U.S. Department of Energy

Washington, D.C.

DOE 4330.4B

2-10-94

SUBJECT: Maintenance Management Program

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1. PURPOSE. To provide general policy and objectives for the establishment of programs for the management and performance of cost-effective maintenance and repair of Department of Energy (DOE) property.

2. CANCELLATION. DOE 4330.4A, MAINTENANCE MANAGEMENT PROGRAM, of 10-17-90.

3. SCOPE. The provisions of this Order apply to all Departmental Elements, except as otherwise provided by statute or by specific delegation of authority from the Secretary, and to all contractors and subcontractors performing work for the Department whose contract may involve maintenance responsibilities for production, operation, research, development, or demonstration. This includes sites owned and leased or controlled by DOE, where maintenance is contractually the responsibility of DOE and where Federal funds are used totally or in part.

4. EXCLUSIONS.

   a. Sites that consist entirely of space controlled and maintained by the General Services Administration (GSA) or property leased by DOE or DOE contractor(s) for which maintenance is contractually the responsibility of the lessor.

   b. In accordance with Section 302 of the Department of Energy Organization Act (Public Law 95-91), the Secretary operates and maintains the Power Marketing Administration (PMA) electric power transmission systems by and through the PMA Administrators. The PMAs have in place maintenance management programs, which are geared to the special needs of utility operations, are responsive to coordinated multi-utility system requirements, and are in conformance with prudent utility practice. In view of the unique nature of the Administrators' obligations to meet their statutory and public utility responsibilities for the safety, security, and reliability of electric power transmission and of their legal and contractual obligation, the Administrators shall determine the appropriate maintenance management program for their facilities, which will include consideration of appropriate parts of the criteria set forth by this Order.

   c. Executive Order 12344, (Order), Title 10 Code of Federal Regulations (CFR) 445.1 et seq., reprinted in Title 42 United States Code (U.S.C.) § 7158 note, establishes the responsibilities and authority of the Director, Naval Nuclear Propulsion Program, Office of Nuclear Energy, over all facilities and activities that comprise the joint Navy-DOE program. In view of the unique nature of Naval nuclear propulsion applications, the Director shall determine the appropriate maintenance and repair criteria applicable to this program's property and activities. Such determination shall include consideration of appropriate parts of the criteria set forth in this Order. Public Law 98-525, Title XVI, § 1634, directs that provisions of this Order pertaining to the Naval Nuclear Propulsion Program shall remain in force until changed by law.

5. REFERENCES.

a. DOE 2200.6A, FINANCIAL ACCOUNTING, of 1-7-93, is the Accounting Handbook and contains definitions of property and maintenance work.

b. DOE 4320.2A, CAPITAL ASSET MANAGEMENT PROCESS, of 2-10-94, establishes policy and responsibilities for the management of DOE assets; for prioritization of capital asset resource requirements; for implementing the Condition Assessment Survey; and for preparing the Capital Asset Management Process Report.

c. DOE 5480.4, ENVIRONMENTAL PROTECTION, SAFETY, AND HEALTH PROTECTION STANDARDS, of 5-15-84, provides requirements for the application of mandatory environmental protection, safety, and health (ES&H) standards applicable to DOE and DOE contractor operations.

d. DOE 5480.10, CONTRACTOR INDUSTRIAL HYGIENE PROGRAM, of 6-26-85, establishes the requirements and guidelines applicable to DOE contractor operations for maintaining an effective industrial hygiene program to preserve employee health and well-being.

e. DOE 5480.11, RADIATION PROTECTION FOR OCCUPATIONAL WORKERS, of 12-21-88, establishes radiation protection standards and program requirements for DOE and DOE contractor operations with respect to the protection of workers from ionizing radiation.

f. DOE 5480.19, CONDUCT OF OPERATIONS REQUIREMENTS FOR DOE FACILITIES, of 7-9-90, establishes requirements and guidelines for conduct of operations at DOE facilities to assure acceptable operations, provide for continuing improvements in operations, and assure the maintenance of acceptable margins of safety.

g. DOE 5480.20, PERSONNEL SELECTION, QUALIFICATION, TRAINING, AND STAFFING REQUIREMENTS AT DOE REACTOR AND NON-REACTOR NUCLEAR FACILITIES, of 2-20-91, establishes the selection, qualification, training, and staffing requirements for maintenance personnel at DOE-owned Category A and B reactors and non-reactor nuclear facilities.

h. DOE 5480.21, UNREVIEWED SAFETY QUESTION, of 12-24-91, sets forth the definition and basis for determining the existence of an Unreviewed Safety Question.

i. DOE 5480.22, TECHNICAL SAFETY REQUIREMENTS, of 2-25-92, delineates the criteria, content, scope, format, approval process, and reporting requirements of Technical Safety Requirements (TSRs) or revisions thereof.

j. DOE 5480.23, NUCLEAR SAFETY ANALYSIS REPORTS, of 4-10-92, establishes requirements to develop safety analyses that establish and evaluate the adequacy of the safety bases of nuclear facilities.

k. DOE 5480.26, TRENDING AND ANALYSIS OF OPERATIONS INFORMATION USING PERFORMANCE INDICATORS, of 1-15-93, establishes a uniform system of Performance Indicators for trending and analyzing operational data from DOE facilities.

l. DOE 5483.1A, OCCUPATIONAL SAFETY AND HEALTH PROGRAM FOR DOE CONTRACTOR EMPLOYEES AT GOVERNMENT-OWNED CONTRACTOR-OPERATED FACILITIES, of 6-22-83, establishes requirements for occupational safety and health protection of DOE contractor employees in Government-owned, contractor-operated facilities.

m. DOE 5700.6C, QUALITY ASSURANCE, of 8-21-91, establishes quality assurance requirements for DOE.

n. DOE 6430.1A, GENERAL DESIGN CRITERIA, of 4-6-89, provides design criteria for DOE facilities.

6. DEFINITIONS AND ACRONYMS. Because of the large number of definitions associated with the maintenance of property, the list of definitions and acronyms for use with this Order and its Chapters are provided in Attachment 1.

7. POLICY. It is the Department's policy that:

a. The maintenance management program for all DOE property be consistent with this Order and that all DOE property be maintained in a manner which promotes operational safety, worker health, environmental protection and compliance, property preservation, and cost-effectiveness while meeting the programmatic mission.

b. Structures, systems, and components that are important to safe operation shall be subject to a maintenance program in order to meet or exceed their design requirements throughout their life.

c. Periodic inspection of structures, systems, components, and equipment be performed to determine deterioration or technical obsolescence which threaten performance and/or safety.

d. Primary responsibility, authority, and accountability for the direction and management of the maintenance programs for all property reside with the line management assigned direct programmatic responsibility.

8. OBJECTIVES. DOE maintenance management objectives are as follows:

a. Develop a cost-effective and efficient maintenance program for all DOE property that is consistent with DOE's mission, safety and health, reliability, quality, and environmental protection objectives.

b. Establish a review and analysis capability for evaluation of maintenance program performance and effectiveness.

c. Ensure the reliability, safety, and operability of structures, systems, and components.

d. Ensure compliance with environmental, safety, and health standards.

e. Ensure that the responsibility, authority, and accountability for maintenance are clearly defined and appropriately assigned.

f. Ensure that, where maintenance requirements or accepted maintenance standards cannot be met, such instances are appropriately documented and acknowledged by line management.

g. Ensure that sufficient resources are budgeted in a timely manner to accomplish the maintenance program.

h. Ensure that effective programs are in place to evaluate and measure property condition.

i. Ensure that a graded approach is taken by the line management in the development and implementation of maintenance programs.

j. Ensure that the maintenance of DOE property meets the equivalent guidelines, as appropriate, as required for the conduct of maintenance in commercial industry.

9. RESPONSIBILITIES AND AUTHORITIES.

a. The Secretary has overall responsibility and authority for the Department's property and shall take the necessary management actions, through the Associate Deputy Secretary for Field Management, to ensure that DOE property is effectively managed and maintained.

b. Associate Deputy Secretary for Field Management, shall:

(1) In conjunction with Heads of Headquarters Elements and Managers of Field Elements, monitor, review, and analyze the efficiency and effectiveness of maintenance management programs.

(2) In conjunction with the Assistant Secretary for Environment, Safety and Health develop, promulgate, and maintain policies and procedures necessary to implement and sustain effective DOE-wide maintenance and repair of property.

(3) In conjunction with Environment, Safety and Health develop, promulgate, and maintain handbooks and other applicable guidance materials and conduct training, as necessary, for line management to implement the above policies and procedures and establish programs for maintenance and repair of property.

(4) In conjunction with Heads of Headquarters Elements develop for the Secretary, as requested, analytical reports concerning maintenance management matters and advise on the status of DOE-wide maintenance of property at all DOE facilities.

(5) Provide formal Departmental interpretations of the nonnuclear maintenance requirements of this Order.

c. Office of Chief Financial Officer shall:

(1) Provide budgeting and accounting advice to Secretarial and program officers to facilitate the budgeting for and accounting, tracking, and reporting of maintenance and repair costs of DOE property.

(2) Upon direction from the Secretary of Energy or designee, develop, implement, and maintain consistent DOE-wide financial systems in support of the DOE maintenance management program.

d. Assistant Secretary for Environment, Safety and Health shall:

(1) Act as the independent element responsible for environment, occupational and nuclear safety and health oversight of line management for the Department.

(2) Monitor and audit all aspects of the implementation of this Order related to safety.

(3) In conjunction with Field Management, develop, promulgate, and maintain policies and procedures necessary to implement and sustain effective DOE-wide maintenance and repair of property.

(4) In conjunction with Field Management, develop, promulgate, and maintain guidance materials and conduct training, as necessary, for line management to implement the above policies and procedures.

(5) Assist line management in developing, implementing, and evaluating criteria, standards, and requirements associated with maintenance of nuclear facilities.

(6) Monitor appraisal reports relative to maintenance activities at DOE nuclear facilities to assess implementation of the requirements of this Order and to identify needed improvements in performance standards.

(7) Provide formal Departmental interpretations of the nuclear maintenance requirements of this Order.

e. Heads of Headquarters Elements have the responsibility to ensure that the requirements of this Order are implemented and shall take all necessary actions to execute programs ensuring that DOE property is maintained to support short-term and long-term goals and missions. Specifically, they shall:

(1) Ensure that resources are provided to maintain property in a reasonable and economic manner and to ensure that the backlog remains consistent with DOE goals and objectives.

(2) Ensure that alternate methods are utilized to comply with the intent of this Order where program activities preclude implementation of specifically stated maintenance requirements.

(3) Make determinations and resolve maintenance issues where conflicting programmatic requirements or other issues cannot otherwise be resolved at lower organizational levels.

(4) Provide guidance on matters concerning incorporation of maintenance activities in annual budget requests.

f. Managers of Field Elements have the responsibility and authority to ensure that all activities under their cognizance have maintenance management programs in place to preserve the property of the Department. The term "field elements" includes operations offices, area offices, and other field organizations such as Golden Field Office, Bartlesville Project Office, and the Pittsburgh Energy Technology Center. Specifically, they shall:

(1) Ensure that adequate maintenance management programs and procedures are in place and implemented at sites under their jurisdiction and that the programs and procedures are consistent with the provisions of this Order.

(2) Review the maintenance backlog and establish plans to ensure the backlog remains consistent with DOE goals and objectives.

(3) Ensure that reviews and appraisals of contractor maintenance programs are performed to assess proper and consistent implementation of this Order as specified in the Site Maintenance Plan/Maintenance Implementation Plan.

(4) Review and approve the Program Implementation and Baseline Activities part of the Site Maintenance Plans, and any subsequent modifications to those plans.

(5) Review and approve contractor-generated nuclear facility Maintenance Implementation Plans and any subsequent modifications to those plans.

(6) Through the Contracting Officer, ensure that applicable contracts contain clauses that meet the policy and objectives of this Order.

(7) Submit to Field Management and the appropriate Heads of Headquarters Elements, the Site Maintenance Action Plan part of the Site Maintenance Plans.

10. REQUIREMENTS.

a. Each DOE contractor in coordination with the appropriate field element shall develop, implement, and document a program in conformance with the policy and objectives of this Order in a Site Maintenance Plan (SMP) and/or a Maintenance Implementation Plan. An approved Maintenance Implementation Plan and the Program Implementation and Baseline Activities part of the SMP constitute agreements between the field element and the contractor on the implementation of the requirements of this Order. The program shall clearly define:

(1) The structures, systems, and components included, using a graded approach and the requirements derived from Technical Safety Requirements.

(2) The management systems used to control maintenance activities, including the means for monitoring and measuring the effectiveness of the program and the management of maintenance backlog.

(3) The assignment of responsibilities and authority for all levels of the maintenance organization.

(4) Mechanisms for feedback of relevant information, such as trend analysis and instrumentation performance/reliability data, to identify necessary program modifications.

(5) Provisions for identification, evaluation, and correction of possible component, system design, quality assurance, or other relevant problems.

(6) Performance indicators and criteria to be utilized to measure equipment, systems, and personnel effectiveness in maintenance activities.

(7) Interfaces between maintenance and other organizations (i.e., operations, engineering, quality, training, environment, safety, and health).

(8) A self-assessment program to monitor the effectiveness and efficiency of the maintenance program.

(9) Provisions for planning, scheduling, and coordination of maintenance activities.

b. Periodic inspections of structures, systems, components, and equipment, particularly those important to the safe and reliable operation of a facility, shall be performed to determine whether deterioration is taking place and to identify and address technical obsolescence that threatens performance, safety, or facility preservation. Where the potential is identified for any event or condition to significantly affect safety margins, a formal program for resolving the problem shall be documented and implemented. References in Paragraphs 5b and k apply.

c. For DOE nonnuclear property, a graded approach utilizing the objectives and criteria provided in Chapter I shall be used in the development and implementation of Maintenance Programs

d. For DOE nuclear facilities, a graded approach shall be used to determine the depth of detail required and magnitude of resources expended for each maintenance program element described in Chapter II. Sound engineering judgment and knowledge of the facility are essential in the application of the graded approach. For each DOE nuclear facility, the maintenance program shall be described in a Maintenance Implementation Plan, which addresses the 18 elements (excluding the introduction) in the sequence and format of Chapter II. DOE nuclear facility maintenance programs may include facility-related nonnuclear equipment provided the Maintenance Implementation Plan clearly identifies all equipment (or systems) and distinguishes those nonnuclear equipment/systems. For those DOE nuclear facilities where deviations from the maintenance program elements are considered necessary and appropriate (or not applicable), such deviations (or nonapplicable elements) shall be identified in the Maintenance Implementation Plan with supporting rationale.

e. Maintenance Implementation Plans for nuclear facilities shall be submitted to the Managers of field elements for approval. For new nuclear facilities, Maintenance Implementation Plans shall be submitted 90 days prior to startup. Changes to Maintenance Implementation Plans shall be submitted and approved prior to implementation.

BY ORDER OF THE SECRETARY OF ENERGY:

ARCHER L. DURHAM
Assistant Secretary for
Human Resources and Administration

DEFINITIONS

The following definitions are established for use in this Order to provide a clear understanding of maintenance management and to promote consistency with other Orders relating to property.

1. CONDITION ASSESSMENT SURVEY (CAS). A periodic inspection of capital assets using universally accepted methods and standards. A CAS results in a determination of the current condition of capital assets, their estimated time to failure, and the estimated cost to correct the identified deficiencies. These methods and standards will be found in the CAS Manuals discussed in Paragraph 5b. CAS assesses the condition of all capital assets including architectural, structural, mechanical, and electrical features; communications, safety, and security systems; exterior features and grounds; and equipment. CAS provides a consistent assessment of capital assets for planning purposes based on actual conditions.

2. CORRECTIVE 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.

3. 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.

   (a) 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.

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

   (c) Other Equipment. Some examples in this category are office machines, vehicles and mobile equipment, helicopters, airplanes, and computers and other automated data processing equipment.

4. GRADED APPROACH. By graded approach, DOE intends that the level of analysis, documentation, and actions necessary to comply with a requirement in the Order are commensurate with:

   (a) The relative importance to safety, safeguards, and security;

   (b) The magnitude of any hazard involved;

   (c) The stage of the facility's life cycle;

   (d) The programmatic mission of the facility;

(e) The particular characteristics of the facility; and

(f) Any other relevant factor.

5. HEADS OF HEADQUARTERS ELEMENTS. Senior program managers within a line organizational structure. For purpose of this Order, these positions include the Assistant Secretaries for Energy Efficiency, Defense Programs, Environmental Restoration and Waste Management, Fossil Energy, and the Directors of Energy Research, Nuclear Energy, and Civilian Radioactive Waste Management. Also included are the Administrators of the Bonneville and Western Area Power Administrations.

6. 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.

7. LINE MANAGEMENT. Secretarial Officers (Secretary, Deputy Secretary, Assistant Secretaries) and supporting program offices in Headquarters, together with the field managers (operations office managers, area office managers, assistant managers, and support staff) who are directly involved in supervising management and operating contractors. It also include the management and operating contractor organization from senior managers through the first line supervisor.

8. MAINTENANCE. Day-to-day work that is required to sustain property in a condition suitable for it to be used for its designated purpose and includes preventive, predictive, and corrective (repair) maintenance.

9. MAINTENANCE BACKLOG. The amount of maintenance and repair work not accomplished that is needed or planned to sustain the assigned mission.

10. NONREACTOR NUCLEAR FACILITY. Those activities or operations that involve radioactive and/or fissionable materials in such form and quantity that a nuclear hazard potentially exists to the employees or the general public. Included are activities or operations that:

(a) Produce, process, or store radioactive liquid or solid waste, fissionable materials, or tritium;

(b) Conduct separations operations;

(c) Conduct irradiated materials inspection, fuel fabrication, decontamination, or recovery operations;

(d) Conduct fuel enrichment operations; or

(e) Perform environmental remediation or waste management activities involving radioactive materials.

Incidental use and generating of radioactive materials in a facility operation (e.g., check and calibration sources, use of radioactive sources in research and experimental and analytical laboratory activities, electron microscopes, and X-ray machines) would not ordinarily require the facility to be included in this definition. Accelerators and reactors and their operations are not included. The

application of any rule/order to a nonreactor nuclear facility shall be applied using a graded approach.

11. NUCLEAR FACILITY. For the purposes of this Order, means reactors and nonreactor nuclear facilities.

12. PROPERTY. All DOE-owned or DOE-utilized and -controlled land, land improvements, structures, utilities, motor vehicles, equipment, and components are included.

    (a) Real Property or Real Estate. Real property includes land, improvements on the land, or both, including interests therein. The chief characteristics of real property (real estate) are its immobility and tangibility. It comprises land and all things of a permanent and substantial nature affixed thereto, whether by nature or by the hand of man. By "nature" is meant trees, the products of the land, natural resources; by "the hand of man," those objects, buildings, fences, bridges, et cetera that are erected upon the land. 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 which are essential to its primary purpose, usually are held to be part of the real property.

    (b) 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 would significantly diminish the economic value of the real property or the related personal property. Examples of related personal property are communications and telephone systems.

    (c) Personal Property. Generally capitalizable property that can be moved, 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 property or real estate. Examples of personal property are shop equipment and automated data processing and peripheral equipment.

13. REACTOR. Means, unless it is modified by words such as containment, vessel, or core, 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 that 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.

14. RELIABILITY-CENTERED MAINTENANCE (RCM). A maintenance system that determines the most effective maintenance activity, based on an analysis of an items failure modes, failure rates, and the importance of the item to the safe operation of the facility.

15. STRUCTURE. Any fixed real property improvement constructed on or in the land that is not a building or utility (e.g., bridges, towers, and tanks).

ACRONYMS

ALARA	As Low As Reasonably Achievable
CAIS	Condition Assessment Information System
M&TE	Measuring And Test Equipment
MIP	Maintenance Implementation Plan
MORT	Management Oversight and Risk Tree
OJT	On-the-job Training
PM	Preventive Maintenance
RCM	Reliability-centered Maintenance
RWP	Radiation Work Permit
SMP	Site Maintenance Plan
SWP	Safe Work Permits

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CHAPTER I

GUIDELINES FOR THE CONDUCT OF MAINTENANCE AT DOE NONNUCLEAR FACILITIES

1. INTRODUCTION. Maintenance has a primary role in preserving DOE property and ensuring safe and reliable operation of facilities. The purpose of these guidelines is to describe the 32 key elements of an overall DOE maintenance management program. The discussion of the key elements includes material that incorporates the concepts included in other Orders associated with matters related to the maintenance program. For example, the discussion on procedures is consistent with the direction of DOE 5480.19, CONDUCT OF OPERATIONS REQUIREMENTS FOR DOE FACILITIES. Similarly, there is considerable carry over from DOE 5700.6C, QUALITY ASSURANCE. The guidance in many cases repeats the information from the referenced Order. This material is retained in these guidelines to facilitate the maintenance organizations' incorporation of the elements and their criteria into the program. In many cases the objectives and criteria of all applicable Orders are consistent and can be met by one program.

   For each element, a performance objective is provided. These performance objectives cover the broad spectrum of requirements of an effective maintenance management program. Each objective generally covers a single well-defined management area. The supporting criteria are results oriented and typically describe a specific activity that contributes to the achievement of the performance objective. Performance objectives may be accomplished utilizing criteria from other DOE Orders and standards. Therefore, all criteria may not be required. The methods for achieving the desired results are generally not stated. The graded approach is required when applying the criteria. Because the criteria listed may not be applicable to every activity or requirement associated with a performance objective, the emphasis must be on meeting the performance objectives. The 32 maintenance management program elements are shown in Figure I-1 and are listed in the Table of Contents. Each of the seven branches is introduced with a summary paragraph, followed by the maintenance management elements under that branch. Descriptions of the performance objectives and criteria for each element in the branch are also included.

   The performance objective for each element uses the term "should" throughout the Chapter as a convention to emphasize the use of a graded approach in developing and implementing the required maintenance programs. This "should" convention is maintained even though the reader would expect to see "shall" in sections where there are interfaces with regulations or other DOE Orders. The elements are principles of management that any prudent manager, familiar with maintenance practices, would use in a program to show good stewardship of the resources allotted.

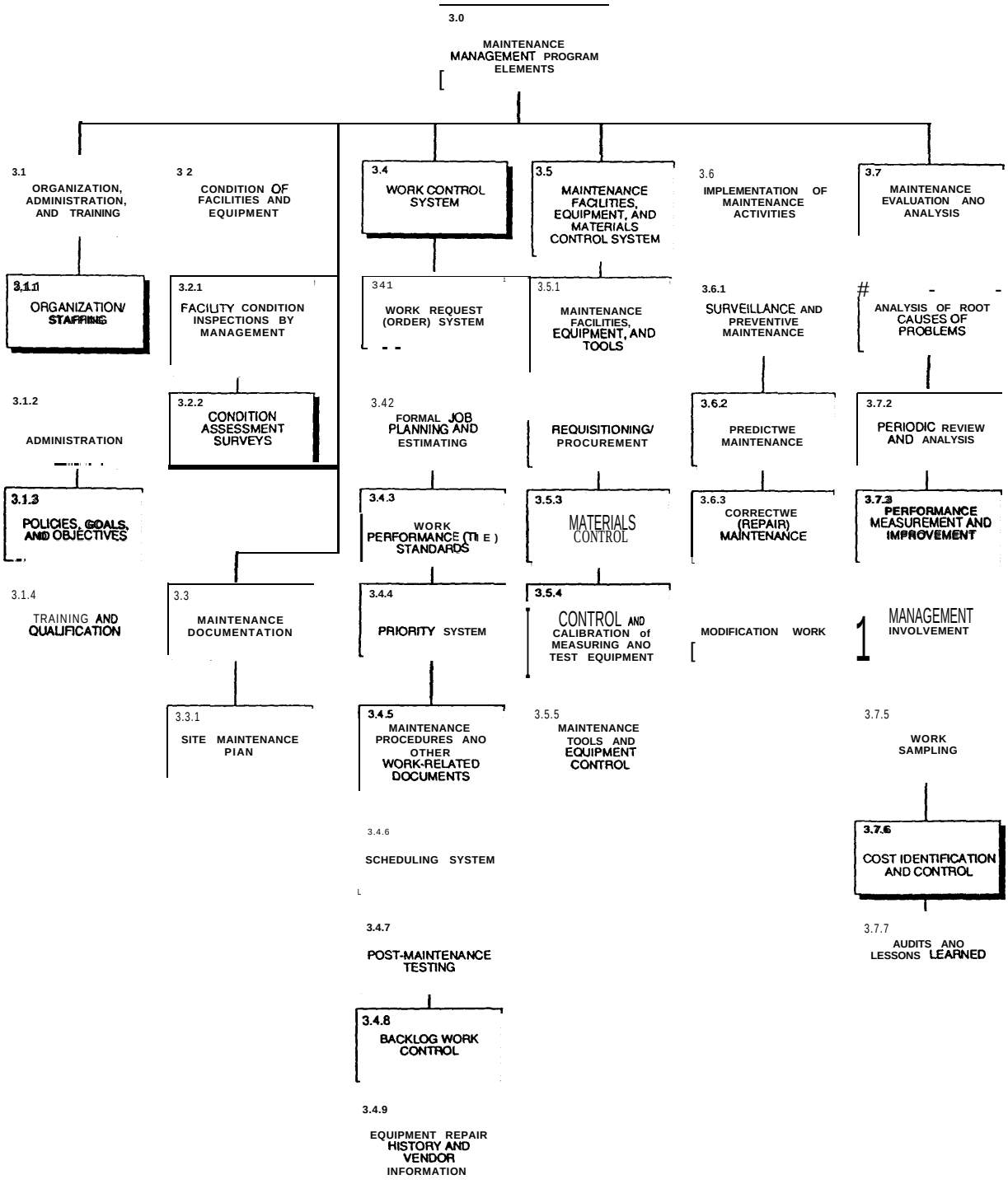

Figure I-1
Maintenance Management Program Elements

The "graded approach" is an important concept that should be used in maintaining DOE's property. By graded approach, DOE intends that, in the development and implementation of maintenance programs by field elements and operating contractors, the depth of detail required and the magnitude of resources expended for a particular maintenance management element should be commensurate with the element's relative importance to safety, environmental protection and compliance, safeguards and security, fulfillment of the programmatic mission, and/or other facility-specific requirements. The application of the graded approach may result in a decision to modify or omit an element. This judgement should be made in a manner to assure that the policy of this Order is met. In order to clarify the use of Graded Approach the following example is provided. Paragraph 3.4 describes a branch titled Work Control System. This branch is made up of nine elements, each of which supports the design of a system to assure efficient and timely accomplishment of maintenance to produce high equipment availability. In some work control systems, all of these nine elements would be required. However, in less complex systems, all nine elements may not be necessary to accomplish the objective. Development of the maintenance program should focus on the objective (i.e., to ensure maintenance is accomplished in a timely manner and provide high equipment availability). For example, programmatic equipment such as a bench top laser may be operated and maintained by the same individual. The Work Control System may not require use of elements such as Work Performance Time Standards, Priority Systems, or Backlog Work Control. If a piece of equipment or a system is important to personnel safety or environmental protection, if it is very costly, or if failure could seriously impact a program mission, then the maintenance and maintenance systems applied to that equipment or system would be expected to be greater than that applied to equipment and systems that do not have safety, environmental, or programmatic consequences. Similarly, for an item of equipment with minimal impacts in these areas, which is reaching the end of its life cycle, a decision to defer or eliminate maintenance may be appropriate.

2. MAINTENANCE MANAGEMENT. Maintenance management is the administration of a program utilizing concepts such as planning, procedures, schedules, cost control, and evaluation for the effective performance and control of maintenance, with adequate provisions for interfaces with other concerned disciplines such as health, safety, environmental compliance, quality control, and security.

Maintenance is a recurring activity that is usually implemented at regular, but sometimes at irregular, cycles. It involves the effort to preserve, protect, and/or sustain property in an acceptable condition so that it may be used for its intended or designated purpose. It includes such proactive methods as inspections, preventive and predictive maintenance programs, surveillance and testing activities, and forecasting/testing techniques.

The maintenance requirements of other Federal or State organizations may apply to DOE property (i.e., General Services Administration or Federal Aviation Administration rules regarding some personal property such as vehicles or ADP equipment). In these cases, if there is conflict Field Management should be advised to seek resolution; as a general rule, the more stringent requirement applies.

Although the primary intent of this Order is to define a Maintenance Management Program applicable to maintenance and repair, the resulting program also defines a management system that should be used for other related work accomplished by maintenance forces at a site, such as custodial work, fabrication, rearrangements, improvements, equipment installation, expense-funded projects, and craft work performed to support environmental and such safety requirements as asbestos abatement. Although this related work is generally performed by craft personnel, it is not "classical maintenance and repair." The Maintenance Management Program should clearly differentiate the budgeting and accounting for classical maintenance and repair from other related work performed by the maintenance organization.

The exclusions of services and improvements from the DOE definition of maintenance and repair does not prohibit them from being funded with operating (expense) funds and performed by the facilities' maintenance organization. Many projects will be a combination of repair and improvements work.

Chargeable classical maintenance and repair work include such items as:

- Regularly scheduled inspections, minor repairs, oiling, and adjustments of equipment performed by craft personnel.

- Work performed on equipment or on a facility to assure its operating capability in fulfilling its designated function. This includes replacements of the same or like parts or work performed to restore original condition. It also includes upgrading of equipment when the primary reason for the upgrade is needed repair or excessive maintenance and operation cost. (Upgrades that are primarily for the purpose of increasing capacity are improvements.)

- Work performed in response to situations or conditions threatening life, the facility, or programmatic integrity. Normally this emergency maintenance should amount to less than 1 percent of the total work performed.

- Costs required to administer the organization responsible for maintenance; for tools and equipment to accomplish the work; for maintenance facility operations and maintenance; for training to meet qualifications standards and required certifications for the performance of maintenance and repairs; for monitoring, evaluating, and tracking work status; and for similar activities.

- Indirect costs associated with maintenance work, including supervision; planning and scheduling; storage and staging of materials and supplies; calibration, care, repair, and storage of equipment used in monitoring or for the performance of work; and similar activities.

Related work that is routinely performed by the maintenance organization but not chargeable as classical maintenance and repair includes:

- 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 (machine tools, facility equipment, etc.).

- 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. An example would be work performed to support the special requirements of the Resource Conservation and Recovery Act.

- Some nonmaintenance roads and grounds work, such as grass cutting and street sweeping.

3. MAINTENANCE MANAGEMENT PROGRAM ELEMENTS

3.1 Organization, Administration, and Training

The manager assigned within the contractor organization for each plant or facility is accountable for the material condition of the property and for the systems and equipment contained therein. The effective conduct of maintenance in the facility is an integral part of that accountability. It is the responsibility of the manager to establish and ensure that the facility organization and its support elements are organized, trained, and qualified to carry out an effective maintenance program. Accountability and responsibility must be clearly defined within the organization and its support elements for each basic function of the maintenance program as follows:

- Definition of Technical Requirements;
- Maintenance Procedures;
- Planning and Scheduling;
- Material Procurement and Control;
- Performance;
- Documentation; and
- Evaluation and Analysis.

It is important that the policies, goals, and objectives pertaining to the conduct of maintenance be formally established, clearly communicated, and documented.

The maintenance management elements of this branch are as follows:

- Organization and Staffing;
- Administration;
- Policies, Goals, and Objectives; and
- Training and Qualifications.

The performance objectives and criteria for each of these elements are discussed in the following subparagraphs.

3.1.1 Organization/Staffing

Performance Objective. A clearly defined maintenance organization with specific lines of authority, responsibility, and accountability should be established. Requirements for communication and interface with other facility organizations should be determined. A sufficient number of properly trained management, supervision, and

craft personnel should be utilized to perform the required maintenance activities.

Criteria:

a. The maintenance organizational functions and responsibilities are defined thoroughly and an appropriate staff is assigned to ensure effective and timely accomplishment of the required work.

b. Engineering and technical support functions have direct and continuous interface with the maintenance organization in order to provide support in determining the cause of repetitive equipment failures and to investigate the root cause of unplanned events.

c. Engineering and technical support functions incorporate the following into all maintenance activities: manufacturers' recommendations, specification for operability, action levels, acceptance criteria, procurement specifications, installation and test requirements, and test equipment and procedures.

d. Engineering and technical support functions identify and evaluate potential degradation mechanisms caused by environment and service over time and provide direction for timely mitigation of their effects.

e. Contracted maintenance services are controlled and overseen to ensure that contracted work is performed to the same standard established for the maintenance organization.

f. Contracted personnel are qualified for the work they are to perform.

g. The Quality Assurance (QA) programs specified by the reference in Paragraph 5m, page 3, are applied to maintenance activities commensurate with their safety and security significance.

h. Authority, responsibility, and accountability for support organizations are defined by identifying personnel interfaces, periodic self-assessments, procedural interfaces, overall maintenance performance indicators, and indicators related to the support of maintenance tracked by each supporting group.

i. The organization achieves a high level of performance in maintenance by effective implementation and control of maintenance activities.

j. The organization provides time for and emphasizes long-range planning.

k. Maintenance personnel are held accountable for their performance through supervisory counseling, performance appraisals, and, when necessary, disciplinary measures.

l. Maintenance staffing and resources are sufficient to accomplish assigned tasks, including time for training.

m. Entry-level criteria is established to ensure that maintenance personnel have the requisite background and experience to be trainable for work in facilities.

n. Appropriate job qualification requirements are established for all facility maintenance positions affecting the safe and reliable operation of facilities.

o. Maintenance job requirements are periodically reviewed, evaluated, and revised, as necessary.

p. Adequate engineering and technical support personnel are readily available.

q. High quality personnel are recruited for temporary increases in staff to support planned outages or other activities.

r. Timely action is taken to anticipate and fill maintenance vacancies, and long-range maintenance staffing plans are developed.

s. Appropriate career progression plans are used to develop the management, supervisory, and technical expertise of personnel and thus help to ensure that future maintenance staff vacancies are filled with qualified personnel.

3.1.2 Administration

Performance Objective: The administration of the maintenance function should ensure that a high level of performance is achieved through effective implementation and control of maintenance activities by establishing written performance standards, periodically observing and assessing the performance of maintenance personnel and systems, and holding personnel accountable for their performance. References in Paragraphs 5f, k, and m, pages 2 and 3, apply.

Criteria:

a. The conduct of maintenance activities in a facility is documented, as necessary, to provide for systematic, coordinated, and accurate implementation consistent with maintenance policies, goals, and objectives.

b. Sufficient staff, equipment, and funding is requested, justified, and available so that the maintenance organization can effectively perform its function and adequately train maintenance personnel.

c. Administrative work control functions are documented in policies, procedures, and checklists.

d. Maintenance documentation establishes the responsibility for maintenance, accountability for work, authority, lines of communication, documentation requirements, required references, and means of review, approval, and updating.

e. Maintenance documentation defines the maintenance program and standards for maintenance activities.

f. The maintenance program and maintenance standards are communicated to the working level by training workers in good work practices and by supervisors who observe and guide work activities.

g. An effective maintenance program need not require extensive documentation, but it should be understood and effectively implemented by all involved personnel in a consistent manner.

h. Administrative controls are employed in the conduct of facility maintenance activities. Examples of such activities include scheduling of preventive maintenance, use of special tools and lifting equipment, and use of measuring and test equipment.

i. Oral and written communications are effective within the maintenance organization and between the maintenance organization and such supporting groups as operations, safety, and engineering.

j. The communication necessary to develop working relationships and keep personnel at all levels cognizant of the information needed in order to perform their function is defined in the maintenance program documents.

k. Technical issues associated with maintenance are identified and resolved with involved organizations.

l. Rewards and other forms of recognition are given to maintenance personnel for superior performance.

m. Maintenance personnel involved in significant or frequent violations of requirements are encouraged to improve through counseling, by remedial training, or by disciplinary measures, as appropriate.

n. Performance appraisals and routine personnel feedback with supervisors or managers are utilized to enhance individual employee performance.

o. Personnel are encouraged to develop methods to improve safety, reliability, quality, and productivity through such activities as employee participation programs.

p. Commitments are routinely met. Open commitment status is tracked and up-to-date.

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

r. Long-range planning of major maintenance activities and facility outages establish a scope for funding and staff resources to meet the needs of the maintenance program.

3.1.3 Policies, Goals, and Objectives

Performance Objective: Maintenance policies, goals, and objectives should be documented in appropriate manuals and communicated to all maintenance personnel. Maintenance should be conducted based on these goals and objectives. References in Paragraphs 5f and m, pages 2 and 3, apply.

Criteria:

a. Policies define the maintenance organization, establish administrative objectives and levels of responsibility, and generally serve to consistently regulate and guide the conduct of maintenance activities.

b. Maintenance personnel are assigned responsibility for achievement of specific objectives and understand the actions necessary, within the scope of their duties and responsibilities, to achieve these objectives.

c. Maintenance goals are developed and used to improve maintenance performance and for measuring maintenance effectiveness.

d. Maintenance objectives are challenging, stated in measurable terms, and address areas where improvement is needed.

e. Maintenance goals such as the following are established:

- Minimize the impact on planned outages by planning and completing maintenance activities in a timely manner;
- Minimize the number of forced outages;
- Minimize unplanned challenges to critical systems;
- Minimize the lost-time accident rate;
- Minimize facility and equipment downtime;
- Minimize personnel errors;
- Minimize process delays in work content and work execution;
- Reduce repeat maintenance work requests (rework);

- Complete scheduled surveillances and preventive maintenance activities in a timely manner;
- Minimize the maintenance backlog and reduce the completion time of outstanding deficiencies;
- Control overtime; and
- Complete outage and nonoutage work on schedule.

f. Goals are substantive in nature, challenging the capability and ingenuity of the maintenance manager.

g. Goals and objectives are attainable and are not to be considered "sacred." Initial objectives are revised if proven unfeasible, irrelevant, or impossible.

h. Effective safety programs are implemented with clearly defined policies, procedures, and responsibilities to protect maintenance personnel. (References in Paragraphs 5c, d, and l, pages 2 and 3, apply).

i. Policies, procedures, and responsibilities clearly define the quality assurance and quality control program interface with maintenance.

3.1.4 Training and Qualification

Performance Objective: Training and qualification programs should develop and maintain the knowledge and skills required by maintenance personnel to effectively perform maintenance activities. The reference in Paragraph 5m, page 3, applies.

Criteria:

a. The responsibility for establishing, maintaining, and implementing the maintenance training programs is defined, understood, and coordinated between the maintenance and training organizations.

b. Maintenance training programs are defined and encompass managerial, supervisory, planner/scheduler, engineering, and craft personnel.

c. Initial training, consisting of classroom and on-the-job training, develops necessary job-related knowledge and skills and includes areas such as the following:

(1) Basic technical and applied science subjects;

(2) Maintenance fundamentals and troubleshooting and repair techniques;

(3) Facility systems and components;

(4) Special maintenance craft skills;

(5) Practical factor demonstration;

(6) Work-control procedures;

(7) Industrial safety, including hazards associated with work on specific equipment/systems and emergency response;

(8) Quality assurance;

(9) Maintenance procedures, workmanship standards, and job-specific work practices, including surveillance procedures;

(10) In-house and DOE-wide operating experience, including actual events; and

(11) Emergency response.

d. Continuing training maintains and improves job-related knowledge and skills in areas such as the following:

(1) Facility system and component changes;

(2) Procedure changes;

(3) DOE-wide and in-house operating experiences, including facility operation;

(4) Seldom-used knowledge and skills that affect safe and reliable facility operation; and

(5) Selected topics from subparagraph c above to correct identified weaknesses.

e. Maintenance organization support and guidance for maintenance training programs normally includes all or portions of the following tasks:

(1) Defining the jobs, tasks, skill levels, and responsibilities and identifying individuals to fill these positions;

(2) Defining training programs for each position;

(3) Determining the content and emphasis of the training needed;

(4) Determining and supporting training schedules;

(5) Determining the training needs of and tailoring the training program for each individual based on previous education, training, experience, and skill level;

(6) Providing instructors and trainers;

(7) Establishing qualification criteria, with emphasis on successful performance in the field;

(8) Coordinating the conduct of and instruction during on-the-job training; and

(9) Providing feedback to the training organizations to enhance and, where necessary, adjust course teaching methods, content, and emphasis.

f. Training implementation is coordinated between the maintenance and the training organization to prepare training schedules, determine who should attend, and ensure qualified instructors are available to teach the courses.

g. A formal part of the maintenance training program is on-the-job training (OJT), in which facility personnel achieve learning objectives through practical hands-on training conducted within the job environment.

h. OJT is conducted in accordance with formally defined training programs that specifically identify items the trainee must accomplish.

i. OJT is conducted by personnel who have successfully qualified as OJT Trainers.

j. When trainees perform maintenance on installed equipment, a qualified OJT instructor observes 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 facility.

k. The number of trainees to simultaneously participate in any OJT is limited in order to ensure that each trainee receives effective and adequate instruction.

l. Trainees independently perform maintenance only on facility equipment for which they are qualified.

m. Qualification standards and evaluation methods are adequate to verify trainee competence.

n. Maintenance managers are directly involved in approving and periodically reviewing the maintenance training program.

o. Training programs are systematically improved to ensure that trainees develop the required skills and knowledge. Feedback from job performance is used to help evaluate and refine maintenance skills.

p. Management and supervisory training include generic areas such as managerial and supervisory skills, accountability, assessment and observation of routine activities, communication skills, teamwork, and company management philosophies. Position-specific training is provided to first-line supervisors.

3.2 Condition of Facilities and Equipment

Facility, equipment, and housekeeping deficiencies should be identified through periodic inspections ranging from management walk-throughs to detailed facility inspections. The maintenance management elements of this branch are:

- Facility Condition Inspections by management; and

- Condition Assessment Surveys.

The performance objectives and criteria for each of these elements are discussed in the following subparagraphs.

3.2.1 Facility Condition Inspections by Management

Performance Objective: To establish and conduct periodic inspections of equipment and facilities, ensuring that proper condition, cleanliness, and housekeeping are maintained to support safe and reliable facility operations.

Criteria:

a. To clearly display the standard for facility condition, managers and supervisors are personally conducting periodic walkdowns and inspections to identify deficiencies and housekeeping discrepancies.

b. Equipment and facility condition, cleanliness, and housekeeping standards are established and communicated to all maintenance personnel.

c. The results of each inspection are transmitted to the facility manager and maintenance manager.

d. Identified deficiencies are corrected in a timely manner so that personnel can see the positive results of the inspection program.

e. Personnel are assigned corrective action and deficiencies are tracked to completion.

f. Reported deficiencies are monitored to identify recurring, generic, and long-term problems.

3.2.2 Condition Assessment Surveys

Performance Objective: All real property and installed equipment should be inspected at predetermined frequencies to

ensure that these facilities are maintained in a condition consistent with assigned missions or long-range planning. The reference in Paragraph 5b applies.

Criteria:

a. Condition Assessment Surveys shall be performed in accordance with the reference in Paragraph 5b.

b. The primary maintenance objective of condition assessments is the early detection of potential problems in order to prevent deterioration, possible damage to adjacent materials or systems, and failure of components.

c. Selected inspection information available from Preventive Maintenance programs and other sources may be entered into the Condition Assessment Information System (CAIS) (the reference in Paragraph 5b applies).

d. After the identification of symptoms of problems or deficiencies, a diagnostic analysis is performed to determine whether there is, in fact, a problem, the nature and extent of the problem, and options for corrective action.

3.3 Maintenance Documentation

A clear understanding of the contractors' efforts related to their maintenance activities is obtained by a totally integrated Site Maintenance Plan. Such a plan not only describes how similar maintenance functions associated with a site contractor are integrated but also describes the baseline maintenance activities. The single maintenance management element of this branch is the Site Maintenance Plan.

3.3.1 Site Maintenance Plan

Performance Objective: Individual operating contractors should develop a Site Maintenance Plan that provides a clear understanding of the total maintenance program as described in Paragraph 10, "Requirements."

Criteria:

a. The Site Maintenance Plan is a two-part document, composed of the following:

(1) The Program Implementation and Baseline Activities.

(2) Site Maintenance Action Plans.

b. The Program Implementation and Baseline Activities part of the Site Maintenance Plan may include:

(1) Site Maintenance Policy.

(2) A description of the contractor's application of the graded approach.

(3) A brief description of the contractor's management and coordination of maintenance-related activities including, for example, Quality Assurance, Engineering, Operations, Training, and Environment, Safety, and Health.

(4) A description of the implementation of Chapter I elements for real property maintenance.

(5) A description of the site's personal property maintenance program.

c. This Program Implementation and Baseline Activities part of the Site Maintenance Plan shall be reviewed and approved by the Manager of the field element. This part of the Site Maintenance Plan will be updated as circumstances dictate.

d. The Site Maintenance Action Plan (SMAP) part of the Site Maintenance Plan is an annual status submittal which may include:

(1) Summary level of maintenance initiatives completed during the past Fiscal Year (FY) by the contractor.

(2) Summary level of maintenance initiatives planned by the contractor for the current FY. This includes schedule and deliverables for these maintenance program improvements.

(3) Summary of performance indicators.

(4) Summary of Maintenance Backlog.

(5) Contractor's fiscal data for FY-1 through FY+3 including narrative description of changes with significant impact on resources.

e. This SMAP part of the Site Maintenance Plan will be reviewed by the field element and forwarded to Field Management.

3.4 Work Control System

The work control system, by which maintenance activities are identified, initiated, planned, approved, scheduled, coordinated, performed, and reviewed for adequacy and completeness, should be designed to ensure that maintenance is accomplished in a timely manner, improves maintenance efficiency, and increases equipment availability. The maintenance management program elements on this branch are:

- Work Request (Order) System;
- Formal Job Planning and Estimating;
- Work Performance (Time) Standards;
- Priority System;
- Maintenance Procedures and Other Work-Related Documents;
- Scheduling System;
- Post-Maintenance Testing;
- Backlog Work Control; and
- Equipment Repair History and Vendor Information.

The performance objectives and criteria for each of these elements are discussed in the following subparagraphs.

3.4.1 Work Request (Order) System

Performance Objective: A formal, well-defined, work request (order) system should be in place to cover work performed, regardless of whether the jobs are repetitive or one-time tasks. The work request system should ensure that jobs are identified, logged, planned and scheduled, performed, tested, formally accepted, and documented in a "user-friendly" manner. The reference in Paragraph 5m applies.

Criteria:

a. A work request (order) system is established that clearly identifies the work needed and provides instructions to perform the work.

b. The work request forms (work package) for facilities provide procedures and guidance for performing the work and allow documentation for the following:

(1) Number sequencing;

(2) Equipment and component identification;

(3) Description of symptom, problem, or work requested and the responsible person identifying them;

(4) Identification of crafts required;

(5) Dating of document package;

(6) Job priority;

(7) Personnel safety;

(8) Identification of the safety class of equipment or components or qualification requirements (such as environmental and seismic qualifications);

(9) Applicable safety requirements, and time restraints;

(10) Identification of special process requirements (such as special work permits, special work instructions, special training, and personnel qualification requirements);

(11) Work instructions, hold points to allow inspections, special requirements, use of special materials or tools, test instrument ranges, accuracy, and cleanup requirements;

(12) Required post-maintenance testing, inspections, and acceptance criteria;

(13) Work supervisor or appropriate person in charge;

(14) Applicable operating and maintenance procedures;

(15) Description of work performed, as-found conditions, repairs made, cause-of-failure evaluations, identification of special tools and parts, calibration data, set points, adjustments made, and as-left conditions;

(16) Cost code to which work performed is to be charged; and

(17) Final reviews and signoff by maintenance, quality control, and other groups in the review process.

c. The work request system provides a method for tracking work in process.

d. A procedure is established for performing and documenting emergency maintenance.

e. The work request (order) system provides for control of modifications, in-service tests, preventive maintenance (PM), and surveillances.

3.4.2 Formal Job Planning and Estimating

Performance Objective: A system of formal job planning and estimating should be used to identify the required support, permits, hold points, work procedures, and material requests that determine the total scope of work and address task sequencing and steps to completion. Outage planning should promote optimum outage performance by providing integration and coordination of all work elements. References in Paragraphs 5f and m apply.

Criteria:

a. Planning maintenance activities are accomplished by a dedicated planning staff or by maintenance supervisors at facilities with small staffs. If done by a supervisor, the workload allows time to supervise work in progress.

b. Adequate procedural controls are established and implemented to assure adequate job planning.

c. In-depth work planning is utilized to identify the required support and detailed scoping necessary to accurately schedule daily maintenance.

d. Involvement of such required support groups as operations (see the reference in Paragraph 5f), engineering, and quality assurance are coordinated to effectively support the maintenance effort.

e. Preplanning obtains such necessary support items as special tools, other equipment, repair parts, and materials required to accomplish the work when needed.

f. The planning process normally includes such items as the following:

(1) Definition of the problem and identification of the work scope;

(2) Identification and review of necessary procedures, drawings, vendor manuals, and maintenance history;

(3) Identification of needed and available data for use in analysis of maintenance problems;

(4) Procurement of necessary repair parts, materials, tools, and equipment;

(5) Assessment of manpower and skill requirements;

(6) Identification and review of resources, including other tasks scheduled to occur in the immediate area during the same time period;

(7) Identification of initial facility conditions and prerequisites required for work to be accomplished;

(8) Identification of quality control and technical inspection requirements;

(9) Establishment of equipment restoration and post-maintenance inspection or testing requirements;

(10) Review of work instructions of work packages for completion;

(11) Identification of applicable maintenance and operation procedures; and

(12) Identification of unique hazards involved (e.g., contaminated systems, confined spaces).

g. Pre- and post-job briefings are performed, as appropriate, to brief personnel on work to be performed and identify lessons learned.

h. 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, staging of documents and material, and coordination of support activities are included.

i. Management of outages and planning for outages is performed to minimize the duration of these conditions and to use the available time effectively.

j. Preoutage milestones are established, and timely corrective actions are taken when milestones are not being met.

k. Outage planning includes the identification of necessary manpower to support the outage and consideration of contingencies that may occur.

l. Elements of outage work are defined into manageable segments that can be accomplished by a typical work unit on a definite schedule and are entered into a tracking system to allow completion status to be monitored.

3.4.3 Work Performance (Time) Standards

Performance Objective: Work-hours required to perform a planned job through the utilization of estimating the application of engineered standards, the use of job slotting techniques, or other industry-recognized methods should be established to allow the determination of cost estimates, establishment of reasonable schedules, and measurement of productivity.

Criteria:

a. Planners are trained in the use or application of work performance (time) standards.

b. Work performance (time) standards are used, where possible, as one basis for job-cost estimates.

c. Work performance (time) standards are used as time estimates to ensure that schedules for each job in the daily and weekly schedules are accurate. The standards are reviewed and periodically updated based on actual times taken to perform the work.

d. Job-slotting techniques or other industry-recognized simplified methods are used for applying time standards.

e. Travel or delay times utilized for planning are derived from records or work sampling, where possible, or developed by the planner for the specific circumstances.

f. Productivity measurements are obtained from the use of work performance (time) standards and reported as performance indicators.

g. Work utilization measurements are obtained through the work-sampling process, reported as a performance indicator, and employed in conjunction with the maintenance backlog indicator to manage staffing levels with respect to the work backlog.

3.4.4 Priority System

Performance Objective: A systematic method of determining job priority or the importance of the work item to be performed should be established and is based on safety, environmental, and facility concerns.

Criteria:

a. The following items are considered when assigning priorities:

(1) Personnel safety;

(2) Mission impact;

(3) Operability of redundant equipment;

(4) Critical path equipment; and

(5) Potential for environmental release and damage.

3.4.5 Maintenance Procedures and Other Work-Related Documents

Performance Objective: Maintenance procedures and other work-related documents (e.g., drawings and instructions) should be used to provide appropriate work direction and to ensure that maintenance is performed safely and efficiently. References in Paragraphs 5c, f, and m apply.

Criteria:

a. Compliance requirements for a given procedure are clearly stated in the procedure or in other overall guidance and thoroughly communicated to each craft person. The normal two levels of compliance are:

   (1) Step-by-step compliance without deviation; or

   (2) General intent compliance.

b. Preparation, review, approval, and revision of procedures and other work-related documents are formally controlled.

c. Documents used in lieu of procedures (such as excerpts from vendor manuals) receive the same level of review and approval as required for procedures.

d. Procedures and other work-related documents (such as vendor manuals, drawings, reference materials, and posted job performance aids) are used in support of maintenance and are technically accurate and up to date.

e. Procedures are readily available and clearly identified.

f. Maintenance procedures are established and utilized as necessary for the conduct of maintenance activities commensurate with the activity's importance to safety and security.

g. New and revised procedures are reviewed or verified for technical accuracy prior to use and checked or validated to ensure usability and correctness prior to or during initial use. Validation is done in a shop or training environment on a mockup or simulator or by the craft person and supervisor during the first use of the procedure.

h. Procedures are clear, concise, and contain adequate information for users to understand and perform their activities effectively. Items to be considered are as follows:

   (1) Portions or steps of other documents that are used or referred to when performing a procedure are specifically identified in the procedure.

   (2) Technical details such as setpoints, control logic, and equipment numbers are consistent among procedures, drawings, and system descriptions.

   (3) Human factor considerations are incorporated into procedures to promote error-free performance.

   (4) Skill and training of the craft personnel performing the function.

i. Cautions, warnings, and hold points (such as quality checks) are included in the procedures, as needed.

j. A policy governing the use of procedures and a procedure writer's guide should be implemented. The guidance includes the following:

(1) Procedures with purpose and scope;

(2) Consistent formats for organization, instruction step format, caution and note format, and page format;

(3) Methods to generate clearly understood text and assure consistent use of illustrations;

(4) Actions to be taken when procedures conflict, are inadequate for the intended tasks, or when unexpected results occur;

(5) Allowances for identification and verification of steps that can be performed out of the written sequence; and

(6) Requirements for use of procedures in hazardous situations, such as in friable asbestos locations.

k. Temporary changes to procedures, if used, are controlled through appropriate review and authorization prior to use and ensure user awareness of applicable temporary changes.

l. A formal program exists to review procedures periodically for technical accuracy, human factor considerations, and the inclusion of in-house and industry operating experience.

m. A feedback mechanism is provided for the maintenance personnel to change and/or improve the usability of the procedure(s).

n. Ensure that an appropriate level of performance expectation is provided. National consensus standards and/or field-tested workmanship standards should be utilized where appropriate.

3.4.6 Scheduling System

Performance Objective: Scheduling and coordinating of corrective and preventive maintenance and modifications should be performed in such a way that maintenance activities are conducted in the proper sequence, efficiently, and within prescribed time limits. An outage schedule should provide for work element completion and testing and should provide management with information necessary to control outage activities.

Criteria:

a. Maintenance activities are scheduled and coordinated for the purpose of avoiding unnecessary removal from service of equipment and systems from service and providing better manpower utilization.

b. The maintenance work-scheduling process incorporates a tracking system for identifying maintenance work requests being performed and post-maintenance testing.

c. Scheduling of daily activities is based on accurate planning estimates to improve the use of craft personnel time on the job.

d. A priority system is utilized to schedule work.

e. Weekly and/or daily job-scheduling meetings are conducted and the resulting work schedules are published.

f. Maintenance activities are scheduled to ensure that appropriate supervision and support is available.

g. Facility personnel, especially facility managers, are apprised of scheduled maintenance activities that affect them, thus ensuring proper activity coordination.

h. Scheduling considers only those planned activities with complete work packages and with all materials and equipment for the job.

i. Within the total available work hours, time is allotted for small call-in jobs, urgent jobs, or other unforeseen events.

j. Timely feedback of work progress to schedulers, supervisors, and management is utilized to modify weekly and/or daily schedules, as necessary.

k. Planned and forced outages are scheduled in a manner ensuring that required maintenance is performed within the time limits available and that opportunities for performing other needed maintenance are maximized.

l. An outage schedule provides for the completion of work elements and testing and provides management with a clear, concise, and understandable method of tracking completion of outage milestones. Supporting schedules are developed where necessary.

m. Outage schedules are updated on a timely basis to reflect changing conditions. When necessary, deviations from the outage plan and schedule are communicated to the proper level of management for action.

3.4.7 Post-Maintenance Testing

Performance Objective: Post-maintenance testing should be performed to verify that equipment, systems, and components fulfill their design function when returned to service following maintenance. The tests performed are commensurate with the maintenance work performed and the importance of the equipment to facility safety and reliability. References in Paragraphs 5f and m apply.

Criteria:

a. Post-maintenance testing is performed, as appropriate, after corrective and preventive maintenance activities.

b. The rigor of the testing performed is based on the work done and the importance of the component or equipment to safe and reliable facility operation.

c. The post-maintenance testing program is clearly defined and includes the following elements:

(1) Test requirements are identified by the appropriate technical authority. Responsibility for determining post-maintenance test requirements are assigned to functional groups such as operations, maintenance, and technical support.

(2) The scope of the post-maintenance testing program is determined to help ensure that appropriate levels of testing are applied to facility equipment and that redundant or unnecessary testing is minimized.

(3) The status of equipment that has undergone maintenance is tracked to ensure that all testing is completed prior to work closeout.

(4) Proper post-maintenance tests are conducted, the results documented, and the resulting data verified to have met acceptance criteria and obtained appropriate signoff.

d. Equipment that is important to reliable facility operation is tested in accordance with approved procedures.

e. Post-maintenance test results are documented and reviewed to ensure proper system/equipment performance prior to returning the system to service.

f. For tests involving the participation of more than one support group, one individual should be responsible for coordinating appropriate personnel (e.g., operations, engineering, and maintenance) to perform post-maintenance testing, review results, and take corrective action, as necessary.

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

3.4.8 Backlog Work Control

Performance Objective: Maintenance backlog should be monitored to ensure that the condition of the property is maintained consistent with the facility's mission. References in Paragraphs 5b and k apply.

Criteria:

a. The maintenance backlog is measured in estimated work-hours and the number of work requests. This is used to adjust staffing, as required.

b. The maintenance backlog is monitored to ensure that proper priority is given to facility conditions important to safety, environment, and facility mission.

c. Deferred critical facility maintenance work is documented and justified in writing by management.

d. Backlog is managed on the basis of prioritization.

e. Budget and staffing levels are evaluated against both the planned maintenance and the amount of work in the backlog.

3.4.9 Equipment Repair History and Vendor Information

Performance Objective: An equipment repair history and vendor information program should be established and maintained to provide historical information for maintenance planning and to support the maintenance and performance trending analysis of facility systems and components. The reference in Paragraph 5m applies.

Criteria:

a. Equipment repair history is used to support maintenance activities, upgrade maintenance programs, optimize equipment performance, and improve equipment reliability.

b. The maintenance history program defines what data are to be collected, how the data are to be recorded, and how the data are to be used.

c. A cost-effective equipment history program is in place for systems, equipment and components that warrant special attention based on initial cost, cost to maintain, or impact on facility operations or safety.

d. Maintenance records are closely correlated with the current issue of the facility master equipment list.

e. The facility master equipment list should be a compilation of system and equipment and provide an engineering data base.

f. Maintenance history records are considered in planning for corrective maintenance, modifications, and preventive maintenance, and development of facility life-cycle plans.

g. Maintenance history records are readily available for use by supervisors, work planners, and maintenance or plant engineers.

h. Maintenance history is periodically and systematically reviewed to identify equipment trends and persistent maintenance problems and to assess their impact on facility reliability.

i. Equipment maintenance and repair history files contain items such as the following: equipment and component identification, maintenance records, diagnostic monitoring data, vendor information (or a reference to this

information), corrective and preventive maintenance or modification information, and spare parts information.

j. The maintenance record is a chronological list of all maintenance repair work and materials expended on a piece of equipment or component.

k. Equipment repair history data is used for such activities as failure analysis, conduct of maintenance assessments, preventive maintenance, predictive maintenance, outage planning, budget preparation, reviews of DOE-wide experience, and plant life extension.

l. Vendor information obtained from suppliers is controlled and indexed for ready retrieval.

3.5 Maintenance Facilities, Equipment, and Materials Control System

Maintenance facilities, tools, and equipment should be periodically evaluated for adequacy; measuring and test equipment should be controlled and calibrated; and maintenance tools and equipment should be controlled in order to be readily available for craft use. All phases of requisitioning, procuring, receiving, inspecting, handling, storing, retrieving, and issuing of equipment, parts, and materials should be controlled. The maintenance management program elements on this branch are:

- Maintenance Facilities, Equipment, and Tools;
- Requisitioning/Procurement;
- Materials Control;
- Control and Calibration of Measuring and Test Equipment; and
- Maintenance Tools and Equipment Control.

The performance objectives and criteria for each of these elements are discussed in the following subparagraphs.

3.5.1 Maintenance Facilities, Equipment, and Tools

Performance Objective: Maintenance facilities, equipment, and tools should be periodically reviewed for adequacy in supporting facility maintenance and maintenance training. The reference in Paragraph 5m applies.

Criteria:

a. Maintenance facilities, including storage facilities and laydown and staging areas, are sized and arranged to promote the safe and effective completion of work.

b. Maintenance training facilities, shops, satellite work areas, laydown and staging areas, storage facilities, mockups, temporary facilities, shower and toilet facilities, lunch areas, conference areas, and offices are evaluated for adequacy.

c. Work area lighting and other environmental conditions should promote safe and effective working conditions.

d. Work areas are uncluttered and in an orderly condition.

e. Facility equipment is accessible for maintenance activities. Fixed local area hoists, ladders, and work platforms are provided, as needed.

f. Storage facilities for parts and materials being gathered for or issued for a job are adequate and provide environmental controls to protect the parts and materials.

g. Tool and equipment storage facilities are located near shops and normal work areas to improve maintenance efficiency.

h. Adequate office equipment is provided for efficient and effective work.

i. Communication equipment is reliable and provides necessary facility coverage.

j. Facility equipment and associated components are properly labeled with sufficient information so that they can be easily identified by personnel.

k. A plan for identifying and using maintenance laydown and staging areas is developed and kept current.

l. Communications systems are available and arranged such that maintenance activities can be conducted without interfering with facility operations and controls. Areas that should be considered in particular are testing and troubleshooting of electrical and electronic equipment.

3.5.2 Requisitioning/Procurement

Performance Objective: Parts, materials, and services required to perform maintenance activities should be available when needed. The reference in Paragraph 5m applies.

Criteria:

a. An effective procurement process is provided to ensure that parts, materials, and services are available for work activities when they are scheduled.

b. Procurement documents provide clear and adequate technical and quality assurance requirements consistent with design specifications.

c. Topics such as storage, in-storage preventive maintenance, and shelf-life requirements are addressed.

d. Proper engineering control and approval are obtained on any deviation from design specifications for parts or materials.

e. Mechanisms are in place to provide for the expeditious procurement of parts and material on a high priority basis when needed.

f. Methods are established to acquire replacement parts not available through the original supplier.

g. Lessons learned from experience, such as leadtimes, parts usage, and supplier reliability, are factored into materials management.

h. Material and parts activity are reviewed to determine possible new additions to be included in spare parts or site stores catalogs.

i. Offsite services are used when justified by specifications and/or economic reasons.

j. Long lead-time maintenance items services, and their procurement sources, are identified in order to expedite their procurement.

k. Deficient, nonconforming, counterfeit, or suspect items are resolved in an effective and timely manner.

l. Applicable quality assurance provisions of the reference in Paragraph 5m are followed and applicable records are controlled and maintained to provide documentation for qualified parts and materials and to ensure traceability.

m. Material Safety Data Sheets (MSDS) are obtained for chemicals and hazardous materials procured.

n. Identification of the need for specialized services from vendors is made early to provide for timely submittal of, bidding on, and award of contracts.

3.5.3 Materials Control

Performance Objective: All phases of receiving, inspecting, handling, storing, retrieving, and issuing of 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 at the facility. The reference in Paragraph 5m applies.

Criteria:

a. Effective material control is practical and is achieved when the right materials in the correct quantities are delivered to the job location at the proper time.

b. Policies and procedures are prepared to specifically describe the responsibilities and techniques for receiving, inspecting, handling, storing, retrieving, and issuing equipment, parts, and materials.

c. Procedures/instructions are available for items requiring special handling.

d. Material is inspected to ensure conformance to purchasing requirements prior to release for use and storage.

e. Documentation for received material can be accounted for and is retrievable.

f. Nonconforming, counterfeit, and suspect items are identified with tags or labels and controlled to prevent unauthorized use.

g. Effective material procurement status is provided, including accurate stock records and tracking of purchase orders.

h. Materials are stored, protected, and identified in a manner that provides ready availability for its intended use.

i. A shelf-life control program is provided for store items that are important to safe and reliable facility operation.

j. Materials and equipment are stored by intended end use to prevent inadvertent use of the wrong category of item.

k. Periodic inspections of staging areas, stores, and warehouses are performed.

l. The quality of stored equipment, parts, and materials is maintained in accordance with vendor information by appropriate means, such as environmental and shelf-life controls and preventive maintenance activities, if necessary.

m. Parts and materials issued for installation are properly controlled. Unused parts and materials should be promptly returned to a controlled storage area. Completed work requests/orders document material traceability.

n. Critical parts are readily traceable from purchase to installation.

o. Flammable and hazardous materials are identified, segregated, and properly controlled during receipt inspection, storage, and issuance.

p. Equipment and materials used by nonfacility personnel (personnel not directly employed by the facility operating contractor) are subject to inspection, storage, and issuance controls equivalent to items received through normal facility processes.

q. For items requiring special handling instructions, procedures are prepared that include such items as the weight, size, chemical reactivity, radioactivity and susceptibility to physical shock, damage, or electrostatic sensitivity. This also includes lifting instructions.

3.5.4 Control and Calibration of Measuring and Test Equipment

Performance Objective: A program for control and calibration of measuring and test equipment (M&TE) should be instituted to ensure the availability of tools and equipment necessary for maintenance, repair, and calibration of installed equipment and instruments. The reference in Paragraph 5m applies.

Criteria:

a. M&TE includes all devices or systems used to inspect, test, calibrate, measure, or troubleshoot in order to control or acquire data for verifying the conformance of an instrument or piece of equipment to specified requirements.

b. M&TE does not include permanently installed system instrumentation, nor does it include test equipment used for preliminary checks where data obtained will not be used to determine acceptability or verify conformance to established criteria.

c. All M&TE devices have unique identification numbers that accurately identify the specific devices and provide positive traceability.

d. A master list identifying all M&TE is developed and kept current.

e. The M&TE calibration program is based on standards that are traceable to a national standard or that are recognized standards unto themselves.

f. Procedures are used to calibrate M&TE to control the performance of calibrations, provide repeatable calibrations, and provide acceptance criteria.

g. A calibration frequency that helps maintain M&TE accuracy and availability is established.

h. Procedures specify that M&TE should be functionally checked before use.

i. Facilities are provided to control storage, issuance, and calibration of M&TE.

j. Any M&TE with suspected or actual deficiencies is segregated and marked to prohibit its use.

k. M&TE devices that are not fully calibrated or usable are clearly marked to indicate their limitations.

l. M&TE documentation includes records for accountability and traceability of use. A recall system is developed for recalibrations.

m. M&TE devices found out of calibration or defective receive timely evaluations to determine the validity of all measurements/tests for which they were used.

n. M&TE reliability problems are trended to determine any corrective actions needed.

o. Periodic reviews are conducted to determine that the control of M&TE is effective.

p. Critical equipment calibrated with out-of-tolerance test equipment is evaluated in a timely manner for operability and should be recalibrated as necessary.

q. Results of M&TE calibrations are trended and corrective actions are determined for any M&TE reliability problems.

3.5.5 Maintenance Tools and Equipment Control

Performance Objective: Methods should be established to provide for the storage, issue, 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.

Criteria:

a. Proper tools, equipment, and consumable supplies are available to support work requirements.

b. The process of providing tools and equipment for the facility includes proper storage and issue controls.

c. Special tools, jigs, and fixtures should be identified and stored to permit retrieval when needed.

d. Proper loading, lifting, and transporting equipment are available.

e. Maintenance tools and other support equipment are included in the preventive maintenance program.

f. Special tools, test rigs, special equipment, lifting and rigging equipment, and mockups are suitable for their intended use and properly identified.

g. Specific instructions are provided to control the use of lifting and rigging equipment.

h. Scaffolding and rigging equipment are identified, tested, and properly stored.

i. Equipment and tools are maintained in a high state of readiness.

j. The process of providing and developing tools and equipment for the facility include consideration of safety, availability for future use, cost-effectiveness, control, and storage.

k. Worn, defective, or otherwise unusable tools are identified, segregated, and disposed of so that only safe, usable tools are available for use.

3.6 Implementation of Maintenance Activities

A proper balance of corrective and preventive maintenance should be employed to provide a high degree of confidence that property degradation is identified and corrected, that equipment life is optimized, and that the maintenance program is cost-effective. Surveillance inspection and testing activities should provide assurance that the equipment needed for safe and reliable facility operation will perform within required limits. Predictive maintenance monitoring and diagnosis techniques should be used to

plan needed maintenance prior to equipment failure. Modification work and temporary modifications should be controlled administratively in the same manner as maintenance activities. The maintenance management program elements on this branch are as follows:

- Surveillance and Preventive Maintenance;
- Predictive Maintenance;
- Corrective Maintenance; and
- Modification Work.

The performance objectives and criteria for each of these elements are discussed in the following subparagraphs.

3.6.1 Surveillance and Preventive Maintenance

Performance Objective: Surveillance, inspecting, and testing activities should provide assurance that the equipment needed for safe and reliable facility operation performs within required limits and that preventive maintenance (PM), defined as including periodic and planned maintenance, is utilized to maintain a piece of equipment within design operating conditions and to realize its maximum reasonable useful life. The potential impact of seasonal variations should be considered. References in Paragraphs 5f and m apply.

Criteria:

a. A master list of equipment to be included in the PM program is developed and analyzed for cost-effectiveness.

b. An effective preventive maintenance program is implemented and includes systems and equipment that affect safe and reliable facility operation.

c. Preventive maintenance is performed at predetermined and scheduled intervals and seeks to maximize equipment availability.

d. Considerations such as operational experience, vendor recommendations, engineering analysis, cost/benefit analysis, climate, and especially reliability considerations are used as a basis to establish preventive maintenance tasks and intervals.

e. Preventive maintenance activities are scheduled and performed within established intervals and, when possible, combined with corrective maintenance activities on the same equipment. A schedule reflecting seasonal transition issues should be established. Preventive maintenance is waived or deferred only with management approval.

f. Preventive maintenance documentation provides a record of activities performed, data collected, and, where appropriate, the "as-found" and "as-left" condition of the equipment.

g. Preventive maintenance is utilized to assess equipment performance, make adjustments, and perform other corrective actions where needed.

h. Preventive maintenance work procedures are utilized for facility equipment requiring special permits, special plant conditions or line up, and/or special tools, parts, or lubricants.

i. As part of the maintenance surveillance program, functional tests of installed equipment and/or systems (such as standby equipment or nonoperating equipment scheduled for rotation) are conducted and documented.

j. Trending data is acquired as part of the maintenance surveillance program for long-term performance evaluations, such as bearing temperatures, pump speed, and vibration data.

k. Administrative systems and controls provide for timely completion and review of required surveillances.

l. Maintenance surveillance testing programs result in a high degree of reliability in the equipment needed for safe facility operation.

m. The effectiveness of the surveillance program is periodically evaluated at an appropriate level of management and the results used to make program improvements.

n. Abnormalities found during surveillances or preventive maintenance are immediately reported to higher authority.

o. The basis for the planned preventive maintenance program is documented. Any deferral of preventive maintenance tasks has a technical basis.

3.6.2 Predictive Maintenance

Performance Objective: A predictive maintenance program should be established and utilized to monitor; determine trends; analyze parameters, properties, and performance characteristics or signatures of equipment in order to forecast equipment degradation so that "as-needed" planned maintenance can be performed prior to equipment failure.

Criteria:

a. Predictive maintenance techniques, such as reliability-centered maintenance (RCM) programs, are used to identify the need for preventive maintenance prior to equipment failure so that the predictive maintenance program is effective in reducing the failure of structures, systems, and components.

b. The data gathered from tests, diagnostic equipment, fluid analysis, and other similar methods are analyzed, trends identified, and action plans/corrective actions defined.

c. In-process monitoring of equipment is controlled by establishing the proper conditions, systems configuration, and operating parameters to help ensure that the data collected are comparable and trendable.

d. Equipment monitoring locations are identified and marked to obtain consistent readings each time predictive maintenance data are recorded.

e. Mechanisms are established to provide feedback to the facility maintenance program in time to preclude equipment failure.

f. The predictive maintenance program provides data to the preventive maintenance program and provides for retrieval of equipment history data.

g. For all system/component/part failures, the root cause is determined, if possible, and the preventive maintenance program modified, as required, by feedback of actions taken or results.

h. Because all equipment conditions and failure modes cannot be monitored, predictive maintenance is selectively applied where experience indicates that it is most cost-effective or best enhances safety.

3.6.3 Corrective Maintenance

Performance Objective: Corrective maintenance should be performed in a manner ensuring that quality repairs are performed and that equipment failing or malfunctioning during service is restored in a timely manner.

Criteria:

a. A detailed master list of equipment, components, and structures to be included in the maintenance program is developed.

b. Maintenance personnel are attentive to identifying and correcting facility deficiencies with a goal of maintaining equipment/systems in optimum operating condition.

c. Corrective maintenance activities are controlled to ensure equipment and/or systems are returned to normal operating configuration.

d. Good maintenance work practices are followed, including:

(1) Proper tools and equipment are used;

(2) Good safety practices are followed;

(3) Foreign materials and contaminants are excluded from open systems and equipment;

(4) Prejob briefings; training; job procedure use; quality workmanship, materials, and parts; and proper postjob reporting are utilized; and

(5) Work sites are clean and orderly.

e. Corrective maintenance activities should ensure that the condition that caused the failure is identified, corrected, and documented.

f. If it is determined that a warranty or guarantee is of economic value, procedures should be established "to flag" future work on this item to ensure that craft personnel and supervisors do not void the agreement by accomplishment of unauthorized maintenance or repair.

3.6.4 Modification Work

Performance Objective: Modifications and temporary modification work should be accomplished under the same basic administrative controls as those applied to maintenance activities so that there are no increases in risk to facility, equipment, environment, or personnel because of the modification work.

Criteria:

a. Temporary modifications, defined as temporary repairs allowing equipment to remain in or be returned to service in a condition that is not the same as the original design specification, receive appropriate reviews prior to implementation to ensure the adequacy of the repair and to assess its effect on personnel and equipment safety and reliability.

b. Temporary modifications are tracked after their completion for consideration of permanent repairs. Permanent corrective action is taken as soon as practicable.

c. Prior to implementation, a review is performed to look at facility modifications to determine future required maintenance activities and to specify that these activities be added to the maintenance surveillance, preventative, and predictive programs, as applicable.

d. Changes to processes, alarm setpoints, and computer software required by modifications are controlled.

e. The modifications packages identify changes to the spare parts system, dispositions of parts/material reused, etc.

f. Documents affected by modifications, such as drawings and procedures commonly used for system operation, tagouts, and maintenance, are updated prior to operation of the system or equipment.

g. Onsite modifications, rework, and repairs performed by vendors or construction forces are controlled in a similar manner as other work activities.

3.7 Maintenance Evaluation and Analysis

Maintenance evaluation and analysis consists of a program to determine root causes of problems, periodic reviews and analyses to determine efficiency, performance measurement to set a basis for improvement, management involvement to demonstrate a commitment to improvement, work sampling to observe personnel work practices, and cost identification and control to ensure cost-effectiveness. The evaluation and analysis aspects of the program should be a continuous, ongoing effort aimed at the overall improvement of the entire maintenance program. Feedback from internal and external audits and lessons learned should be factored into the maintenance program. The maintenance management program elements on this branch are as follows:

- Analysis of Root Causes of Problems;
- Periodic Review and Analysis;
- Performance Measurement and Improvement;
- Management Involvement;
- Work Sampling;
- Cost Identification and Control; and
- Audits and Lessons Learned.

The performance objectives and criteria for each of these elements are discussed in the following subparagraphs.

3.7.1 Analysis of Root Causes of Problems

Performance Objective: A systematic analysis methodology should be used to determine and correct root causes of problems, unplanned events, and occurrences related to maintenance. The reference in Paragraph 5f applies.

Criteria:

a. Recurring maintenance problems are reduced by identifying and resolving the root causes of the problems.

b. An analysis program is established to investigate unplanned occurrences that have an impact on safety or reliability or are of a recurring nature. This program includes the methodical collection of facts describing the unplanned occurrence.

(1) All available information and probable causes of an incident or problem should be evaluated.

(2) Analyses of information should include one or more techniques, including the following: event and causal factor charting; barrier analysis; walk-through task analysis; change analysis; and fault tree analysis.

(3) Outside experts are utilized when required.

c. An acceptable root cause will meet the following criteria:

(1) Its correction prevents recurrence of the unplanned occurrence;

(2) Its correction is feasible; and

(3) Its correction does not adversely impact safety, reliability, or operational goals.

d. Root causes are categorized in terms of either human performance or equipment performance.

e. When all root causes involved have been determined, a corrective action plan is developed, executed, and tracked to completion.

f. The analysis program addresses any generic corrective actions that need to be taken after problems with the specific piece of equipment have been determined and corrected.

g. After analysis is performed to determine the root cause(s) of failure, corrective action is taken that includes feedback into the preventive and predictive maintenance programs and maintenance training and qualification programs.

3.7.2 Periodic Review and Analysis

Performance Objective: Standardized procedures, methodologies, and systems should be developed and utilized for the review and analyses of the efficiency of maintenance programs. References in Paragraphs 5f and m apply.

Criteria:

a. A periodic assessment of equipment, systems, and facilities is conducted to adjust preventive maintenance actions and tools and equipment availability and to determine inadequacies.

b. Reviews of the overall effectiveness and efficiency of the procurement and material control process are conducted.

c. Measuring and test equipment is periodically reviewed to verify that it is supporting the safe and reliable operation of the facility.

d. The maintenance training program is periodically reviewed to identify training program enhancements or changes in emphasis.

e. The work control system is periodically reviewed to ensure that documentation is consistent with the work accomplished and that all necessary work is being accomplished.

f. Periodic self-assessments are performed in accordance with the reference in Paragraph 5m.

g. Review of a consistent broad range of performance indicators is performed periodically. The results of this review and analysis are used as the basis for program improvements such as the following:

(1) Adjustments to preventive maintenance frequencies;

(2) Addition or deletion of preventive maintenance activities;

(3) Proposed design changes;

(4) Adjustments to spare parts and materials stock levels;

(5) Adjustments to staffing and/or training; and

(6) Adjustments in tools, equipment, and facilities or modifications to improve facility equipment maintainability.

h. The backlog management program is periodically reviewed to verify that actions are effective in maintaining or reducing the backlog to comply with the Backlog Work Control criteria of Paragraph 3.4.8.

3.7.3 Performance Measurement and Improvement

Performance Objective: Management and maintenance organizations should have a quantitative means of measuring performance and effectiveness to improve the maintenance system. References in Paragraphs 5k and m apply.

Criteria:

a. Each maintenance organization develops a method of measuring maintenance system performance (such as the maintenance and repair costs of buildings measured in dollars per square foot, the growth of backlog of maintenance and repair, the amount of unscheduled maintenance and repair costs, the amount of emergency maintenance costs, or other similar items).

b. Programs are routinely implemented to monitor, collect, trend, and analyze performance data (including thermal, hydraulic, electrical, acoustical, and mechanical data) for equipment, systems, and components important to facility reliability and efficiency.

c. Performance data is analyzed and the results used to determine the reliability of key facility systems and components and to identify ways to optimize facility reliability and efficiency.

d. Maintenance performance indicators and trends such as the following are used to focus management attention on areas that should be documented and addressed:

(1) Post-maintenance test results;

(2) Periodic surveillance test results;

(3) Ratio of preventive maintenance costs to corrective maintenance costs;

(4) Maintenance work request backlog;

(5) Time to restore component function after failure discovery; and

(6) Frequency of maintenance rework.

3.7.4 Management Involvement

Performance Objective: To enhance the safety of facility operations, maintenance managers should be sufficiently involved with facility operations and maintenance to be technically informed and personally familiar with conditions at the operating facility. References in Paragraphs 5f and m apply.

Criteria:

a. Maintenance managers are involved and know what is going on by frequently touring the facility. Effective corrective actions are taken for noted problems. The maintenance program is periodically reviewed by facility management in self-assessments.

b. Maintenance performance is checked by observing people at work and also by inspecting, monitoring, and checking equipment and by timely followup of corrective actions.

c. Facility tours and personnel contacts are also performed during "off-shifts" and cover selected facility areas and personnel activities. The results and observations of these tours are documented and corrective action plans created where appropriate.

d. Senior managers monitor the assessment activities of their subordinate managers and supervisors.

e. Management and supervisory assessment and improvement efforts are performance oriented. Line managers and supervisors are responsible for determining and implementing corrective actions.

f. Management assessments are conducted to determine the reasons for success or failure in achieving objectives. Results are incorporated into future objectives.

g. Maintenance management establishes the percentage of time that first line supervisors are expected to spend supervising field work.

h. A key element of management involvement is the establishment of a feedback system to identify problem areas and create participation in improvements.

3.7.5 Work Sampling

Performance Objective: A work sampling program for the purpose of determining the extent of various craft activities and their related delay times should be established such that they may be used to measure the utilization of craft personnel in performing work in a maintenance management program.

Criteria:

a. When performing work sampling, the craft or shop group is utilized as the unit of measure, not the individual.

b. When performing work sampling, the categories of time affecting the total job (such as travel, job preparation, direct work, and delay time or idle status associated with the work activities) are determined and utilized.

c. Work sampling provides a base case or basis against which all subsequent improvements can be measured.

d. Work sampling is utilized to measure the effects of planned improvements to craft utilization.

e. Maintenance performance is checked by observing people at work.

3.7.6 Cost Identification and Control

Performance Objective: Cost accumulation and reporting systems should be established to facilitate the work control system utilized to evaluate maintenance performance. The reference in Paragraph 5a applies.

Criteria:

a. Accounting for maintenance is established to allow management to understand clearly the scope of planned maintenance efforts for the funding allotted.

b. Procedures are in place to define proper cost coding and cost verification.

c. Managers and supervisors review cost data to prevent overruns and to detect adverse trends.

d. Estimated job costs from the planning effort are evaluated against final job costs.

e. Budgets are justified by factual or historical maintenance costs or by some other industry-recognized method that provides information on the resources required to maintain the capital asset in a state of good repair.

3.7.7 Audits and Lessons Learned

Performance Objectives: External and internal audits, such as self-assessments, lessons learned, and experience from other DOE sites, should be evaluated and considered for utilization for making appropriate changes to systems, procedures, and management concepts to obtain needed improvements and/or to delete nonessential, noncost-effective, or redundant activities. References in Paragraph 5f and m apply.

Criteria:

a. Inspections, audits, reviews, investigations, and self-assessments are utilized to provide feedback to the maintenance program.

b. The ability to apply lessons learned from in-house maintenance experiences (and the experiences of others) is considered an essential aspect for long-term success.

c. Related maintenance experience at other facilities or DOE sites is evaluated and appropriate changes made to systems procedures, and management concepts.

d. Procedures are in place to assign responsibility for areas needing improvement corrective action and followup. Corrective actions are tracked and reported until completion.

e. Quality assurance, safety, and environmental audits and inspections are promptly evaluated and appropriate action taken.

f. Changes or modifications resulting from audits and lessons learned are documented in policies and procedures.

CHAPTER II

GUIDELINES FOR THE CONDUCT OF MAINTENANCE AT DOE NUCLEAR FACILITIES

1. GENERAL INTRODUCTION. Maintenance has a primary role in ensuring safe and reliable operation of Department of Energy (DOE) reactor and nonreactor nuclear facilities. To carry out this role, a strong maintenance philosophy and culture (i.e., a set of standards, values, and convictions) should exist based on sound and established principles. Achievement of excellence in maintenance requires a team effort and a dedicated commitment to raising standards.

   These guidelines describe key elements of programs that support maintenance at DOE nuclear facilities. Their implementation, using the graded approach as discussed below, should result in a high level of performance in facility maintenance and, therefore, contribute to safe and reliable facility operation. The discussion of the key elements includes material that incorporates the concepts included in other Orders associated with matters related to the maintenance program. For example, the discussion on procedures is consistent with the direction of DOE 5480.19, CONDUCT OF OPERATIONS REQUIREMENTS FOR DOE FACILITIES. Similarly, there is considerable carry over from DOE 5700.6C, QUALITY ASSURANCE, DOE 5480.20, PERSONNEL SELECTION, QUALIFICATION, TRAINING, AND STAFFING REQUIREMENTS, AT DOE REACTOR AND NON-REACTOR NUCLEAR FACILITIES. The guidance in many cases repeats the information from the referenced Order. This material is retained in these guidelines to facilitate the maintenance organization's incorporation of the elements and their criteria into the program. In many cases the objectives and criteria of all applicable Orders are consistent and can be met by one program.

   Experience has shown that better operating facilities have well-defined, effectively administered policies and programs to govern maintenance activities. These guidelines have been prepared to assist Managers of Field Elements and contractors in the review and development of programs important to facility maintenance. For the purpose of these guidelines, maintenance includes those functions performed primarily by mechanical, electrical, instrument and control, and material management/services procurement organizations. Although these organizations may be under different managers, applicable sections of the guidelines still apply to these respective organizations and functions. Not all activities in the maintenance area are addressed. Some activities, such as methods for compliance with Technical Safety Requirement surveillance and in-service inspection requirements and the technical aspects of specific equipment maintenance, are not included because they involve facility-specific situations requiring unique direction; however, use of these guidelines should support and complement performance in those activities.

   These guidelines have also been written to assist contractors and field elements in understanding and conducting a maintenance program at DOE nuclear facilities to meet the underlined performance objectives contained in the elements described in Chapter II. These guidelines use the term "should" throughout the Chapter as a convention to emphasize the use of a graded approach in developing the required maintenance implementation plans previously described in Paragraph 10d. This "should" convention is maintained even though the reader would expect to see "shall" in sections where there are interfaces with other DOE Orders

such as 5700.6C. It is expected that contractors may use different approaches or methods than those defined in these guidelines, but all facilities are required to meet the intent of these guidelines. Some explanation of the intent of the guidelines is provided in the Introduction and Discussion sections for each element, and the specific guidelines that follow reflect generally accepted methods for conducting maintenance functions and related activities.

It is recognized that, because of the Department's diverse nuclear facilities, not all guidance established in the guidelines applies to all nuclear facilities. Therefore, a graded approach for maintenance programs for nuclear facilities is directed. However, because of the significance of these facilities, documentation and approval of the maintenance program must be obtained as required in Paragraphs 10d and e.

At those DOE facilities where the graded approach indicates deviations from these guidelines are considered to be necessary and appropriate, or because of the uniqueness of the DOE nuclear facility, the guidelines do not appear to be applicable, such deviations or nonapplicability should be identified in the Maintenance Implementation Plan, and the approval of the Manager of the Field Element per Paragraph 10e.

These guidelines should also be useful to field element and contractor managers and staff members responsible for the oversight of facility programs supporting maintenance. In particular, this document could be used to assess the effectiveness and adequacy of contractor policies, procedures and facility actions in the area of maintenance. Groups reviewing nuclear facility maintenance performance could use this document as a reference to support some aspects of their activities.

Each section of this document is organized into three subsections. The Introduction subsection briefly describes the objective to be achieved. Addressing each of the objectives is a requirement for an adequate maintenance program. The Discussion subsection describes the actions needed to accomplish the objective and includes a brief explanation of why these actions are necessary or important. The final subsection, Guidelines, provides specific guidance for meeting the section objective. 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.

Persons wishing to obtain an overview of this document need only read the Introduction and Discussion subsections of each section.

2. MAINTENANCE ORGANIZATION AND ADMINISTRATION

2.1 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. Effective implementation and control of maintenance activities are achieved primarily by establishing written policies, procedures, and standards for maintenance; periodically observing and assessing performance; and holding personnel accountable for their performance.

This Paragraph discusses the policies resources, goals and objectives, and accountability needed in facility maintenance. The reference in Paragraph 5f applies.

2.2 Discussion

A high level of performance in facility maintenance is accomplished by establishment of high standards by senior management, communicating standards to personnel who perform maintenance, selecting and training high quality personnel, providing sufficient resources to the maintenance organization, setting goals and objectives, closely observing and assessing performance in maintenance, effectively coordinating maintenance activities with operations and other facility organizations, and holding workers and their supervisors accountable for their performance in conducting maintenance activities. Another key to obtaining and maintaining high quality maintenance performance is establishing an organization that provides time for and emphasizes long-range planning.

Sufficient staff, equipment, and funding should be allocated to the maintenance organization so that its functions can effectively be performed. Resources can be allocated on a case-by-case basis, depending on the organization utilized. One indication that sufficient resources have been allocated is how well the maintenance goals are met. Maintenance goals and objectives are discussed later in this Paragraph.

Contractor and facility management should establish maintenance standards, considering input from the maintenance staff and craft personnel who will more eagerly support standards they have helped to develop. These standards should define maintenance objectives, establish expected performance levels, and clearly define maintenance responsibilities and accountabilities. Standards for maintenance activities should be integrated into maintenance procedures and programs. Maintenance standards should also be communicated to the working level by training workers in good work practices and by supervisors observing and guiding work activities. Performance in maintenance should be closely monitored by field element personnel and facility managers through direct observation and maintenance reports. Progress toward achieving goals should be examined to effectively measure the performance of the maintenance organization. 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.

2.3 Guidelines

2.3.1 Maintenance Organization Policies

It is a primary responsibility of the maintenance manager[1] 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

[1]The term maintenance manager is used throughout the guidelines to denote the manager responsible and hence accountable for the maintenance functions.

policies, including the responsibility of maintenance personnel,[2] 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 that are used to guide maintenance organization activities. These documents should also specify the types of controls necessary to implement maintenance policies.

2.3.2 Maintenance Strategy

a. Working Relationships

Each facility should develop an integrated approach to maintenance so that working relationships are developed among all organizational units that support the maintenance function (e.g., operations, health physics, stores, quality control, engineering, and procurement).

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

- 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 for each supporting group (e.g., number of plant work orders on hold because of a lack of spare parts).

b. Long-Range Planning

Effective management of the maintenance program requires long-range planning. By establishing a scope of long-range major activities, funding and staff resources can be managed to meet the needs of the maintenance program. Items such as the following should be part of long-range planning:

- Recurring major maintenance items such as major component overhaul, inspections, and rebuilds;
- Timing of planned maintenance and reactor refueling outages or equipment outages;
- Major projects and modifications requiring maintenance organization involvement;

[2]The term maintenance personnel denotes any individual performing a maintenance function.

- 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 end of their service life;
- Outage planning should reflect availability of resources;
- Value-impact assessment of maintenance methods, processes, and approaches/alternatives to performing work should be done periodically;
- Government and industry issues and events that will change or impact the maintenance program;
- Budget changes or projects that may divert major dollars from maintenance activities; and
- Contractor and corporate long-range support.

2.3.3 Staffing Resources

Maintenance managers are responsible for helping to select high-quality personnel, for effective use of available resources, for assessment of resource adequacy, and for making recommendations regarding needed changes to the appropriate managers. They should be involved in defining entry-level criteria and screening of new personnel. High-quality personnel should be selected to establish a staff of supervisory, engineering, planning, technical (craft), warehousing, and other support personnel needed to support the maintenance program. The entry-level criteria should ensure that maintenance personnel have the requisite background and experience to be trainable for work in nuclear facilities. A written or practical test has been used to demonstrate this minimum level of competence. If engineering personnel are not directly assigned to the maintenance organization, the maintenance manager should ensure that adequate engineering support is readily available (e.g., system engineers who are actively involved with daily maintenance activities such as troubleshooting and the evaluation of 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 for training activities. A training and qualification program should be developed for maintenance supervisors, planners, craft, and warehouse personnel to ensure that high-quality performance by maintenance personnel is achieved and maintained. Career progression plans should be developed that help ensure that future maintenance staff vacancies can be filled with qualified personnel. These progression plans include providing experience opportunities and training to potential candidates for specific positions. All maintenance management and supervisory positions should be filled with permanent contractor personnel.

2.3.4 Goals and Objectives

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:

- Minimize the impact on planned outages by planning and completing maintenance activities in a timely manner;
- Minimize the number of forced outages;
- Minimize the lost-time accident rate;
- Minimize facility and equipment downtime;
- Minimize personnel errors;
- Minimize process delays in work controls and work execution.
- Minimize radiological exposure consistent with the reference in Paragraph 5e;
- Control and reduce contaminated areas;
- Reduce repeat maintenance work requests (rework);
- Complete scheduled surveillances and preventive maintenance activities in a timely manner;
- Minimize the maintenance backlog and reduce the completion time of outstanding deficiencies;
- Control overtime; and
- Complete outage and nonoutage 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 determination and estimate, a challenging but achievable goal should be established. Meeting goals generally requires a definite set of actions. Action plans should be developed with input from personnel involved in conducting maintenance activities, reviewed by the maintenance manager, and approved by the facility manager. Guidance is provided in Paragraph 15 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 accomplishment; rather, the purpose of goals is to improve maintenance performance. Goals for routine tasks or tasks that are easy to meet with little action should not be used.

2.3.5 Accountability

Managers, supervisors, engineers, planners, craft, warehouse personnel, and other personnel who support maintenance should be recognized for their performance. Rewards and other forms of recognition should be given for superior performance. Personnel involved in significant or frequent violations of maintenance requirements should be encouraged to improve through counseling, by remedial training, or by disciplinary measures where appropriate. A performance feedback program, such as performance appraisals, should be used to evaluate facility maintenance personnel. This program should include or should 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 their manager or supervisor.

3. TRAINING AND QUALIFICATION OF MAINTENANCE PERSONNEL

3.1 Introduction

A maintenance training and qualification program consistent with references in Paragraphs 5g and m should be implemented to develop and maintain the knowledge and skills needed by maintenance personnel to effectively perform maintenance activities. The program should be designed so that the maximum potential of maintenance personnel is fulfilled.

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

The maintenance manager and supervisors should be directly involved in training maintenance personnel. This involvement should, as a minimum, include close coordination with the contractor 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.

3.2 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 these 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 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 of and instruction during OJT;
- Qualifying individuals as they complete their training programs; and
- 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 a key consideration in obtaining safe, efficient, and high-quality maintenance. The maintenance manager should be involved in the construction of new maintenance training facilities and 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:

- Training class size;
- Type of training (e.g., classroom, laboratory, on-the-job training);
- Use of mockups;
- Environmental controls;
- Services (e.g., electricity, air, water, and gas);
- Training equipment (e.g., lecture boards, projectors and screens, and simulators); and
- Equipment similar to that installed in the facility for practical training.

3.3 Guidelines

3.3.1 Responsibilities

The responsibilities for establishing, maintaining, and implementing the maintenance training programs should be clearly defined and understood. A key element for success is personal involvement of managers and supervisors in the development, scheduling, and conduct of maintenance training.

3.3.2 Maintenance Training Programs

Training should be defined and should include managerial, supervisory, planning, engineering, warehousing, craft positions, contractor personnel, and other positions, as deemed necessary. Courses should then be obtained or developed.

3.3.3 Training Schedules and Support

The maintenance manager and supervisors should work closely with the training organization to accomplish items such as the following:

- Prepare schedules that reflect instructor, training facility, and trainee availability and 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 can be exempted for the position. One method to accomplish this is to require potential employees to pass a written test as part of the interview process. Based on the test results, the training program and milestones for that individual are established.

- Ensure qualified instructors are available to teach specific courses.

3.3.4 On-the-Job Training

On-the-job (OJT) training is practical hands-on training in which employees achieve learning objectives through training conducted in 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 day-to-day work activities. Accordingly, maintenance department supervisors and selected experienced craft personnel are directly involved in OJT. Some key elements of OJT are listed below:

- OJT 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 what the 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.

- OJT Trainer Qualification--OJT should be conducted by personnel who have successfully qualified as OJT trainers. Personnel with maintenance experience in the training department, as well as personnel in the maintenance department itself, may be used as OJT trainers. These trainers should have good verbal communication skills and technical knowledge and should have the ability to effectively provide trainees with 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 facility. Prior to 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 components that will be manipulated. The results

of incorrect actions should be discussed, particularly if they would 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 a radiation work permit is used).

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

- Number of Trainees--To determine the number of trainees allowed to simultaneously participate 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 distracted 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. However, it may be prudent to have only one trainee for work involving a live, high-voltage circuit or conducting a reactor protection system surveillance test.

- Trainee Conduct of Maintenance--The maintenance manager should establish a policy that allows trainees to independently perform 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 requirements before being assigned to perform independently a task on that equipment. The need to make progress in training should be considered when scheduling maintenance tasks for the trainee.

3.3.5 Qualification

In conjunction with the training organization, maintenance management should review an individual's training accomplishments prior to qualification for a given task. A similar method should be established to review the qualification of contractor personnel. This review should include the following:

- Verifying completion of all designated 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 acquired (not as a verification of total expertise and proficiency but as an indicator of competency upon which to build); and

- Formal qualification approval and documentation.

3.3.6 Training In Root-Cause Analysis

In addition to training in technical maintenance functions as described in the preceding, 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 individual(s) 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 given the background necessary to select and implement an approach that is suitable for a particular situation.

3.3.7 Training Program Approval, Effectiveness, and Feedback

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 initial and continuing training program enhancements and emphasis. Feedback on the trainee's perception of and suggestions for improving the training program should be obtained. Any performance trends that indicate maintenance knowledge or skills needing improvement should be considered during the review of the maintenance training programs. Changes to the training programs by the training organization should include recommendations from the maintenance manager.

3.3.8 Management and Supervisory Training

There should be a formalized training program that addresses and provides the necessary training to develop and maintain management and supervisory skills. This training should include generic areas such as 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 properly communicate with their people and carry out their responsibilities. This is especially important to the first-line supervisors to aid them in managing maintenance activities. Career progression planning should be used to help customize the training program for personnel being considered for specific supervisor and manager positions.

4. MAINTENANCE FACILITIES, EQUIPMENT, AND TOOLS

4.1 Introduction

Maintenance facilities, equipment, and tools should efficiently support facility maintenance and maintenance training. Maintenance

facilities directly affect maintenance personnel training and the ability to maintain the facility in an optimum state of readiness. Maintenance facilities include storage for equipment, tools, supplies, and parts.

This Paragraph provides guidance in determining needs for the facilities, tools, and equipment necessary to support maintenance. References in Paragraphs 5l and m apply .

4.2 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 area, 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 work place where high quality work can be performed.

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 effectively accomplish maintenance depend on such variables as facility purpose, design and layout, installed equipment, and work force composition. The process of providing and developing tools and equipment should include considerations of cost, control, and storage. Tool and equipment control are addressed in Paragraph 13. 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.

Maintenance facilities, tools, and equipment use 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 a long-range project and not done to address an immediate need.

4.3 Guidelines

4.3.1 Facilities

a. Shops and Satellite Work Areas

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 are:

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

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

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

b. Laydown and Staging Area

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, area 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;
- Radiological control;
- Labeling of facilities to designate responsibility and entry authorization; and
- Contingency plans for changes (such as unanticipated radioactive airborne contamination) that could render a facility unusable for its intended purpose.

Reactor refueling and other 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.

c. Storage Facilities

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 items 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 items such as material receipt, inspection, handling, storage, retrieval, and issuance (Paragraph 11) and tool and equipment control (Paragraph 13).
- Inventory level of spare parts, supplies, and equipment to support safe and reliable operation of the facility (Paragraphs 10 and 11).

d. Temporary Facilities

Temporary facilities are required for activities involving airborne radioactivity and contamination control and contractor support during outages. Planning and coordinating temporary facilities with other groups, such as radiological protection and operations, results in more efficient use of space. Such necessary services as electrical 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. Major temporary facilities should be controlled through the plant's design change programs to ensure additional building services (such as electrical, compressed air, and water requirements) do not overload the installed plant systems.

e. Decontamination Facilities

Decontamination facilities should be used to reduce the volume of solid radioactive solid waste, permit clean work on formerly contaminated equipment, and reduce contamination on reusable tools and equipment. Examples of decontamination facilities and methods include a wash-down area, solvent rinse, ultrasonic bath, acid bath,

electropolishing, hydroblasting, and sand blasting. Use of these facilities and methods can reduce exposure, repair time, and solid radioactive waste volume and provide better tool management.

4.3.2 Tool and Equipment Storage

Storage facilities should be centrally located to shops and normal work areas to improve maintenance efficiency. Storage facilities should provide for day-to-day tool and equipment use for craft personnel and for special tools and equipment, test rigs, and the ready retrieval of mockups when needed. These facilities should provide environmental controls for temperature, humidity, dust, and radioactive contamination, as needed. Facilities should also meet manufacturers' special 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 of tools. See Paragraph 13 for additional information on tool and equipment control.

4.3.3 Office Equipment

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 office equipment should be accessible and maintained in a reliable working condition. When computerized data bases 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.

5. TYPES OF MAINTENANCE

5.1 Introduction

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

This Paragraph provides guidelines in establishing the proper relationship of the types of maintenance in the maintenance program. This Paragraph does not address Technical Safety Requirements; however, operations maintenance surveillance, inspections, and in-service inspections should be considered as essential source data in establishing the scope of the predictive and preventive maintenance program. References in Paragraphs 5e and f apply.

5.2 Discussion

Many factors should be considered in establishing an effective and efficient balance of the types of maintenance. On important systems and equipment, a thorough technical analysis using methods such as reliability-centered maintenance (RCM) may be needed to establish this balance. On less important systems, the amount of preventive

maintenance to be performed may be determined using a more basic judgmental engineering analysis.

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

Costs associated with preventive maintenance should be offset by improved facility reliability and availability and by reduced corrective maintenance. Excessive or unnecessary preventive maintenance can consume resources that could otherwise be used to extend the scope of the preventive maintenance program and may also increase maintenance errors, rework, and personnel radiation exposure.

For the purposes of these guidelines, the types of maintenance are defined as follows:

- Corrective maintenance is repair and restoration of equipment or components that have failed or are malfunctioning and are not performing their intended function. As a rule of thumb, if the specific component (e.g., packing or bearing) requiring maintenance has failed, the action required to repair it should be classified as corrective maintenance.

- Preventive maintenance includes periodic and planned maintenance actions taken to maintain a piece of equipment within design operating conditions and extend its life and is performed prior to equipment failure or to prevent equipment failure. This includes technical specification surveillance, in-service inspections, and other regulatory forms of preventive maintenance.

  Operations maintenance surveillances are, in addition to Technical Safety Requirement surveillance, the periodic actions, tests, or inspections conducted by the operations or maintenance organization to improve the reliability of equipment. These surveillances may include minor component lubrication, functional tests of standby equipment or nonoperating equipment scheduled for rotation, and data acquisition at specific frequencies for long-term performance evaluation such as bearing temperature, pump speed, and the data requirements for predictive maintenance described in Paragraph 5.3.2c.

  - Periodic preventive maintenance activities are accomplished on a routine basis (typically based on operating hours or calendar time) and may include any combination of external inspections, alignments or calibrations, internal inspections, overhauls, and component or equipment replacements.

  - Planned preventive maintenance activities are performed prior to equipment failure and can be initiated by predictive or periodic maintenance results, by vendor

recommendation, or by experience. These include items such as scheduled 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 due to packing leakage would be corrective maintenance, but scheduled repacking prior to leakage would be planned maintenance.

- Predictive maintenance activities involve continuous or periodic monitoring and diagnosis in order to forecast component degradation so that "as-needed" planned maintenance can be performed prior to equipment failure. Not all equipment conditions and failure modes can be monitored; therefore, predictive maintenance must be selectively applied. Reliable predictive maintenance is normally preferable to periodic internal inspection or equipment overhauls.

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

- A master equipment list should be developed to help in selecting and scheduling preventive maintenance and for 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 preventive maintenance actions required and the frequency needed for performing each preventive maintenance action.

- Each preventive maintenance action should be scheduled in a manner that allows consideration for performing other related maintenance at the same time (Paragraph 7).

- Preventive maintenance actions that are deferred past a grace period (normally, 25 percent of the established interval) or missed should be reviewed and approved by the maintenance manager, and reported periodically to the facility manager.

- The maintenance program should be reviewed periodically to determine the effectiveness of the program on overall facility reliability. Changes should be considered during this review to optimize the maintenance program (Paragraph 15).

5.3 Guidelines

5.3.1 Master Equipment List

A detailed master list of 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. This list can also be used effectively in establishing the maintenance history program (Paragraph 16).

5.3.2 Types of Maintenance

a. Corrective Maintenance

Corrective maintenance consists of all those actions performed to restore failed or malfunctioning equipment to service. 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 or causes of failure and corrective action should be taken, including feedback into the preventive and predictive maintenance programs and maintenance training and qualification programs. Priorities for corrective maintenance should be established, based on plant objectives and the relative importance of the equipment.

b. Preventive Maintenance

Preventive maintenance consists of all those systematically planned and scheduled actions performed for the purpose of preventing equipment failure. The preventive maintenance program should define the required activities and the frequency at which they should be performed. Selection of required preventive maintenance actions should be based on manufacturer's recommendations, plant experience, and good engineering practice. The frequency of preventive maintenance should be based on adequately implementing the entire program, considering such elements as predictive maintenance results, vendor recommendations, ALARA considerations, and monitoring of performance. Further, any deferral of planned tasks should have a technical basis.

Maintenance action is often scheduled on a routine basis (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 done prior to equipment failure. This can be initiated by predictive or periodic maintenance results, by vendor recommendation, or by experience. This 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; and
- Replacement of known life-span components.

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

c. Predictive Maintenance

Predictive maintenance consists of the actions necessary to monitor, find trends, and analyze parameter, property, and performance characteristics or signatures associated with a piece of equipment that indicate the equipment may be

approaching a state in which it may no longer be capable of performing its intended function. The predictive maintenance program should be effective in reducing the failure of structures, systems, and components by using techniques that indicate the need for preventive maintenance prior to equipment failure. The data gathered should be analyzed, trends should be identified, and action needed should be defined. Action should be taken to provide feedback to the maintenance program in time to preclude equipment failure. The predictive maintenance program should provide data to the preventive maintenance program and provide and retrieve equipment history data. Root causes should be determined, if possible, and action taken and results fed back into the program.

Predictive maintenance actions are determined by the data required to describe equipment performance, for example:

- Vibration analysis (including spectral analysis and bearing temperature monitoring) and lube oil analysis (ferrography) are used to monitor rotating equipment.
- Infrared surveys (thermography) are performed on heat-producing equipment such as motors, circuit breakers, batteries, load centers, and insulated areas to monitor for high resistance or insulation breakdown.
- Motor-operated valves are tested and analyzed. Such tests as operating current, voltage, and timing checks should be used.
- Selected instrument data are identified, normal values and acceptance criteria are established, and readings are monitored and trended for the operation condition of the equipment to detect degradation.

When predictive maintenance requires in-process monitoring of the equipment, such action should specify establishing the proper conditions, systems configuration, and operating parameters to help ensure that the data collected are comparable and trendable. Equipment monitoring locations should be identified and marked to obtain consistent readings each time the predictive maintenance data are provided. Knowledgeable individuals must review and analyze these data for the predictive maintenance program to be successfully used to predict and address incipient failures.

5.3.3 Maintenance Action and Frequency Selection

Using the master equipment list, preventive actions and their frequencies are analyzed to identify periodic actions that should be taken to improve equipment performance. The actions selected and their frequencies should be determined, based on such considerations as the following:

- Regulatory and code requirements;
- Vendor recommendations;

- Experience at this and similar facilities;
- Maintenance history;
- Engineering judgment;
- Cost/benefit evaluations;
- Available personnel;
- Minimizing personnel radiation exposure using the ALARA principles;
- Function, ease of replacement, and demonstrated reliability of equipment or system;
- Optimizing equipment or system availability during unit operating conditions; and
- Operating history.

This effort should include the analysis of failure modes and frequencies, the determination of failure causes (Paragraph 17), and identification of preventive maintenance actions that could improve facility reliability and reduce operating costs. The justification for the preventive maintenance program should be documented, and the maintenance manager should approve the preventive maintenance program, including new or revised preventive maintenance actions and their frequencies. Effective monitoring and diagnostic methods (predictive maintenance) are normally preferred to periodic internal inspection or equipment overhauls. These techniques can reduce maintenance errors, rework, and radiation exposure.

In establishing a balance between corrective and preventive maintenance as they pertain to the various facility systems and equipment, the overriding consideration must be safe and reliable facility operations achieved on a cost-effective basis. Methods used to determine how each type of maintenance is to be applied to each facility system and equipment should be established by the facility.

5.3.4 Scheduling

Each preventive maintenance action should be scheduled at appropriate intervals and, when possible, combined with corrective maintenance activities on the same equipment and with other related maintenance based on equipment similarity or proximity. See Paragraph 7.3.2 for additional information on scheduling.

6. MAINTENANCE PROCEDURES

6.1 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. One of the key elements needed to consistently perform maintenance in a safe and efficient manner is

the proper use of written procedures. A balanced combination of written guidance, craft skills, and worksite supervision is required to achieve the quality workmanship essential to safe and reliable facility operation.

This Paragraph describes important concepts for preparation, verification, validation, approval, control, use, and periodic review and revision of maintenance procedures. References in Paragraphs 5f and m apply.

6.2 Discussion

Experience has shown that deficient procedures and failure to follow procedures are major contributors to many significant, undesirable events. The probability of error increases with the use of poorly written procedures. Maintenance procedures should provide technical guidance to craft personnel to help ensure that work is accomplished 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.

Guidance should be provided for the development and issuance of maintenance procedures including development and writing, verification and validation, approval, control, periodic review, use, revision, and change control. Other factors, such as control of reference material, procedure identification and storage, and the requirement to maintain accurate procedures, must also be considered.

6.3 Guidelines

6.3.1 Procedures Development and Writing

Procedures should be written for and used in all work that could result in a significant process transient, degraded facility reliability, or a personnel or equipment hazard. The complexity of the work is also an indicator of the need for a procedure. Procedures should also be written for each preventive maintenance action or written generically for similar preventive maintenance actions (including applicable equipment lists). Since these procedures are used repeatedly, information such as resources and skill levels required; time to accomplish the action; special tools and materials needed; facility or system conditions needed; and clearance, radiation work permit, and other safety requirements and precautions should be included in the procedure, as well as the actual steps to perform the preventive maintenance.

Information provided in procedures should be clear and concise and should minimize the need for interpretation. 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 for the audience intended to use them--that is, for the craft person--and should consider the following:

- Procedure identification and status (titling or numbering, location, and page and revision identification);
- Procedure purpose and scope;

- Consistent format (for organization, instruction step format, instruction step designation, caution and note format, and page format);
- Clearly understood text, using standard grammar and punctuation; appropriate level of detail; concise instruction steps in logical sequence; proper arrangement of multiple verb objects; 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 use of illustrations (e.g., preparation, compatibility, views, level of detail, 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 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 will be delayed and extended past the anticipated schedule and/or across shift changes; and
- Procedure 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.

6.3.2 Procedure Verification

Verification is a review to ensure the proper format and technical accuracy of a new or revised procedure. This review should ensure that the format incorporates human-factors principles and other appropriate administrative policies. The technical accuracy review should also include a review of the procedure against the design requirement for that system or component. This may be accomplished by comparing the vendor manual and design specifications to the procedures.

Verification should be conducted by one or more reviewers who were not involved in writing the procedure. Other disciplines such as health physics and operations should be considered for the review process.

6.3.3 Procedure Validation

Validation is a review of a procedure to ensure its usability and correctness. This validates that the procedure provides sufficient and understandable guidance and direction to the craft person and that the procedure is compatible with the equipment or system being maintained.

Validation may be conducted in a shop, in a training environment, on a mockup or simulator, or in some cases by the craft person and supervisor during the first use of the procedure.

6.3.4 Procedure Approval

Approval should be consistent with facility technical specifications or their equivalent and administrative procedures. As a minimum, the maintenance manager or designee should approve maintenance procedures.

6.3.5 Procedure Use

Procedures should be readily available and clearly identified to ensure the user can determine the 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 is the most current revision. Procedures should be checked prior to use to ensure that the most current and correct revision is being used.

Procedure compliance requirements should be clearly stated in the procedure or provided as general administrative guidance and should be thoroughly understood by facility personnel. Compliance requirements may vary considerably, depending on the proficiency of the craft person and the potential impact of the maintenance being performed on safety, reliability, and continuity of operations. 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 (such compliance is normally expected for maintenance on safety equipment, for equipment important to facility reliability, and for any activity that could result in a transient or facility shutdown).

- General intent compliance (the experienced judgment of the craft person or 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. 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. Procedure users should question and seek resolution for any situation that, in their judgment, warrants supervisory assistance. Supervisors or managers should resolve such inquiries in a timely manner.

Maintenance and, if appropriate, operations supervisors should be notified immediately when a procedure cannot be followed as written or unexpected results occur. In these instances, work should be stopped with the equipment or system restored to a safe condition. Procedures may need to be changed or revised as described in Paragraph 6.3.6 before restarting.

6.3.6 Procedure Control, Periodic Review, and Revision

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 prior to use for infrequently used procedures) for changes affecting content (such as reference material revisions, permanent incorporation of changes, incorporation of industry and in-house experience) and for philosophy and format enhancements and human-factors considerations. Checklists for the review should be utilized to ensure the scope and depth of the review is consistent and adequate. Procedure revisions should receive the same review and approval as new procedures as described in Paragraphs 6.3.2 through 6.3.4 above, with the extent of these reviews varying dependent upon the extent of the revision. A method should exist to ensure that technical specification and other commitments are not inadvertently changed or deleted in the process of revising procedures.

Controls are needed to allow for procedure changes (temporary alternations of procedures so that work can be safely continued) and revisions (permanent alterations of procedures 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. As a minimum, these changes should be reviewed and approved by technically competent supervisors, even though these changes may or may not become permanent later. 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, facility operations, and approval. Changes that are needed to remain in effect beyond their original intent should receive the same review and approval as a revision as soon as feasible (normally, within 2 weeks). Procedure change information should be inserted neatly in the body of the procedure to avoid missing the changes when the procedure is used.

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 is difficult to follow. When the procedure is revised, all

effective procedure changes should normally be incorporated into the revision.

A system should also be in place to ensure that facility, system, and component changes or modifications adequately identify procedures impacted 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 used in lieu of facility-prepared maintenance procedures (e.g., an instruction section of a vendor manual and vendor or contractor drawings) 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.

7. PLANNING, SCHEDULING, AND COORDINATION OF MAINTENANCE

7.1 Introduction

An effective system for planning, scheduling, and coordinating maintenance activities should be implemented in order to: ensure that maintenance is accomplished in a timely manner; improve maintenance efficiency; reduce radiation exposure (ALARA); and increase equipment availability. Planning and scheduling involve assigning priorities that reflect the importance of maintenance work relative to safe and reliable facility operation; identifying 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., clearance tagouts, radiation work permits, quality control) is available (References in Paragraphs 5f, e, and m apply).

The processes of planning, scheduling, and coordinating work are discrete tasks that are closely related and 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 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.

This Paragraph describes a system for effective planning, scheduling, and coordinating routine maintenance activities, as well as forced and planned outages.

7.2 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 accurately schedule daily maintenance. Defining the work to be performed and providing appropriate procedures or instructions can reduce maintenance errors. 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, 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.

Scheduling of corrective and preventive maintenance and of planned and forced 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 the use of time on the job and help reduce radiological exposure. Scheduling of 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 schedule should be maintained so that if a forced outage occurs, the forced outage time is minimized and effectively used and that needed maintenance is performed prior to restart.

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 (SWP), radiation work permits (RWP), and fire or burn permits; entering confined spaces; equipment clearance tagouts; and quality control verifications. Intradepartmental coordination is also needed among the mechanical, electrical, instrument and control, and contractor groups for many work activities. A planner, supervisor, or a 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.

7.3 Guidelines

7.3.1 Planning for Maintenance Activities

a. Planning Group Organization

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 decentralized with planners for each discipline working within their respective groups.

A centralized planning group offers the benefit of improving the coordination among the various facility groups and providing a central point for obtaining planning and scheduling information. A decentralized planning group facilitates a closer working relationship between each planner and the individual shop craft person and can lead to increased planner credibility. However, this approach

can diminish coordination among the planners. In addition to maintenance personnel, the planning effort can be enhanced by assigning knowledgeable and experienced personnel from disciplines such as safety, operations, quality control, and radiological protection to the planning group. 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 the maintenance supervisors to carry out all of their assigned responsibilities properly.

A small facility may function well with maintenance supervisors 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 and allow adequate time for other supervisory duties such as observing and directing ongoing maintenance activities at the work sites.

b. Planning Group Responsibilities

All work requests or work packages should be reviewed by the 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 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 preventive maintenance activities, and other corrective maintenance that should or could be worked within the tagout boundary for the equipment);
- ☐ 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 (Paragraph 17);
- ☐ Procurement of necessary repair parts, materials, tools, and equipment;
- ☐ Assessment of staffing and skill requirements for facility, non-facility, and subcontractor personnel;
- ☐ Identification and review of resources including other tasks scheduled to occur in the immediate area during the same time period;
- ☐ Pre-job ALARA planning;
- ☐ Identification of initial conditions and prerequisites, including applicable technical specifications and limiting conditions of operation;
- ☐ Identification of quality control inspection, code, and technical specification requirements;

- Establishment of equipment restoration and post-maintenance inspection or testing requirements; and

- Review of work instructions or work packages for completeness.

Following completion of the work, the review should address the following items:

- Review of completed work packages for proper documentation, adequate post-maintenance testing, and possible changes to the preventive maintenance program (Paragraph 5); and

- Equipment history update (Paragraph 16).

7.3.2 Scheduling Maintenance Activities

a. Control of Maintenance Backlog

The work control system should provide the maintenance manager and supervisors with the means for identifying and recording the status of all valid work requests. The system should consider a work request as part of the backlog from the time the work is identified until all actions are complete, including post-maintenance testing and administrative reviews. The system should provide a serialized list of work requests with a brief description of the work required, priority assigned, date the work requests was initiated, and facility conditions required to perform the work. Features of the system that could be helpful in managing the maintenance backlog include the following:

- A computerized system with the ability to sort work requests by priority, work request date, facility conditions required, and systems affected;

- A status of all work requests on hold for planning, parts, material, or other constraints;

- A tracking system to maintain the status of all work requests currently being worked; and

- A tracking system to ensure that all required post-maintenance testing is accomplished prior to the return of a piece of equipment or a system to service (especially important following outages where many jobs may be performed on a system that is removed from service for an extended period or where several jobs are done under one clearance).

Each preventive maintenance action 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 with an upcoming preventive maintenance (PM) action that requires the same or a similar

tagout, PM routes could be established that allow the craft person to lubricate all equipment on a particular elevation, and an annual PM could be scheduled with a quarterly PM.

Conversely, preventive maintenance for the equipment should be reviewed and included with corrective maintenance activities as appropriate. When feasible, all preventive and corrective maintenance activities on the equipment that should or could be worked should be accomplished when a clearance is issued for maintenance. 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 preventive maintenance schedules. It may be done independently 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 preventive maintenance action to be accomplished.

Delays beyond the schedule dates for preventive maintenance actions should be approved by the work discipline supervisor. If the action has the potential to exceed the grace period (normally, 25 percent), the maintenance manager should be informed and be directly involved in the decision process.

Delays beyond the approved grace period of the scheduled interval in performing preventive maintenance actions should be approved by the maintenance manager. The maintenance manager should report this exception status periodically (e.g., quarterly) to the facility manager indicating the reasons and intended actions.

Maintenance backlog should be monitored to help ensure that important jobs are not being necessarily delayed and control is maintained over the amount of work in the backlog.

b. Work Priority

Each work request related to production equipment repairs should be reviewed by the operations department to determine its impact on facility operations. Meaningful priorities that determine how soon an work request needs to be worked should be set based on safety and reliability. Communication among cognizant groups should be established to set priorities properly . 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 simple in order to enhance its use and accuracy. Typically, the priority system 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 the system or equipment importance.

Items that should be considered when assigning priorities to work requests include the following:

- Personnel and radiological safety;
- Equipment repair urgency;
- Operability of redundant equipment;
- Operating approval commitments (e.g., Technical Safety Requirements);
- Facility conditions required for equipment repair;
- Repair or replacement parts status;
- Such ALARA considerations as exposure and contamination control;
- Personnel availability; and
- Minimizing the spread of contamination from leaks.

The following listing illustrates a priority system for a reactor facility.

- Non-outage work:
  - Priority 1--Emergency or 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); and
  - Priority 4--As time permits.
- Outage work (subcategories for Priority 5 and 6 work as part of outage planning are also useful):
  - Priority 5--Hot shutdown or hot standby;[3] and
  - Priority 6--Cold shutdown.[3]

[3]Analogous conditions can be defined for nonreactor facilities.

7.3.3 Coordination of Maintenance Activities

The planning group (or maintenance supervisors) should maintain the status of all open work requests and preventive maintenance items that are overdue or coming due, and recommend work assignments from this list based on job priority. Meetings involving routine job scheduling should be held frequently to properly communicate priorities, current problems, job interferences, and requests for support among facility organizations. These meetings should be chaired by a designated individual closely involved in the planning process. Supervisors or responsible spokespersons from all maintenance disciplines, safety, operations, quality control, 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 done by publishing and updating a short-duration, rolling schedule covering approximately 3 days. A schedule of this nature would identify scheduled activities for the next 1 to 2 days and planned activities for the remaining days. This schedule should be updated either daily or every other day following the routine planning meeting.

The responsible maintenance supervisor should be provided with work packages soon enough for adequate shop-level preparation 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, easily coordinated, and easily initiated. If this is not the case, the fill-in work 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 emergency work requirements. Work requests that could be postponed or stopped should be identified, or some similar method should be used to allow the work force to accomplish emergency work. Appropriate managers should approve such postponements and work stoppages.

After jobs have been assigned and scheduled on the rolling schedule, the responsibility for support coordination should be assumed by the lead group having responsibility for the most significant portion of the job. The lead group should then be responsible for coordinating such activities as verifying that clearance tagouts are available as required, that quality control inspectors are available as required, and that parts are available at the job site.

7.3.4 Outage Planning, Scheduling, and Coordination

Responsibility should be assigned for the overall control of planned outages and forced outages of significant duration (typically, 3 or more days) 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 each shift

during the outage. The outage management system should be structured so that individuals assigned responsibility for areas of outage work report status directly to outage management staff in addition to reporting to their line managers.

A summary of the outage status should be prepared at least weekly. This should include the following types of information:

- Time ahead of or behind schedule;
- Percentage estimates of completion status for long-duration activities (e.g., exceed 1 week in duration);
- Completion estimates of all critical path and near-critical path activities in progress; and
- Any problems that are delaying or are expected to delay completion of schedule major activities, with the intended course of action and individual responsible to resolve each problem.

Past outage schedules (planned and actual) should be maintained for reference in planning for future outages. These schedules can be especially useful in planning forced outage schedules.

a. Planned Outages

Outage planning and scheduling for major outage activities should commence no later than immediately following that unit's completion of the current outage. Planning and scheduling for major maintenance activities and modifications may have to be planned 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.

A critique of a major outage should be held shortly after the outage is completed to ensure that lessons learned during that outage are factored into the preparations for the next outage. 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 leadtime planning functions.

A current list of proposed outage activities should be maintained. The list should include all demands for resources such as non-facility contractor and subcontractor resources, and activities such as corrective maintenance, preventive maintenance, surveillance, in-service tests and inspection, 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, preventive maintenance, surveillance, and in-service test requirements;
- Identification of major modifications, dates for design work, work package preparation, and procurement of material, 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, scaffold erection);
- Identification of facilities required for outage support and milestones for their construction;
- 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 with sufficient lead time to allow adequate resource allocation. Issuance of the schedule should represent a cutoff date for addition of new outage work. This should include all modification work and all major maintenance to be accomplished. This schedule should identify and allocate critical resources such as personnel, shop facilities, cranes, equipment accessibility, person-rem exposure, and availability and scheduling of outside subcontractors and non-facility contractor groups.

Based upon the overall schedule, a detailed outage schedule should be issued with sufficient leadtime for resource commitment. This schedule should be a commitment of all groups affected by the schedule. 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 management of a successful and timely outage.

b. Forced Outages, Power Reductions, or Other Limitations to Facility Operations

Management of forced outages, power reductions, and other facility operating limitations is necessary to minimize the duration of these conditions and to effectively use

available time. A listing should be maintained of corrective maintenance, modifications, surveillance, preventive maintenance, special items, or commitments that must be performed under a system or facility outage condition or power reduction. These items should be prioritized based on their importance to facility operation. Resource requirements 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 material, special tools, clearance boundaries, and personnel entry forms (such as radiation work permits or confined space entry permits) should be prepared.

Potential short outage or load reduction work should be grouped by the required facility condition and approximate duration. Forced-outage schedules of various lengths should be prepared. Activities should also be grouped to accomplish as much work as possible on one tagout. Other maintenance activities such as surveillance or preventive maintenance should be reviewed to determine if they should be performed while equipment or systems are out of service. A computerized work request system can provide significant assistance in accomplishing the above tasks.

A forced-outage work list should be prepared, and outage activities should be coordinated. Forced-outage planning meetings should be conducted periodically to update the list (typically, once every 2 weeks). Copies of the proposed forced outage list reflecting current planning for forced outages should be sent to all affected facility organizations after each planning meeting.

If a forced outage, power reduction, or other major limitation occurs, appropriate facility managers should initiate selected work from the forced-outage list based on the estimated duration of the outage and available resources. For longer duration forced outages (commonly, greater 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 forced outage list and identify any additional significant work to be conducted during the outage. If a forced outage can be delayed, the outage manager should schedule and coordinate work for the expected duration of the outage.

Once the outage duration has been determined, coordination meetings should be conducted 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 organizations. During the outage, a status should be obtained during each shift to measure the progress and make any required adjustments, such as coordinating special support needs. After completion of each outage, a critique should be conducted to determine how outage improvements could be made, and personnel should be designated to implement these improvements.

8. CONTROL OF MAINTENANCE ACTIVITIES

8.1 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, other 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.

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, post-maintenance acceptance of work, return-to-service procedures, review of completed work records, control of temporary repairs, and controls placed on non-facility contractor and subcontractor personnel working in the facility. The program should also make provision for collecting and storing equipment maintenance data (Paragraph 16).

This Paragraph describes the attributes of an effective program for controlling facility maintenance activities. References in Paragraphs 5e, f, l, and m apply.

8.2 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:

- Administrative procedures should describe the control of work from identification and planning through completion, review, and storage of history data. Personnel (including key non-facility contractor and subcontract personnel) involved in the conduct and support of maintenance should be trained in the use of these procedures.

- The responsibility for various types of work (such as packing adjustments, equipment lubrication, and maintenance on health physics portable instrumentation) should be identified.

- A work request 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. The work request should be used to control maintenance activities by ensuring correct equipment isolation, personnel safety, and the proper conduct of maintenance and post-maintenance tests.

- Troubleshooting should be controlled to prevent unplanned repairs and unauthorized modifications.

- The requested work should be reviewed to ensure unauthorized modifications are not accomplished by the maintenance request.

- Goals for high-quality workmanship, safe work practices, and improving radiological protection should be emphasized to maintenance personnel. A key factor in achieving these goals is worksite 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.

- Work accomplished and the results of post-maintenance tests, including satisfactory return to service of the equipment or system, should be documented.

- Work requests should be reviewed following 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.

- Temporary repairs should be performed 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.

- Non-facility contractor personnel and subcontractors conducting maintenance should be controlled and held accountable to the same policies and procedures as facility personnel.

The work control system should provide the data necessary to properly plan and schedule maintenance activities (Paragraph 7). The work control system also provides a means of collecting facility maintenance data to be used for failure analysis (Paragraph 17) and maintenance history (Paragraph 16). The system used should be comprehensive enough to fulfill these functions, yet simple enough to function efficiently.

High standards should be established for all maintenance personnel engaged in supervising and performing maintenance activities (Paragraphs 2 and 15). These standards should ensure that work is conducted in accordance with DOE, contractor, and facility policies and procedures.

Operational control of facility maintenance is facilitated by the proper use of system status and clearance tagout procedures and by communications among operations, maintenance, and other functional groups at the worksite.

Configuration control is maintained by ensuring that systems and equipment are restored to their original condition following maintenance.

8.3 Guidelines

8.3.1 Work Control Procedure

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, to avoid redundant identification of these deficiencies, and to guide the accomplishment of work and subsequent post-maintenance activities. If the work control system does not include modifications, in-service tests, surveillance, and preventive maintenance actions, the system(s) controlling these activities should interface with the work control system.

The work control procedures should describe the work request form, including applicable attachments, and should, as a minimum, address the following:

- Personnel responsibilities for identifying deficiencies and initiating work requests that adequately describe the symptoms or problems;
- Supervisory responsibility for controlling the conduct of maintenance activities and processing work requests;
- Description of the process for initiating and processing the work requests, including the prejob review, approval cycle, and postjob review;
- Definition of the priorities used to schedule work;
- Determination of the impact of maintenance activities on facility operations;
- Work planning and scheduling (Paragraph 7);
- The conduct of routine maintenance planning meetings (Paragraph 7);
- Requirements for personnel and equipment safety and radiological protection (e.g., confined space entry permits, welding and burning permits, clearance tagouts, radiation work permits);
- Post-maintenance testing (Paragraph 9); and
- Collection of maintenance history (Paragraph 16).

The work control procedure may cross-reference to or include outage scheduling and control procedures (Paragraph 6).

8.3.2 Work Request

Maintenance performed on facility systems should be controlled by the facility work request or another approved work control document. The document(s) should clearly define the work to be performed and should address the following items:

- Equipment identification;
- Name of the person initiating the work request;

- Date work request initiated;
- Description of the symptom, problem, or work requested;
- Job priority;
- Personnel safety and radiation protection requirements or permits (e.g., confined space entry permit, welding and burning permit, clearance tagout, isolation, draining, depressurization of the component, and radiation work permit);
- Applicable technical specifications, time restraints, and associated limiting conditions for operations;
- Identification of qualification requirements (such as environmental and seismic qualifications);
- Applicable work instructions and references;
- Inspection, safety, or ALARA hold points associated with the work;
- Required post-maintenance 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 post-maintenance testing and inspection results;
- Acceptance of the equipment by operations; and
- Final reviews and signoff by maintenance, quality control, and other groups in the work request review cycle.

The work request should be reviewed by affected groups or representatives of these groups (such as maintenance, operations, technical support, quality control, 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.

8.3.3 Supervision of Maintenance Activities

Maintenance supervisors should routinely monitor work in progress to help ensure that maintenance activities are conducted 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. Examples of work practices that should be checked include the following:

- ☐ Proper use of prejob briefings and applicable training (e.g., mockup training);
- ☐ Industrial safety and radiological protection practices (e.g., appropriate use of safety equipment, proper handling of hazardous chemicals, proper use of ALARA concepts, and minimizing spread of contamination);
- ☐ Quality of workmanship, material, and parts;
- ☐ Procedure use, including adherence to step-by-step requirements, signoff, 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 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 a Limiting Condition for Operation exists;
- ☐ Work being performed on the correct component, system, or unit; and
- ☐ Proper use of postjob reporting and, when applicable, postjob critiques.

8.3.4 Review of Completed Work Requests

The operations shift supervisor should compare the work accomplished to the post-maintenance testing or inspection performed to determine that all work is acceptable prior to returning the equipment or system to normal service.

Maintenance supervisors should review completed work requests for the adequacy of repair, complete documentation, 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 the review is to determine whether any unexpected problems occurred and/or how the activity can be accomplished more efficiently the next time. Other reviews should be accomplished by the technical support, quality control, 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.

8.3.5 Temporary Repairs

For temporary repairs or modifications to the facility, see Paragraph 18.3.2 of this Chapter.

8.3.6 Control of Non-facility Contractor and Subcontractor Personnel

Non-facility contractor and subcontractor personnel who perform maintenance or modifications on facility systems should be trained and qualified for the work they are to perform. These personnel should also receive general employee training and specific training in appropriate facility administration, safety, quality control, 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. Non-facility contractor and subcontract personnel who are not fully trained and qualified for the job to be performed should be continually supervised by qualified personnel.

Non-facility contractor and subcontract personnel should perform maintenance under the same controls as and to the same high work standards expected of facility maintenance personnel. Non-facility contractor and subcontract 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 post-maintenance testing and acceptance inspections to the extent needed to enforce these requirements.

Use of subcontractor personnel to perform routine facility maintenance should not normally be relied upon to the detriment of the development of permanent staff expertise.

9. POST-MAINTENANCE TESTING

9.1 Introduction

Post-maintenance testing should be performed to verify that components will fulfill their design function when returned to service after maintenance. Post-maintenance testing includes all testing performed after maintenance activities. An effective post-maintenance testing program should apply to all maintenance activities and address each organization's responsibilities, equipment to be included, degree and type of testing, procedure needs, acceptance requirements, testing control, and results documentation. Post-maintenance 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.

This Paragraph describes a program for specifying, performing, documenting, and accepting post-maintenance testing. References in Paragraphs 5f and m apply.

9.2 Discussion

Post-maintenance testing is used to verify that the maintenance was performed correctly and that the equipment operates correctly and performs its desired function. A post-maintenance test should be

performed after corrective maintenance and after some preventive maintenance activities. The test performed should be commensurate with the maintenance work performed and the importance of the equipment to safety and reliability. In some cases, this may include testing of additional equipment to verify system performance. A post-maintenance testing program should include the following elements:

- Assigning responsibility for determining post-maintenance test requirements using functional groups such as operations, maintenance, and technical support.
- Determining the scope of the post-maintenance 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 all testing is completed prior to work closeout.
- Conducting proper post-maintenance tests, documenting the results, and verifying that the resulting data meet acceptance criteria.

9.3 Guidelines

9.3.1 Post-Maintenance Test Requirements

A program should be established to control and document post-maintenance testing. This program may be a part of the facility work control system and may use the facility work request or work package to specify testing, assign

responsibility, and document acceptance of all post-maintenance tests. The work request should provide specific instructions or cross-reference a test procedure and should provide traceability to post-maintenance test data. This may be accomplished by recording the data directly on the work request or by referencing data recorded on post-maintenance test data sheets or documents.

When work requests are received for planning, a review should be conducted to determine post-maintenance test requirements and whether the proposed repair is to equipment covered by applicable codes or technical specifications. Such tests should be reviewed by cognizant personnel. These reviews should ensure incorporation of testing required by the applicable code and technical specifications and any additional testing, data recording, or special documentation requirements. Technical support organization assistance is also normally required on tasks that are complex and require engineering assistance, even though no code and technical specification requirements apply. The work request should be reviewed by the operations organization to verify that the post-maintenance testing requirements listed will provide adequate verification that the equipment will be capable of performing its designed functions.

9.3.2 Post-Maintenance Test Program Scope

Since 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 preventive maintenance activities also require post-maintenance testing. The rigor of the testing performed should be based on the work done and the importance of the component to safe and reliable facility operation. Post-maintenance testing should be accomplished on equipment, systems, or activities such as the following:

- Maintenance that affects the 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 in-service inspection and environmental qualification programs;
- Maintenance that affects or removes design-approved radiation shielding;
- Electrical distribution equipment such as breakers, bus work, or high-voltage connections;
- Electrical 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;
- Measuring and test equipment; and
- Temporary systems that have been installed as substitutes for normally operational systems or portion of systems.

Equipment that is important to safe and reliable facility operation should be tested in accordance with approved procedures. Post-maintenance test 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 post-maintenance testing. Where applicable, existing surveillance test procedures can be used to verify the operational acceptability of the equipment. If the entire procedure is not 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. Post-maintenance test procedures used for a range of generic equipment, such as manual valves or flow controllers, should have data sheets for specific equipment

when acceptance specifications or performance data are required.

For "troubleshooting" work requests, it may not be feasible to determine fully the post-maintenance test requirements until the troubleshooting is complete. The responsible individual should add instructions to the troubleshooting work request stating that post-maintenance test instructions will be specified after completion of the work. Upon completion of the work, the appropriate post-maintenance test should be specified, verified by the appropriate individuals, and performed.

The following are representative examples of post-maintenance tests:

- Hydrostatic or other pressure tests with visual inspection for leaks;
- Visual inspection for loose fasteners and mechanical misalignment or nondestructive examinations;
- 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; and
- System or component inspections for cleanliness.

A single test or a combination of the tests such as those listed above should be specified to provide complete post-maintenance testing. The specific testing that is to be performed should be referenced on the work request or test procedure.

9.3.3 Post-Maintenance Test Control

A program should be established to control post-maintenance testing. When more than one group is involved in the post-maintenance test or where the test must be delayed until conditions permit, one organization, such as the operations organization, 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 post-maintenance test should assign an individual with overall responsibility for conducting the test and an individual for reviewing test data and determining the acceptability of equipment.

If facility conditions dictate that the post-maintenance testing cannot be completed immediately after maintenance is performed, the work request should be held open or some other tracking method should be 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 post-maintenance testing can be completed. Equipment should not be declared operable until post-maintenance testing has been satisfactorily completed. Operators should know the status of equipment on hold for post-maintenance testing and minimize the amount of equipment in this condition. This status should be reviewed prior to any scheduled mode change. Equipment that can be
tested during the upcoming mode change should be identified and the post-maintenance tests accomplished in that process or as soon as feasible after reaching the new condition.

9.3.4 Post-Maintenance Test Performance, Documentation, and Acceptance

The operations organization should be assigned responsibility for the operational acceptability of all equipment and systems. Accordingly, operators should normally perform or be closely involved in post-maintenance testing. Maintenance, technical support, quality control, and other personnel may also be involved in or called upon to perform post-maintenance testing. For tests involving participation of more than one group, an individual in the lead group should be assigned to coordinate testing activities. Minor equipment post-maintenance testing may be performed by the operator returning the equipment to service, the craft person performing the maintenance, the engineer following the maintenance, or a combination of these and other needed individuals. The organization responsible for specifying the post-maintenance test should review the work actually performed to ensure that the post-maintenance test is appropriate. Any questions should be resolved with the organization that determined the post-maintenance testing requirements.

Operational acceptance of the equipment, based on satisfactory post-maintenance test completion, should be verified by the operations organization by signature on the work request or another reference document. This verification should be made from objective evidence, such as conducting or witnessing the post-maintenance test and reviewing completed procedures and documented test results. Post-maintenance test data and its acceptability should be entered or cross-referenced to maintenance history with the work request (Paragraph 16).

Deficiencies identified during post-maintenance testing should be documented and corrected on the original work request and on a new work request or on another reporting system before the original work request is accepted as complete by operations. The original work request should reference any new work requests or other documents written to resolve these deficiencies.

If a post-maintenance test fails and the equipment or system cannot be repaired and tested satisfactorily in a short period of time (normally, prior to the next shift change), the degraded or inoperable status of the equipment should be documented such that operators understand the limitations of this equipment. Technical specifications should be consulted

and appropriate actions should be taken until the equipment is properly tested and returned to service.

10. PROCUREMENT OF PARTS, MATERIALS, AND SERVICES

10.1 Introduction

Parts, materials, and services required for maintenance activities should be available when needed. Proper parts and materials in good condition are necessary to maintain design requirements for maintenance activities during normal facility operation periods and to support both forced and planned outages. Services are periodically needed to provide unique or supplementary maintenance support. An effective procurement process should be developed in conjunction with the Quality Assurance requirements of the reference in Paragraph 5m to ensure that parts, materials, and services are available when needed.

This Paragraph 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 Paragraph 11.

10.2 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. This objective 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.

10.3 Guidelines

10.3.1 Procurement Policy and Procedures

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 the stores and purchasing operation, such as maintenance supervisors, planning, and scheduling personnel.

Procedures should be prepared to specifically describe the responsibilities of personnel involved in the procurement function. Specific procurement actions should be included in these procedures.

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.

10.3.2 Procurement Initiation

Timely procurement of parts, materials, and services for maintenance activities can be enhanced by considering items such as the following:

- Early identification of "long leadtime" items;
- Selection of procurement sources based on approved vendors and past vendor performance;
- Identification of appropriate quality, engineering, environmental, shelf life, preventive maintenance, and vendor technical manual requirements;
- Update spare parts inventory following design modifications; and
- Participation in a "pooled" spare parts system with other facilities that share common or nearby sites.

10.3.3 Procurement Control

Controls should be developed and maintained throughout the procurement process to help obtain parts, materials, and services in a timely manner. Controls such as the following should be provided:

- Reliability of supplier performance should be verified. This can be accomplished by audits, inspections, or surveillance of supplier facilities, processes, methods, or records relevant to the part, material, or service provided.
- Deficient or nonconforming items should be resolved in an effective and timely manner. Technical reviews should be initiated promptly to aid in the resolution of these items.
- Quality assurance records need to be controlled and maintained to provide documentation for qualified parts and materials and to ensure traceability of parts and materials.
- A process should be provided to qualify nonqualified material. An effective upgrade process will result in improved availability of quality parts and materials.
- A process for acceptable substitution should be provided 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.

- Design requirements should be reviewed 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.

- Emergency procurement and an expediting process should be developed to obtain parts, materials, and services that are needed immediately to support safe and reliable facility operation. Due dates should be clearly identified for parts, materials, and services that require emergency procurement.

- A parts and materials reorder system should be established that assures material availability for anticipated usage while minimizing unnecessary inventory. For example, a "minimum/maximum" stock level can be established to determine when reorders should be initiated (the minimum level) and limit the amount ordered (the maximum level). Changes to these levels should be controlled by review of usage history and maintenance experience.

- Multiple applications of requested parts or materials should be identified; use of specific parts or materials in more than one piece of equipment or system should be considered as part of the procurement and stocking process.

- The procurement organization should be able to track procurement progress and take necessary measures to meet maintenance and outage schedules.

10.3.4 Services

Identification of the need for specialized services from vendors should be made in time to provide for solicitation of bidders, bidding on, and awarding contracts. Provisions should be made when possible for general service agreements so that services can be supplied at short notice.

11. MATERIAL RECEIPT, INSPECTION, HANDLING, STORAGE, RETRIEVAL, AND ISSUANCE

11.1 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 consistent with the Quality Assurance requirements of the reference in Paragraph 5m from the time an item is received until it is installed in the facility.

This Paragraph establishes the functions that a stores organization should perform in administering the stores program.

11.2 Discussion

Many personnel at a nuclear 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 it is issued. Therefore, policies should be established to address these functions. These policies must be understood by stores personnel and other organizations that interface with the stores operation, such as purchasing, quality assurance, quality control, engineering, radiological protection, operations, safety, and maintenance. Procedures should be prepared to specifically describe the responsibilities and the techniques for receiving, inspecting, handling, storing, retrieving, and issuing material from stores. Quality assurance and quality control (QC) aspects of the stores function should be incorporated into these procedures.

Procurement (Paragraph 10) is the first step in the process of ensuring that the correct parts and materials are available, usable, and readily retrievable for issuance for maintenance activities.

11.3 Guidelines

11.3.1 Receipt and Inspection

Upon receipt, stores personnel should inspect parts, materials, and equipment before they are accepted for storage or used. This is done 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 items that are important to safe and reliable facility operations, physically inspect the items 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 it is accepted into the stores system. Technical staff and QC personnel should also approve any upgrade of material or equipment. An acceptance tag or label placed on the received material may be used to signify that the receiving inspection was satisfactory and that the applicable requirements have been met.

A separate receiving and inspection area should be provided as well as a separate hold area. The latter area is used to hold material and equipment that has not been officially received into the stores system because of a nonconformance.

Nonconforming material must also be clearly tagged or labeled to prevent inadvertent issue. A tracking or followup method should be established to ensure nonconformance problems are promptly resolved.

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 the material or part will perform acceptably when placed in service. This method should also address material that has been issued and is sent back to stores for reissue.

Warehouse documents should be updated to reflect receipt of the material and any shelf life or preventive maintenance requirements.

11.3.2 Handling

Procedures should be prepared for items requiring special handling instructions. The procedure should include information such as the 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 or not a specific procedure is used.

Hoisting equipment should be certified by the manufacturer, indicating maximum loads to be handled. The facility inspection program for hoisting equipment and rigging should be applied to items that are used in the stores operation. Personnel required to operate cranes, fork lifts, and other lifting equipment should be properly trained and qualified.

11.3.3 Storage Material and Equipment

Material and equipment should be stored in a manner that provides maximum protection and ready availability for its intended use. It should be stored with due consideration for environmental conditions. For example, preventive maintenance should be performed on large pumps and motors (greater than 25 horsepower) that are in storage. This includes periodically checking energized heaters, periodically changing desiccant, meggering of motors, rotating shafts on pumps and motors, changing oil on rotating equipment, and other maintenance requirements specified by the vendor. Also, a method should be developed to provide controlled access to storage areas. Controls should also be established for field storage of consumables such as lubricants and solvents to ensure they are properly stored, identified, and used.

A shelf-life control program should be provided for stores items 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 lifetime or be disposed of and reordered. The reorder date should consider material lead times so that sufficient material with good shelf life is ready for issue.

Material and equipment should be stored by intended end use 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 method should be established to identify parts or materials that are designated for maintenance activities or modification. Methods such as staging, tagging, or other designation may be used.

Items placed into or removed from stores should be promptly documented so that the stores inventory accurately reflects current status. 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 upon each reorder) and adjusted based on usage, maintenance experience, cost, and leadtime.

Periodic general inspections of the stores issue room(s) and warehouse areas should be performed (e.g., quarterly). The following are examples of items that should be observed and corrected if improperly stored:

- Corrosive chemicals not segregated and near equipment and metal stock;
- Flammables not properly stored;
- Radioactive material not properly controlled;
- 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 while in 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 not established to protect material and equipment.

11.3.4 Retrieval and Issuance

Parts, materials, or equipment removed from storage should receive the same care they received when handled for storage (Paragraph 11.2 above). A method should be established to control parts, materials, and equipment after issue to ensure use in the correct application and to maintain the necessary traceability.

All receipt documents and inspections should be satisfactorily completed before an item is issued. For items such as environmentally qualified spare materials and parts, proper documentation should be maintained to ensure traceability.

A catalog for parts, materials, and equipment should be developed allowing facility personnel to determine what is available for issue. This catalog should provide a cross-reference listing that provides such information as manufacturer part number, facility part number, noun name, and component or system for which a part is used. This catalog could assist in more efficient planning and execution of maintenance activities.

12. CONTROL AND CALIBRATION OF MEASURING AND TEST EQUIPMENT

12.1 Introduction

The program for control and calibration of measuring and test equipment (M&TE) should be consistent with the Quality Assurance requirements of the reference in Paragraph 5m and ensure the accurate performance of facility instrumentation and equipment for testing, calibration, and repairs. M&TE includes all tools, gauges, instruments, devices, or systems used to inspect, test, calibrate, measure, or troubleshoot in order to control or acquire data for verifying the conformance of an instrument or piece of equipment to specified requirements. M&TE does not include permanently installed facility process or control instrumentation, nor does it 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 application. Control and calibration requirements

for M&TE apply to both onsite and offsite calibration facilities and non-facility contractor or subcontractor groups that are engaged in maintenance activities.

This Paragraph describes the policies, actions, and records that form the basis of an effective M&TE control and calibration program.

12.2 Discussion

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. A comprehensive M&TE program should include the following elements:

- All M&TE should have unique identification numbers that accurately identify the specific devices and provide positive traceability.
- A master list identifying all M&TE should be developed and kept current.
- The M&TE calibration program must be based upon standards that are traceable to a national standard or that are recognized standards unto themselves.
- Procedures should be used to calibrate M&TE to help control the performance of calibration, provide repeatable calibrations, and provide acceptance criteria.
- A calibration frequency that helps maintain M&TE accuracy and availability should be established.
- M&TE should be functionally checked, when applicable.
- Facilities should be provided to control storage, issue, and calibration of M&TE.
- M&TE with suspected or actual deficiencies should be segregated and marked to prohibit its use.
- M&TE devices that are not fully calibrated or usable should be clearly marked to indicate their limitations.
- M&TE issues should include records for accountability and traceability of use. A recall system should be developed for recalibrations.
- A maintenance policy that minimizes contamination of M&TE should be developed.
- M&TE devices found out of calibration or defective should receive timely evaluations to determine the validity of all measurements and/or calibrations for which they were used.
- M&TE reliability problems should be trended to determine any corrective actions needed.

- Reviews to determine that the control of M&TE is effective should be periodically conducted.

12.3 Guidelines

12.3.1 Identification

Each piece of M&TE should be assigned a unique identification number that is permanently marked on or attached to the M&TE (the identification number may consist of the manufacturer's serial number). These numbers assist in identifying, tracing, and positively controlling M&TE. A master list of all controlled M&TE should be maintained. If separate organizations control their own M&TE, each organization should maintain or have access to a list of its own equipment. Lists should include the following, as a minimum:

- Generic description of equipment, trade or marketing name of equipment, manufacturer, model, and serial number;
- Unique identification number;
- Equipment range(s) and accuracy;
- Calibration procedure;
- Calibration frequency; and
- Responsible organization or person.

12.3.2 Calibration

a. Calibration Standards

Only calibration standards that are traceable to the National Institute of Standards and Technology or other nationally recognized standards should be used for calibration of M&TE. If repair or calibration of a standard is necessary, the recalibration must be traceable to the National Institute of Standards and Technology or to the standard of record for the M&TE. Calibration standards maintained at the facility should be kept in the calibration facilities in designated storage locations. If calibration standards are issued for field use, the supervisor responsible for the standard should authorize and minimize the period of issue. The issue 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.

b. 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 Paragraph 6 and should contain the following:

- Precautions or limitations;
- Accuracy of calibration standards to be used;
- Calibration standards to be used;
- Calibration instructions and data sheets for as-found and as-left data; and
- 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);

c. Calibration Frequency

Calibration frequency should be determined based on the manufacturer's 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 to the MT&E needed to support peak activity periods such as outages. This information can help determine calibration frequency and schedule requirements that result in adequate M&TE support for facility needs.

d. 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. These checks are not substitutes for calibration checks.

12.3.3 Control

a. Storage

As discussed in Paragraph 4, proper facilities are needed to help ensure that equipment is protected from damage in storage, is properly maintained, and is readily retrievable. M&TE devices that are relatively easy to damage when transporting and handling should be provided more protection by boxing or special mounting rigs (e.g., test gauges mounted in portable frames). M&TE in the issue area should be segregated from defective, out-of-calibration, or other M&TE requiring investigation so that only calibrated M&TE is available for issue. This should be a physically and distinctively marked separation.

b. Uncalibrated M&TE

New M&TE devices should be calibrated prior to use to verify that 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 that is 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-ohm meter might be checked for operability every 6 months.

c. M&TE with Limited Use

M&TE devices that have special uses, limitations, or restrictions should be clearly labeled to describe their applications or limitations. The following are examples of information that should be reflected on M&TE tags or labels:

- Scales or ranges that are inaccurate or inoperable, 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 an oil, oxygen, salt water, or demineralized water systems.

d. Issue 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 M&TE found to be deficient. 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 were 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 prior to or at the 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, as a minimum, the date recalibration is due. This information is normally needed for work documentation; therefore, calibration stickers provide a convenient

method for users to obtain this information and to ensure 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 day-to-day use.

e. Contaminated M&TE

Equipment subject to radioactive contamination should be packaged and used in a manner that minimizes the possibility of external and internal contamination (e.g., wrapping in clear plastic, taping, isolating). This should be emphasized as part of the on-the-job training program addressed in Paragraph 3. These practices can help minimize the spread of contamination and minimize 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.

12.3.4 Evaluation

a. Out-of-Calibration and Defective M&TE

When an M&TE device is found or suspected to be out of calibration, defective, or otherwise unreliable, an evaluation of the instruments and equipment a particular device has measured or tested since the M&TE was last calibrated should be performed promptly to determine whether recalibration or rework is needed. 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 above in Paragraph 12.3.3.

b. Performance Trending

Results of M&TE calibrations should be trended, and corrective actions should be determined for any M&TE reliability problems. This predictive 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.

13. MAINTENANCE TOOLS AND EQUIPMENT CONTROL

13.1 Introduction

Methods should be established to provide 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 Paragraph addresses considerations for an effective tool and equipment program.

13.2 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. Craft personnel should be able to readily obtain the tools and equipment needed to perform maintenance and then return them as soon as practicable after completion of the work. Tools and equipment should be kept in a high state of readiness, some by inclusion in the preventive maintenance program. Proper preventive maintenance can also result in improved personnel safety and extended life of tools and equipment.

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. This should not be so strict that employee innovation is discouraged. 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.

13.3 Guidelines

13.3.1 Storage and Issuance

Responsibility should be assigned for the proper storage and issuance of both stationary and portable tools and equipment.

Permanent issuance of tools to individuals or groups of craft personnel who use them on a day-to-day basis and who are responsible for maintaining them contributes to worker efficiency. Other tools and equipment should be available on an as-needed basis. For these items, proper storage facilities should be centrally located to shops and normal work areas and should be readily accessible to the craft personnel in order to promote worker efficiency. Controls, such as sign-out sheets and tool crib attendants, should be employed in tool storage areas in order to provide accountability and availability of tools. A policy should be established for the storage, issue, 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 for use. Unrepairable tools should be disposed of in a timely manner.

Special tools and equipment are sometimes obtained on a temporary basis from other sources such as a vendor or contractor. A method should exist to identify the availability 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.

13.3.2 Tool and Equipment Maintenance

Maintenance tools and other support equipment should be included in the preventive maintenance program (Paragraph 5). Inclusion in the preventive maintenance program enhances the availability and reliability of equipment such as cranes, portable lifting and rigging equipment, welding machines, weld rod ovens, shop machinery, and measuring and test equipment.

13.3.3 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 tool 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. Some of the subjects that should be included in the instructions are:

- Where rigging equipment can be safely attached and the load limits for each (e.g., pipes, beams, and structures);
- Allowable lifting limits for different types of loads;
- Safe load paths; and
- Training and qualification requirements for craft personnel using lifting and rigging equipment.

14. FACILITY CONDITION INSPECTION

14.1 Introduction

Management should conduct periodic inspections of equipment and facilities to assure excellent facility condition and housekeeping. The condition of a facility is dependent on many factors, including design, fabrication, modifications, ongoing maintenance, the 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 facility walkdowns and inspections clearly displays management standards to all personnel and can significantly improve the

condition of the facility. A program for identification and dispositioning of facility condition deficiencies and housekeeping discrepancies is an important step in maintaining facilities and equipment in a condition of maximum safety, reliability, and availability.

This Paragraph describes the attributes of an effective inspection program for maintaining a high state of facility condition and housekeeping. The reference in Paragraph 5f applies.

14.2 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 deficiencies when they are in the facility and take prompt corrective action. Additionally, there needs to be a periodic focused inspection effort to assist in effective identification and correction of facility deficiencies.

Maintaining systems and equipment within design conditions results in benefits such as minimizing fluid leakage, minimizing control room alarms caused by malfunctioning equipment, and maintaining equipment environmental integrity. Another benefit of good facility condition and housekeeping is easier access for operations and maintenance by reducing the sources and spread of radioactive contamination.

Properly used, a facility condition and housekeeping inspection program is an effective means to identify and correct discrepancies. 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 provide a clear understanding of these standards.
- Appropriate personnel should receive inspection techniques training.
- Facility managers and supervisors should personally participate in inspections.
- Inspection areas should be assigned such 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.
- Identified deficiencies should be reported and corrected in a timely manner so that personnel can see the positive results of the inspection program.

The following are examples of additional elements that may be useful in developing a facility and housekeeping inspection program:

- 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 is considered a minor deficiency, 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.

14.3 Guidelines

14.3.1 Standards

Setting standards involves establishing an atmosphere of proper work ethics, positive attitudes, and specific expectations by management that are realistic, 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. Adherence to these standards should be assessed by facility managers and supervisors through the conduct of routine inspections. Some indicators of good facility condition and housekeeping standards are as follows:

- Rotating equipment is operating 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, filters).

- Fluid system integrity is maintained. Leaks that can be corrected during operation are repaired in a timely manner. Leakage that cannot be repaired under existing conditions is collected and routed to appropriate drains or collection facilities, particularly if this 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 indicating values representative of the existing system and equipment conditions.

- ☐ Energized electrical and electronic equipment is operable, 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, clean filters).
- ☐ 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 stepoff pads properly established; sources of contamination are identified).
- ☐ Walkway and equipment access is maintained.
- ☐ Equipment is clean (e.g., dirt, debris, tools, parts, and miscellaneous materials are not allowed to accumulate on equipment or inside electrical panels).
- ☐ Facility areas, rooms, and grounds are maintained in a clean and orderly condition, including the storage of needed tools and materials.
- ☐ Coatings or coverings used to seal walls and floors in potentially contaminated areas are in good condition and assist in controlling contamination.
- ☐ Unauthorized modifications or changes to the facility do not exist.
- ☐ Illumination of areas, rooms, and grounds is maintained in a manner that provides sufficient light to perform inspections and minor maintenance.

14.3.2 Training

Personnel involved in inspection activities should be knowledgeable of the standards expected by the facility manager and the techniques required to perform facility condition inspections. In addition, all personnel should be aware of the importance of good facility condition and housekeeping. An effective method of imparting expected standards is for the facility manager to conduct some

inspections with selected individuals as discussed below in Paragraph 14.3.4.

14.3.3 Procedures

Administrative procedures that describe the inspection program should define expected standards, provide for documentation of deficiencies, provide for a means to follow up on deficiency corrective actions, assign responsibilities for program implementation, and establish a means to measure program effectiveness. Facility inspection implementing procedures could be incorporated into the preventive maintenance 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 work request, 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.

14.3.4 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 improve inspection techniques and convey the expected standards for facility condition and housekeeping.

Inspections should include, but not be limited to identifying such deficiencies as those discussed above in Paragraph 14.3.1. The facility manager may designate specific types of deficiencies that should be given special attention during the inspection, based on the 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, and not simply walk through the area. The inspector must look closely at individual components and notice deficiencies that would not normally be seen during a casual walk through an area. Once a deficiency is seen, the inspector should look closer and attempt to determine the source or cause, how long it has existed, and if the deficiency has been previously identified. For example, steam blowing 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.

14.3.5 Inspection Program Elements

Routine inspections should include the following elements:

- Limit the size of inspection areas so that they are small enough to be thoroughly inspected in the time allotted;
- Schedule each facility area for periodic inspection; and
- Periodically rotate inspectors through the various inspection areas. (This practice helps to avoid familiarity with an inspection area, which can hinder deficiency identification.)

14.3.6 Reporting Deficiencies

The inspector should report the results of each inspection to the inspection coordinator. Significant facility condition and safety deficiencies observed should be immediately reported to the shift supervisor for appropriate near-term attention.

If a facility deficiency tagging system is in use, the individual identifying the deficiency should attach a deficiency identification tag to the equipment or hang it in the area for nonequipment deficiencies. These tags should be removed after the deficiency has been corrected or the equipment has been functionally accepted by operations.

In addition to routine inspections, all personnel should be responsible for the prompt identification, correction (if feasible), or documentation of facility condition and housekeeping deficiencies during the normal course of their duties.

14.3.7 Deficiency Followup

A list of all deficiencies not included in the work control system or some other corrective action system with responsibility for correction or disposition of each deficiency should be prepared. Personnel assigned corrective action should periodically report results of the actions planned or conducted to the inspection coordinator, and deficiencies should be tracked to completion.

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 may be due to leakage or to an improper lubrication schedule. Adjustment to the lubrication schedule or additional training of personnel may be needed to maintain correct oil levels. Paragraph 17 addresses the analysis of maintenance problems.

Followup of selected corrective action from previous inspections is necessary for evaluating the timeliness and effectiveness of the corrective action and obtaining the maximum benefit from the inspection program. Several methods may be used to accomplish this followup. For example, the inspection coordinator may select some previously identified deficiencies to verify that these deficiencies 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 actual 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.

15. MANAGEMENT INVOLVEMENT

15.1 Introduction

To ensure the safety of DOE nuclear facility operations, DOE and contractor corporate and facility managers should be sufficiently involved with facility operations to be technically informed and personally familiar with conditions at the operating facility. Responsible DOE and contractor corporate managers should visit the facility, including visits 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 program(s) to verify that they are effectively accomplishing the intended objectives and are upgraded as needed.

This Paragraph 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. The reference in Paragraph 5f applies.

15.2 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 frequently touring the facility. 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 craft personnel in the field requires managers to take the lead and set an example. Pride in the craft person's work may be bolstered by direct observation and immediate feedback, especially when given 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 and also by inspecting, monitoring and checking equipment, and by timely followup on corrective actions. Key assistants and selected supervisors should also be trained to do these types of

activities. If done properly, management efforts will be multiplied to the point where personnel in all levels of the organization feel responsible for and help in the early identification of problems.

A system for converting identified facility, personnel, or programmatic problems into corrective actions is needed to assure workers that management is interested in the workers' inputs for improvement. Such a system should consider routine reporting of maintenance effectiveness trends, as well as timely escalation of significant problems to the level of management having resolution authority.

15.3 Guidelines

15.3.1 Manager Involvement

Managers should include time in their routine 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 field work. The workload should be monitored and adjusted to allow first-line supervisors sufficient time to spend monitoring work in the field. Facility tours and personnel contacts should also be planned for irregular hours (selected weekend or backshift) and cover selected facility areas and personnel activities. The results and observations of these tours should be documented and reviewed for action. Further guidance on some techniques that may be used to conduct facility inspections is given in Paragraph 14.

15.3.2 Performance Indicators, Goals, and Objectives Results

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 that are discussed below. Paragraph 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.

15.3.3 Feedback

A key element of management involvement is the establishment of a feedback system where feedback and communication are continuously encouraged. This system should include planners, engineers, craft personnel, warehouse personnel, and others so that participation in improvements is promoted at all levels of the maintenance organization. Project teams (for such purposes as discussing proposed modifications to the facility,

prioritizing industrial safety actions, and improving facility material condition) should include representatives from the affected crafts.

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. Maintenance 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.

15.3.4 Program Reviews

Inspections, audits, reviews, investigation, and self-assessments are necessary for 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 identifying and correcting program deficiencies. An evaluation of each maintenance program element should be conducted at least every other year and should include inputs from managers and supervisors from maintenance 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 followup. Examples of program elements to be considered in this evaluation include the following:

a. Assessment of facility equipment and systems, and the ability of craft personnel to perform high quality maintenance, should be routinely performed. Elements that should be evaluated include the following:

   - Equipment failures and their impact on facility operations;
   - Identification and analysis of repetitive corrective maintenance on the same or similar equipment;
   - Current condition of equipment and systems;
   - Number 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;
- Personnel needs and parts expenditures;
- Occurrences of tools, equipment, or facility inadequacies;
- Equipment accessibility or laydown problems;
- Planning, scheduling, and coordination problems; and
- 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 preventive maintenance frequencies;
- Addition or deletion of preventive maintenance;
- Proposed design changes;
- Adjustments to spare parts and materials stock levels;
- Adjustments to staffing and/or training; and
- Adjustments in tools, equipment, and facilities, or modifications to improve equipment maintainability.

b. Assessment of 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 maintenance knowledge and skills improvement should be considered during the review of the maintenance training programs. Trainee feedback for improving the training program should also be obtained. Needed changes should be made to the training program by the training organization, based on recommendations from the facility manager and maintenance manager.

c. Assessment of 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 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 due to lack of spare parts or materials;
- Parts and materials "service factor" (the percentage of requested parts or materials that were available in the store room when requested);
- Recurring or long-standing nonconforming items (deviations from procurement specifications);
- Status of spare parts and materials special handling, storage, preventive maintenance, and shelf-life programs;
- Accuracy of stores records compared to actual inventory;
- Number of requisitions and frequency of requests for service contracts; and
- Amount spent compared to amount budgeted for service contracts.

d. Assessment of Measuring and Test Equipment

The M&TE program should be periodically reviewed to verify that it is supporting the safe and reliable operation of the facility. The review should include an assessment of M&TE availability.

16. MAINTENANCE HISTORY

16.1 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 facility life extension becomes an issue. Trending should be directed toward identifying improvements for the maintenance program as well as needed equipment modifications. Paragraphs 5, 7, and 17 provide guidance on programs that contribute to and are augmented by the maintenance history program.

This Paragraph addresses the development and use of a maintenance history program. The reference in Paragraph 5k applies.

16.2 Discussion

One objective of good equipment history program is to be able to readily retrieve equipment maintenance, performance, and reference information in order to improve facility reliability. The work control system may be useful for 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 individual group responsible for collecting the data. In either case, easy access should be provided to all groups needing this information. This 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 the systems and equipment to be included, what to collect, how to record data, and how the data are to be used.

16.3 Guidelines

16.3.1 Program Development

a. Equipment Identification

The maintenance history program should clearly define the systems and equipment that require documentation and retention of historical data. Systems and components that affect safe and reliable facility operation are obvious candidates for the program. In addition, equipment requiring repetitive maintenance should be considered for inclusion in this program. This compilation of system and equipment should provide an engineering data base or allow easy cross-reference to such information as the equipment unique identification number and name; system, manufacturer, model, serial number, and other appropriate name plate data; lubrication data; applicable vendor manuals and drawings; spare parts reference numbers; and common equipment cross-references. The master equipment list (discussed in Paragraph 5) could be effectively used to establish this compilation.

b. 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 Paragraph 16.3.3. Some examples of data that should be included or cross-referenced in the program are corrective maintenance records, appropriate preventive maintenance records, modification packages, vendor repair information (e.g., correspondence on component repairs and modification bulletins), startup 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, post-maintenance testing, and any other information that may be useful at a later date.

16.3.2 Data Collection

Data on systems and equipment that have been selected for history retention should be sent to the person or group responsible for maintenance history retention and applicable data should then be entered in the maintenance history program. Any apparent errors, inconsistencies or lack of detail should be referred back to the maintenance supervisor or another appropriate supervisor for resolution.

16.3.3 Program Use

Maintenance history data should be readily available for use by all organizations, especially the maintenance and technical support organizations. If maintenance history is computerized, users should be trained to access and manipulate the history data bases.

Maintenance planners, coordinators, supervisors, and craft personnel should use maintenance history on a routine basis for maintenance planning to provide such data as previous maintenance work and results, special tool needs, type and quantity of lubricants needed, staffing and time requirements, parts information, and procedure or instruction needs.

Maintenance history should be periodically reviewed and problems trended. This can be done manually or with automated analysis techniques. Persistent or recurring equipment and system problems should be reported to maintenance or technical support supervisors for corrective action (Paragraph 17). These reviews can also help identify areas where decreased maintenance effort is warranted (e.g., reduced preventive maintenance frequency).

Uses of maintenance history data are as follows:

- Failure analysis (provides some of the data needed to support analyzing and trending failures);
- Conduct of maintenance assessments (provides an input to identify rework for the purpose of identifying maintenance program improvements);
- Preventive maintenance (provides some of the data useful for identifying and justifying preventive maintenance program changes);
- Outage planning (provides some of the data useful for post-outage evaluation and as a basis for planning the next outage);
- Post-maintenance test planning and execution;

- ALARA program (provides work time data useful for radiological exposure evaluation and planning);
- Budget preparation (provides an input for determining future maintenance needs based on experience and a justification for these expenditures);
- Review of DOE and industry experience, vendor information, and other documents to assess plant-specific applicability;
- Conduct of maintenance assessment (provides an input to identify rework for the purpose of identifying maintenance program improvements); and
- Facility-life extension (provides some of the data needed to support extension of plant design life).

Communication of maintenance history information, including root-cause analyses and categorization (Paragraph 17), among similar facilities can contribute greatly to both avoiding and understanding failures.

17. ANALYSIS OF MAINTENANCE PROBLEMS

17.1 Introduction

Systematic analysis should be used to determine and correct root causes of unplanned occurrences related to maintenance. Paragraph 16 provides guidance for collecting and trending maintenance history for recurring or persistent equipment failures that should be reviewed by the analysis program. Incident reports, post-trip reviews, and other similar operating experience review methods supplement the maintenance history program and provide data, including human error data, which should be reviewed by the analysis program.

This Paragraph describes an analysis program that may be used effectively to reduce recurring maintenance problems by identifying and resolving root causes of the problems. The references in Paragraphs 5k and 5m apply.

17.2 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 the root cause(s) of the problem. The symptom of an unplanned occurrence should be addressed. However, for long-term corrective action, it is necessary that the actual cause or causes of the problem be determined and corrected. Root cause is defined as the most basic reason or collection of reasons for an unplanned event, which, if 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 develop 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, tools, and design may be involved in contributing to an unplanned occurrence. Corrective action followup should then be performed to help verify that the problem is resolved.

17.3 Guidelines

17.3.1 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 analysis, 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, adequacy of communications, maintenance procedures, and relevant information obtained from documentation of maintenance history (Paragraph 16). Additionally, data collection 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 viewpoint. A walk-through of how they have performed the task may be used as part of the interview.

17.3.2 Event Analysis

The purpose of the analysis phase is to reconstruct the event. A detailed sequence of facts and activities is developed and the apparent event 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 procedure and documents--Inappropriate maintenance, operating or special test procedure/ instruction, inappropriate drawing(s) equipment manual(s), technical specification(s).
- Person-machine interface--Insufficient or incorrect label, gauge, annunciator, control device.
- Environmental conditions--Inadequate lighting, work space, 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 procedure.
- Work organization/planning--Insufficient time to prepare or to perform, maintenance not scheduled.
- 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 on-the-job training.
- Change management--Inappropriate plant modification; lack of change-related retaining, procedures, documents.
- Resource management--Unavailability of tools, information, personnel, supervision.
- Managerial methods--Insufficient/lack of accountability, policy, goals, schedule; failure to ensure previous problem 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 establishing operational limits; improper selection of materials, components; operating environment not considered in original design.
- Equipment specification, manufacture, and construction--Improper heat treatment, machining, casting, onsite fabrication, installation.
- Maintenance/testing--Inadequate maintenance, insufficient post-maintenance testing, inadequate preventive maintenance, inadequate quality control function.
- Facility/system operation--Operating parameters, changes in parameters, performance.
- External--Storm, flood, earthquake.

The explanatory examples used above are not inclusive and there may be many others similar to these in each category.

In using the above categories, one or more of the above categories may be primary causes, one or more of the above categories may be secondary causes, and others may be possible causes. In all cases, the reason why a category is chosen is known and documented.

17.3.3 Cause Determination

The above actual or probable causes of a problem should be evaluated by one or more techniques or methodologies to establish a final root cause. An acceptable root cause should meet three criteria: (a) its correction should prevent recurrence of the unplanned occurrence; (b) its correction should be feasible; and (c) 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 utilizes 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), list in a block just below the cause (effect) two reasons you know it to be true. If only one reason is known or not firm, then all possible causes should be evaluated as potential causes. When this process gets to the point where a cause(s) can be corrected to prevent reoccurrence, then the root cause or causes have been found.

A walk-through task analysis may be utilized 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 a step-by-step reenactment of their actions for the observer without carrying out the actual function. If appropriate, it may be possible to use the simulator for performing the walk-through rather than the control room. The objective is to determine how a task was really performed and identify problems in human factors design, discrepancies in procedural steps, or training.

Fault tree analysis is a systematic approach, similar to the management oversight and risk tree (MORT) 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 flow chart 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 deviation between what is expected and what actually happened. The evaluator essentially asks what differences occurred to make the outcome of this task or activity different from all other times when this task or activity was successfully completed. This technique consists of asking the questions what, when, where, who, and how. The answers to these questions 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, 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 reoccurrence. 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(s) that meets the three necessary 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 by applicable line managers and supervisors in this process is essential to consistently achieve the 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 pursued to find the underlying causes. Some examples where treating only the symptom would prove inadequate are as follows:

- 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 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 preventive maintenance activity 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 preventive maintenance 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.

- A reactor 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.

17.3.4 Corrective Action

When all of 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 preventive maintenance frequency, counseling personnel, or modifying the training program slightly. It may also be extensive, such as developing and installing a major modification, procuring long leadtime parts and materials, contracting for specialized services, revising procedures, and training personnel for continued operation and maintenance of the installation.

17.3.5 Corrective Action Followup

In the case of an equipment problem, post-maintenance testing should be used to determine whether 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 an extended period of operation to provide sufficient assurance that the cause or causes have been properly addressed may also be necessary. Similar long-term followup is appropriate to determine whether the desired results are obtained from such corrective actions as retraining, procedural changes, and preventive maintenance changes.

17.3.6 Generic Followup

The analysis program should address any generic corrective actions needed to be taken after problems with one piece of equipment have been determined and corrected. This could include such items as review of similar equipment, preventive maintenance and surveillance programs, improvement of training and qualification programs for various facility and or company personnel, and changes to maintenance and operating procedures. It is also useful to categorize root causes and to accumulate this knowledge into 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.

18. MODIFICATION WORK

18.1 Introduction

Facility modification work, including 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.

This Paragraph describes the required updating to the maintenance program as result of facility modifications and the handling of temporary modifications.

18.2 Discussion

The intent of this Paragraph is to provide guidance on temporary modifications and the required updating to the maintenance program as a result of facility modifications and not to provide additional or redundant engineering and construction project requirements for modifications.

Modifications to structures, systems, and components 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 prior to actual maintenance work being initiated on the modified structure, system, or component.

18.3 Guidelines

18.3.1 Maintenance Program Interface with Modifications

A modification is a planned and controlled change to a permanent facility structure, system, or component 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 prior to maintaining modified

structures, systems and equipment. The required changes to such documents as drawings, procedures, spare parts lists, and vendor information should be accomplished prior to operation of the system or equipment and any subsequent maintenance activities.

The maintenance program should require that all plant modifications be reviewed to identify future required maintenance activities and should specify that these activities be added to the preventive and predictive maintenance programs, as applicable.

18.3.2 Temporary Repairs/Temporary Modifications

Temporary repairs are temporary modifications to the facility that allow equipment to remain in or be returned to service in a condition that is not the same as the original design specification. Prior to 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.

19. ADDITIONAL MAINTENANCE MANAGEMENT REQUIREMENTS

19.1 Seasonal Facility Preservation Requirements

19.1.1 Introduction

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.

19.1.2 Discussion

The program should include the preparation of a freeze protection plan which includes details on inspections, preventive maintenance, and corrective maintenance imposed on nuclear facility equipment and buildings to assure continued safe facility operations. Inspections and self-assessments of freeze protection programs should be appropriately scheduled to assure correction of deficiencies on preparation of other compensatory measures to protect DOE nuclear facilities prior to 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.

19.1.3 Guidelines

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 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 prior to those taken to restrict or cutoff nuclear systems coolant, will be reviewed by facility operations and safety personnel to assure that 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 that:

- ☐ Heating systems in all nuclear facilities will be cleaned, serviced, and functionally tested.
- ☐ Antifreeze used in cooling systems will be checked and replaced 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 severe weather is expected.