganizational and intraorganizational coordination problems that create work delays and reduce productivity. Areas needing improvements should be assigned for corrective action and follow-up. Examples of program elements to be considered in this evaluation are discussed in the following paragraphs.

Facility Condition and Worker Practices During Maintenance. Assessments of facility safety equipment and systems and of crafts workers' ability to perform high-quality maintenance should be routinely performed. Elements that should be identified and evaluated include the following.

- Equipment failures and their impact on facility operations.
- Repeated corrective maintenance on the same or similar equipment.
- Current condition of equipment and systems.
- Numbers and types of deferred and missed maintenance actions.
- Occurrences of improper radiological control or industrial safety practices.

- Occurrences of improper tool usage or failure to prevent foreign material from entering systems.
- Expenditures for labor needs and parts.
- Occurrences of tool, equipment, or facility inadequacies.
- Equipment accessibility or laydown problems.
- Planning, scheduling, and coordination problems.
- The number and age of backlogged corrective maintenance requests.

The results of this evaluation will be the basis for program improvements such as the following:

- adjustments to PM frequencies;
- additions to or deletions from PM;
- proposed design changes;
- adjustments to spare parts and materials stock levels;
- adjustments to labor and/or training; and
- adjustments in tools, equipment, and facilities, or modifications to improve equipment maintainability.

Maintenance Training. Management should be directly involved in approving and periodically reviewing the maintenance training program. The performance of maintenance personnel should be monitored to identify needed initial and continuing training-program enhancements and shifts in emphasis. Any management reviews and performance trends that indicate the need for improvement in maintenance knowledge and skills should be considered during the review of the maintenance training programs. Trainee feedback for improving the training program should also be obtained. Needed changes to the training program should be made by the training organization and should be based on recommendations from the facility manager and maintenance manager.

Procurement Activities. Periodic assessments of the overall effectiveness and efficiency of the procurement process should be conducted. Appropriate data and trends should be monitored to support the assessment of procurement activities and to help identify needed improvements. Examples of items that could be monitored include the following.

- Parts and materials usage and stock levels.
- Frequency and reasons for emergency procurement activities.
- Maintenance deferrals because of lack of spare parts or materials.
- Parts and materials “service factor” (the percentage of requested parts or materials that were available in the storeroom when requested).
- Recurring or long-standing nonconforming items (deviations from procurement specifications).

- Status of programs for special handling, storage, PM, and shelf life of spare parts and materials.
- Accuracy of stores records compared to actual inventory.
- Number of requisitions and frequency of requests for service contracts.
- Amount spent compared to amount budgeted for service contracts.

Measuring and Test Equipment. The M&TE program should be periodically reviewed to verify that it is supporting safe and reliable operation of the facility. The review should include an assessment of M&TE availability.

4.14.4 Management Involvement Performance Objectives [23]

Formal management involvement objectives should be used to improve facility maintenance performance.

CRITERIA

A. Specific objectives for maintenance organizations are published and kept current.

B. Objectives address areas where improvement is needed. Objectives are challenging and set at the level of performance desired by management. Objectives are stated in measurable terms.

C. Where appropriate, action plans with specific milestones are used to help achieve objectives and improve the level of performance.

D. Maintenance division objectives are consistent and complement contracting organization and facility objectives.

E. Responsibilities are assigned for achievement of specific objectives. Assignments reflect actions needed by each contributing department to achieve common objectives.

F. Personnel understand the actions necessary, within the scope of their duties and responsibilities, to achieve the objectives.

G. Managers and supervisors are held accountable for the achievement of assigned objectives.

H. Management reviews are periodically conducted to assess progress toward achieving objectives and to determine changes in planned actions necessary to achieve them.

4.14.5 Management Involvement Assessment Objectives

Management and supervisory personnel should monitor and assess facility maintenance activities to improve all aspects of maintenance performance.

CRITERIA

A. Line managers and supervisors are responsible for and personally take part in monitoring and assessing maintenance activities. Assessments by other independent groups, such as QA, are used by line managers and supervisors as a management tool to assist them in assessing maintenance performance.

B. Managers and supervisors frequently tour the plant and observe ongoing work. Effective corrective actions are taken for noted problems.

C. Senior managers monitor the assessment activities of their subordinate managers and supervisors.

D. Management and supervisory assessment and improvement efforts are performance-oriented. Line managers and supervisors are responsible for determining and implementing corrective actions.

E. Selected maintenance data reflecting facility performance are analyzed and trended, and the results are forwarded to appropriate levels of management.

F. Root causes are determined for problems identified during monitoring of maintenance activities and by analysis of trends. Corrective actions are initiated and tracked to completion.

G. Management assessments are conducted to determine the reasons for success or failure in achievement of objectives. Results are incorporated into future objectives.

4.15 MAINTENANCE HISTORY (Replaces DOE-STD-1068-94)[78, 112]

4.15.1 Introduction

A maintenance history and trending program should be maintained to document data, provide historical information for maintenance planning, and support maintenance and performance trending of facility systems and components. The documentation of complete, detailed, and usable history will be increasingly important as plant-life extension becomes an issue. Trending should be directed toward identifying improvements for the maintenance program and needed equipment modifications. Sections 4.4, 4.6, and 4.16 provide guidance on programs that contribute to and are augmented by the maintenance history program.

The maintenance history program should document SSC maintenance and performance data as a basis for improving facility reliability. This history should assist in ensuring that root causes of failures are determined, corrected, and used in future work planning. This may be accomplished by a thorough review and analysis of maintenance performed, diagnostic monitoring data, and industry experience reports.

Maintenance history files should include component identification numbers and descriptions; complete maintenance records for all components/facilities in the system; diagnostic monitoring data; and relevant correspondence, including correspondence with vendors. To be an effective method for maintenance history control, the files should be computerized, with individual groups responsible for collecting data and populating the system. Provisions should be made for engineering review and analysis of both the history files and the overall program.

This section addresses the development and use of a maintenance history program.

NOTE: Examples of component identification/descriptions and maintenance records are shown in Figures 4.15 A and 4.15 B, respectively.

4.15.2 Discussion

One objective of a good equipment maintenance history program is the ability to readily retrieve equipment maintenance, performance, and reference information to improve facility reliability. The work-control system may be useful as a maintenance history data collection tool. The maintenance history program should provide a system to document component identification and description, vendor reference information and correspondence, diagnostic monitoring data, corrective and preventive maintenance or modification information, and spare parts information. This system may be maintained centrally or locally by the group responsible for collecting the data. In either case, easy access should be provided to all groups needing the information. The historical data, combined with operating experience at similar facilities, operating logs and records, and facility performance monitoring data, can be effective in analyzing trends and failures in equipment performance and making adjustments to the maintenance program. The maintenance history program should clearly define systems and equipment to be included, data to be collected, methods for recording data, and uses for the data.

4.15.3 Guidelines

4.15.3.1 Program Development

Equipment Identification. The maintenance history program should clearly define the safety systems and equipment that require documentation and retention of historical data according to the MEL for which maintenance provides support. In addition, nonsafety equipment requiring repeated maintenance should be considered for inclusion. The MEL, discussed in previous sections, could provide much of the information for the system. Alternatively, if the MEL is computerized, the history files could be cross-referenced to it.

Data Identification. The maintenance history program should define the type of data that should be collected and recorded to effectively support the uses discussed below in Section 4.15.3.3. Some examples of data that should be included or cross-referenced in the program are corrective maintenance records; appropriate PM records; modification packages; vendor repair information (e.g., correspondence on component repairs and modification bulletins); start-up tests and other baseline data; appropriate surveillance test data; calibration data; and applicable industry experience information. The specific data to be collected should include details of the work performed, special equipment and tools used, procedures or drawings needed, spare parts installed, personnel safety and radiation protection requirements, postmaintenance testing results, and any other information that may be useful later.

4.15.3.2 Data Collection

Data on systems and equipment selected for history retention should be sent to the person or group responsible for maintenance history retention and should then be entered in the maintenance history program. Any apparent errors, inconsistencies, or lack of detail should be referred to the maintenance supervisor or another appropriate supervisor for resolution.

4.15.3.3 Maintenance History File Development

Normally, components are grouped by system; however, in cases of like components such as valves, circuit breakers, and controllers, it may be more appropriate to group components by type. The maintenance history file for each component should include the following four sections.

Component Identification and Description. Engineering support personnel should ensure information like that shown in Figure 4.15-A (as a minimum) is recorded. Each component is identified by its name and number as listed in the MEL. In the case of like components grouped by type, this may be an index of all individual components and their associated systems. The description should include the manufacturer's name, model, serial number, and priority classification. Additional reference may be made to purchase order number; vendor manuals; drawings; system logic and/or flow diagrams; owner/operator cost center; acquisition data (i.e., purchase information and date accepted); location (technical area, building, and room numbers); applicable engineering documents; operating requirements/characteristics/history; spare parts list; owner/operator documents; and applicable maintenance procedures. In the event the component is replaced or modified, the original record should be annotated to indicate the change and retained in the file. A new record, referencing the original record, is prepared and placed in the file. Computerizing may assist in the access/use of the file.

Maintenance Record. The maintenance record is a chronological record of all significant work performed. All activities related to items selected for history retention should be deliberately and regularly recorded. The maintenance supervisor, or designee, extracts the information from the work package during the initial review of completed work and documents the as-found and as-left conditions. An example is included as Figure 4.15-B. Each entry should include the date, WR/WO number, and a clear, concise statement describing the deficiency and corrective action, with reference to postmaintenance testing results, as-found and as-left data, parts replaced or repaired, special tools used, craft-resource-hours and man-rem used. (Note: Where applicable, portions of this data need not be maintained in the maintenance record, provided it is cross-referenced to and easily retrievable from other record systems.) In the event the component is one of several grouped by type, the component identification is included. Similar entries are made in the event deficiencies are noted and corrective action taken when performing PM or surveillance tests. Periodic engineering review of the history file is also recorded. A common format for information entry enhances data entry ease, user familiarity, information retrieval, and repeated application.

Diagnostic Monitoring Data. This section should contain all performance-related information derived from baseline tests and checkout data, preventive and predictive maintenance, surveillance tests, and PMTs. Engineering support personnel should review designated completed test documents and ensure data are analyzed and recorded. Trending of data (e.g., vibration levels) should be used whenever feasible to facilitate analysis.

Vendor Correspondence. This section should contain any correspondence, inspections, and test results received from the vendor that relate to routine or PM servicing, parts, changes to as-built drawings, etc. Engineering support personnel should review this information and ensure it is filed and properly applied.

4.15.3.4 Program Use

Equipment failures should be analyzed promptly. Abnormal trends noted during diagnostic monitoring should be analyzed and corrective action recommended in a timely manner. In addition, periodic engineering reviews of the maintenance history file should be conducted in accordance with a schedule recommended by the engineering support supervisor and approved by the responsible manager. Component files should be reviewed at least every two years. The purpose of the reviews is to determine whether recurring maintenance problems or other performance trends indicate a need for corrective maintenance. Trending is also directed toward identifying improvements for the maintenance program and needed equipment modifications. The assigned engineer should determine the probable cause and recommend a course of action. This may result in corrective maintenance, component modification or replacement, a change in the preventive or predictive maintenance schedule, or a change in a procedure. These reviews can also help identify areas where decreased maintenance effort is warranted (e.g., reduced PM frequency). The assigned engineer should track performance after corrective action has been performed to ensure deficiencies have been corrected.

Maintenance history data should be readily available for use by all organizations, especially the maintenance and technical support organizations. Regular users should be trained to access and manipulate the history databases and files.

Maintenance coordinators, supervisors, craft personnel, and work planners should review the maintenance history file on defective components and like components for information on similar deficiencies, performance trends, special tools involved, parts information, labor and time requirements, personnel protection requirements, cautions, warnings, and applicable hazardous aspects, and procedure or instruction needs when preparing WRs/WOs and/or work package repair instructions. They should also consider use of interactive data retrieval for like components at other facilities and consult with engineering support on the applicability of any industry experience reports. In addition, work planners should advise engineering support of any persistent maintenance problems revealed during their reviews.

The following are some additional uses of maintenance history data.

- Failure analysis (providing some of the data needed to support analyzing and trending failures).
- Maintenance assessments (providing input to identify rework and/or maintenance program improvements).
- PM (providing some of the data useful for identifying and justifying PM program changes).
- Outage planning (providing some of the data useful for postoutage evaluation and as a basis for planning the next outage).
- PMT planning and execution.
- ALARA program (providing work-time data useful for radiological exposure evaluation and planning).
- Budget preparation (providing input for determining future maintenance needs).
- Review of industry experience, vendor information, and other documents (to assess plant-specific applicability).
- Plant-life extension (providing some of the data needed to support extension of plant design life).

The record of craft resource hours and materials expended to perform maintenance provides useful data for outage, ALARA, and budget planning. Schedules may be developed based on actual craft resource hours expended for past tasks that more realistically define the outage end point. More accurate estimates of hazard exposure may also be made based on experienced levels. Maintenance costs may be accurately projected based on actual craft resource hours and materials used in performance of maintenance.

Communication of maintenance history information, including root-cause analyses and categorization (Section 4.16), among similar facilities can contribute greatly to avoiding and understanding failures and saving time and money.

4.15.3.5 Computerized Maintenance History Engineering Database

A computerized maintenance history engineering database is a set of computer software modules and equipment databases containing facility data and the capability to process the data for facilities maintenance management functions. Computer software modules provide historical data, report writing capabilities, job analyses, and more. The data describe equipment, parts, jobs, crafts, costs, step-by-step instructions, and other information involved in the maintenance effort. This information may be stored, viewed, analyzed, reproduced and updated with just a few keystrokes. The maintenance-related functions typically include the following:

- maintenance cost and reliability data,
- facility/equipment inventories
- facility/equipment histories,
- work input controls,
- job estimating,
- work scheduling and tracking,
- preventive and predictive maintenance,
- facility inspections and assessments,
- material management, and
- utilities management.

A computerized maintenance history engineering database can emphasize SSC maintenance needs, costs, and reliability at DOE nuclear facilities, principally through the feedback of maintenance experience and SSC condition data to DOE contractor facility planners, designers, maintenance managers, craftsmen, and manufacturers, and to DOE for prioritization and allocation of funds for maintenance. This information is instrumental for continually upgrading the SSC specifications for increased reliability. Increased reliability leads to fewer SSC failures and, therefore, greater availability for mission support and lower maintenance costs.

Maintenance history data provide historical information for future maintenance planning, and support maintenance trending of systems and equipment. The documentation of complete, detailed, and usable history is important as historical data are analyzed for optimum maintenance actions that maximize equipment reliability and as support for DOE nuclear facility life-extension decisions.

Clearly defined guidance should be provided addressing maintenance history for the SSCs to be included, what to collect, how to record data, and how the data are to be used. This history may be maintained centrally or locally by the individual group responsible for collecting the data. In either case, easy access should be provided to all groups needing this information.

While the complete database is maintained locally by individual contractors operating DOE nuclear facilities, the data on actual maintenance costs, required maintenance costs, deferred maintenance costs, mission critical and SSC failure rates, and availability should be reported annually to DOE by the contractor for use in FIMS. The contractor's complete computerized maintenance history engineering database should contain and be capable of providing this data for incorporation into FIMS. Actual maintenance cost, required maintenance cost, and deferred maintenance cost data should be reported in dollars as part of property management and financial accounting reporting requirements. Nuclear facility failure rates can be determined in a number of different ways and may depend on SSC-specific factors such as whether the SSC is continuously operating or is mostly on standby. Failure rates should be reported in FIMS in two data fields, normally-in-use and standby; and, expressed as the total number of mission critical and safety SSC failures divided by an interval such as time or cycles. For both normally in-use and standby mission critical and safety SSCs, the failure rate should be expressed as probability per hour per year. Recognized methods for estimating failure rates are given in the PRA Procedures Guide, NUREG/CR-2300, January 1983.

Availability should be expressed in a single data field in FIMS as the time mission critical and safety SSCs are available for use. The actual run time of mission critical and safety SSCs is divided by the scheduled run time. Availability should be determined by dividing the number of hours in a specified time interval that the SSCs are capable of providing service by the total number of hours in the time interval examined. This should be expressed in percent per year as an indication of a nuclear facility's availability for use during that period; that is, the fraction of the time that mission critical and safety SSCs are capable of providing service, whether or not they are actually in service. FIMS is a Microsoft-Windows-based application designed to address DOE's real property information needs. Users access FIMS from their personal computers via modems or the Internet. Benefits include a central user database, inquiry access to data at all DOE sites, and interfaces with other facilities management systems. DOE should make FIMS maintenance history information readily available for use by all DOE organizations implementing effective action programs [see DOE G 433.1-1, Sections 4.1.3.6–4.1.3.13, 4.4.3.3.1–4.4.3.3.3, 4.6, 4.7, 4.9, 4.10, 4.11, and 4.15; 41 CFR 101-3; 10 CFR 830.122(d); 48 CFR 45.509 and DOE O 200.1[5, 6, 7, 8, 71]].

4.15.4 Maintenance History Performance Objectives [23, 112]

Maintenance history should be used to support maintenance activities, upgrade maintenance programs, optimize equipment performance, and improve equipment reliability.

CRITERIA

A. Maintenance history records are computerized and maintained for SSCs and equipment that affect safe and reliable facility operations.

B. Maintenance work and inspection/test results are effectively documented.

C. Maintenance history records are appropriately considered in planning for corrective maintenance, modifications, and PM.

D. Maintenance history records are readily available for use.

E. Maintenance history is periodically reviewed to identify equipment trends and persistent maintenance problems and to assess their impact on facility reliability. Maintenance program adjustments are made or other corrective actions are taken as needed.

4.15.5 In-house Operating Experience Review Performance Objectives

In-house operating experiences should be evaluated, and appropriate actions should be undertaken to improve safety and reliability.

CRITERIA

A. In-house events are screened for significance and prioritized for evaluation.

B. Rigorous investigation is performed on significant in-house events to determine root causes, generic implications, and necessary corrective actions to prevent recurrence.

C. Relevant in-house and industry operating experience is reviewed as part of the investigation of significant in-house events.

D. Significant in-house events receive a second, multidisciplinary review to ensure that all concerns have been addressed.

E. Other facilities receive timely notification of important in-house events of generic interest.

F. Post–facility-emergency-shutdown reviews are comprehensive and include the following:

- identification and resolution of the causes of the shutdown,
- identification and resolution of discrepancies between actual and expected facility responses to the shutdown, and
- documentation to support results and recommendations.

G. Pertinent in-house operating experience information is distributed to appropriate personnel and departments and recommended corrective actions are completed in a timely manner.

H. In-house events are trended to identify recurring problems and determine appropriate corrective actions.

4.15.6 Industry Operating Experience Review Performance Objectives

Significant industry operating experiences should be evaluated, and appropriate actions should be undertaken to improve safety and reliability.

CRITERIA

A. A comprehensive evaluation is performed on applicable, significant industry operating experiences, and appropriate corrective action is completed in a timely manner.

B. Sources of significant industry operating experience information are reviewed for applicability, including the following:

- DOE letters, bulletins, and information notices,
- Lessons Learned and Alert System, and
- supplier and architect/engineer reports.

C. Appropriate checks are performed to verify that industry operating experience information is being properly classified for applicability.

D. Applicable significant industry operating experience information is distributed to appropriate personnel and departments in a timely manner.

E. Distribution of conflicting or extraneous industry operating experience information to operators and other personnel is minimized.

SAFETY INJECTION PUMP 1

PEI SI 19724	Bingham Pump
Class I	Model 4 X 6 X 9-CP
Purchase Order AC-4286316	Serial Number 14 SA 479
Vendor Man. Vol. II - Bingham Pumps	Eng. Drawing E6-390162
Flow Diagram AL 480526, Safety Injection	

Applicable Procedures

MA-4.1924, Safety Injection Pump Disassembly
MA-4.1925, Safety Injection Pump Assembly
MA-4.1926, Safety Injection Pump Seal Replacement
SP-6.2163, Safety Injection Pump Performance Test - Monthly
PM-5.1372, Safety Injection Pump Inspection - Quarterly
PM-5.3916, Safety Injection Pump Inspection - Annual

NOTE: **8 ½-in. x 11"-in. cards are recommended when manual recording is used.**

Figure 4.15-A. Example Component Identification and Description.

SAFETY INJECTION PUMP 1

6-12-78	M.J.R. 49731 Inboard seal excessive leakage. Removed and inspected seal; excessive wear. Cleaned and inspected shaft. Installed new seal, part no. 187421. Conducted SP-6.2163; perform SAT. Total craft-resource-hours expended 80.
11-15-79	M.J.R. 51874 Modified first stage impeller retaining nut staking as per Bingham instructions 6-15-79. Internals cleaned and inspected-SAT. Assembled and realigned. Conducted SP-6.2163; perform, SAT. Total craft-resource-hours expended 50.
1-12-80	Reviewed maintenance history file—no problems noted.

Figure 4.15-B. Example Maintenance Record.

4.16 ANALYSIS OF MAINTENANCE PROBLEMS (see DOE-STD-1004-92; DOE-STD-1027-92; and DOE-STD-7501-95)

4.16.1 Introduction

Systematic analysis should be used to determine and correct root causes of unplanned occurrences related to maintenance. Section 4.15 provides guidance for collecting and trending maintenance history to reduce recurring or persistent equipment failures that should be reviewed by the analysis program. Incident reports, posttrip reviews, and other similar operating experience review documents and methods supplement the maintenance history program and provide data, including human error data, which should be reviewed by the analysis program.

This section describes an analysis program that may be used effectively to reduce recurring maintenance problems by identifying and resolving their root causes.

4.16.2 Discussion

An analysis program should be established to investigate unplanned occurrences that have an impact on safety or reliability or that are of a recurring nature, indicating that corrective actions have not been effective in solving their root causes. The symptom(s) of an unplanned occurrence should be addressed. However, for long-term corrective action, it is necessary that the root cause of the problem be determined and corrected. The root cause is defined as the most basic reason or collection of reasons for an unplanned event, which, once corrected, will prevent recurrence of that event. Analyzing and correcting the causes of both equipment and human error problems result in improved reliability by decreasing the probability of recurrence.

An analysis program should include the methodical collection of facts describing the unplanned occurrence. These facts should then be reviewed from the standpoint of management controls and engineering and human performance perspectives to pinpoint probable causes for the unplanned occurrence. Seldom does one single root cause exist by itself. A combination of such factors as supervision, workmanship, procedures, manufacturing flaws, training and qualification, improper tool use, and design may contribute to an unplanned occurrence. Corrective action follow-up should then be performed to help verify that the problem is resolved.

4.16.3 Guidelines

4.16.3.1 Information Collection

When all initial information (e.g., operator logs and records, recorder and computer records, interviews, and personnel statements) related to the unplanned occurrence is collected, additional information pertinent to the investigation should be identified and obtained. This may include diagnostic information (such as vibration measurements, infrared heat distribution profiles, lube oil sample analyses, and previous operating and maintenance history); operating procedures; vendor-recommended maintenance requirements; maintenance schedules; recommended maintenance that was not accomplished; information related to personnel training and qualifications and adequacy of communications; maintenance procedures; and relevant information obtained from documentation of maintenance history (Section 4.15). Additionally, collection of data for use in analyses of maintenance problems should be considered during the planning phase of maintenance activities. Other personnel who have performed the task or job in the past should be interviewed to obtain their viewpoints. A walk-through of how they performed the task may be a useful part of the interview.

4.16.3.2 Event Analysis [24, 25, 26, 53, 54, 55, 56, 99]

The purpose of the analysis phase is to reconstruct the event. A detailed sequence of facts and activities is developed and the event's apparent causal factors are identified and categorized into human performance or equipment performance problems. The following are the event causal factors for human performance problems, with explanatory examples.

- Verbal communication—Inadequate information exchange face-to-face or by telephone.
- Written procedures and documents—Inappropriate maintenance, operating, or special test procedures/instructions; inappropriate drawing(s), equipment manual(s), technical specification(s).
- Human-machine interface—Insufficient or incorrect label, gauge, annunciator, control device.
- Environmental conditions—Inadequate lighting, workspace, clothing; noise; high radiation, ambient temperature.
- Work schedule—Excessive overtime; insufficient time to prepare for or accomplish the task.
- Work practices—Lack of self-check; failure to follow procedures.
- Work organization/planning—Insufficient time to prepare or to perform unscheduled maintenance.
- Supervisory methods—Inadequate direction, supervisor interface; overemphasis on schedule.
- Training/qualification—Insufficient technical knowledge; lack of training; inadequate training materials; improper use of tools; insufficient practice; ineffective OJT.
- Change management—Inappropriate plant modification; lack of change-related retraining, procedures, documents.
- Resource management—Unavailability of tools, information, personnel, supervision.
- Managerial methods—Insufficient/lack of accountability, policy, goals, schedule; failure to ensure previous problem was resolved; insufficient use of operating experience; lack of proper assignment of responsibility; lack of communication or nonenforcement of high standards; lack of safety awareness.

The following are the event causal factors for equipment performance problems, with explanatory examples.

- Design configuration and analysis—inappropriate layout of system or subsystem; inappropriate component orientation; component omission; errors in assumptions, methods, or calculations during design or while establishing operational limits; improper selection of materials, components; failure to consider operating environment in original design.
- Equipment specification, manufacture, and construction—improper heat treatment, machining, casting, onsite fabrication, installation.
- Maintenance/testing—inadequate PM; insufficient postmaintenance testing; inadequate QC.
- Facility/system operation—changes in operating parameters, performance.
- External—storm, flood, earthquake, fire.

The explanatory examples given above are not all-inclusive; there may be many others similar to these in each category.

Of the above categories, one or more may be primary causes, one or more may be secondary, and others may be possible. In all cases, the reason why a category is chosen is known and documented.

4.16.3.3 Cause Determination [24, 25, 26, 53, 54, 55, 56, 80, 99]

The above actual or possible causes of a problem should be evaluated by one or more techniques or methodologies to establish a root cause. The root cause should meet three criteria: (1) its correction should prevent recurrence of the unplanned occurrence; (2) its correction should be feasible; and (3) its correction should not adversely impact safety, reliability, or operational goals. Examples of a number of proven and accepted techniques for analyzing information to determine causes of problems include the following:

- event and causal factor charting,
- walk-through task analysis,
- fault tree analysis,
- change analysis, and
- barrier analysis.

Event and causal factor charting uses a block diagram to depict cause and effect. This technique is most effective for solving complicated problems because it provides a means to organize the data, provides a concise summary of what is known and unknown about the event, and results in a detailed sequence of facts and activities. The first block on the chart is the primary effect. For each effect, there is a cause that becomes the effect in the next block to the right. For each cause (effect), two reasons that are known to be true are listed in a block just below the cause (effect).

If only one reason is known or the reason is uncertain, then all possible causes should be evaluated as potential causes. When this process gets to the point where a cause can be corrected to prevent recurrence of the event, the root cause has been found.

A walk-through task analysis may be used to supplement other techniques described here. This task analysis is a method in which personnel who actually do the task where the problem occurred conduct for the observer a step-by-step reenactment of their actions, without carrying out the actual function. The objective is to determine how a task was really performed and identify problems in human factors design, discrepancies in procedural steps, or inadequacies in training.

Fault tree analysis is a systematic approach, similar to the management oversight and risk tree process, which may be used when the problem is known but the cause is not clear. Questions are used to determine what was less than adequate and why. A flowchart is created by the use of "AND" and "OR" gates to record what was less than adequate.

Change analysis is used when the problem is obvious. It is generally used for a single event and looks at a problem by analyzing the discrepancy between what is expected and what actually happened. The evaluator essentially asks what differences occurred in this task or activity to make its outcome different this time from all other times. This technique consists of asking What? When? Where? Who? and How? The answers should provide direction toward answering the root-cause-determination question, "Why?"

Barrier analysis is a systematic questioning process that can be used when the problem appears to be programmatic. It identifies physical, administrative, and procedural controls, and other controls or barriers that should have prevented an event from happening. This technique should be used to assess why existing barriers, both physical and administrative, failed and what additional barriers are needed to prevent recurrence. Secondary questions in this technique ask "Why?" and "How do you know?"

One effective general approach is to employ a team of experts headed by an experienced, independent leader to systematically track causes and effects to successively more generic levels until a root cause or group of causes meeting the three criteria is identified. The team may include experts in system operation and testing, maintenance and repair techniques, materials, and failure analysis. No matter what technique is used, direct involvement of applicable line managers and supervisors in this process is essential to consistently achieving desired long-range improvements.

Care must be taken not to limit analysis to merely addressing the symptoms of a problem. The symptoms are sometimes causes in themselves; however, they are often only indications that must be examined to discover the underlying causes. Following are some examples showing the inadequacy of treating only the symptom:

- An instrument setpoint is found out of tolerance every time it is calibrated. Increasing the calibration frequency may correct the symptom by keeping the setpoint drift within tolerance. However, evaluating an instrument replacement, a range change, or a calibration procedure revision could lead to correction of the causes of the repeated failure.

- Brush wear is found to be excessive for motor-generator sets. Increasing the PM frequency for brush replacement may correct the symptom, but evaluation of the use of longer wearing brushes or detection of specific reasons for the excessive wear could be steps that should be taken beyond treatment of the symptom.

- Bearings fail frequently on rotating equipment. Adding a PM action to replace bearings periodically may correct the symptom by replacing the bearings before they fail. However, evaluating lubrication practices, frequency, and type of lubrication; correcting a misalignment; and training personnel performing lubrication could lead to correction of the contributing causes.

- An equipment protection channel inadvertently trips during a protection system surveillance. Improving the surveillance procedure and providing further training to instrument and control technicians may correct the symptom. However, an equipment design review could identify a design weakness that, once corrected, eliminates the potential for the technician to cause this type of channel trip.

4.16.3.4 Corrective Action

When all the causes involved have been determined, a corrective action plan should be developed, executed, and tracked to completion. The plan may be as simple as initiating a maintenance request for repair, changing a PM frequency, counseling personnel, or modifying the training program slightly. It may also be extensive, such as developing and installing a major modification, procuring long-lead-time parts and materials, contracting for specialized services, revising procedures, and training personnel for continued operation and maintenance of the installation.

4.16.3.5 Corrective Action Follow-up

In the case of an equipment problem, postmaintenance testing should be used to determine if additional maintenance work or diagnostic fact-finding should be performed. Upon completion of the additional fact-finding or repairs, an additional retest should be performed and the test results analyzed to determine whether the cause or causes of the malfunction have been corrected. Retest alone, however, does not always ensure that all causes have been detected and corrected. Closely monitoring the equipment during extended operation to provide sufficient certainty that the cause or causes have been properly addressed may also be necessary. Similar long-term follow-up is appropriate to determine whether the desired results are obtained from such corrective actions as retraining, procedural changes, and PM changes.

4.16.3.6 Generic Follow-up

The analysis program should address any generic corrective actions needed after problems with one piece of equipment have been determined and corrected. This could include such items as review of similar equipment, PM and surveillance programs, improvement of training and qualification programs for various facility or company personnel or both, and changes to maintenance and operating procedures. It is also useful to categorize root causes and to add this knowledge to the maintenance history program. Categorization of root causes will help to focus maintenance concern and resources and will aid future root-cause analyses and maintenance management.

4.16.4 Quality Assurance

Contractors responsible for a nuclear facility are required to implement a DOE-approved QAP in accordance with 10 CFR 830, Subpart A, Quality Assurance (the QA rule). Consequently, a QAP that applies to the maintenance management program should already be in place at each DOE nuclear facility. The QA rule includes ten criteria for the management, performance, and assessment of work so that it meets requirements. One of the criteria explicitly requires that items be maintained to prevent their damage, loss, or deterioration. A maintenance management program established using this Guide will satisfy that explicit criterion and address the other QA criteria in an integrated fashion.

Examples of the maintenance management program elements that integrate and satisfy the QA criteria include—

- organization—program, training, and qualification;
- condition of facilities and equipment—inspection and test;
- maintenance documentation—documents and records;
- work-control system—work processes; and
- maintenance evaluation and analysis—quality improvement, independent assessment, and management assessment.

A maintenance management program that integrates the QA criteria will perform continuing analysis and surveillance of the facility activities for safety, mission objectives, economics, system function, and compliance. It should provide constant oversight of nuclear operations, maintenance and program performance and should make the results available to contractor and DOE management or external regulators through the following:

- reports on organization and system performance;
- identification of maintenance problem areas;
- system corrective action plans; and
- assurance that corrective actions have been accomplished to prevent recurrence of the root cause of problems on a continuing basis, thereby assuring compliance on a continuing basis.

DOE nuclear facility QA programs should be an integrated management plan for fitting all hardware and administrative controls together in a framework which provides for management visibility of the operation, clear decision-making authority, identification of decision makers according to the matter under consideration, identification of interfaces and communication channels and all control points. The details of the program should be in written form and provide attributes of such a program that apply to all modes of facility operation, accident prevention, and accident mitigation. The administrative attributes intended to ensure that all SSCs required for safe operation of the facility are present should be identified in the facility SAR and should be classified by quality application such that they can be properly controlled.

All external organizations interfacing and performing work affecting the quality of a DOE nuclear facility design and operation should be identified in writing. This includes those organizations providing criteria, designs, specifications, and technical detail to cover the preparation, review, and approval of documents involving design and operational interfaces.

Persons and organizations performing independent assessment of the maintenance management program must have sufficient internal authority and organizational freedom to identify quality problems; initiate, recommend, or provide solutions; and verify implementation of solutions for QA (see 10 CFR 830, Subpart A; DOE O 414.1A).

4.17 MODIFICATION WORK

4.17.1 Introduction

This section is concerned with temporary modifications, permanent or minor modifications. Facility modification work, including minor modifications and temporary modifications, should be accomplished under the same basic administrative controls as those applied to facility maintenance activities so that there are no increases in risk to facility equipment, environment, or personnel because of the modification work. Changes to the maintenance program to incorporate facility modifications should be commensurate with the complexity of the task, the extent of the modification, and the importance of the equipment (see DOE-STD-1073-93; DOE-STD-1039-93, and DOE-STD-1120-98).

This section describes the updating of the maintenance program required as a result of nuclear facility modifications and also describes the handling of temporary modifications.

4.17.2 Discussion

The intent of this section is to provide guidance on modifications and the required updating of the maintenance program as a result of facility modifications, not to provide additional or redundant engineering and construction project requirements for modifications.

Modifications to SSCs may impact many aspects of the maintenance program. These modification-required changes should be recognized at an early enough date that they may be incorporated into the maintenance program before maintenance work begins on the modified SSC.

Temporary modifications should be controlled to ensure necessary personnel are aware of all changes and the expected duration of temporary modifications and that temporary alterations made to facility SSCs do not unacceptably alter or degrade the original design, facility safety, or reliability. The number and duration of temporary modifications should be minimized. Use of this guideline should control temporary modifications by requiring them to be adequately identified, reviewed, approved, documented, and periodically reassessed for continued applicability.

A temporary modification is any short-term alteration made to facility SSCs that does not conform with approved drawings or other design documents. The following are examples of temporary modifications:

- lifted leads,
- electrical jumpers,
- pulled circuit boards,
- disabled annunciators/alarms,
- mechanical jumpers/bypasses,
- temporary setpoint changes,
- installed or removed blank flanges,
- disabled relief or safety valves,
- installed or removed filters or strainers,
- plugged floor drains, and
- temporary pipe supports.

A facility program to control temporary modifications should include the following elements:

- owner/operator approval of temporary modifications before installation or removal;
- positive identification of electrical temporary modifications with independent verification before installation;
- independent verification or functional test of all temporary modifications after they are installed or removed;
- record of all installed temporary modifications;
- assurance that operators and supervisors are trained on installed temporary modifications and their impact on system/component operation before returning the system to service;
- safety reviews of temporary modifications installed on in-service (operable) equipment to ensure that the modified equipment should continue to perform as intended and not adversely affect plant or personnel safety;

- assurance of the quality of work and suitability of materials used for temporary modifications (For example, this guideline suggests that temporary modifications be installed or removed using an approved WR/WO.);
- method to review the temporary modifications periodically for errors and continued need;
- method of clearly identifying installed temporary modifications; and
- method to provide operators with instructions for operating temporarily modified equipment and/or guidance regarding the periodic monitoring of its operation (e.g., drawings and procedures should be marked up or annotated to reflect the new configuration before returning the system to operation).

4.17.3 Guidelines

4.17.3.1 Maintenance Program Interface with Modifications

A modification is a planned and controlled change to a permanent facility SSC that is accomplished in accordance with the requirements and limitations of applicable procedures, codes, standards, specifications, licenses, and predetermined safety restrictions identical to or commensurate with those of the item being modified.

Facility maintenance personnel should be cognizant of the effects of modifications on structures, systems, and equipment. After modifications, the required changes to documents such as drawings, procedures, spare parts lists, and vendor information should be accomplished before the structure, system, or equipment is operated and any subsequent maintenance activities are conducted.

The maintenance program should require that all plant modifications be reviewed under a change control program to identify future required maintenance activities and should specify that these activities be added to the maintenance programs, as applicable.

4.17.3.2 Temporary Repairs or Temporary Modifications

Temporary repairs are temporary modifications to the plant that allow equipment to remain in or be returned to service in a condition that is not the same as the original design specification. Before implementation, temporary repairs should receive a safety review in accordance with the facility temporary modification program to ensure the adequacy of the repair and its effect on personnel and equipment safety and reliability.

Temporary repairs should be tracked after their completion for consideration of permanent repairs. Permanent corrective action should be taken as soon as practicable.

4.17.3.3 Limitations and Precautions

Wherever possible, electrical circuits should be de-energized before the installation of jumpers or lifting of leads. If the temporary modifications shall be made with electrical circuits energized, specific approval of the owner/operator is required. Consideration should be given to using fused or switched jumpers. The effects of arcing and electrical noise should also be considered during energized installations.

- Lifted leads should be suitably insulated from other circuits and from the ground.
- All exposed electrical leads should be taped or insulated when left unattended.
- Jumper cables should be of sufficient length and contrasting color to stand out from other cables. Mechanical jumpers should be uniquely marked to stand out from other hoses or pipes.
- Jumpers (both electrical and mechanical) should be suitable for the use intended (i.e., size, terminal type, insulation, pressure rating, material, piping construction). The use of "alligator clips," clamps, or other attachment devices subject to inadvertent disconnect is discouraged.
- Before disconnecting any leads or installing any jumpers, the affected component or circuit should be verified to be the correct component or circuit. Discrepancies should be resolved by Technical Support before installation. This verification is in addition to the independent verification performed by operations personnel following installation.
- In cases of emergency, the owner/operator may give permission to deviate from this guideline when necessary to prevent injury to personnel, damage to equipment, or increase the margin of safety. The emergency deviation should then be documented and reviewed as soon as possible after installation.

4.17.3.4 Request and Description

The individual who desires to make a temporary modification should complete the description section of the Temporary Modification Sheet (Figure 4.17-B) with the assistance of the technical staff. Sketches/drawings needed to describe the temporary modification should be attached to the temporary modification sheet. The following information should be part of the description section:

- affected equipment and functions—this information should provide a brief statement of the effects on facility operation in all modes;
- reason for the modification;
- the expected duration of the installation (normally should be less than three months); and
- applicable drawings or design documents affected.

The type of temporary modification should be indicated. The information to be recorded for each type of temporary modification is as follows:

- lifted lead—cabinet name/location/number, terminal block number, terminal number, wire number, and tag number;

- electrical jumper—cabinet name/location/number (to/from), terminal block number; (to/from), terminal number (to/from), tag number (to/from), wire size, wire type, and type connector;
- disabled annunciator alarm—panel name/location/number, window location, window nomenclature, and tag number;
- pulled circuit card—cabinet name/location/number, circuit card, and tag number;
- mechanical jumpers—location (to/from), line number or valve number (to/from), tag number (to/from), jumper material, jumper size, pressure rating, and type connection;
- blank flange—location, line number or flange number, tag number, type, size, material, and bolt size and type; and
- other—type of device and enough information for location and evaluation of the temporary modification.

Maintenance crafts people should draft appropriate revisions to affected procedures and drawings. These revisions should be included in the temporary modification package. Temporary procedure and drawing revisions should be approved in accordance with facility administrative procedures.

The person requesting the temporary modification should sign the description section. If the person requesting the temporary modification is other than the person providing the description, both people should sign the description section.

4.17.3.5 Evaluation

The maintenance supervisor and a system engineer should complete the evaluation section of Figure 4.17-B, the temporary modification sheet. If possible, the maintenance supervisor of the person requesting the temporary modification should be the person to sign indicating approval. The maintenance supervisor and a system engineer should ensure that the temporary modification does not adversely affect the intended safety, reliability, or design of the facility.

The maintenance supervisor and the system engineer should determine whether the equipment is to be returned to service with the temporary modification installed. If the equipment is inoperable and removed from service in accordance with the facility tagging procedure (or other approved means), the steps outlined in the following paragraphs do not need to be completed. Temporary modifications installed on out-of-service equipment should be noted on the applicable tagging sheet or other controlling document to ensure that the temporary modification is either removed or evaluated before returning the equipment to service.

Cognizant engineers and maintenance personnel should complete Section A, Design Verification and Safety Review, of Figure 4.17-B by answering the questions. The reasons for each answer should provide sufficient information for approvers to determine that the temporary modification is safe. The questions of Section A should not be considered all-inclusive, and good engineering judgment should be used at all times when determining that a temporary modification is safe.

Assistance from technical support should be used when needed. The technical support manager should review and approve Section A.

Cognizant engineers and maintenance personnel should attach Section B, Safety Evaluation, of Figure 4.17-B to the temporary modification sheet. This safety evaluation should be controlled by a separate procedure.

All special actions, technical specification requirements, temporary operating instructions, etc., that are a result of the temporary modification should be noted on the temporary modification sheet. Any design requirements (e.g., pressure; temperature; fluid chemistry; voltage; current; material compatibility; or seismic, wind, thermal, and dynamic loading) resulting from the review should also be noted. All attachments (procedure revisions, drawing changes, etc.) should be a permanent part of the temporary modification package. Copies of the approved temporary modification sheet and supporting documentation should be forwarded to the owner/operator for installation.

The system engineer, with assistance from the Technical Support Organization, should identify the functional test requirements and responsible organizations for performance of the functional test. The maintenance supervisor and system engineer who complete the evaluation section should document their approval by signing the temporary modification sheet. The temporary modification sheet and all attachments should be forwarded to the facility manager for review and approval of the temporary modification before return of the affected system to service.

NOTE: If the temporary modification involves a technical specification change or USQ, DOE approval is required before installation.

A copy of the approved temporary modification package should be sent to the training department. Training should be conducted on the temporary modification and procedure changes.

A copy of the approved temporary modifications should be sent to the design organization within two weeks.

4.17.3.6 Installation

A temporary modification should be approved by the owner/operator before installation. He/she should do the following.

- Assign the next sequential entry number from the Temporary Modification Index (Figure 4.17-A) to the Temporary Modification Sheet (Figure 4.17-B).
- Make the appropriate entries on the Temporary Modification Index.
- Review the Temporary Modification Sheet to ensure it is complete and all required reviews and approvals have been obtained.

- Review the temporary modification to ensure it is compatible with existing facility conditions.
- Implement any special actions or technical specification requirements noted in the evaluation section.
- Ensure all required drawing changes, special instructions, and temporary procedure changes are completed and distributed and operating personnel on shift have been briefed. These instructions should be noted in the evaluation section of the Temporary Modification Sheet.
- Issue identification or caution tags, as appropriate, and note them in the comments section of the temporary modification sheet.
- Ensure an independent verification or functional test of the installation has been identified.
- Place the original copy of the Temporary Modification Sheet in the temporary modification log (including supporting documentation).
- Include the new temporary modification on the turnover checklist if it is installed longer than the present shift

The persons installing the temporary modification should do the following.

- Install the temporary modification in accordance with an approved WR/WO.

NOTE: Jumpers that are of such length that both ends are not visible when installed should have a temporary modification tag attached to each end with each tag bearing the same number.

- Fill out and install a temporary modification tag (Figure 4.17-C) for each temporary modification. The tag should identify the termination points of the temporary modification device.
- Insulate lifted leads from other circuits and from the ground.
- Identify the proper circuits or other components and terminals before disconnecting any leads or installing any jumpers. Independent verification should be provided.

The person responsible for performing the functional test should ensure the temporary modification is installed properly and authorization for the test has been obtained from the system engineer before initiating the test. He/she should perform the testing as specified by the system engineer, ensuring that all required data are taken and acceptance criteria are met. If criteria are not met, he/she should notify the system engineer.

4.17.3.7 Restoration

The maintenance supervisor should do the following:

- authorize restoration after ensuring the restoration is permissible;

- make the appropriate entry in the temporary modification index;
- remove any information or caution tags and delete any special instructions issued as a result of the temporary modification and brief operators on shift;
- perform an independent verification;
- ensure functional testing has been performed, if identified by the System Engineer;
- remove the original copy of the temporary modification sheet when completed and forward it to the appropriate owner/operator for review and filing
- ensure that documents changed in accordance with Section 4.17.3.1 are returned to normal and operating personnel on shift have been briefed; and
- note the temporary modification removal on the turnover sheet if it was installed longer than one shift.

Assigned personnel should remove the temporary modification in accordance with an approved WR/WO. The individuals performing the restoration and verification should ensure that the temporary modification is removed properly and all tags are removed. The appropriate owner/operator management should notify training by memo that the temporary modification has been removed.

4.17.3.8 Reviews and Audits

All operations personnel on shift should review the temporary modification log every shift as part of their shift turnover process to ensure that they are aware of all existing temporary modifications. They should also review the log before each mode change to ensure that no temporary modifications are required to be removed or have further evaluations completed.

The owner/operator should perform a monthly review and audit of the log for administrative errors. This review also should identify those temporary modifications either no longer needed, past their expected duration, or installed for more than 3 months. The number and duration of temporary modifications should be minimized.

- Those temporary modifications with administrative errors should receive prompt corrective action.
- Temporary modifications that are no longer needed should be removed in accordance with Section 4.17.3.5.
- A copy of temporary modification sheets that have exceeded their expected duration date or have been installed for longer than three months should be forwarded to the facility manager for review.
- Temporary modification index sheets on which all temporary modifications have been removed should be forwarded to the owner/operator for review and disposal.
- This review and audit should be documented by noting it on the temporary modification index.

The facility manager should review all temporary modifications installed longer than 6 months to determine whether they are still needed and should be made permanent or should be removed.

- Temporary modifications that are no longer needed should be removed in accordance with Section 4.17.3.5.
- The technical support department should be notified to submit permanent design change requests for modifications that should be made permanent.
- Temporary modifications that are to be left installed longer than their expected duration date should be assigned a new duration date on the temporary modification sheet.
- For temporary modifications installed longer than 6 months, written justification for continued installation should be attached to the temporary modification sheets to include items such as design change request number and new expected removal date (if changed).

The owner/operator should ensure a physical check of all temporary modifications is made monthly. The check should include verifying the following.

- The temporary modification is installed properly.
- The temporary modification tag is attached.
- The temporary modification is in good condition.

The person making the checks should initial and date each temporary modification tag and note the results of the checks in the comments section of the temporary modification sheet.

The owner/operator should ensure that critical facility drawings and procedures are updated or annotated to reflect temporary modifications before operation of the affected system. This may require the assistance of the technical support department on more complex modifications. The temporary modification requestor should coordinate the support required.

Before start-up following a scheduled outage, the owner/operator should conduct an audit of the temporary modification program. This audit should include physical checks for unauthorized tags and correct placement and tagging of temporary modifications.

Every 6 months the systems engineer should conduct a thorough walkdown of his/her system to identify unauthorized temporary modifications. Discrepancies should be promptly removed by a WR/WO or controlled by this guideline.

The technical support department manager, with the aid of the design organization, should conduct a quarterly assessment to verify the status and evaluate the design implications of installed temporary modifications. In the event a large number of temporary modifications are in place, the frequency of this assessment should be increased.

NUMBER	TYPE TM	AFFECTED EQUIP FUNCTION	RESTORATION REQUIRED BY DATE	INSTALLATION INSTALLED BY SIGN/DATE	INSTALLATION VERIFIED BY SIGN/DATE	RESTORATION RESTORED BY SIGN/DATE	RESTORATION VERIFIED BY SIGN/DATE

Figure 4.17-A. Example Temporary Modification Index.

TEMPORARY MODIFICATION SHEET

Page 1 of 4

TM Number: ____________

Date: ____________ Expected Duration/Condition: ____________

Description

SSC & Functions Affected: ____________

Reason: ____________

Drawing(s): ____________

Type TM (Circle One) (1) Disabled Annunciator Alarm (2) Lifted Lead (3) Electric jumper

(4) Pulled circuit card (5) Mechanical jumper (temp. piping) (6) Blank flange (7) Other

Additional Comments: ____________

Requested by: ____________ Date: ____________

Evaluation:

1. Will this system be operable while the TM is installed?

   Yes ☐ Complete Sections A & B; send copy of TM sheet to the facility manager

   No ☐ Go to step 4 and document TM on tagout or other administrative control

2. Technical Safety Requirement Reference: ____________

3. Special-Actions/Instructions/Requirements: ____________

4. Facility conditions for which the Temporary Modification may remain installed: ____________

Approved By: ____________ ____________
Maintenance Supervisor Date

Approved By: ____________ ____________
System Engineer Date

Approved By: ____________ ____________
Facility Manager Date

Figure 4.17-B. Example Temporary Modification Sheet.

TEMPORARY MODIFICATION SHEET

Page 2 of 4

INSTALL

Tag Number	Location	Description—Attach drawing, if necessary (wire number, terminal board and number, etc.)

Approval of installation: ______________________ Owner/Operator ______________ Date

Positive Identification:

Verified By: ______________________ ______________ Date
(electrical TMs)

Installed By: ______________________ ______________ Date

Verification/Function:

Checked By: ______________________ ______________ Date

RESTORE

Approval of Restoration: ______________________ Owner/Operator ______________ Date

Restored By: ______________________ ______________ Date

Verification/Function:

Checked By: ______________________ ______________ Date

Comments (tags issued-functional checks-periodic audit): ______________________

Figure 4.17-B. Example Temporary Modification Sheet (continued).

TEMPORARY MODIFICATION SHEET
Page 3 of 4

A. DESIGN VERIFICATION AND SAFETY REVIEW (attach additional pages as necessary)

1. The TM (including components, connections, and terminations) is consistent with design inputs such as pressure, temperature, fluid chemistry, voltage, current, material compatibility, or seismic, wind, thermal, and dynamic loading because: ____________________
____
____

2. The TM should not alter the environmental qualification of any safety-related component.

3. The TM should have no detrimental effect on the loading of an electrical system because: ____________________
____
____

4. The effect of this TM on the pressure-retaining features of any code class 1, 2, or 3 components is not detrimental because: ____________________
____
____

5. The TM should not detrimentally alter the performance characteristics of any safety-related component or system because: ____________________
____
____

6. The TM has no detrimental effect on a safety actuation system within the isolation output buffers of the system because: ____________________
____
____

7. The TM or its failure should not affect more than one train of components (including separation criteria and common mode failure) because: ____________________
____
____

8. The TM does not create a condition beyond those conditions assumed in the fire hazards analysis because: ____________________
____
____

9. The potential for personnel injury or SSC damage from this TM is: ____________________
____
____

10. The ability of operators to control or monitor the facility or system significantly reduced because (take credit for increased surveillance due to the TM.):
____
____
____

11. The effect of this TM on the levels of radiation or airborne radioactivity is not detrimental because:
____
____
____

Figure 4.17-B. Example Temporary Modification Sheet (continued).

TEMPORARY MODIFICATION SHEET
Page 4 of 4

This TM is Safe: ______________________________ ______________
Design Verification and Safety Review Preparer — Date

Safety Review Approved By: ______________________________ ______________
Owner/Operator — Date

______________________________ ______________
Technical Support Manager — Date

B. SAFETY EVALUATION (attach additional pages as necessary): ______________________________

Figure 4.17-B. Example Temporary Modification Sheet (continued).

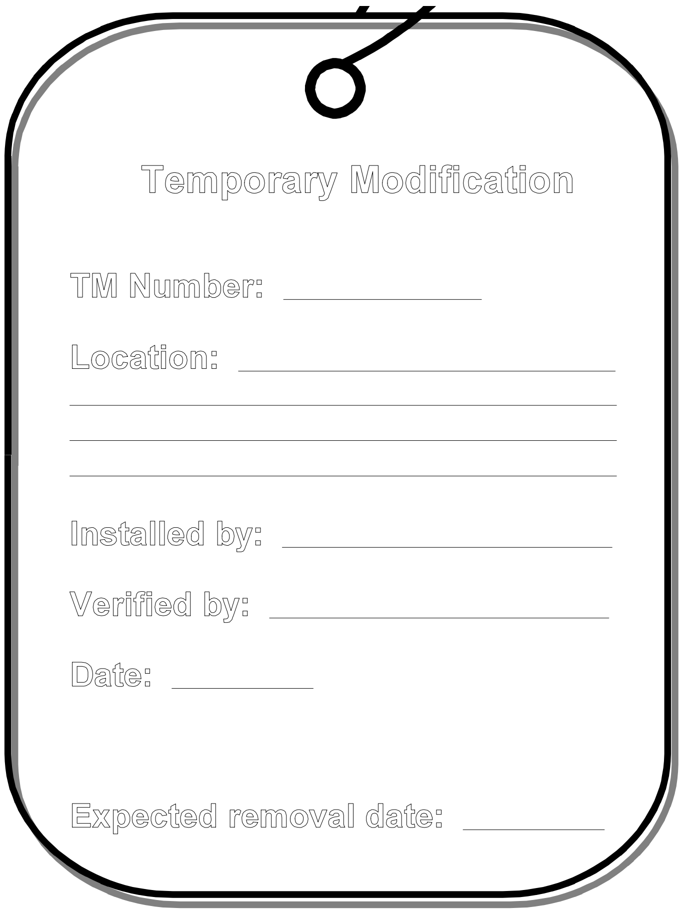


Figure 4.17-C. Example Temporary Modification Tag.

4.18 SEASONAL/SEVERE WEATHER AND ADVERSE ENVIRONMENTAL CONDITIONS MAINTENANCE (Replaces DOE-STD-1064-94)

4.18.1 Introduction

Seasonal facility preservation includes developing and implementing a plan to address severe weather, environmental, and wildfire conditions, referred to as severe conditions, for the safe operation and preservation of DOE nuclear facilities. This section describes examples of proactive measures that should be taken by maintenance organizations to adapt the facilities to changing external weather/environmental conditions. Additional information pertinent to the implementation of this guidance may be found in Sections 4.4 and 4.13.

4.18.2 Discussion

The fundamental objective of an effective severe conditions facility preservation plan should be to ensure continued safe facility operations. This objective requires that appropriate controls be established for inspections and self-assessments of severe conditions facility preservation plans to ensure correction of deficiencies or preparation of other compensatory measures to protect DOE nuclear facilities.

The plan should clearly define responsibilities, accountabilities, and interfaces for each functional organization supporting each step in the plan. A severe conditions facility preservation plan, as a minimum, should include steps to address the following:

- cold weather, including freezing conditions, hail, snow, and ice;
- flash floods and mud slides;
- hurricane watches and warnings;
- tornado watches and warnings (high winds);
- extreme hot/dry weather; and
- wildfires.

NOTE: **Facility status at the time a severe weather condition exists should dictate actions required to place the plant in a state of readiness for seasonal facility preservation.**

Facility managers should consider severe conditions related problems as priority and take immediate corrective action, such as the following, to minimize damage (Section 4.18.3.7 may be used as an example checklist for cold weather conditions.):

1. regularly evaluating severe conditions facility preservation plan activities involving maintenance organizations to determine and implement enhancement/improvement opportunities in a timely manner;

2. making decisions to temporarily curtail operations (safe shutdown) of a facility identified as having a high probability for sustaining damage when subjected to unusually severe conditions;

3. identifying personnel to be evacuated during severe conditions and ensuring any such evacuation is carried out in accordance with approved emergency procedures;

4. ensuring that adequate severe conditions protection plans are validated, verified, approved, and implemented;

5. ensuring predetermined operational changes are executed to protect equipment and facilities assigned as their area of responsibility involving modification of equipment set-ups or shut down/start-up of equipment as required to ensure protection from potential damage and to minimize loads on power distribution lines;

6. making decisions for operation or shutdown of all primary heating, ventilating, and air-conditioning (HVAC) building equipment that may affect ambient temperatures in any facility susceptible to severe conditions damage. Secondary equipment such as unit heaters and desk heaters may be operated by others;

7. ensuring PM is current for emergency diesel generators, uninterruptable power supplies, and plant battery banks to ensure operability when severe conditions are expected;

8. inspecting for damage and initiating repairs during and/or severe conditions;

9. securing operations for safe shutdown of critical systems;

10. examining all facilities and equipment assigned to their area of responsibility on a seasonal basis. This may be included in the Facility Condition Inspection process in accordance with Section 4.13;

11. identifying facilities having a high probability for sustaining damage when subjected to unusually severe conditions;

12. monitoring their assigned facilities for protection and assuring any necessary on-site actions are taken and/or correct personnel are notified to protect equipment and facilities assigned to their area of responsibility;

13. monitoring conditions in climate sensitive areas during normal daytime operations;

14. identifying deficiencies requiring repair or modification to mitigate/prevent problems;

15. verifying routine actions are taken annually before seasonal hazards to provide protection for their assigned areas of responsibility;

16. initiating necessary damage inspections and applicable repairs following severe conditions;

17. identifying and submitting corrective actions on deficiencies requiring repair or modification to systems/equipment to prevent seasonal hazard problems and to ensure that, in extreme (high/low) temperature conditions, proper operation of equipment is maintained within their assigned areas of responsibility;

18. scheduling craft activities to correct previously identified deficiencies that may lead to seasonal hazard problems that prevent proper system/equipment operation in extreme (high/low) temperature conditions;

19. maintaining a crew call-in list for maintenance crews to respond to specific seasonal hazard related problems;

20. accomplishing scheduled PM, WRs/WOs, repairs and/or modifications to correct deficiencies that may lead to seasonal hazard problems that prevent proper system/equipment operation in extreme (high/low) temperature conditions;

21. inspecting the on-going job sites for loose materials and debris, which may become missiles in strong winds, and securing them to the maximum extent possible;

22. ensuring freestanding materials or objects in staging/laydown areas have been tied and anchored or moved inside buildings to the maximum extent practical;

23. ensuring adequate foul weather and fire protection gear, tools, and equipment are available for use in the applicable seasonal hazard; and

24. regularly evaluating emergency diesel generators, uninterruptable power supplies, and plant battery banks to ensure operability when severe weather conditions are expected.

4.18.3 Guidelines

4.18.3.1 Facility Preservation During Severe Conditions Plan

Plans should be developed, implemented, and documented to prevent equipment and building damage at DOE facilities, because of the severe seasonal and environmental conditions listed in Section 4.18.2. A task team should be established to develop and implement policies, goals, and objectives for severe conditions protection plans. Buildings and equipment with the potential for damage from seasonal weather conditions should be identified, and a risk assessment based on the graded approach should be conducted. The plan should include contingencies for the critical facilities or equipment that are likely to sustain damage when severe conditions are expected. The plan should ensure that, in all cases, the preparatory actions and requirements imposed to provide severe conditions protection, particularly those taken to restrict safety system functions, are reviewed by facility operations and safety personnel before implementation to ensure that the facility is maintained in a safe condition to protect the health and safety of the public.

As a minimum, this plan should address the following.

- A checklist for building managers to ensure the implementation of actions to provide protection for their assigned areas of responsibility before severe conditions.

- Identification of items requiring major modifications or redesign to mitigate/prevent equipment damage. For items that may not be changed before the upcoming severe condition, interim actions should be taken to prevent equipment damage.

- Specific responsibilities for the operations staff and building managers for monitoring the temperatures in facilities on and off shifts, including weekends and holidays.

- Provisions for alerting personnel and providing increased surveillance in periods of extreme, unusual, or extended severe conditions. Maintenance personnel should be on call to respond to such events.

- Adequate foul weather and fire protection gear, tools, and equipment are available for use for emergency and operations personnel.

- The recalibration of exposed instrument loops when instrument lines or transmitters are subjected to severe conditions.

- A review of the status of safety related equipment during severe conditions and assurance inoperable equipment is available for return to service, if possible.

- A review of surveillance schedules and considerations given to performing surveillances early, if possible, or delaying them until after the severe condition passes, if permitted, to minimize equipment out of service.

- Inspection of outside areas for loose materials and debris, which may become missiles in a strong wind, and securing to the maximum extent possible.

- The availability of adequate lumber and other supplies for wind protection or damage control.

- Verification of operability and availability of communications equipment.

- Identification of plant vehicles needed for emergency use and ensure vehicles have a full tank of fuel and are in good repair.

- The availability of equipment for making emergency repairs.

- Ensuring materials susceptible to severe conditions damage are properly stored and protected.

- Ensuring the protection of accumulation site waste containers and bulk chemicals from potential damage as a result of seasonal hazards.
- Ensuring all building doors and windows can be properly secured.

- Provisions to remove seasonal weather protection features after the weather season is over with appropriate verification and documentation of return to normal service through the facilities configuration management system. (An example related to cold weather is given in Section 4.18.5.)

4.18.3.2 Cold Weather Preparation

In addition to the list of items in Section 4.18.3.1, the following should be included to minimize equipment and building damage from cold weather conditions, temperatures less than or equal to 35º F, including hail, snow, and ice.

- Identifying areas where portable heating may be required and obtaining portable heating equipment, approved by the fire protection engineering group.
- Monitoring the conditions surrounding fire protection sprinkler systems to ensure a temperature of above 40º F is maintained.
- Ensuring air intakes, windows, doors and any other access points that may result in abnormal flow of cold air into an area susceptible to freeze damage are secured.
- Ensuring heating systems are cleaned, serviced, and functionally tested.
- Ensuring antifreeze used in cooling systems is checked and replaced as necessary.
- Ensuring heating system power and temperature controls are protected against inadvertent deactivation.
- Ensuring systems requiring or deserving special protection due to hazards or costs associated with freeze damage have temperature alarms and/or automatic backup heat sources.
- Inspecting, testing, and staging portable auxiliary heaters and identifying sources to obtain more, if needed.
- Training personnel in the safe use of portable heaters.
- Ensuring the main water supply cutoffs for each critical facility are identified, tested, and readily accessible to emergency personnel responding to a freeze/thaw incident.
- Inspecting outside storage pads and unheated storage areas to ensure that there are no materials susceptible to freeze damage.
- Implementing snow and ice removal activities.
- Ensuring employees are aware of the need to identify and report any suspected problem with heating or other cold weather protection equipment (e.g., noninsulated water or process pipes, steam trace heaters valved off, electrical trace heaters turned off or burned out, broken windows, holes in exterior walls).
- Evaluating the removal of freeze protection equipment from service during the seasonal freeze period.

- Reviewing wet-pipe sprinkler systems for areas susceptible to freezing and taking appropriate actions such as making provisions for auxiliary heat, draining, and/or posting a fire watch.

- Ensuring availability and use of salt, sand, and "ice-chaser" as needed.

- Inspecting outside areas to ensure that gutters and downspouts are provided where there is a potential for ice buildup that may restrict egress.

4.18.3.3 Flash Floods and Mud Slides

In addition to the list of items in Section 4.18.3.1, the following should be included to minimize equipment and building damage due to flash flooding and mud slides.

- Doors and windows closed.
- Vulnerable items covered with tarps.
- Storm drains kept clear of debris.
- Sandbags and dikes used where necessary.
- Water-vulnerable items raised above the expected water line.
- All vehicles parked/moved to high ground as necessary.

4.18.3.4 Hurricane Watches and Warnings

In addition to the lists of items in Section 4.18.3.1 and Section 4.18.3.3, the items listed below should be included to minimize equipment and building damage from a hurricane.

- Windows boarded up or taped as necessary during a hurricane watch.
- Safe shutdown of vulnerable equipment.
- Emergency evacuation policies and routes.

4.18.3.5 Tornado Watches and Warnings (High Winds)

In addition to the lists of items in Section 4.18.3.1, and Section 4.18.3.3, the following should be included to minimize equipment and building damage from tornadoes.

- Plan for the safe shutdown of vulnerable equipment.
- Develop emergency evacuation policies and routes, and ensure that personnel are familiar with them.

4.18.3.6 Extreme Hot/Dry Weather

In addition to the guidelines listed in Section 4.18.3.1, the following should be included to minimize equipment and building damage from extreme hot/dry weather.

- Plan for the safe shutdown of vulnerable equipment.
- Restrict operations which involve heat (welding, burning, sparks, etc.).
- Restrict fire hazards (smoking, etc.).
- Ensure an ample supply of portable fire extinguishers are available.
- Ensure fire protection personnel are alerted.
- Ensure all exits are kept clear.

4.18.3.7 Example Cold Weather Checklist

SEPTEMBER

Building Managers	Increase surveillance of assigned facilities to identify areas having a high probability for sustaining freeze damage. Generate Standing WOs or WRs/WOs for corrective action.
Maintenance Department	Increase surveillance of facilities to identify areas having a high probability for sustaining weather related damage. Generate WRs/WOs for corrective action. Check status of winter and foul weather gear, tools, and equipment for personnel required to work outdoors. Plan and schedule final outages on steam system(s). Coordinate semiannual boiler inspections. Plan and schedule seasonal facility preservation WRs/WOs and PM job request.

OCTOBER

Facility Manager	Annual reminder to the plant of seasonal facility preservation precautions.
Building Managers	Coordinate with maintenance managers to assure timely scheduling and completion of seasonal facility preservation related WRs/WOs.
Maintenance Department	Complete semiannual boiler inspections. Complete maintenance activities requiring outages of steam system. Request extended work week for the shops involved in seasonal facility preservation maintenance activities, if required.

Ensure a crew call-in list is available for maintenance crews to respond to cold weather related problems.

Complete execution of cold weather related WRs/WOs and PM job request.

MARCH

Building Managers	Increase surveillance of assigned facilities in anticipation of the spring season. Generate standing WOs and/or WRs/WOs for corrective action.
Maintenance Department	Plan, schedule, and begin execution of standing WOs and/or WRs/WOs relating to the spring season. Schedule PM job request related to the spring season.

APRIL

Building Managers	Coordinate with the Maintenance Department to schedule and execute freeze protection/prevention standing WOs and/or WRs/WOs that require close down or turn around work during the warm weather season.
Maintenance Department	Plan, schedule, and execute freeze protection/prevention standing WOs and/or WRs/WOs which require close down or turn around work during the warm weather season. Continue execution of WRs/WOs and PM relating to spring/summer operations.

4.18.3.8 Example Wildfire Condition Checklists

In addition to the guidelines listed in Section 4.18.3.1, the following should be included to minimize personnel safety concerns as well as equipment and building damage due to wildfire conditions.

- Activate the Emergency Operations Center.
- Where appropriate secure HVAC and other vulnerable equipment systems to isolate SSCs from soot and smoke damage.
- Ensure safe shutdown of vulnerable equipment.
- Verify all exits are kept clear.
- Evacuate Laboratory and local areas as appropriate.

IV. REFERENCES

REGULATIONS

1. 10 CFR 830, Subpart A, Quality Assurance.
2. 10 CFR 834, Radiation Protection of the Public and the Environment (Proposed).
3. 10 CFR 835, Occupational Radiation Protection.
4. 29 CFR 1910.119, Process Safety Management of Highly Hazardous Chemicals.
5. 41 CFR, Subtitle C, Chapter 109, DOE Property Management Regulations.
6. 41 CFR101.3, Annual Real Property Inventories.
7. 41 CFR 101, Federal Property Management Regulations.
8. 41 CFR 102, Federal Management Regulations.
9. 48 CFR 45.509, Care, Maintenance and Use of Government Property.
10. 52 CFR 952.211.72, Uniform Reporting System.
11. DEAR 970.5223-1, Integration of Environment, Safety and Health into Work Planning and Execution.

POLICIES

12. DOE P 411.1, *Safety Management Functions, Responsibilities and Authorities Policy*.
13. DOE P 430.1, *Land and Facility Use Planning.*
14. DOE P 440.1, *Department of Energy Radiological Health and Safety Policy*.
15. DOE P 450.1, *Environment, Safety and Health Policy for the Department of Energy Complex.*
16. DOE P 450.2A, *Identification, Implementation and Compliance with Environment, Safety and Health Requirements.*
17. DOE P 450.4, *Safety Management System Policy*.
18. DOE P 450.5, *Line Environment Safety and Health Oversight.*

ORDERS

19. DOE O 130.1, *Budget Formulation Process.*
20. DOE O 135.1, *Budget Execution-funds Distribution and Control.*
21. DOE O 200.1, *Information Management Program.*
22. DOE O 210.1, *Performance Indicators and Analysis.*
23. DOE O 224.1, *Contractor Performance-based Management Process.*

24. DOE O 225.1A, *Accident Investigations.*
25. DOE O 231.1, *Environment, Safety, and Health Reporting.*
26. DOE O 232.1A, *Occurrence Reporting and Processing of Operations Information.*
27. DOE O 360.1, *Training*.
28. DOE O 412.1, *Work Authorization System.*
29. DOE O 413.1, *Management Control Program.*
30. DOE O 414.1A, *Quality Assurance.*
31. DOE O 420.1, *Facility Safety.*
32. DOE O 425.1, *Startup and Restart of Nuclear Facilities.*
33. DOE O 430.1A, *Life-Cycle Asset Management.*
34. DOE O 440.1A, *Worker Protection Management for DOE Federal and Contractor Employees.*
35. DOE O 450.1A, *National Environmental Policy Act Compliance Program.*
36. DOE O 452.1A, *Nuclear Explosive and Weapon Surety*.
37. DOE O 452.2A, *Safety of Nuclear Explosive Operations.*
38. DOE 1332.1A, *Uniform Reporting System.*
39. DOE 3790.1B, *Federal Employee Occupational Safety and Health Program.*
40. DOE 4330.4B, *Maintenance Management Program.*
41. DOE 4330.5, *Surplus Facility Transfer.*
42. DOE 5400.1, *General Environmental Protection Program.*
43. DOE 5400.5, *Radiation Protection of the Public and the Environment.*
44. DOE 5480.4, *Environmental Protection, Safety, and Health Protection Standards.*
45. DOE 5480.19, *Conduct of Operations Requirements for DOE Facilities.*
46. DOE 5480.20A, *Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities.*
47. DOE 5480.21, *Unreviewed Safety Question.*
48. DOE 5480.22, *Technical Safety Requirements.*
49. DOE 5480.23, *Nuclear Safety Analysis Reports.*
50. DOE 5480.24, *Nuclear Criticality Safety.*
51. DOE 5480.26, *Trending and Analysis of Operation Information Using Performance Indicators.*
52. DOE 5480.30, *Nuclear Reactor Safety Design Criteria.*
53. DOE 5480.31, *Startup and Restart of Nuclear Facilities.*
54. DOE 5484.1, *Environmental Protection, Safety, and Health Protection Information Reporting Requirements.*
55. DOE O 412.1, *Work Authorization System*.

MANUALS

56. DOE M 231.1-1, *Environment, Safety, and Health Reporting Manual.*
57. DOE M 232.1-1A, *Occurrence Reporting and Processing of Operations Information.*
58. DOE M 411.1-1, *Manual of Safety Management Functions, Responsibilities and Authorities.*

NOTICES

59. DOE N 430.1, *Energy Systems Acquisition Advisory Board Procedures.*
60. DOE N 441.1, *Radiological Protection for DOE Activities.*
61. DOE N 441.3, *Extension of DOE N 441.1, Radiological Protection for DOE Activities.*

GUIDES

62. DOE-EGS-95-01, Enforcement Guidance Supplement.
63. DOE-EGS-98-01, Enforcement Guidance Supplement.
64. DOE-EGS-98-02, Enforcement Guidance Supplement.
65. DOE-EGS-99-01, Enforcement Guidance Supplement.
66. DOE-EGS-99-02, Enforcement Guidance Supplement.
67. DOE-EGS-00-01, Enforcement Guidance Supplement.
68. DOE G 430.1-1, *Cost Estimating Guide.*
69. DOE G 430.1-2, *Implementation Guide for Surveillance and Maintenance During Facility Transition and Disposition.*
70. DOE G 440.1-1, *Worker Protection Management for DOE Federal and Contractor Employees Guide for use with DOE Order 440.1.*
71. DOE G 440.1-2, *Construction Safety Management Guide for use with DOE Order 440.1.*
72. DOE G 440.1-3, *Implementation Guide for Use with DOE O 440.1, Occupational Exposure Assessment.*
73. DOE Personal Property Letter 970-3, High Risk Personal Property
74. DOE G 440.1-4, *Contractor Occupational Medical Program Guide for use with DOE Order 440.1.*
75. DOE G 440.1-5, *Implementation Guide for use with DOE Orders 420.1 and 440.1 Fire Safety Program.*
76. DOE G 440.1-6, *Implementation Guide for use with Suspect/Counterfeit Items Requirements of DOE Order 440.1, Worker Protection Management; 10 CFR 830.120; and DOE 5700.6C, Quality Assurance.*

77. DOE G 440.1-7A, *Implementation Guide for use with 10 CFR Part 850, Chronic Beryllium Disease Prevention Program.*
78. DOE G 450.4-1B, *Integrated Safety Management System Guide for use with Safety Management System Policies (DOE P 450.4, DOE P 450.5, and DOE P 450.6); the Functions, Responsibilities, and Authorities Manual; and the Department of Energy Acquisition Regulation.*
79. DOE G 452.2A-1A, *Implementation Guide for DOE Order 452.2A, Safety of Nuclear Explosive Operations.*
80. DOE G 1324.5B, *Implementation Guide for use with 36 CFR Chapter XII–Subchapter B, Records Management.*

SECRETARY OF ENERGY NOTICES

81. SEN 35-91, *Nuclear Safety Policy*.

STANDARDS

82. DOE STD-1004-92, *Root Cause Analysis Guidance Document.*
83. DOE STD-1012-92, *Guide to Good Practices for On-the-Job Training.*
84. DOE STD-1027-92, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports.*
85. DOE-STD-1029-92, *Writer's Guide for Technical Procedures.*
86. DOE-STD-1030-96, *Guide to Good Practices for Lockouts and Tagouts.*
87. DOE-STD-1031-92, *Guide to Good Practices for Communications.*
88. DOE-STD-1032-92, *Guide to Good Practices for Operations Organization and Administration.*
89. DOE-STD-1033-92, *Guide to Good Practices for Operations and Administration Updates Through Required Reading.*
90. DOE-STD-1034-93, *Guide to Good Practices for Timely Orders to Operators.*
91. DOE-STD-1035-93, *Guide to Good Practices for Logkeeping.*
92. DOE-STD-1036-93, *Guide to Good Practices for Independent Verification.*
93. DOE-STD-1037-93, *Guide to Good Practices for Operations Aspects of Unique Processes.*
94. DOE-STD-1038-93, *Guide to Good Practices for Operations Turnover.*
95. DOE-STD-1039-93, *Guide to Good Practices for Control of Equipment and System Status.*
96. DOE-STD-1040-93, *Guide to Good Practices for Control of On-Shift Training.*
97. DOE-STD-1041-93, *Guide to Good Practices for Shift Routines and Operating Practices.*

98. DOE-STD-1042-93, *Guide to Good Practices for Control of Area Activities.*
99. DOE-STD-1043-93, *Guide to Good Practices for Operator Aid Postings.*
100. DOE-STD-1044-93, *Guide to Good Practices for Equipment and Piping Labeling.*
101. DOE-STD-1045-93, *Guide to Good Practices for Notifications and Investigation of Abnormal Events.*
102. DOE-STD-1050-93, *Guideline to Good Practices for Planning, Scheduling, and Coordination of Maintenance at DOE Nuclear Facilities.*
103. DOE-STD-1051-93, *Guideline to Good Practices for Maintenance Organization and Administration at DOE Nuclear Facilities.*
104. DOE-STD-1052-93, *Guideline to Good Practices for Types of Maintenance Activities at DOE Nuclear Facilities.*
105. DOE-STD-1053-93, *Guideline to Good Practices for Control of Maintenance Activities at DOE Nuclear Facilities.*
106. DOE-STD-1054-93, *Guideline to Good Practices for Control and Calibration of Measuring and Test Equipment (M&TE) at DOE Nuclear Facilities.*
107. DOE-STD-1055-93, *Guideline to Good Practices for Maintenance Management Involvement at DOE Nuclear Facilities.*
108. DOE-STD-1059-93, *Guide to Good Practices for Maintenance Supervisor Selection and Development.*
109. DOE-STD-1064-94, *Guideline to Good Practices for Seasonal Facility Preservation at DOE Nuclear Facilities.*
110. DOE-STD-1065-94, *Guideline to Good Practices for Postmaintenance Testing at DOE Nuclear Facilities.*
111. DOE-STD-1067-94, *Guideline to Good Practices for Maintenance Facilities, Equipment, and Tools at DOE Nuclear Facilities.*
112. DOE-STD-1068-94, *Guideline to Good Practices for Maintenance History at DOE Nuclear Facilities.*
113. DOE-STD-1069-94, *Guideline to Good Practices for Maintenance Tools and Equipment Control at DOE Nuclear Facilities.*
114. DOE-STD-1070-94, *Guidelines for Evaluation of Nuclear Facility Training Programs.*
115. DOE-STD-1071-94, *Guideline to Good Practices for Material Receipt, Inspection, Handling, Storage, Retrieval, and Issuance at DOE Nuclear Facilities.*
116. DOE-STD-1072-94, *Guideline to Good Practices for Facility Condition Inspections at DOE Nuclear Facilities.*
117. DOE-STD-1073-93, *Guide for Operational Configuration Management Programs, Including the Adjunct Programs of Design Reconstitution and Material Aging Management.*
118. DOE-STD-1120-98, *Integration of Environment, Safety, and Health into Facility Disposition Activities.*
119. DOE-STD-7501-95, *Development of DOE Lessons Learned Programs.*

HANDBOOKS

120. DOE-HDBK-1003-96, *Guide to Good Practices for Training and Qualification of Maintenance Personnel.*
121. DOE-HDBK-1085-95, *DOE Enforcement Program Roles and Responsibilities Guidance.*
122. DOE-HDBK-1087-95, *Operational Procedures for Enforcement.*
123. DOE-HDBK-1089-95, *Identification, Reporting, and Tracking Nuclear Safety Noncompliances.*
124. DOE-HDBK-1110-97, *ALARA Training for Technical Support Personnel.*
125. DOE-HDBK-1117-99, *Guide to Good Practices for Maintenance Supervisor Selection and Development.*