National Nuclear Security Administration

Facility Maintenance Management

Qualification Standard

Reference Guide

NOVEMBER 2009

Table of Contents

FIGURES ..... **iv**
TABLES ..... **iv**
ACRONYMS ..... **v**
PURPOSE **1**
SCOPE **1**
PREFACE **1**
TECHNICAL COMPETENCIES **3**
1. Facility maintenance management personnel shall demonstrate a working-level knowledge of the guidelines for maintaining maintenance facilities, equipment, and tools. 3
2. Facility maintenance management personnel shall demonstrate a working-level knowledge of the application of the different types of maintenance. 9
3. Facility maintenance management personnel shall demonstrate a working-level knowledge of the documentation used for controlling maintenance. 13
4. Facility maintenance management personnel shall demonstrate a working-level knowledge of the requirements for controlling maintenance activities. 16
5. Facility maintenance management personnel shall demonstrate a working-level knowledge of planning, scheduling, and coordination of maintenance activities. 24
6. Facility maintenance management personnel shall demonstrate a working-level knowledge of industrial property management practices as related to stores, spare parts, and essential materials. 31
7. Facility maintenance management personnel shall demonstrate a working-level knowledge of the control and calibration of measuring and test equipment. 35
8. Facility maintenance management personnel shall demonstrate a working-level knowledge of modification work. 40
9. Facility maintenance management personnel shall demonstrate a working-level knowledge of the requirements of post-maintenance testing. 43
10. Facility maintenance management personnel shall demonstrate a working-level knowledge of the requirements for material receipt, inspection, handling, storage, retrieval, and issuance. 45
11. Facility maintenance management personnel shall demonstrate a working-level knowledge of the requirements of maintenance tools and equipment control. 50
12. Facility maintenance management personnel shall demonstrate a working-level knowledge of the requirements for facility condition inspections. 51
13. Facility maintenance management personnel shall demonstrate a working-level knowledge of the requirements for management involvement. 54
14. Facility maintenance management personnel shall demonstrate a working-level knowledge of the requirements of maintenance history and configuration control. 56
15. Facility maintenance management personnel shall demonstrate a familiarity-level knowledge of the principles and concepts of natural phenomena hazards and their effect on systems and structures. 58

Table of Contents

16. Facility maintenance management personnel shall demonstrate a working-level knowledge of DOE's requirements for facility maintenance management as outlined in DOE O 433.1, Maintenance Management Program for DOE Nuclear Facilities. 76
17. Facility maintenance management personnel shall demonstrate a familiarity-level knowledge of the requirements for a training and qualification program as identified in the following Department of Energy (DOE) Orders: 81
18. Facility maintenance management personnel shall demonstrate a familiarity-level knowledge of the facility maintenance management-related sections and/or requirements of the following related DOE Orders: 88
19. Facility maintenance management personnel shall demonstrate a working-level knowledge of the following maintenance management-related Department of Energy Technical Standard and Maintenance Management Program Guide: 91
20. Facility maintenance management personnel shall demonstrate a familiarity-level knowledge of DOE Order 231.1A, Environment, Safety, and Health Reporting. 92
21. Facility maintenance management personnel shall demonstrate a familiarity-level knowledge of DOE Order 414.1C Chg 1, as it pertains to facility maintenance. 94
22. Facility maintenance management personnel shall demonstrate a familiarity-level knowledge of 10 CFR 830.203, Unreviewed Safety Question Process. 96
23. Facility maintenance management personnel shall demonstrate a familiarity-level knowledge of the TSRs as described in 10 CFR 830.205, Technical Safety Requirements. 99
24. Facility maintenance management personnel shall demonstrate a familiarity-level knowledge of nuclear safety analysis reports as described in 10 CFR 830.204, Documented Safety Analysis Reports. 102
25. Facility maintenance management personnel shall demonstrate a familiarity-level knowledge of DOE -STD-1073-93, Configuration Management. 107
26. Facility maintenance management personnel shall demonstrate a familiarity-level knowledge of DOE O 413.3, Program and Project Management for the Acquisition of Capital Assets. 114
27. Facility maintenance management personnel shall demonstrate a familiarity-level knowledge of the following DOE technical standards and Order related to natural phenomena hazards: 120
28. Facility maintenance management personnel shall demonstrate a familiarity-level knowledge of methods to maintain communication with Headquarters, field elements, and the public. 121
29. Facility maintenance management personnel shall demonstrate a familiarity-level knowledge of facility maintenance management-related data management requirements. 125
30. Facility maintenance management personnel shall demonstrate a working-level knowledge of contractor and Department organization and structure as they relate to maintenance management responsibilities and authority. 127
31. Facility maintenance management personnel shall demonstrate a working-level knowledge of assessment techniques (such as the planning and use of observations, interviews, and document reviews) to assess facility performance, report results of assessments, and follow-up on actions taken as the result of assessments. 130

Table of Contents

32. Facility maintenance management personnel shall demonstrate a working-level knowledge of lessons learned and problems impacting the Department's maintenance activities across the complex. 134
33. Facility maintenance management personnel shall demonstrate a working-level knowledge of the requirements of a maintenance management program. 138
34. Facility maintenance management personnel shall demonstrate the ability to conduct independent assessments of a contractor's compliance with the requirements of DOE O 433.1, Maintenance Management Program for DOE Nuclear Facilities. 141
35. Facility maintenance management personnel shall demonstrate a working-level knowledge of problem analysis principles and techniques necessary to identify maintenance problems, determine potential causes of problems, and identify corrective action(s). 142
36. Facility maintenance management personnel shall demonstrate the ability to apply problem analysis techniques necessary to identify maintenance problems, determine potential causes, and identify corrective action(s). 147
37. Facility maintenance management personnel shall demonstrate the ability to trend facility maintenance management-related data. 147
38. Facility maintenance management personnel shall demonstrate a familiarity-level knowledge of financial management practices and the application of contractor resources to meet commitments to the quality, safety, cost, and schedule of systems. 148
39. Facility maintenance management personnel shall demonstrate the ability to perform project management duties as required to provide facility maintenance management technical support to a project. 153
40. Facility maintenance management personnel shall demonstrate a familiarity-level knowledge of the DOE project management system, including the application of contractor resources to meet commitments to quality, safety, cost, and schedule. 153
41. Facility maintenance management personnel shall demonstrate a familiarity-level knowledge of the DOE/facility contract provisions necessary to provide oversight of a contractor's performance. 163
42. Facility maintenance management personnel shall demonstrate the ability to conduct independent assessments of the contractor's maintenance training and qualification program(s) in accordance with DOE Order 433.1, Maintenance Management Program for DOE Nuclear Facilities, and DOE Order 5480.20A, Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities. 166

Selected Bibliography and Suggested Reading 167

Table of Contents

FIGURES

Figure 1. Flood evaluation process 60
Figure 2. Combined probabilistic and deterministic methods to achieve performance goals 72
Figure 3. Configuration management interfaces 110
Figure 4. Typical DOE acquisition management system 119
Figure 5. DOE corporate operating experience approach 135
Figure 6. DOE lessons learned flow 137

TABLES

Table 1. Summary of minimum wind design criteria 63
Table 2. Recommended peak gust wind speeds for straight winds and tornadoes 64
Table 3. Recommended missile barriers for performance category 3 68
Table 4. Critical decision authority thresholds 118
Table 5. DOE project lifecycle phases 162

ACRONYMS	
ACs	administrative controls
ACWP	actual cost of work performed
ALARA	as low as reasonably achievable
APC	atmospheric pressure change
BCWP	budgeted cost of work performed
BCWS	budgeted cost of work scheduled
CD	critical decision
CM	configuration management
DBFL	design basis flood
DOE	U.S. Department of Energy
DSA	documented safety analysis
EAC	estimate at completion
EPA	U.S. Environmental Protection Agency
ES&H	environment, safety, and health
EV	earned value
EVMS	earned value management system
FAQS	Functional Area Qualification Standard
FHA	fire hazard analysis
GOCO	government-owned, contractor-operated
ISMS	Integrated Safety Management System
KPP	key performance parameter
KSA	knowledge, skill, and ability
LCO	limiting condition for operation
LCS	limiting control setting
M&O	management and operating
M&TE	measuring and test equipment
MEL	master equipment list
MIP	maintenance implementation plan
MPFL	maximum possible fire loss
mph	miles per hour
NIST	National Institute of Standards and Technology
NNSA	National Nuclear Security Administration
NPH	natural phenomena hazard
OJT	on-the-job training
OLs	operating limits
OMB	Office of Management and Budget
OPC	other project cost
PC	performance category
PDSA	preliminary documented safety analysis
PM	preventive maintenance
PMT	post-maintenance tests/testing
QA	quality assurance
QAP	quality assurance program
QC	quality control

S/CI	suspect/counterfeit item
SAR	safety analysis report
SL	safety limit
SRs	surveillance requirements
SSC	structure, system, or component
TEC	total estimated cost
TPC	total project cost
TSRs	technical safety requirements
USQ	unreviewed safety question
WBS	work breakdown structure
WO	work order
WR	work request

PURPOSE

The purpose of this reference guide is to provide a document that contains the information required for a Department of Energy (DOE)/National Nuclear Security Administration (NNSA) technical employee to successfully complete the Environmental Compliance Functional Area Qualification Standard (FAQS). Information essential to meeting the qualification requirements is provided; however, some competency statements require extensive knowledge or skill development. Reproducing all the required information for those statements in this document is not practical. In those instances, references are included to guide the candidate to additional resources.

SCOPE

This reference guide addresses the competency statements in the March 2004 edition of DOE-STD-1181-2004, *Facility Maintenance Management Functional Area Qualification Standard*. The qualification standard contains 42 competency statements.

Please direct your questions or comments related to this document to the NNSA Learning and Career Development Department.

PREFACE

Competency statements and supporting knowledge and/or skill statements from the qualification standard are shown in contrasting bold type, while the corresponding information associated with each statement is provided below it.

A comprehensive list of acronyms and abbreviations is found at the beginning of this document. It is recommended that the candidate review the list prior to proceeding with the competencies, as the acronyms and abbreviations may not be further defined within the text unless special emphasis is required.

The competencies and supporting knowledge, skill, and ability (KSA) statements are taken directly from the FAQS. Most corrections to spelling, punctuation, and grammar have been made without remark, and all document-related titles, which variously appear in roman or italic type or set within quotation marks, have been changed to plain text, also mostly without remark. Capitalized terms are found as such in the qualification standard and remain so in this reference guide. When they are needed for clarification, explanations are enclosed in brackets.

Every effort has been made to provide the most current information and references available as of November 2009. However, the candidate is advised to verify the applicability of the information provided. It is recognized that some personnel may oversee facilities that utilize predecessor documents to those identified. In those cases, such documents should be included in local qualification standards via the Technical Qualification Program.

In the cases where information about a FAQS topic in a competency or KSA statement is not available in the newest edition of a standard (consensus or industry), an older version is referenced. These references are noted in the text and in the bibliography.

Only significant corrections to errors in the technical content of the discussion text source material are identified. Editorial changes that do not affect the technical content (e.g., grammatical or spelling corrections, and changes to style) appear without remark.

TECHNICAL COMPETENCIES

1. **Facility maintenance management personnel shall demonstrate a working-level knowledge of the guidelines for maintaining maintenance facilities, equipment, and tools.**

   a. **Discuss the importance of maintaining proper maintenance facilities.**

   The following is taken from DOE G 433.1-1.

   Management involvement in control of maintenance activities should ensure that maintenance practices are effective in maintaining safe and reliable facility operation. This control should extend to all facility, contractor, and subcontractor personnel involved in maintenance activities. Rigorous control of maintenance activities should be directed toward achieving high-quality work performance, personnel safety (including radiological protection), equipment and system protection, and facility safety and reliability.

   b. **Describe the criteria used when designing the layout of a shop or satellite work area.**

   The following is taken from DOE G 433.1-1.

   The layout of shop and satellite work areas should be designed with a high priority on industrial safety and efficiency. As shops are modified and satellite work areas are changed throughout the life of the facility, safety and efficiency should remain foremost considerations. Location and type of work performed should be considered in determining the types and level of environmental controls and services to be included in each maintenance shop and satellite work area. Examples of some environmental controls and services include the following:

   - fume removal;
   - temperature, humidity, and dust control;
   - equipment space considerations;
   - lighting;
   - demineralized water;
   - noise control;
   - facility service and instrument air;
   - electric power supplies;
   - radiological controls.

   Environmental conditions often have a significant impact on personnel performance. Supervisors need to be responsive to maintaining workplace environmental controls conducive to increased maintenance quality and work efficiency. Each shop and satellite work area should have storage that is convenient and that encourages craft personnel to keep the area neat and clean. Shelves, cabinets, lockers, and toolboxes are examples of storage facilities that could be provided for items such as tools, parts, reference materials, and personal effects.

c. Discuss when temporary facilities are used, the factors to consider when approving, purchasing, designing, and locating temporary facilities.

The following is taken from DOE G 433.1-1.

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

d. Discuss the reasons for segregating tools, supplies, and parts.

The following is taken from DOE G 433.1-1.

The following practices should be utilized for storage and handling of tools, supplies and parts:

- Facilities should be provided for segregation, calibration, and repair of maintenance and test equipment;
- Contaminated tools are segregated from clean tools to prevent cross-contamination;
- Parts and material required for maintenance activities should be identified and purchased in time to allow for receipt and inspection well before they are needed. After processing, these parts and material should be identified for specific work packages and segregated from other stock inventory;
- Adequate storage and protection of parts and materials segregated for planned maintenance activities should be provided. This is particularly important for material staged at the job site and not within normal storage areas;
- Controls should be developed and maintained throughout the procurement process to help obtain parts, materials, and services promptly. Nonconforming items should be clearly identified and segregated from normal items to prevent inadvertent use;
- Items receiving special inspection [especially safety-class items and safety-significant structures, systems, or components (SSCs)] should be appropriately identified and segregated from normal stock to indicate status and ensure proper application;
- Safety material and equipment should be segregated from non-safety-related material and equipment to prevent inadvertent use of the wrong category of item. If segregation is not practical, marking and tagging techniques should be developed to preclude use of the wrong material or equipment;
- A system should be established to ensure the proper storage, segregation, and control of hazardous materials such as chemicals, radioactive/reactive organics, reagents, explosives, flammables/combustibles, corrosives, and pesticides/herbicides; specialty equipment and tools; and general materials, equipment, and tools.

- Worn, defective, or otherwise unusable tools should be segregated so that only safe, usable tools are available. Unrepairable tools should be disposed of in a timely manner.

e. Discuss the use of contaminated tools versus clean tools.

The following is taken from DOE G 433.1-1.

An adequate supply of tools and equipment dedicated for exclusive use in radiological areas should minimize the number of unnecessarily contaminated tools used to perform work within the radiological area. The control of these tools, including issuance, decontamination, inventory, and repair, should be assigned to a single facility department manager. A sufficient supply of radiological area tools and equipment should be established for routine maintenance needs to prevent introduction of additional non-contaminated items. The input and the cooperation of all maintenance work groups are required during maintenance planning to determine the types and numbers of tools and equipment needed. Input should be obtained from maintenance, operations, planning, engineering, radiological protection, and contractor groups.

f. Discuss the concerns affecting the selection and state of readiness of maintenance facilities.

The following is taken from DOE G 433.1-1.

Maintenance facilities, equipment, and tools should efficiently support the facility maintenance and maintenance training functions. Maintenance facilities directly affect the training of maintenance personnel and the ability to maintain the facility in an optimum state of readiness.

Evaluation of the adequacy of maintenance facilities is needed to help ensure that maintenance activities can be effectively accomplished. Industrial safety, location, access, communication, environmental controls, radiological controls, power sources, and the type of activity to be performed are examples of items to be considered in providing adequate maintenance facilities. Maintenance training facilities, shops, satellite work areas, laydown and staging areas, storage facilities, mockups, temporary facilities, decontamination facilities, shower and toilet facilities, lunch areas, conference areas, and offices are examples of maintenance facilities that need evaluation. In addition, adequate office equipment should be provided to support efficient and effective work. The objective is to create and maintain a safe and productive workplace where high-quality work can be performed.

g. Describe the objective of maintenance facilities.

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

- reduce the impact of planned outages by planning and completing maintenance activities promptly;
- reduce the number of unplanned outages;
- minimize unplanned challenges to safety systems;

- reduce the lost-time accident rate;
- reduce station and equipment downtime;
- reduce personnel errors;
- reduce radiological exposure;
- control and reduce contaminated areas;
- reduce repeat maintenance work requests (WRs) (rework);
- complete scheduled surveillance and PM activities promptly;
- manage the corrective maintenance backlog to minimize it and the completion time of resolving outstanding deficiencies;
- control overtime;
- staff and train the maintenance organization; and
- complete outage and no outage work on schedule.

h. Describe the types and levels of environmental controls and services included in shops and satellite work areas.

See item b of competency 1.

i. Discuss the elements to consider when planning for the identification and use of maintenance lay down and staging areas.

The following is taken from DOE G 433.1-1.

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

- authorization for access, with provisions for security and fire protection;
- radiological control;
- labeling of facilities to designate responsibility and entry authorization;
- contingency plans for situations (such as unanticipated radioactive airborne contamination) that could render a facility unusable for its intended purpose.

j. Discuss the issues addressed when determining storage facility needs.

The following is taken from DOE G 433.1-1.

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

- environmental controls, considering such issues as isolation/segregation of chemicals, flammability of lubricants and paint, qualification of parts/components, damage to elastomers and polypropylene parts because of exposure to light, and control of radioactive materials;
- storage activity controls, considering such subjects as material receipt, inspection, handling, storage, retrieval, and issuance, and tool and equipment control;
- inventory level of spare parts, supplies, and equipment to support safe and reliable operation of the facility.

k. Discuss the requirements for storing, issuing, and maintenance of tools and equipment.

The following is taken from DOE G 433.1-1.

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

The maintenance organization should assign responsibility for the proper storage and issuance of both stationary and portable tools and equipment. Permanent issuance of tools to individuals or groups of crafts persons who use them daily and who are responsible for maintaining them contributes to worker efficiency. Tools and equipment used less often should be available on an as-needed basis. Controls, such as sign-out sheets and tool crib attendants, should be used in tool storage areas to provide accountability for, and availability of tools. A policy should be established for the storage, issuance, decontamination, and reuse of contaminated tools and equipment.

An inventory system should be established for tools and equipment. This inventory should be computer-based, compatible with existing facility inventory systems, and adaptable to daily supply changes.

Maintenance tools and other support equipment should be included in the preventive maintenance (PM) program. Inclusion in the PM program enhances the availability and reliability of equipment such as cranes, portable lifting and rigging equipment, welding machines, weld rod ovens, shop machinery, and measuring and test equipment (M&TE).

l. Describe the requirements for office equipment to support the maintenance organization.

The following is taken from DOE G 433.1-1.

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

m. Discuss the criteria of a program for the development of new or special tools and equipment.

The following is taken from DOE G 433.1-1.

Instructions should be provided for the use of special tools, test rigs, equipment, lifting and rigging equipment, welding equipment, safety devices, personnel protective equipment, and mock-ups. These instructions should be written so as to improve tool and equipment use and enhance job performance and efficiency. Maintenance supervisors should review proposed special tool and equipment designs to determine cost justification, effectiveness, safety considerations, and the need for reviews by other departments. These tools should be stored and controlled in accordance with the direction provided in item k of competency 1.

Applicable training facilities and equipment (including simulators and mock-ups) should be provided, where warranted, to perform needed training in an environment and under conditions expected during normal use. Performance-based training and applicable licensing, when required, should be provided before use is authorized.

n. Discuss suspect/counterfeit item (S/CI) controls and applicability to maintenance.

The following is taken from DOE G 414.1-3.

[Note: DOE O 414.1B has been cancelled and superseded by DOE O 414.1C, *Quality Assurance.*]

A suspect item is one in which visual inspection, testing, or other means indicate that it may not conform to established Government or industry-accepted specifications or national consensus standards; or one whose documentation, appearance, performance, material, or other characteristics may have been misrepresented by the supplier or manufacturer. A counterfeit item is a suspect item that has been copied or substituted without legal right or authority to do so or one whose material, performance, or characteristics are misrepresented by the supplier or manufacturer.

DOE/NNSA is committed to effective controls for the prevention, detection, and disposition of S/CIs to mitigate any potential safety threat in the DOE/NNSA complex. The principal objectives of S/CI controls are as follows:

- Ensure that items intended for application in safety systems and mission critical facilities comply with design and procurement documents.
- Maintain current, accurate information on S/CIs and associated suppliers using all available sources within the Government and industry and disseminate relevant information on S/CIs to field organizations and contractors.
- Identify, control, and disposition S/CIs that create potential hazards in safety systems and applications.
- Report discoveries of, and disseminate information about S/CIs to field organizations, contractors, and government agencies.
- Train and inform managers, supervisors, and workers of S/CI controls and indicators, including prevention, detection, and disposition of S/CIs.

These controls should also include obtaining contractual remedies from suppliers of S/CIs.

DOE G 414.1-3 is for use by all DOE/NNSA organizations and contractors to assist them in developing site-and facility-specific quality assurance (QA) policies, processes, and procedures to address the following S/CI controls:

- procurement;
- item inspection and acceptance;
- engineering involvement;
- safety systems, non-safety systems, and critical load paths;
- identification, notification, disposition and disposal;
- reporting;
- trend analysis;
- training; and
- assessment and oversight.

2. Facility maintenance management personnel shall demonstrate a working-level knowledge of the application of the different types of maintenance.

a. Discuss and compare the following:
- **Corrective maintenance**
- **Preventive maintenance**
- **Predictive maintenance**

The following is taken from DOE O 430.1B.

Corrective Maintenance

Corrective maintenance is the repair or restoration of failed or malfunctioning equipment, systems, or facilities to their intended functions or design conditions. It does not result in a significant extension of the expected useful life.

Preventive Maintenance

Preventive maintenance involves periodic and planned actions taken to maintain a piece of equipment within design operating conditions and extend its life and performance before equipment failure or to prevent equipment failure.

Predictive Maintenance

Predictive maintenance includes activities involving continuous or periodic monitoring and diagnosis to forecast component degradation so that "as needed" maintenance can be scheduled.

b. Describe the purpose, use, and content of a master equipment list.

The following is taken from DOE G 433.1-1.

A master equipment list (MEL) is a detailed master list of equipment, components, and structures to be included in the maintenance program. This list includes both safety-related and non-safety-related systems and equipment. A MEL helps in selecting and scheduling PM and in evaluating the effectiveness of the maintenance program.

In addition, each piece of M&TE should be assigned a unique identification number that is permanently marked on or attached to it (the identification number may consist of the manufacturer's serial number). These numbers assist in identifying, tracing, and controlling M&TE. A MEL of all controlled M&TE should be maintained.

The maintenance history program should clearly define the safety systems and equipment that require documentation and retention of historical data according to the MEL for which maintenance provides support. In addition, non-safety equipment requiring repeated maintenance should be considered for inclusion. The MEL can provide much of the information for the system. Alternatively, if the MEL is computerized, the history files can be cross-referenced to it.

c. Discuss the role of the types of maintenance in an effective and efficient maintenance program.

The following is taken from DOE G 433.1-1.

Many factors should be considered in establishing an effective and efficient balance of the types of maintenance performed. On important systems and equipment, a thorough technical analysis using methods such as reliability-centered maintenance may be needed to establish this balance. On less important systems, the amount of 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 PM for equipment that is allowed to run until it fails if the failure would not adversely impact facility operations, to the other extreme, where extensive PM may be required for equipment whose failure could limit safe or reliable operation or result in forced outages. The purpose of PM is to eliminate or minimize this latter type of failure.

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

d. Discuss the relationship between predictive maintenance and technical safety requirements.

The following is taken from DOE G 433.1-1.

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

The interval during which predictive maintenance tasks are performed may vary depending on whether the maintenance is a time-directed task, condition-monitoring task, condition-directed task, or failure-finding task. The highest priority is given to safety related maintenance based on predictive maintenance results.

e. Discuss the importance of maintaining a proper balance of preventive, predictive, and corrective maintenance.

See item c of competency 2.

The following is taken from DOE G 433.1-1.

Work planning is an evolutionary process that should be periodically assessed through field observation of work being performed and direct feedback from maintenance personnel to maintenance planners. A planning control system should determine when maintenance is to be accomplished and record that it has been accomplished. The planning system should be responsible for the maintenance activity required to achieve a balanced flow of preventive vs. corrective maintenance. When this balanced flow cannot be achieved, the planning system should identify and direct corrective actions as required.

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

f. Discuss the elements needed to successfully implement a maintenance program that balances the three types of maintenance.

See items c and e of competency 2.

g. Describe the relationship in scheduling between preventive and predictive maintenance.

The following is taken from DOE G 433.1-1.

Each PM action should be scheduled in a manner that provides an opportunity to perform other related maintenance at the same time. PM should be scheduled at appropriate intervals, and where practical, it should be scheduled with corrective maintenance, surveillance, and in-service inspections/in-service testing activities on the same equipment and with other related maintenance.

h. Discuss the relationship between the results of predictive maintenance and preventive maintenance.

The following is taken from DOE G 433.1-1.

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

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

Using the results of the PM and predictive maintenance program evaluations, the following improvements should be addressed and implemented as appropriate:

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

i. Discuss the considerations used when determining maintenance actions and their frequencies.

The following is taken from DOE G 433.1-1.

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

Optimization of maintenance intervals involves the following general activities:

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

j. Define the term "life limiting component" and its impact on facility operation.

[Note: Life limiting components are also referred to as problem components and functionally critical equipment.]

The following is taken DOE-STD-1073-93.

A life limiting component is a structure, system, and component whose failure could result in termination of facility operations.

3. Facility maintenance management personnel shall demonstrate a working-level knowledge of the documentation used for controlling maintenance.

a. Discuss the purpose, use, and content of a work package.

The following is taken from DOE G 433.1-1.

A maintenance work package is a consolidated document used by maintenance organizations that contains all the necessary procedures, instructions and requirements to perform a maintenance task safely and effectively. A maintenance task should not be considered complete until all of the requirements of the maintenance work package have been satisfied.

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

- equipment identification;
- name of the person initiating the WR;
- date WR was initiated;
- description of the symptom, problem, or work requested;
- location of equipment and deficiency tag;
- job priority;
- personnel safety and radiation protection requirements or permits (e.g., confined-space entry permit, welding and burning permit, lockout/tagout, isolation, draining, depressurization of the component, and radiation work permits);
- applicable TSR, time constraints, and associated limiting conditions for operations (LCOs);
- 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 (PMT), 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 PMT and inspection results;
- acceptance of the equipment by operations; and
- final reviews and signoffs by maintenance, quality control (QC), and other groups in the WR review cycle.

b. Discuss the purpose, use, and contents of maintenance procedures, including the following considerations:
- **Development, including human factor considerations**
- **Verification**
- **Validation**
- **Approval**
- **Actions taken when procedures cannot be followed as written or when unexpected results occur**

The following is taken from DOE G 433.1-1.

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

Development

Procedures should be written for and used in all work that could result in a significant process transient, a condition of degraded facility reliability, or a personnel or equipment hazard. Work complexity is also an indicator of the need for a procedure. Procedures should be written for each PM action or written generically for similar PM actions (including applicable equipment lists). Because procedures are used repeatedly, they should include information such as personnel and skill levels required; time needed to accomplish the action; special tools and materials needed; facility or system conditions needed; and clearance, radiation work permit, and other safety requirements and precautions needed to perform the PM. Workers should be involved in procedure development and verification whenever possible.

Information provided in procedures should be clear and concise, minimizing the need for interpretation and the possibility of misinterpretation. Experienced craft personnel and engineers can be trained to write maintenance procedures, or procedure writers can be used, with craft personnel or engineers providing technical input. Maintenance procedures must be written with the users (crafts workers) in mind and should include the following:
- procedure identification and status (titling or numbering, location, and page and revision identification);
- procedure purpose and scope;
- consistent organization, presentation and designation of instruction steps, caution and note style, and page style;
- clearly understood text, using correct grammar and punctuation; appropriate level of detail; concise instruction steps in logical sequence; specific nomenclature; quantitative and compatible values; referencing and branching methods; coordination of multiple actions; warning and caution location; effective formatting; and clear table, graph, and data sheet layout;
- consistent presentation of illustrations (e.g., preparation, compatibility, views, level of detail, and legibility when reproduced);
- clear indication of steps that could initiate an equipment trip or transient or the initiation or interruption of any process action;

- clear indication of hold points, independent verification requirements, or data to be recorded;
- systematic nuclear facility and system prerequisites, precautions and limitations, required special tools and materials, and required personnel;
- clear indication of acceptance criteria, follow-on steps, and restoration instructions;
- steps that inform operations personnel of expected alarms or equipment operations;
- guidance to craft personnel to notify the operations organization of maintenance that cannot be completed as originally planned, or that will be delayed and extended past the anticipated due date and/or across shift changes;
- development and preparation using personal computer, desktop-publishing, and computer-aided writing programs; this also aids in providing easy-to-read text and clear illustrations.

Verification

Verification is review of a new or revised procedure to determine whether it is technically accurate and properly arranged. This review should ensure that the procedure incorporates human factors principles and appropriate administrative policies. The technical accuracy review should also include a review of the procedure against the design requirement for the system or component it concerns. This may be accomplished by comparing the vendor manual and design specifications to the procedures.

Verification should be conducted by one or more reviewers from the facility producing the procedure who were not involved in writing the procedure. Reviewers from other disciplines, such as health physics, engineering, and operations, should also be considered for involvement in the process.

Validation

Validation is review of a procedure to determine its usability and correctness. This review evaluates whether the procedure provides sufficient and understandable guidance and direction to the craft personnel and that it is compatible with the equipment or system being maintained. Validation may be conducted in a shop, in a training environment, or on a mockup or simulator.

Approval

Approval should be consistent with facility TSR or their equivalents and with administrative procedures. At a minimum, the maintenance manager or his/her designee should approve maintenance procedures.

Procedure Change Control, Periodic Review, and Revision

All procedures should be periodically reviewed (e.g., every 2 years or before use for infrequently used procedures) for changes affecting content (such as revisions of reference material, permanent incorporation of changes, and incorporation of industry and in-house experience) and for philosophy and format enhancements and human factors considerations. Reviewers should use checklists to ensure that the scope and depth of the review are consistent and adequate.

Revisions of procedures should receive the same review and approval as new procedures with the extent of these reviews varying depending on the extent of the revision. A method should exist to ensure that TSR and other commitments are not inadvertently changed or deleted in the process of revising procedures.

Controls are needed to allow for procedure changes (temporary alterations so that work can be safely continued) and revisions (permanent alterations that incorporate outstanding temporary changes and other needed updates). Changes and revisions are necessary to correct errors and to ensure that procedures reflect current maintenance practices and requirements.

c. Discuss the considerations for developing maintenance procedures.

See item b of competency 3.

d. Describe the control, review, and revision of maintenance procedures.

See item b of competency 3.

e. Discuss the minimum items addressed in effective work control procedures.

The following is taken from DOE O 433.1-1.

A work control program should be integrated with the planning system. The implementation of this program should ensure that the maintenance activities in nuclear facilities are conducted in a manner that preserves and restores the availability and operability of the SSCs important to safe and reliable facility operation. The work control program should include a work order (WO) system, job planning and estimating, time standards, a priority system, procedures and documentation, scheduling, PMT, backlog work management, equipment repair history and vendor information, training and qualifications, an integrated safety management system (ISMS,) lockouts/tagouts, work performance standards, human factors, and engineering.

4. Facility maintenance management personnel shall demonstrate a working-level knowledge of the requirements for controlling maintenance activities.

a. Discuss the elements of an effective work control program, including the following:
- **Adherence to facility procedures, practices, and policies**
- **Work control procedures**
- **Work requests**
- **Review of completed work requests**
- **Control of temporary repairs**
- **Control of non-facility contractor and sub-contractor personnel**
- **Work site cleanliness**
- **Job briefings**
- **Control of troubleshooting**
- **Tagout/lockouts, radiological work permits, confined space permits**
- **Independent verification requirements**
- **Maintenance problem identification, correction, and evaluation**

- **Deficiency identification and correction**
- **Response to abnormal maintenance conditions**
- **Configuration control**
- **Work authorization to start and conduct work**
- **Control of work conducted under emergency conditions**

Adherence to Facility Procedures, Practices, and Policies

The following is taken from DOE G 433.1-1.

On-the-job training (OJT) is practical, hands-on training in which employees achieve learning objectives through training conducted within the job environment. OJT is a formal part of the maintenance training program. Adherence to facility procedures, practices, and policies is strengthened by OJT and formally defined training programs that specifically identify items the trainee must accomplish. Knowledge requirements for each item, as well as the action a trainee must do (perform, simulate, observe, or discuss), should be defined. Both the trainer and the trainee should understand what is required for each training item.

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

Work Control Procedures

The following is taken from DOE G 433.1-1.

Each facility or group of facilities should have an administrative procedure describing the work control system. Administrative requirements may be contained in separate documents covering individual areas or in one overall procedure that describes the administrative control of maintenance activities. The work control procedure helps all personnel understand the requirements and controls required for performing work. The basic intent of the work control system is to identify all facility deficiencies and work needed, avoid redundant identification of deficiencies, and guide the safe accomplishment of work and subsequent post-maintenance activities. If the work control system does not include modifications, in-service tests, surveillance, and PM actions, the systems controlling these activities should interface with the work control system.

Work Requests

The following is taken from DOE G 433.1-1.

The maintenance manager should have overall responsibility for the establishment, implementation, and performance of the planning, scheduling, and coordination of maintenance activities through the planning function's processing of WR/WOs. A maintenance WR/WO should be initiated and a maintenance deficiency tag/sticker attached as soon as practical after discovery of a facility equipment deficiency.

All WR/WOs for facility equipment should be delivered to the owner/operator designated representative for review and appropriate action to minimize further equipment damage. Reviewed WR/WOs should be initialed by the owner/operator representative and forwarded to the maintenance planning department. The planning supervisor, or designated individual

should review the WR/WO to determine whether the work on the WR/WO should be performed as a minor maintenance task and assign the WR/WO to the responsible craft planner.

Review of Completed Work Requests

The following is taken from DOE G 433.1-1.

The operations shift supervisor should compare the work accomplished to the PMT or inspection performed to determine that all work is acceptable before returning the equipment or system to normal service.

Maintenance supervisors should review completed WRs for adequacy of repair, complete documentation, notation of generic corrective actions, and identification of rework. A post-job review should be held with the craft personnel involved. This review could be a brief discussion or an involved critique. The purpose of this review is to determine whether any unexpected problems or unsafe conditions occurred and/or how the activity can be accomplished more efficiently and safely the next time. Other reviews should be accomplished by technical support, QC, safety, radiation protection, and other organizations, as appropriate and in accordance with facility instructions. Feedback should be provided to planning, scheduling, and maintenance personnel to highlight areas that were exemplary and areas that needed improvement.

Control of Temporary Repairs

The following is taken from DOE G 433.1-1.

Temporary repairs are temporary modifications to the plant that allow equipment to remain in or be returned to service in a condition that is not the same as the original design specification. Before implementation, temporary repairs should receive a safety review in accordance with the facility temporary modification program to ensure the adequacy of the repair and its effect on personnel and equipment safety and reliability.

Temporary repairs should be tracked after their completion for consideration of permanent repairs. Permanent corrective action should be taken as soon as practicable.

Facility modification work, including minor modifications and temporary modifications, should be accomplished under the same basic administrative controls as those applied to facility maintenance activities so that there are no increases in risk to facility equipment, environment, or personnel because of the modification work. The following are examples of temporary modifications:

- lifted leads,
- electrical jumpers,
- pulled circuit boards,
- disabled annunciators/alarms,
- mechanical jumpers/bypasses,
- temporary setpoint changes,
- installed or removed blank flanges,
- disabled relief or safety valves,
- installed or removed filters or strainers,

- plugged floor drains, and
- temporary pipe supports.

A facility program to control temporary modifications should include the following elements:

- owner/operator approval of temporary modifications before installation or removal;
- positive identification of electrical temporary modifications with independent verification before installation;
- independent verification or functional test of all temporary modifications after they are installed or removed;
- record of all installed temporary modifications;
- assurance that operators and supervisors are trained on installed temporary modifications and their impact on system/component operation before returning the system to service;
- safety reviews of temporary modifications installed on in-service (operable) equipment to ensure that the modified equipment should continue to perform as intended and not adversely affect plant or personnel safety; assurance of the quality of work and suitability of materials used for temporary modifications (e.g., this guideline suggests that temporary modifications be installed or removed using an approved WR);
- method to review the temporary modifications periodically for errors and continued need;
- method of clearly identifying installed temporary modifications; and
- method to provide operators with instructions for operating temporarily modified equipment and/or guidance regarding the periodic monitoring of its operation (e.g., drawings and procedures should be marked up or annotated to reflect the new configuration before returning the system to operation).

Control of Non-facility Contractor and Sub-contractor Personnel

The following is taken from DOE G 433.1-1.

Non-facility contractor and subcontractor personnel (workers not directly employed by the facility operating contractor) who perform maintenance or modifications on facility systems should be trained and qualified for that work they are to perform. These personnel should also receive general employee training and specific training in appropriate facility administration, safety, QC, and radiation protection procedures and practices. Adequate time should be provided for this training. Recognition should be given to individual needs and previous training and experience. Experienced personnel could be allowed to bypass training by proving proficiency through examination and demonstration. Non-facility contractor and subcontractor personnel who are not fully trained and qualified for the job to be performed should be continuously supervised by qualified personnel.

Non-facility contractor and subcontractor personnel should perform maintenance under the same controls as and to the same high work standards as are expected of facility maintenance personnel. Non-facility contractor and subcontractor managers and supervisors should be held accountable for the work performance of their personnel. Facility supervisors should review the work of these personnel during preparation for work, at the job site, and during PMT and acceptance inspections to the extent needed to enforce these requirements.

Use of subcontractor personnel to perform routine facility maintenance should not be relied upon to the extent that it deters the development of expertise of permanent staff.

Work Site Cleanliness

The following is taken from DOE G 433.1-1.

The appearance and proper functioning of facility systems and equipment are key indicators of a well-maintained and -operated facility. Good facility condition, cleanliness, and housekeeping can be established and maintained by knowledgeable individuals who are alert to onsite deficiencies and who take prompt corrective action. Additionally, there should be a periodic, focused inspection effort, by thoroughly trained personnel, to assist in effective identification and correction of facility deficiencies.

Job Briefings

The following is taken from DOE G 433.1-1.

PM tasks should be performed using procedures or instructions and controlled by methods such as task cards or detailed PM job requests. Good work practices, such as pre-job and post-job briefings, quality craftsmanship, observations, data recordings, cleanliness, correct tool use, and history update are essential to the PM task.

In-depth pre-job briefings should be held to ensure crafts persons have a clear understanding of the tasks to be performed. Post-job briefings can be a brief discussion or an involved critique. The purpose of the post-job brief is to determine whether any unexpected problems or unsafe conditions occurred and/or how the activity can be accomplished more efficiently and safely the next time.

Control of Troubleshooting

The following is taken from DOE G 433.1-1.

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

Before developing the troubleshooting methodology the following sources of information should be reviewed as necessary to understand the equipment/systems interactions:

- system engineers,
- owner/operator personnel (organization responsible for the equipment),
- training,
- TSRs,
- final safety analysis report (SAR),
- equipment vendor manuals,
- equipment manufacturers,
- applicable procedures,
- applicable system/circuit drawings,
- vendor drawings.

Troubleshooting activities are controlled by WRs to prevent unplanned repairs and unauthorized modifications. A record should be kept of work performed during troubleshooting to ensure that PMT covers the troubleshooting scope. The supervisor responsible for the troubleshooting should generate a new WR for necessary work. Testing requirements should then be identified through the normal planning and review process.

Tagout/lockouts, Radiological Work Permits, Confined Space Permits

The following is taken from DOE G 433.1-1.

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, radiation work permits, and fire or burn permits; entering confined spaces; equipment lockouts/tagouts; and QC verifications. Intradepartmental coordination is also needed among the mechanical, electrical, instrumentation and control, and contractor groups for many work activities. A planner, supervisor, or designated individual within the maintenance organization or within the group responsible for the major portion of the job should be assigned the lead in identifying and coordinating needed support.

Flame permits, confined space permits, tagging requests, radiation work permit requests, etc., should be included in the work package.

Independent Verification Requirements

The following is taken from DOE-STD-1036-93.

Independent verification is the act of checking, by a separate qualified person, that a given operation, or the position of a component, conforms to established criteria. Independent verification compensates for the human element in facility operation. It recognizes that any operator, no matter how proficient, can make a mistake. However, the chance that two operators will independently make the same mistake is unlikely. Therefore, independent verification provides an extra measure of safety and reliability to facility operations. Industry experience shows that verifying, or double-checking, important operating parameters and component alignments reduces the occurrence of unintended operational events (shutdowns, environmental violations, etc.).

Independent verification should be performed on systems, structures, and components that impact the safety and reliability of facility operations. Facilities should identify components requiring independent verification on the basis of safety analysis and evaluation of the effects that may be caused by mispositioning. Independent verification should be performed on systems, structures, and components that perform functions in the following categories:

- related to nuclear safety (for reactors and non-reactor nuclear facilities);
- essential for preserving environmental, safety, or health controls; and
- critical to performance of the facility's designated mission.

Maintenance Problem Identification, Correction, and Evaluation

The following is taken from DOE G 433.1-1.

Inspections, audits, reviews, investigations, and self-assessments are necessary parts of an effective maintenance program. Senior managers should periodically review and assess elements of the maintenance program. These assessments can assist line managers and supervisors in the identification and correction of program deficiencies. An evaluation of each maintenance program element should be conducted at least every other year and should include inputs from maintenance managers and supervisors and other groups, such as operations, technical staff, and appropriate corporate departments. This evaluation should address the overall effectiveness of the program element. It should also address inter-organizational and intra-organizational coordination problems that create work delays and reduce productivity. Areas needing improvements should be assigned for corrective action and follow-up.

Systematic analysis should be used to determine and correct root causes of unplanned occurrences related to maintenance. The symptom(s) of an unplanned occurrence should be addressed. However, for long-term corrective action, it is necessary that the root cause of the problem be determined and corrected. The root cause is defined as the most basic reason or collection of reasons for an unplanned event, which, once corrected, will prevent recurrence of that event.

An analysis program should include the methodical collection of facts describing the unplanned occurrence. These facts should then be reviewed from the standpoint of management controls and engineering and human performance perspectives to pinpoint probable causes for the unplanned occurrence. Seldom does one single root cause exist by itself. A combination of such factors as supervision, workmanship, procedures, manufacturing flaws, training and qualification, improper tool use, and design may contribute to an unplanned occurrence. Corrective action follow-up should then be performed to help verify that the problem is resolved.

The actual or possible causes of a problem should be evaluated by one or more techniques or methodologies to establish a root cause. The root cause should meet three criteria: (1) its correction should prevent recurrence of the unplanned occurrence; (2) its correction should be feasible; and (3) its correction should not adversely impact safety, reliability, or operational goals. Examples of a number of proven and accepted techniques for analyzing information to determine causes of problems include the following:

- event and causal factor charting,
- walk-through task analysis,
- fault tree analysis,
- change analysis, and
- barrier analysis.

Deficiency Identification and Correction

The following is taken from DOE G 433.1-1.

Deficiencies should be tagged using numbered, coded, duplex deficiency identification tags to facilitate tracking. Inspectors should enter a description of the deficiency in the “note” section of the tag. The same tag should be used for multiple deficiencies of a similar nature, in close proximity to each other, that are to be included on the same WR. The fact that the tag is for multiple deficiencies should be indicated in the note section of the tag. Entry of the date

is particularly important. The date should be used in conjunction with the tag number to obtain the WR number that corresponds to the identified deficiency. The inspector should attach the hard copy of the tag to the equipment or component, as close as possible to the deficiency. The duplicate copy, which contains the information necessary for completing a WR, should be retained until a WR is initiated.

The individual identifying a deficiency should initiate a WR according to the following steps:

- Enter the deficiency identification tag or sticker number in the WR index. Because the date on the deficiency tag is the date of the WR, the index provides a cross-reference.
- Use the duplicate portion of the deficiency identification tag to enter key information on the WR.

Maintenance personnel should ensure that deficiency tags and stickers are removed following the completion of corrective maintenance and after verification that the deficiency has been satisfactorily corrected.

Response to Abnormal Maintenance Conditions

The following is taken from DOE G 433.1-1.

For every operation, whether it is routine, infrequent, abnormal, emergency or casualty, a procedure should be in place so workers know how the operation should be conducted.

In cases of abnormal or emergency conditions, the owner/operator may give permission to deviate from normal procedures when necessary to prevent injury to personnel, damage to equipment, or increase the margin of safety. The emergency deviation should then be documented and reviewed as soon as possible after procedural changes and installation of modifications.

Configuration Control

The following is taken from DOE G 433.1-1.

Management should ensure that plant configuration, including the manner in which the facility is maintained, conforms to the established design basis requirements. Many routine activities, if carried out improperly, can have an adverse impact on facility configuration and cause eventual equipment damage or increase the probability or consequences of a significant event.

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

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

Work Authorization to Start and Conduct Work

The following is taken from DOE Order 5480.19.

The operations supervisor or his/her designee should authorize all shift activities (including maintenance) on equipment that is important to safety, that affects operations, or that changes control indications or alarms. This authorization should be in writing on the document controlling the work. Documentation of the status of work in progress should be available in the control area for review by operating personnel. These activities could include such things as maintenance, test, fuel movement, radiography, and others.

Control of Work Conducted Under Emergency Conditions

This topic was previously discussed in *Response to Abnormal Maintenance Conditions* in the current KSA item.

b. Describe the maintenance supervisor's role and responsibilities in the supervision of maintenance activities and review of completed work requests.

The following is taken from DOE G 433.1-1.

It is a primary responsibility of the maintenance manager/supervisor to ensure implementation of contractor management and facility policies that affect the maintenance organization. Procedure approval should be consistent with facility TSRs or their equivalents and with administrative procedures. At a minimum, the maintenance manager or his/her designee should approve maintenance procedures. The maintenance manager should have overall responsibility for the establishment, implementation, and performance of the planning, scheduling, and coordination maintenance activities through the planning function's processing of WRs.

A computerized work control system should be used to provide the maintenance manager and his/her supervisors with the means for identifying, recording, and tracking the status of all valid WRs. The planning group or maintenance supervisors should maintain the status of all open WRs and PM items that are overdue or coming due and should recommend assignments from this list based on job priority.

Maintenance supervisors should review completed WRs for adequacy of repair, complete documentation, notation of generic corrective actions, and identification of rework. A post-job review should be held with the craft personnel involved.

An evaluation of the PM and predictive maintenance programs should be conducted annually by the maintenance manager with assistance from the applicable/affected operations, technical support, and engineering groups. This evaluation should address the overall effectiveness of the program in improving facility and/or equipment availability, as well as reducing the cost of maintenance.

5. Facility maintenance management personnel shall demonstrate a working-level knowledge of planning, scheduling, and coordination of maintenance activities.

a. Discuss the importance of planning, scheduling, and coordinating maintenance activities and the factors to be considered in scheduling maintenance work.

The following is taken from DOE G 433.1-1.

An effective system for planning, scheduling, and coordinating maintenance activities should be implemented to ensure maintenance is accomplished in a timely manner, ensure worker safety, improve maintenance efficiency, reduce radiation exposure, and increase equipment availability. Planning and scheduling involves assigning priorities that reflect the importance of maintenance work relative to safe and reliable facility operation; personnel safety; identification of logistics; personnel support; and other preparation; and minimizing any adverse impact that the maintenance activity has on facility operation. Coordination of work ensures that needed support [e.g., lockouts/tagouts, radiological work permits (RWPs), QC] is available.

The processes of planning, scheduling, and coordinating work are discrete tasks that are closely related and that are usually delegated to one of several functional groups. Planning, scheduling, and coordinating work usually involves a planning group, a scheduling system (work control system), a scheduling group (which may be a part of the planning group), and a coordination group (which may also be a part of the planning group). Outage planning, scheduling, and coordination are usually managed by a dedicated group of individuals in order to control this significant effort.

b. Discuss the prioritization of maintenance activities.

The following is taken from DOE G 433.1-1.

Each WR related to repairs of production equipment should be reviewed by the operations department to determine its impact on facility operations. Meaningful priorities that determine how soon a WR needs to be worked should be set based on operational and industrial safety and reliability. Communication among cognizant groups should be established to enable proper priorities to be set. A method should be established that avoids congesting the work control system with jobs that are not important to safe and reliable operation.

- The priority system should be kept simple to enhance its use and accuracy; typically, it is limited to about six categories. Corrective maintenance should be assigned a priority based on the maximum time allowed before corrective action must be taken, as well as on the importance of the system or equipment.

c. Describe the elements of a priority system used for maintenance planning.

The following is taken from DOE G 433.1-1.

Items that should be considered when priorities are assigned to WRs include the following:

- personnel and radiological safety;
- equipment repair urgency;
- operability of redundant equipment;
- operating approval commitments (e.g., TSR, LCO);
- facility conditions required for equipment repair;
- status of repair or replacement parts;
- ALARA considerations such as exposure and contamination control;
- personnel availability; and

- minimization of the spread of contamination from leaks.

d. Define backlog.

The following is taken from DOE G 433.1-1.

Maintenance backlog is defined as the number of overdue incomplete maintenance WRs for either planned or unplanned maintenance activities, including backlog due to aging and deterioration of facilities or facilities-related equipment not accomplished at the end of the fiscal year.

e. Discuss the use of backlog as a management tool (mission, goals, budget, and staff).

The following is taken from DOE G 433.1-1.

The maintenance backlog should be monitored to ensure important jobs are not being delayed unnecessarily and control is maintained over the amount of work in the backlog.

DOE contractors should develop a maintenance implementation plan (MIP) for each nuclear facility under their cognizance. The MIP should contain a summary of the maintenance backlog, should establish maintenance priorities based on mission needs, and the priorities should be tracked directly to maintenance budget requests.

The MIP will facilitate DOE maintenance planning, performance evaluation, and prioritizing in a way that balances safety requirements, the maintenance backlog, and facility availability so that resources can be effectively allocated to address safety, programmatic, and operational considerations.

f. Describe the elements of a system used to manage the maintenance backlog.

The following is taken from DOE G 433.1-1.

A computerized work control system should be used to provide the maintenance manager and his/her supervisors with the means for identifying, recording, and tracking the status of all valid WRs. Computerized systems offer the following features that could be helpful in managing the work backlog:

- the ability to sort WRs by deficiency tag, priority, WR date, facility conditions required, and systems affected;
- the ability to indicate the status of all WRs on hold for planning, parts, material, or other constraints;
- the ability to track the status of in-progress WRs; and
- the ability to track PMT to ensure that all required post-maintenance tasks are accomplished before a piece of equipment or a system is returned to service (especially important after outages, when many jobs may be performed on a system that is removed from service for an extended period or when several jobs are completed under one clearance).

g. Understand and describe the relationship between operations and maintenance organizations. Include a discussion on resource and time requirements.

The following is taken from DOE G 433.1-1.

Senior management can achieve a high level of performance in facility maintenance by establishing high standards, by communicating these standards to personnel who perform maintenance, by selecting and training high-quality personnel, by providing sufficient resources to the maintenance organization, by setting goals and objectives, by closely observing and assessing performance, by effectively coordinating maintenance activities with operations and other facility organizations, and by holding workers and their supervisors accountable for their performance.

Performance in maintenance should be closely monitored by operations office personnel and facility managers through direct observation and development of maintenance reports.

Each facility should develop an integrated approach to maintenance that encourages working relationships among all organizational units that support the maintenance function [e.g., operations, health physics, stores, QC, engineering, procurement, and modifications].

Each WR related to repairs of production equipment should be reviewed by the operations department to determine its impact on facility operations. Meaningful priorities that determine how soon a WR needs to be worked should be set based on operational and industrial safety and reliability. Communication among cognizant groups should be established to enable proper priorities to be set. A method should be established that avoids congesting the work control system with jobs that are not important to safe and reliable operation.

The planning group or maintenance supervisors should maintain the status of all open WRs and PM items that are overdue or coming due and should recommend assignments from this list based on job priority. Meetings involving scheduling of routine jobs need to be held frequently to ensure proper communication concerning priorities, current problems, job interferences, and requests for support among facility organizations. These meetings should be chaired by a designated individual from the operations department. Supervisors or responsible spokespersons from all maintenance disciplines, safety, environmental protection, QC, radiological protection, technical support, and the warehouse should attend these meetings. Other personnel should be invited as needed.

h. Discuss the role of planning meetings to coordinate activities.

The following is taken from DOE G 433.1-1.

Well managed planning and scheduling meetings are necessary to keep facility personnel aware of significant maintenance activities that are in progress and to make corrections to schedules. Meetings should be effectively managed to limit the time personnel spend in the meetings. Participation in meetings should be limited to those personnel affected. Three types of meetings (daily directional meetings, planning meetings, and shift work coordination meetings) have been shown to be effective in improving communications among work groups and in enhancing job coordination.

A daily directional meeting may be held after the start of the primary work shift. This meeting should be attended by management personnel and representatives from all major work groups. The meeting should focus on major jobs and evolutions planned for the next 48 hours and identify any redirection necessary due to significant problems such as lack of materials, shortage of other support resources, delays in key support activities, or other problem areas.

A planning meeting should be held each day following the directional meeting to review the near-term (next 3 to 5 days) schedule and verify that jobs may be worked as scheduled. Planners and representatives of the operations manager, radiological protection, and other support departments should attend.

A shift work coordination meeting should be held shortly before the start of each shift. This meeting should be attended by oncoming shift supervision for each of the groups supporting the maintenance schedule, including maintenance, health physics, technical staff engineering, area coordinators, and task coordinators, for jobs requiring significant support. The operations supervisor for the oncoming shift should also attend. The shift work coordination meeting should address all scheduled work for the upcoming shift by exception and should modify the schedule as necessary to reflect last-minute changes.

i. Describe the importance of pre-briefings and what should be included in a pre-brief.

The following is taken from DOE-HDBK-1028-2009.

A pre-job briefing is a meeting of individual performers and supervisors conducted before performing a job to discuss the tasks, critical steps, hazards, and related safety precautions. This meeting helps individuals to better understand the task(s) to be accomplished and the associated hazards. Participants clarify the task's objectives, roles and responsibilities, and resources. Knowing clearly what needs to be done improves error recognition. Similarly, precautions, limitations, hazards, critical steps, controls, contingencies, and relevant operating experience are discussed.

j. Discuss the relationship between normal maintenance and outage maintenance.

The following is taken from DOE G 433.1-1.

Scheduling corrective and PM and planned and unplanned outage work is necessary to ensure that maintenance is conducted efficiently and within prescribed time limits. Scheduling daily activities based on accurate planning estimates will improve use of time on the job and help reduce radiological exposure. Scheduling planned outages is important to support the return of the facility to service on schedule (and within the approved budget) and results in improved availability and capacity factors. A contingency work schedule (shutdown file) should be maintained so that if an unplanned outage occurs, the duration is minimized and effectively used and so that needed maintenance is performed before restart.

For equipment whose failure can limit safe or reliable operation or result in unplanned outages, extensive PM may be required. The purpose of PM is to eliminate or minimize this type of failure.

k. Discuss the requirements for scheduling and coordinating planned outages.

The following is taken from DOE G 433.1-1.

Responsibility should be assigned for the overall control of long-term (typically, 3 or more days) planned and unplanned outages and for adherence to the outage schedule. Revisions to the schedule should be made as required to ensure that the schedule reflects achievable goals and real-time progress. Activities on the critical path and near-critical paths should be monitored at least once per shift during the outage. The outage management system should be structured so that individuals responsible for areas of outage work present status reports directly to outage management staff as well as to their line managers.

A summary of outage status should be prepared at least once a week and should include the following types of information:

- time ahead of or behind schedule;
- completion status (expressed as a percentage) for long-duration activities (i.e., those that exceed 1 week);
- completion estimates for all critical-path and near-critical-path activities in progress;
- problems that are delaying or are expected to delay completion of scheduled major activities, with the intended course of action and individual(s) responsible for resolving each problem; and
- industrial safety issues that have arisen as a result of the nature of the outage.

Schedules of past outages (planned and unplanned) should be retained for reference in planning for future outages. They can be especially useful in preparing unplanned outage schedules.

Preparations and scheduling for future long-term planned outage activities should begin no later than immediately after a unit's completion of the current outage. Preparation for and scheduling of major maintenance activities and modifications may have to begin several years in advance, depending on the complexity of the effort. A designated outage manager or coordinator should be assigned to direct preparations for and management of the outage.

Shortly after a major planned outage is completed, a critique of it should be held to ensure that lessons learned during that outage are factored into the preparations for the next one. Outage jobs held over should be assessed and factored into the following outage or deleted with appropriate justification.

Engineering work should be completed as early as possible. Adequate time should be allowed for review of work packages, resolution of comments, budgeting, contracting, procurement, and other long-lead-time planning functions.

A current list of proposed outage activities should be maintained. It should include all demands for resources (such as nonnuclear facility contractor and subcontractor resources) and activities (such as corrective maintenance, PM, surveillance, in-service tests and inspections, and modifications). Outage planning meetings should be held periodically to refine and update this list.

An initial milestone list that identifies cutoff dates for major activities required to support outage planning should be prepared. This list should include items such as the following:

- identification of major jobs;
- letting of bids for contracts and materials;
- identification of corrective maintenance, PM, surveillance, and in-service test requirements;
- identification of major modifications and dates for design work, work package preparation, and procurement of materials, parts, and services;
- identification of pre-outage work that can and should be performed to reduce the demand for resources during the outage (such as pipe prefabrication, cable pulling, conduit runs, raceway installation, fabrication of supports, and scaffold erection);
- identification of facilities required for outage support and milestones for their construction;
- identification of temporary services that may be provided to craft personnel when lockout/tagout of equipment related to the maintenance activity disrupts normal services (e.g., electricity, lighting, air, and water);
- staging of special tools and equipment and preparation of work areas; and
- development of schedules.

An overall outage schedule should be developed as soon as all major outage activities are identified. Periodic revisions to this schedule should be issued throughout the outage planning process. The schedule should be approved and issued at least 90 days before the scheduled outage start date. Issuance should represent a cutoff date for addition of new outage work. This should include all modification work and all major maintenance to be accomplished. The schedule should identify and allocate such critical resources as labor, shop facilities, cranes, equipment accessibility, personnel radiation dosage, and availability and scheduling of outside subcontractors and non-facility contractor groups.

Based on the overall schedule, a detailed outage schedule should be issued at least 30 days before the scheduled outage start date. This schedule should be a commitment by all affected groups. Addition of unanticipated work to the outage schedule should require a formal review and approval process. Depending on the severity of impact on outage resources or critical-path time, successively higher management levels should approve the changes. Schedule-change constraints are mandatory for the successful and timely management of an outage.

I. Discuss the requirements for scheduling and coordinating forced outages or other limitations to facility operations.

The following is taken from DOE G 433.1-1.

Management of unplanned outages and other facility operating limitations is necessary to minimize the duration of these conditions and to use available time effectively. Facility management or the maintenance supervisors should maintain a prioritized list of corrective maintenance, modifications, surveillance, PM, special items, or commitments that must be performed under a system or facility outage or power reduction. Resource requirements, industrial safety considerations, and task completion time for each of the identified jobs should be estimated to aid in planning, scheduling, and coordination. To the extent possible,

an up-to-date list of prioritized outage tasks and assembled work packages, including procedures, repair parts and materials, lockout/tagout requests, special tools, and personnel entry forms (such as RWPs or confined-space entry permits) should be prepared.

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

An unplanned outage work list should be prepared, and outage activities should be coordinated. Facility management should conduct planning meetings periodically to update the list (typically, once every 2 weeks). Copies of the proposed outage list, reflecting current planning, should be sent to all affected facility organizations after each planning meeting.

If an unplanned outage, power reduction, or other major limitation occurs, appropriate facility managers should initiate selected work from the outage list based on the estimated duration of the outage and resources available. For unplanned outages of longer duration (commonly, more than 3 days), preparations should be started for additional outage work while managerial decisions are being made to determine the actual length of the outage. In this case, each organization should review its current unplanned outage list and identify any additional significant work to be conducted during the outage. If an unplanned outage can be delayed, the outage manager should schedule and coordinate work for the expected duration of the outage.

Once the duration of the outage has been determined, facility management should conduct coordination meetings to determine the critical path and major milestones and to accept or reject any new or significant work to be accomplished. Support requirements should be verified and coordinated among cognizant departments. During the outage, a status should be obtained during each shift to measure progress and to make any required adjustments, such as coordinating special support needs. After completion of each outage, facility management should conduct a critique to determine how outage improvements could be made and designate personnel to implement these improvements.

6. Facility maintenance management personnel shall demonstrate a working-level knowledge of industrial property management practices as related to stores, spare parts, and essential materials.

a. Discuss how component availability impacts plant reliability and safety.

The following is taken from DOE G 433.1-1.

Proper 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 and to support both unplanned and planned outages. 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 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.

b. Discuss the concerns related to maintaining inventory of critical components that affect limiting conditions of operations.

The following is taken from DOE G 433.1-1.

Parts and material required for maintenance activities should be identified and purchased in time to allow for receipt and inspection well before they are needed. After processing, these parts and material should be identified for specific work packages and segregated from other stock inventory.

When parts, materials, and equipment are received, stores personnel should inspect them before they are accepted for storage or are used. This inspection is conducted to verify that the items delivered agree with the approved purchase documentation, are packaged in accordance with purchase order specifications, have necessary product control requirements furnished by the vendor (such as special storage or shelf-life information), and appear to be in good condition. In the case of safety items and designated critical items important to reliable facility operations, stores personnel should inspect them to ensure that the vendor has supplied what was ordered, that the necessary formal documentation has accompanied the shipment or is otherwise on hand, and that items have been received in an acceptable condition. Technical staff and maintenance personnel may be needed to assist in the inspection of more complicated parts, materials, and equipment.

A system should exist that provides for current storage inventory status information to be maintained, to be made available to, and to be usable by authorized individuals upon request. The following information should be included on storage inventory lists:

- stores catalog number;
- noun name;
- manufacturer/vendor part number;
- application and contact for controlled item disposition;
- reorder criteria, when applicable;
- quantity on-hand;
- material safety data sheet information; and
- any special considerations for configuration-managed items.

c. Describe the following terms as they relate to procurement:

- **Just-in-time**
- **Shelf life**
- **Long lead time**

The following is taken from DOE G 433.1-1.

Just-In-Time

Although not procedurally defined, just-in-time refers to parts which can be ordered to support repairs prior to a component failure. This method of procurement strategy helps to reduce the cost of maintaining an inventory.

Shelf Life

Shelf life is a specific period or interval of time after which a stored item may not meet its original design specifications, quality, or manufacture requirements.

Long Lead Time

Although not procedurally defined, long lead time refers to the need to order a part a long time before it is needed for maintenance or repairs. Many items, particularly material needed for modifications and repair parts for older equipment, may be long-lead-time items. The component or part must be ordered with sufficient time for the manufacturer or supplier to fabricate or obtain it.

d. Describe the Department's procurement process.

The following is taken from DOE G 433.1-1.

Policies should be established for the procurement of parts, materials, and services. These policies must be understood by stores and purchasing personnel and other personnel who interface with them, such as maintenance supervisors, planning personnel, and scheduling personnel.

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

Procedures should be prepared to describe specific procurement actions and the specific responsibilities of personnel involved in the procurement of:

- safety-class items,
- safety-significant SSCs,
- critical spare parts,
- major project purchases,
- routine procurement purchases,
- contracted work and services, and
- hazardous materials.

Established procedures should provide for the update of spare part stocking levels and removal of outdated/obsolete items as part of the design change process.

A system should be established as part of the design change process to update spare parts needs and remove outdated/obsolete materials from the stock system.

e. Describe controls that should be developed and maintained throughout the procurement process.

The following is taken from DOE G 433.1-1.

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

- Segregation and status resolution of damaged, nonconforming, or otherwise deficient items. Technical reviews should be initiated promptly to aid in the resolution of these items.
- Special receiving inspection documentation to support future procurement.
- Ensuring initial deliverable quantities and spare part stocking levels are adequate.
- Emergency procurement process and practices that ensure that acquired items support safe and reliable application.
- The ability to track procurement status by the requester.
- The ability to track procurement status from receiving through delivery to issue-for-use.
- Assurance that procurement documents and controls prevent the delivery or use of suspect/counterfeit parts.
- Verification of the reliability of supplier performance. This can be accomplished by audits, inspections, or surveillances of supplier facilities.
- Prompt and effective resolution of deficiency or nonconformance of items. Technical reviews should be initiated promptly to aid in resolving these issues.
- Control and maintenance of QA records to provide documentation for qualified parts and materials and to ensure traceability of parts and materials.
- Provision of a means of qualifying nonqualified material. An effective upgrade process will result in improved availability of quality parts and materials.
- Provision of a method for acceptable substitution to obtain parts that are no longer available from the original supplier, that have new identification numbers, or that have different material specifications. Engineering and maintenance experience should be provided to support this process. Change approval documentation and substitution information should be maintained in a retrievable form.
- Review of design requirements by appropriate personnel to ensure that upgraded or substitute parts are consistent with the application of the part and component. Retrievable documentation should exist to support the identification of inspection and testing requirements necessary to ensure the qualification and acceptability of the part.
- Development of emergency procurement policies and an expediting process to obtain parts, materials, and services that are needed immediately to support safe and reliable facility operation. Acquisition deadlines should be clearly identified for parts, materials, and services that require emergency procurement.
- Establishment of a parts and materials reorder system that ensures material availability for anticipated usage while minimizing unnecessary inventory. For example, a minimum/maximum stock level can be established to determine when items should be reordered (the minimum level) and to limit the amount ordered (the maximum level). Changes to these levels should be controlled by review of usage history and maintenance experience.

- Identification of multiple applications of requested parts or materials; use of specific parts or materials in more than one system or piece of equipment should be considered as part of the procurement and stocking process.
- Ability of the procurement organization to track procurement progress and take necessary measures to meet maintenance and outage schedules.

f. Discuss S/CI concerns, issues, and controls.

See item n of competency 1.

7. Facility maintenance management personnel shall demonstrate a working-level knowledge of the control and calibration of measuring and test equipment.

a. Discuss the elements that are included in a comprehensive measuring and test equipment program.

The following is taken from DOE G 433.1-1.

The control and calibration of M&TE used on safety-class items, safety-related SSCs, or SSCs that affect critical facility performance and reliability play an important role in maintenance and the safe operation of DOE nuclear facilities. Ensuring that properly calibrated measuring, tooling and test equipment performs as intended is essential to a comprehensive maintenance program, and is an important factor in enabling facilities to move from corrective maintenance to effective PM. A computer-based system should be considered as necessary for the establishment of an M&TE program to allow for frequent updates of M&TE status and permit personnel access to current information as quickly as possible.

Operators depend on installed facility instrumentation for accurate indications, process control actions, and trip functions to operate the facility safely and reliably. The accuracy of the installed instrumentation is established and maintained through the M&TE control and calibration program. Such a comprehensive M&TE program should include the following elements:

- Unique identification numbers on all M&TE that accurately identify the specific devices and provide traceability.
- A current MEL identifying all M&TE.
- Calibration standards that are traceable to a national standard or that themselves are recognized as standards.
- Procedures for calibrating M&TE to help control the performance of calibration and to provide repeatable calibrations and acceptance criteria.
- Establishment of a calibration frequency that helps maintain M&TE accuracy and availability.
- Provision for checking the function of M&TE, when applicable.
- Provision of facilities to control storage, issue, and calibration of M&TE.
- Segregation and marking of M&TE devices with suspected or actual deficiencies to prohibit their use.
- Clear marking to indicate limitations of M&TE devices that are not fully calibrated or usable.

- Records for accountability and traceability of use. A recall system should be developed for recalibrations.
- A maintenance policy that minimizes contamination of M&TE.
- Timely evaluations of M&TE devices found out of calibration or defective to determine the validity of all measurements and/or calibrations for which they were used.
- Trending of M&TE reliability problems to determine if any corrective actions are needed.
- Periodic reviews to determine whether the control of M&TE is effective.

This section establishes guidance for a process to ensure that M&TE is properly controlled, calibrated, and certified with standards for calibration and certification. The certification data should be traceable to the National Institute of Standards and Technology (NIST) or analysis and design calculations should be performed to verify design and/or predict performance during a design effort (i.e., during the preconceptual activities, or to verify that evolving designs meet specified requirements).

b. Describe the guidelines for the identification of measuring and test equipment.

The following is taken from DOE G 433.1-1.

Each piece of M&TE should be assigned a unique identification number that is permanently marked on or attached to it (the identification number may consist of the manufacturer's serial number). These numbers assist in identifying, tracing, and controlling M&TE. A MEL of all controlled M&TE should be maintained. If separate organizations control their own M&TE, each should maintain or have access to a list of its own equipment. Equipment lists should include the following at a minimum:

- generic description, trade or marketing name, manufacturer, model, and serial number;
- unique identification number;
- range(s) and accuracy;
- calibration procedure;
- calibration frequency;
- calibration interval;
- expiration date;
- date of last calibration;
- systems/stations number (this identifies a specific document which establishes parameters,
- range, precision, accuracy and other requirements for application of the individual item listed);
- responsible organization or person; and
- normal storage location(s).

c. Discuss the following aspects of calibration as they relate to measuring and test equipment:

- **Calibration standards**
- **Calibration procedures**
- **Calibration frequency**

- **Functional checks**

The following is taken from DOE G 433.1-1.

Calibration Standards

Only calibration standards traceable to NIST or other nationally recognized standards organizations should be used for calibration of M&TE. M&TE should be calibrated using reference standards (secondary or working) whose calibration has a known valid relationship to nationally recognized standards or accepted values of natural physical constants. If national standards do not exist, the basis for calibration should be documented. Calibration standards maintained at the facility should be kept in calibration facilities in designated storage locations. If calibration standards are issued for field use, the supervisor responsible for them should authorize and minimize the period of issuance. Issuance of laboratory standards for field use should be discouraged. Standards should be calibrated on a frequency consistent with vendor recommendations and facility experience. Calibration records for standards should be consistent with those of all other M&TE.

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 contain the following:

- precautions or limitations.
- calibration standards to be used and their accuracy.
- calibration instructions and data sheets for as-found and as-left data.
- acceptance criteria for each scale, expressed as a range and in the units that are being measured (e.g., represent 9.75 volts as 9.726 - 9.774 volts rather than as 9.75 volts ± 0.25 percent). Acceptance criteria should be rounded up on the - side and down on the + side to be within the range of accuracy of the instrument being read.

Calibration Frequency

Frequency of calibration should be determined based on the manufacturers' recommendations, M&TE usage, and M&TE historical reliability. Consideration should be given to the amount and type of M&TE available for use compared with that needed to support periods of peak activity such as outages. This information can help determine calibration frequency and schedule requirements that result in adequate M&TE support for facility needs.

Functional Checks

When operational tests, functional checks, or battery checks of M&TE are performed, the desired response or acceptance criteria should be clearly specified or indicated on the equipment. These types of checks are intended to detect M&TE problems before and after an instrument is used in the field; they are not substitutes for calibration checks.

d. Describe the four-to-one rule as it relates to the accuracy of calibrating instrumentation.

The following is taken from DOE G 433.1-1.

The reference standard used should have an accuracy at least four times greater than the device under test. If this accuracy ratio cannot be met, analysis of the errors should be estimated to provide a valid uncertainty of the calibration process. If repair or calibration of a standard is necessary, the recalibration must be traceable to NIST or to the standard of record for the M&TE.

e. Discuss the requirements for the control of measuring and test equipment.

The following is taken from DOE G 433.1-1.

The control process used for M&TE should be a well-established recall program containing total inventory listing, weekly calibration due notices, individual automatic job opener and information cards, weekly calibration overdue notices, exception report for program errors, and scheduled and nonscheduled action history reporting.

f. Discuss the storage, segregation, and labeling of measuring and test equipment.

The following is taken from DOE G 433.1-1.

DOE M&TE storage areas should be authorized by the maintenance manager. All equipment should be stored in a manner that assures integrity is maintained and unintended contamination is minimized. Each piece of M&TE should be assigned a unique identification number that is permanently marked on or attached to it (the identification number may consist of the manufacturer's serial number). These numbers assist in identifying, tracing, and controlling M&TE. Equipment in these storage areas should be labeled as to its current calibration status. The M&TE storage areas should provide sufficient separation of the ready-to-use equipment (calibrated and restricted use) from other equipment (expired) to preclude inadvertent use.

The environment of M&TE storage areas should be controlled to preclude any adverse effect on equipment accuracy. Environmental factors that should be considered include, but are not limited to, temperature, humidity, vibration, radio frequency interference, electromagnetic interference, and fumes.

Security of the M&TE storage area should be maintained by designated individuals responsible for control of M&TE. In the absence of these individuals, the storage area should be locked with access controlled by the responsible department manager and/or supervisor.

Instruments used on systems that contain oil, brackish water, etc., should be cleaned thoroughly after each use.

Proper facilities are needed to help ensure equipment is protected from damage in storage, is properly maintained, and is readily retrievable. M&TE devices that are relatively easy to damage during transport and handling should be provided more protection by being boxed or by being mounted in special rigs (e.g., test gauges mounted in portable frames). M&TE in the issue area should be in an area segregated from M&TE that is defective, out of calibration, or that requires investigation, ensuring that only calibrated M&TE is available for issuance. This should be a physically and distinctively marked separation.

g. Describe the methods used for resolving out-of-calibration equipment.

The following is taken from DOE G 433.1-1.

When an M&TE device is found to be, or suspected to be out of calibration, defective, or otherwise unreliable, an evaluation of the instruments and equipment it has measured or tested since it was last calibrated should be performed promptly to determine whether recalibration or rework is needed. Also, records of the field instruments calibrated by the M&TE should be reviewed to determine whether recalibration is necessary.

New M&TE devices should be calibrated before they are used to verify they meet acceptance criteria, are functional, and are safe to use. Uncalibrated test equipment used only for troubleshooting should be clearly marked so that it is not used as M&TE for taking data. Test equipment used only for troubleshooting does not need to be fully calibrated, but it should be periodically checked for operability and safety.

h. Discuss the issuance and recall of measuring and test equipment.

The following is taken from DOE G 433.1-1.

One or more controlled issue points should be provided to help ensure that only qualified persons are allowed access to M&TE. Traceability of M&TE should be provided to support a timely evaluation of instruments, systems, and other equipment associated with deficient M&TE. This can be accomplished by recording the M&TE user, when the equipment was used, what instrument or equipment it was used on and for what purpose (typically by referencing maintenance request or procedure number), and what ranges were used or values read. Maintenance history that can be readily sorted by specific M&TE used to perform maintenance is an alternative method for providing traceability.

A recall system should be implemented to ensure that M&TE devices are removed from service before or at expiration of their calibration. This recall system can be enhanced by the use of calibration stickers on each M&TE device. If used, such a sticker should be attached to the M&TE device, designating, at a minimum, the date recalibration is due. This information is normally needed for work documentation; calibration stickers, therefore, provide a convenient method for users to obtain this information and ensure that the M&TE is currently calibrated. The recall system should stagger calibration due dates to meet M&TE needs for peak-use periods such as outages, as well as for day-to-day use.

i. Describe the actions taken for contaminated measuring and test equipment.

The following is taken from DOE G 433.1-1.

Equipment subject to contamination should be packaged and used in a manner that minimizes the possibility of external and internal contamination (e.g., being wrapped in clear plastic, being taped, and being isolated). This should be emphasized as part of the OJT program. These practices can help minimize the spread of contamination and the amount of M&TE kept only for use on contaminated systems and equipment. In addition, consideration should be given to establishing an area for storing and calibrating contaminated M&TE.

The following controls should be incorporated:

- Handle potentially contaminated tools and equipment in accordance with applicable facility procedures.
- Mark or label each potentially contaminated item as radioactive material. Small hand tools and minor equipment should be uniquely identified by permanent marking to clearly distinguish them from similar items intended for non-radiological areas of the facility.
- Label or mark all containers of temporarily stored radiological area tools and equipment such as barrels, toolboxes, "gang" boxes, crates, etc., as radioactive material, along with the identity of the contents, the levels of radioactive contamination, and the radiation dose rates, in accordance with applicable facility procedures.
- Designate storage areas for highly radioactive tools and equipment which may cause high radiation areas. These areas may need to be shielded and locked and should be as remote as possible from traffic areas. High-radiation areas should be controlled as specified in applicable facility procedures.

j. Discuss the guidelines for the evaluation of measuring and test equipment.

The following is taken from DOE G 433.1-1.

Results of M&TE calibrations should be trended, and corrective actions should be determined for any M&TE reliability problems. This predictive maintenance technique can identify needed corrections or changes to the M&TE program, such as adding or deleting M&TE devices, adjusting calibration frequencies, correcting procedures, or upgrading M&TE quality.

When an M&TE device is found to be, or suspected to be out of calibration, defective, or otherwise unreliable, an evaluation of the instruments and equipment it has measured or tested since it was last calibrated should be performed promptly to determine whether recalibration or rework is needed. Also, records of the field instruments calibrated by the M&TE should be reviewed to determine whether recalibration is necessary. This information should be recorded in the devices history file.

8. Facility maintenance management personnel shall demonstrate a working-level knowledge of modification work.

a. Describe the difference between temporary and permanent repairs/work.

The following is taken from DOE G 433.1-1.

A temporary modification is any short-term alteration made to facility SSCs that does not conform with approved drawings or other design documents. Temporary repairs are temporary modifications to the plant that allow equipment to remain in or be returned to service in a condition that is not the same as the original design specification. Before implementation, temporary repairs should receive a safety review in accordance with the facility temporary modification program to ensure the adequacy of the repair and its effect on personnel and equipment safety and reliability. Temporary repairs should be tracked after

their completion for consideration of permanent repairs. Permanent repairs should be scheduled when facility conditions permit.

b. Discuss the restrictions associated with temporary modifications.

The following is taken from DOE G 433.1-1.

A facility program to control temporary modifications should include the following elements:

- owner/operator approval of temporary modifications before installation or removal;
- positive identification of electrical temporary modifications with independent verification before installation;
- independent verification or functional test of all temporary modifications after they are installed or removed;
- record of all installed temporary modifications;
- assurance that operators and supervisors are trained on installed temporary modifications and their impact on system/component operation before returning the system to service;
- safety reviews of temporary modifications installed on in-service (operable) equipment to ensure that the modified equipment should continue to perform as intended and not adversely affect plant or personnel safety;
- assurance of the quality of work and suitability of materials used for temporary modifications (For example, this guideline suggests that temporary modifications be installed or removed using an approved WR/WO.);
- method to review the temporary modifications periodically for errors and continued need;
- method of clearly identifying installed temporary modifications; and
- method to provide operators with instructions for operating temporarily modified equipment and/or guidance regarding the periodic monitoring of its operation (e.g., drawings and procedures should be marked up or annotated to reflect the new configuration before returning the system to operation).

c. Explain who can authorize temporary modifications.

The following is taken from DOE G 433.1-1.

The facility owner/operator approves temporary modifications prior to installation or removal.

d. Describe the process for temporary modifications.

The following is taken from DOE G 433.1-1.

The individual who desires to make a temporary modification should complete the description section of the temporary modification sheet with the assistance of the technical staff. Sketches/drawings needed to describe the temporary modification should be attached to the temporary modification sheet. The type of temporary modification should be indicated such as a lifted lead, pulled circuit card, electrical or mechanical jumper, etc.

Maintenance crafts people should draft appropriate revisions to affected procedures and drawings. These revisions should be included in the temporary modification package. Temporary procedure and drawing revisions should be approved in accordance with facility administrative procedures.

The maintenance supervisor and a system engineer should complete the evaluation section of the temporary modification sheet. If possible, the maintenance supervisor of the person requesting the temporary modification should be the person to sign, indicating approval. The maintenance supervisor and a system engineer should ensure that the temporary modification does not adversely affect the intended safety, reliability, or design of the facility.

Cognizant engineers and maintenance personnel should complete the design verification and safety review section of the temporary modification sheet by answering the questions. The reasons for each answer should provide sufficient information for approvers to determine that the temporary modification is safe.

All special actions, technical specification requirements, temporary operating instructions, etc., that are a result of the temporary modification should be noted on the temporary modification sheet. Any design requirements (e.g., pressure; temperature; fluid chemistry; voltage; current; material compatibility; or seismic, wind, thermal, and dynamic loading) resulting from the review should also be noted. All attachments (procedure revisions, drawing changes, etc.) should be a permanent part of the temporary modification package. Copies of the approved temporary modification sheet and supporting documentation should be forwarded to the owner/operator for installation.

A copy of the approved temporary modification package should be sent to the training department. Training should be conducted on the temporary modification and procedure changes.

e. Discuss the requirements and controls in place to prevent unapproved modifications.

See item d of competency 8.

The following is taken from DOE G 433.1-1.

Temporary modifications should be controlled to ensure necessary personnel are aware of all changes and the expected duration of temporary modifications and that temporary alterations made to facility SSCs do not unacceptably alter or degrade the original design, facility safety, or reliability. The number and duration of temporary modifications should be minimized. Use of DOE G 433.1-1 should control temporary modifications by requiring them to be adequately identified, reviewed, approved, documented, and periodically reassessed for continued applicability.

9. Facility maintenance management personnel shall demonstrate a working-level knowledge of the requirements of post-maintenance testing.

a. Discuss the importance of post-maintenance testing.

The following is taken from DOE G 433.1-1.

PMT should be performed to verify that components will fulfill their current, authorized design function when returned to service after maintenance. PMT includes all testing performed after maintenance activities. The objective of PMT is to verify that SSCs are capable of performing their intended function when returned to service following maintenance and to ensure that the original deficiency is corrected.

b. Describe the elements of an effective post-maintenance testing program.

The following is taken from DOE G 433.1-1.

PMT involves the following key elements:

- responsibilities of each group are clearly defined;
- scope of equipment tested includes all facility equipment;
- specifying appropriate tests includes inputs from maintenance, owner/operator, and technical support groups;
- guidance is available to planners for identifying appropriate tests;
- testing is conducted with owner/operator's authorization, uses approved procedures or instructions, and is performed and reviewed by qualified personnel;
- tests are conducted under the appropriate system operating parameters;
- a form is used to authorize, document, and review the results of post-maintenance tests;
- post-test system restoration is formally controlled (restoring system to normal and/or standby modes following completion of PMT).

c. Describe the scope, such as equipment, systems, or activities, of a post-maintenance testing program.

The following is taken from DOE G 433.1-1.

Because corrective maintenance is performed to correct a deficient condition, most corrective maintenance should have a retest associated with it to verify that the equipment functions properly. Some PM activities also require PMT. 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. PMT should be accomplished on safety and non-safety equipment, systems, or activities.

d. Describe the control of a post-maintenance testing program.

The following is taken from DOE G 433.1-1.

A program should be established to control PMT. When more than one group is involved in the PMT or when the test must be delayed until conditions permit, one organization, such as

the operations department, should be responsible for coordinating test performance. The designated organization should review the total work scope to minimize redundant testing. The department performing or having the lead for performing the PMT should assign an individual with overall responsibility for conducting the test and an individual with responsibility for reviewing test data and determining the acceptability of equipment.

If facility conditions dictate that the PMT cannot be completed immediately after maintenance is performed, the WR should be held open or some other tracking method used by the department having lead responsibility for testing until the equipment can be tested. Danger or caution tags may be required for the equipment until proper PMT can be completed. Safety equipment should not be declared operative until PMT has been satisfactorily completed. Operators should know the status of equipment on hold for PMT and should minimize the amount of equipment in this condition. This status should be reviewed before any scheduled mode change. Equipment that can be tested during the upcoming mode change should be identified and the PMTs accomplished in that process or as soon as feasible after the new condition is reached.

e. Discuss the requirements of test performance, documentation, and acceptance of post-maintenance testing.

The following is taken from DOE G 433.1-1.

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

Operational acceptability of the equipment, based on satisfactory completion of PMTs, should be verified by the operations organization obtaining an appropriate signature on the WR or other reference document. This verification should be made from objective evidence, such as conducting or witnessing the PMT and reviewing completed procedures and documented test results. PMT data and their acceptability should be entered or cross-referenced to maintenance history with the WR.

Deficiencies identified during PMT should be documented and corrected on the original WR and on a new WR or on another reporting system before the original WR is accepted as complete by operations. The original WR should reference any new WRs or other documents written to resolve these deficiencies.

If a PMT fails and the equipment or system cannot be repaired and tested satisfactorily in a short time (normally, before the next shift change), the degraded or inoperative status of the

equipment should be documented such that operators understand its limitations. TSR should be consulted for safety equipment, and appropriate actions should be taken until the equipment is properly tested and returned to service.

10. Facility maintenance management personnel shall demonstrate a working-level knowledge of the requirements for material receipt, inspection, handling, storage, retrieval, and issuance.

a. Discuss the requirements for the receipt and inspection of parts, materials, and equipment.

The following is taken from DOE G 433.1-1.

When parts, materials, and equipment are received, stores personnel should inspect them before they are accepted for storage or are used. This inspection is conducted to verify that the items delivered agree with the approved purchase documentation, are packaged in accordance with purchase order specifications, have necessary product control requirements furnished by the vendor (such as special storage or shelf-life information), and appear to be in good condition. In the case of safety items and designated critical items important to reliable facility operations, stores personnel should inspect them to ensure that the vendor has supplied what was ordered, that the necessary formal documentation has accompanied the shipment or is otherwise on hand, and that items have been received in an acceptable condition. Technical staff and maintenance personnel may be needed to assist in the inspection of more complicated parts, materials, and equipment.

Technical staff and QC personnel should approve any deviation from design specifications of material or equipment received before the item is accepted into the stores system. They should also approve any upgrade of material or equipment from a non-safety to a safety category. An acceptance tag or label placed on the received material may be used to signify that the receiving inspection was performed and that the applicable requirements have been met.

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

Nonconforming material must also be clearly tagged or labeled to prevent its inadvertently being issued. A tracking or follow-up method should be established to ensure that problems with nonconforming items are promptly resolved.

A method should be developed to accept material that has been repaired or reworked by the facility maintenance organization. Whenever materials or parts are repaired or reworked, suitable testing and inspection requirements should be specified by design engineering to ensure that the materials or parts perform acceptably when placed in service. This method should also address material that has been issued and is sent back to stores for reissuance.

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

b. Discuss the requirements for establishing a procedure for items requiring special handling instructions.

The following is taken from DOE G 433.1-1.

A procedure should be prepared for items requiring special handling. It should include information such as weight, size, chemical reactivity, radioactivity, and susceptibility to physical shock, damage, or electrostatic sensitivity. Sling location balance points, method of attachment to the load, and other pertinent factors in handling loads should be clearly identified. Sound handling practices should be followed whether a specific procedure is used or not.

Hoisting and lifting equipment should be certified by the manufacturer, indicating maximum loads to be handled, and the information marked on the equipment. The maximum load capability, as marked on the equipment, should not be violated when handling or moving items. Hoisting and lifting equipment should be regularly tested, inspected, and acceptance tagged to ensure integrity. The facility inspection program for hoisting and lifting equipment and rigging should be applied to items used in the stores operation. Personnel required to operate cranes, forklifts, and other lifting equipment should receive performance-based training and be appropriately licensed to verify their qualifications.

Clearly defined instructions or job plans, including unusual, unique, or deceptive weight, balance, or lift points and other critical information, should be communicated to the handler for items to be lifted or otherwise handled. Likewise, clearly defined instructions/job plans should be developed and communicated for items that require special handling such as vibration isolation, protection from the environment, specific orientation, etc., to ensure integrity. Calibrated/certified items should be handled in a manner that ensures their integrity is not jeopardized.

c. Discuss the requirements for storing material and equipment.

The following is taken from DOE G 433.1-1.

Material and equipment should be stored in a manner that provides maximum protection and ready availability. Material and equipment should also be stored with due consideration for environmental conditions. For example, PM should be performed on large pumps and motors (those having more than 25 horsepower) that are in storage. This includes periodically checking energized heaters, periodically changing desiccant, meggering motors, rotating shafts on pumps and motors, changing oil on rotating equipment, and performing other maintenance specified by the vendor.

Also, a method should be developed that provides controlled access to storage areas. Controls should be established for field storage of such consumables as lubricants and solvents to ensure that they are properly stored, identified, and used.

A shelf-life control program should be provided for items in stores that are important to safe and reliable facility operation. Various items with finite storage lifetimes (such as paints, recorder paper, adhesives, sealants, valve diaphragms, and gasket material) should be tracked so that stock that has exceeded its shelf life is not issued. Any material reaching the end of its

shelf life should receive proper engineering analysis with appropriate vendor input to extend its storage life. If storage life cannot be extended, the material should be disposed of and new material ordered. Reordering/restocking programs should incorporate appropriate lead times to ensure sufficient material with good shelf life is available for issuance.

Safety material and equipment should be segregated from non-safety-related material and equipment to prevent inadvertent use of the wrong category of item. If segregation is not practical, marking and tagging techniques should be developed to preclude use of the wrong material or equipment.

A system should be established to ensure the proper storage, segregation, and control of hazardous materials such as chemicals, radioactive/reactive organics, reagents, explosives, flammables/combustibles, corrosives, and pesticides/herbicides; specialty equipment and tools; and general materials, equipment, and tools.

d. Describe examples of items that should be observed and corrected during periodic general inspections of stores.

The following is taken from DOE G 433.1-1.

A system for the periodic general inspection of storage areas should exist. Typical storage control observations should verify the following:

- corrosive chemicals are segregated from sensitive equipment and metal items;
- flammables are in proper containers and marked;
- radioactive substances are properly shielded and marked;
- stainless steel and other "pedigree" metals are segregated from other metals (particularly carbon steel);
- motors, pumps, relief valves, and other items are stored on their bases;
- stacking of items, crates, boxes, barrels, etc. does not exceed stacking recommendations;
- packaging and seals have not been violated leaving contents exposed to degradation caused by the intrusion of foreign materials or environmental conditions;
- machined surfaces are left adequately protected;
- applicable insect and rodent controls are in effect;
- applicable shelf-life conditions are in effect;
- carcinogens are segregated from other materials and equipment; and
- reordering/restocking is clearly indicated.

e. Discuss the requirements for retrieving and issuing of parts, materials, or equipment.

The following is taken from DOE G 433.1-1.

Parts, materials, or equipment removed from storage should receive the same care they received when placed into storage. A method should be established to control parts, materials, and equipment after issuance to ensure use in the correct application and to maintain the necessary traceability.

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

A system should exist to ensure that items are identified and stored to facilitate ready retrieval upon approved request. Items should be selectively and judiciously controlled, on the basis of their risk to safety and/or importance to reliable operations, during the interval between stores issue and installation to ensure intended traceability and/or integrity is not violated before installation.

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

f. Discuss S/CI concerns and safety impacts.

See item n of competency 1.

g. Discuss the requirements to specify material inspection and verification.

The following is taken from DOE G 414.1-3.

Item/part number verification and review of certification documentation alone are not sufficient to verify the quality of purchased items. Engineering attributes and QA criteria should also be specified and verified. Consideration should be given to the following:

- history of S/CI concerns with the item;
- intended safety function of the item;
- attributes required to perform the function;
- processes that impart these attributes;
- supplier past performance information;
- source inspection, surveillance, assessments, or QA audit results;
- receipt inspection and acceptance testing results;
- special test and examination methods (e.g., chemical analysis, hardness and tensile testing);
- post-installation testing.

Onsite stores and inventories should be periodically inspected to assure S/CIs are not present.

Large lots of received items may be sampled using the criteria of ANSI/ASQ Z1.4 – 2008, *Sampling Procedures and Tables for Inspection by Attributes*. If S/CIs are discovered during inspection or sampling, the nonconforming lot should be controlled and dispositioned in accordance with site procedures. Items exhibiting S/CI characteristics should be presumed to be defective and should be rejected and processed through site nonconformance and S/CI procedures. S/CIs, including those items lacking appropriate documentation, should be identified, documented, controlled, dispositioned, and reported as early as possible in the inspection process.

Items should be inspected by personnel who are trained to recognize S/CIs. Observations that a product appears to be an S/CI should be documented in accordance with applicable nonconformance procedures during the inspection process. Items confirmed as S/CIs should be documented, reported and controlled in accordance with applicable procedures. S/CIs should not be returned to the supplier. If a suspect item is found to be acceptable (through engineering evaluation, verification testing, or the disposition process), the item may be installed or used.

Verification testing may be conducted on a sampling basis, either at the purchaser's facility or at a qualified independent test laboratory. Purchased equipment that is found at any time to contain S/CIs should be withheld from installation or use pending engineering evaluation. If the evaluation determines that the S/CI has the potential to adversely affect the safe performance of the equipment, the S/CI should be replaced at the supplier's expense and the manufacturer notified. If it is determined (through engineering evaluation, verification, or disposition process) that the item conforms to specified requirements and will not create a potential safety hazard, the item may be installed or used.

When the design specifies the use of commercial-grade items in safety systems, ensure that the item will perform the intended function and will meet design requirements applicable both to the replaced item and its application. The acceptance process used by the purchaser to provide sufficient confidence that the items meet specified requirements should include inspections, tests, or analysis by the purchaser or third-party dedicating entity after delivery, supplemented as necessary by one of the following:

- commercial grade surveys;
- product inspections or witness at hold points at the manufacturer's facility;
- analysis of historical records for acceptable performance;
- documentation, as applicable to the item, that it was received and is acceptable.

h. Describe field inspection techniques available to verify the adequacy of parts.

The following is taken from DOE Guide 414.1-2A.

The qualified supplier's performance should be evaluated periodically during the life of the contract to confirm its continuing capabilities. Suppliers should be monitored to ensure that acceptable items or services are produced and schedule requirements are being met. Supplier monitoring of the work process should be performed to ensure conformance to those requirements that cannot be readily determined by inspection or test of the product. Monitoring may include:

- surveillance of work activities;
- inspection of facilities and processes;
- review of plans and progress reports;
- surveillance of manufacturing processes and methods;
- processing and use of change information;
- review of internal assessments;
- review and disposition of nonconformances; and
- selection, qualification, and performance monitoring of sub-tier suppliers.

Inspections should include verification that specified documentation has been provided by the supplier and that items were not damaged during shipment. Inspection may include the following methods:

- inspections of materials or equipment at the supplier's plant,
- receipt inspection of the shipped items,
- review of objective evidence such as certifications and reports, and
- verification or testing of items before or following shipment.

Supplier-generated documents should be accepted through the procurement system and controlled and processed by the end-user organization. These documents may include certificates of conformance, drawings, analyses, test reports, maintenance data, nonconformance documentation, corrective actions, approved changes, waivers, and deviations.

11. Facility maintenance management personnel shall demonstrate a working-level knowledge of the requirements of maintenance tools and equipment control.

a. Discuss the criteria of a program for the development of new or special tools and equipment.

See item m of competency 1.

b. Discuss the guidelines for storing and issuing maintenance tools and equipment.

See item k of competency 1.

c. Discuss the guidelines for tool and equipment maintenance.

The following is taken from DOE G 433.1-1.

Maintenance tools and other support equipment should be included in the PM program. Inclusion in the PM program enhances the availability and reliability of equipment such as cranes, portable lifting and rigging equipment, welding machines, weld rod ovens, shop machinery, and M&TE. Worn, defective, or otherwise unusable tools should be segregated so that only safe, usable tools are available. Unrepairable tools should be disposed of in a timely manner.

The following items, as a minimum, should be included in the tool and equipment maintenance process:

- Regular-issue hand tools should be checked by the user to ensure safe, reliable use.
- A recall system should be established for the periodic inspection of welding, lifting, hoisting, and rigging equipment, as well as for safety devices and personnel safety equipment. The recall system should also provide for scheduled equipment and tool inspection (including some portable hand tools such as electrical drill motors) on the basis of risk to safety and importance to reliable use.
- When worn or defective items are identified, a method should be established to remove them from service and to segregate them from normal items to prevent unsafe use.

- Unrepairable tools and equipment should be disposed of as soon as practical.
- The system should provide for repair/replace decisions based upon established guidelines for worn/damaged/defective tools and equipment.
- Instructions should be developed which define responsibilities regarding deficiency-tagged equipment.

12. Facility maintenance management personnel shall demonstrate a working-level knowledge of the requirements for facility condition inspections.

The information for all KSA items in this competency is taken from DOE G 433.1-1.

a. Explain the purpose of a facility condition and housekeeping program.

Management should conduct periodic inspections of safety equipment and facilities to ensure excellent facility condition and housekeeping. The condition of a facility depends on many factors, including design, fabrication, modifications, ongoing maintenance, facility work control programs, and day-to-day operation.

The appearance and proper functioning of facility systems and equipment are key indicators of a well-maintained and -operated facility. Good facility condition, cleanliness, and housekeeping can be established and maintained by knowledgeable individuals who are alert to onsite deficiencies and who take prompt corrective action. Additionally, there should be a periodic, focused inspection effort, by thoroughly trained personnel, to assist in effective identification and correction of facility deficiencies.

The maintenance of systems and equipment within design conditions produces such benefits as minimizing fluid leakage, minimizing control room alarms caused by malfunctioning equipment, and maintaining environmental integrity of equipment. Providing easier access for operations and maintenance activities by reducing the sources and spread of radioactive contamination constitutes another benefit of good facility condition and housekeeping.

b. Discuss the elements of an effective inspection program.

The following elements should be included in the inspection program:

- Facility managers should set high facility condition and housekeeping standards and communicate them to all personnel to promote a clear understanding of these standards.
- Appropriate personnel should receive training in inspection techniques.
- Facility managers and supervisors should personally participate in inspections.
- Inspection areas should be assigned to ensure that the entire facility is periodically inspected, including areas with difficult access (e.g., high-radiation areas and locked areas).
- An inspection coordinator should be assigned to implement, schedule, and monitor the effectiveness of the inspection program.
- Deficiencies identified should be reported and corrected promptly, thus allowing personnel to see the positive results of the inspection program.
- A condition assessment survey with assigned risk assessment code could be used to prioritize schedules for repair.

- Instructions could be prepared to establish the program and define responsibilities for conducting inspections, correcting deficiencies, and accomplishing other tasks associated with the program, such as on-the-spot correction of minor deficiencies. What are considered minor deficiencies, who is allowed to correct them, and the limitations and documentation associated with this type of work should be clearly defined.
- Inspection guidelines and criteria could be prepared to assist the assigned inspectors in performing their inspections.

c. Describe indicators of good facility conditions and housekeeping standards.

Setting standards involves management establishing an atmosphere of proper work ethics; positive attitudes; and specific expectations that are realistic, that are within the capabilities of the staff, and that are consistent with sound engineering judgment and good economic practice. Standards must be communicated effectively to all personnel so that they are clearly understood. Facility managers and supervisors should conduct routine inspections to assess adherence to these standards. Indicators of good facility condition and housekeeping standards include the following:

- Rotating equipment operates in accordance with design specifications (e.g., bearing temperatures normal, vibration levels normal, and shaft seal leakage limited to that required to cool and lubricate the shaft seals).
- Equipment is properly serviced (e.g., lubrication, drive belts, and filters).
- Fluid system integrity is maintained (e.g., leaks that can be corrected during operation are promptly repaired; leakage that cannot be repaired under existing conditions is collected and routed to appropriate drains or collection facilities, particularly if the leakage could cause a further degradation of equipment, present a safety hazard, or cause the spread of radioactive contamination).
- Temporary repairs are recorded and controlled by the facility temporary modification program. Permanent repairs are scheduled when facility conditions permit.
- Instruments and gauges are operational, calibrated, on scale, and indicate values representative of the existing system and equipment conditions.
- Energized electrical and electronic equipment is operative, supplied from normal power sources, and protected from adverse environmental effects such as leaks and overheating.
- Protective cabinet doors and electrical enclosure covers are installed to maintain design integrity (e.g., all fasteners installed and tightened, filters clean).
- Equipment and systems are insulated to control heat transfer to or from the environment, to control ambient noise levels, and to promote personnel safety.
- Facility equipment and systems subject to corrosion are protected with a preservative to minimize corrosion.
- Temporary environmental protection is provided, where appropriate.
- Industrial safety and radiological hazards are minimized (e.g., chemicals, oils, and solvents properly stored; fire barriers maintained; trip hazards nonexistent; radiological postings current and in place; radiological barriers and step-off pads properly established; and sources of contamination identified).
- Walkway and equipment access is maintained.
- Equipment is clean (i.e., dirt, debris, tools, parts, and miscellaneous materials are not allowed to accumulate on equipment or inside electrical panels).

- Station areas, rooms, and grounds, including the storage areas for needed tools and materials, are maintained in a clean and orderly condition.
- Coatings or coverings used to seal walls and floors in potentially contaminated areas are in good condition and assist in controlling contamination.
- No unauthorized modifications or changes to the facility exist.
- Illumination of areas, rooms, and grounds is maintained in a manner that provides sufficient light to perform inspections and minor maintenance.

d. Discuss the elements of an effective procedure addressing facility condition inspections.

Administrative procedures that describe the inspection program should define expected standards, provide for documentation of deficiencies, provide a means to follow up on deficiency corrective actions, assign responsibilities for program implementation, and establish a means to measure program effectiveness. Implementation procedures for facility inspection could be incorporated into the PM or surveillance program in a manner similar to other visual inspections, such as housekeeping inspections. Deficiencies identified during the inspection should be documented by the inspector (e.g., by initiation of a maintenance request or by use of an area inspection report). Checklists of equipment to be inspected and types of problems to look for could be useful as guides for inspectors.

e. Describe the importance of training personnel in inspection techniques.

Personnel involved in inspections should be knowledgeable of the standards expected by laboratory requirements and the techniques required to perform facility condition inspections. In addition, all personnel should be aware of the importance of good housekeeping and maintaining the facility in good condition. An effective method of imparting expected standards is for the facility manager to conduct some inspections with selected individuals.

f. Describe the elements of routine inspections.

Routine inspection programs should include the following elements:
- inspection areas small enough to be thoroughly inspected within the time allotted;
- each facility area scheduled for periodic inspection;
- periodical rotation of inspectors to avoid familiarity with an inspection area, which can hinder deficiency identification.

g. Discuss the requirements for reporting deficiencies and deficiency follow-up.

The inspection coordinator should provide blank inspection report forms to inspectors. Inspectors should submit an inspection report to the inspection coordinator within 3 working days of each inspection.

For some deficiencies, on-the-spot corrections may be possible. In those cases, corrective action should be initiated at the time of the inspection and noted on the report. Significant deficiencies in facility condition and safety should be reported immediately to the shift supervisor for appropriate near-term attention and so noted on the report.

Once a deficiency is identified, the inspector should look closer and attempt to determine the source or cause, how long it has existed, and whether it has been previously identified.

The inspection coordinator should forward copies of each inspection report to the appropriate department managers for corrective actions. He/she should maintain the original inspection reports on file for tracking and evaluating program effectiveness. He/she should periodically review his/her files to identify repetitive problems and trend progress.

Department managers should note on the inspection report the corrective actions planned and conducted for each deficiency under their responsibility and return the inspection report to the inspection coordinator to clear deficiencies on file.

The inspection coordinator should keep the owner/operator informed of program progress. This may be done by written report or by verbal update and should include discussions of generic or specific performance deficiencies, as well as particularly good areas.

13. Facility maintenance management personnel shall demonstrate a working-level knowledge of the requirements for management involvement.

The information for all KSA items in this competency is taken from DOE G 433.1-1.

a. Discuss the importance of management's involvement in maintenance.

To ensure the safety of DOE facility operations, DOE and contractor corporate and facility managers should be technically informed and personally familiar with conditions at the operating facility. Responsible DOE and contractor corporate managers should visit the facility, including visiting at irregular hours; assess selected activities and portions of the facility; and leave a written record of their observations. Additionally, DOE, contractor corporate, and facility managers should periodically review the maintenance programs to verify that they are effectively accomplishing their intended objectives and are upgraded as needed.

Managers should include time in their schedules for walking through the facility. This time should be directed at improving face-to-face communications and feedback at all levels of the maintenance organization. Maintenance management should establish the percentage of time that first-line supervisors are expected to spend supervising fieldwork.

b. Discuss the role and responsibilities of maintenance managers.

Rules, responsibilities and accountability between DOE and contractor and facility managers should be clearly delineated and communicated to all levels of the maintenance organization. DOE managers should be responsible and accountable for the management and maintenance of DOE assets in accordance with federal regulations, DOE directives, and contractual agreements. DOE contractors should be responsible for the operation, management, and maintenance of DOE nuclear facilities in accordance with commitments and agreements for satisfactory deliverables under the contract.

c. Discuss the guidelines for management involvement, objective results, and feedback in relation to a maintenance program.

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 progress and feedback reviews. 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.

A well-structured formal quality management program should be developed within the maintenance organization. Various councils, task analysis teams, and engineering and technical support groups should continually review:

- significant program elements to determine and recommend opportunities for maintenance program improvement,
- critical work in progress,
- system and procedure applicability,
- real-time and history data,
- root-cause resolution,
- activity intervals and acceptance criteria,
- value-added new technology for acquisition potential,
- project status,
- nonfacility maintenance personnel performance, and
- site planning.

Meetings with affected individuals/groups should be conducted on a regular schedule to provide for sharing information through interrogative/interactive participation. Reported accomplishments should be tracked and regularly evaluated for trends (both positive and negative) which provide timely visibility and opportunity for informed knowledge-based management decisions leading to continued improvement. Trends (both positive and negative) should be analyzed for root-cause determination. Action plans to correct deficiencies and reverse negative trends should be implemented, when appropriate. Positive indicators should be evaluated for stability, reliability, and the potential for broader application.

d. Discuss the elements of a maintenance program evaluation.

Inspections, audits, reviews, investigations, and self-assessments are necessary parts of an effective maintenance program. Senior managers should periodically review and assess elements of the maintenance program. These assessments can assist line managers and supervisors in the identification and correction of program deficiencies. An evaluation of each maintenance program element should be conducted at least every other year and should include inputs from maintenance managers and supervisors and other groups, such as operations, technical staff, and appropriate corporate departments. This evaluation should address the overall effectiveness of the program element. It should also address interorganizational and intraorganizational coordination problems that create work delays

and reduce productivity. Areas needing improvements should be assigned for corrective action and follow-up.

Examples of program elements to be considered in this evaluation include:

- facility condition and worker practices during maintenance,
- maintenance training,
- procurement activities, and
- M&TE.

14. Facility maintenance management personnel shall demonstrate a working-level knowledge of the requirements of maintenance history and configuration control.

The information for all KSA items in this competency is taken from DOE G 433.1-1.

a. Discuss the importance of maintaining a maintenance history.

A maintenance history and trending program should be maintained to document data, provide historical information for maintenance planning, and support maintenance and performance trending of facility systems and components.

The documentation of complete, detailed, and usable history will be increasingly important as plant-life extension becomes an issue. Trending should be directed toward identifying improvements for the maintenance program and needed equipment modifications.

b. Describe the guidelines for the following elements of a maintenance history program development:

- **Equipment identification**
- **Data identification**

Equipment Identification

The maintenance history program should clearly define the safety systems and equipment that require documentation and retention of historical data according to the MEL for which maintenance provides support. In addition, non-safety equipment requiring repeated maintenance should be considered for inclusion. The MEL can provide much of the information for the system. Alternatively, if the MEL is computerized, the history files should be cross-referenced to it.

Data Identification

The maintenance history program should define the type of data that should be collected and recorded to support the use of the program effectively. Some examples of data that should be included or cross-referenced in the program are:

- corrective maintenance records;
- appropriate PM records;
- modification packages;
- vendor repair information (e.g., correspondence on component repairs and modification bulletins);
- start-up tests and other baseline data;
- appropriate surveillance test data;

- calibration data; and
- applicable industry experience information.

The specific data to be collected should include:

- details of the work performed,
- special equipment and tools used,
- procedures or drawings needed,
- spare parts installed,
- personnel safety and radiation protection requirements,
- PMT results, and
- any other information that may be useful later.

c. Describe the guidelines for data collection.

Data on systems and equipment selected for history retention should be sent to the person or group responsible for maintenance history retention and should then be entered in the maintenance history program. Any apparent errors, inconsistencies, or lack of detail should be referred to the maintenance supervisor or another appropriate supervisor for resolution.

d. Discuss common uses of a maintenance history.

The following are common uses of maintenance history data:

- failure analysis (providing some of the data needed to support analyzing and trending failures);
- maintenance assessments (providing input to identify rework and/or maintenance program improvements);
- PM (providing some of the data useful for identifying and justifying PM program changes);
- outage planning (providing some of the data useful for post-outage evaluation and as a basis for planning the next outage);
- PMT planning and execution;
- ALARA program (providing work-time data useful for radiological exposure evaluation and planning);
- budget preparation (providing input for determining future maintenance needs);
- review of industry experience, vendor information, and other documents (to assess plant-specific applicability); and
- plant-life extension (providing some of the data needed to support extension of plant design life).

e. Describe configuration control and its relationship to the maintenance work control process and the maintenance history file.

Management should ensure that plant configuration, including the manner in which the facility is maintained, conforms to the established design basis requirements. Many routine activities, if carried out improperly, can have an adverse impact on facility configuration and cause eventual equipment damage or increase the probability or consequences of a significant event.

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 reviewing WRs after the completion of maintenance to verify that the activity was satisfactorily completed in accordance with facility procedures and standards and to capture maintenance history data.

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

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

f. Discuss the process by which new equipment is incorporated into maintenance history.

In the event a component is replaced or modified, the original record should be annotated to indicate the change and retained in the file. A new record, referencing the original record, is prepared and placed in the file.

For new equipment, baseline data should be obtained to verify correction of problems or to establish new reference points.

The maintenance history file for each component should include the following four sections:

- component identification and description,
- maintenance record,
- diagnostic monitoring data, and
- vendor correspondence.

15. Facility maintenance management personnel shall demonstrate a familiarity-level knowledge of the principles and concepts of natural phenomena hazards and their effect on systems and structures.

a. Discuss the potential impact on systems and structures at defense nuclear facilities from the following natural hazards:

- **Flooding**
- **Wind**
- **Tornado**
- **Earthquake and/or other seismic events**
- **Fire**
- **Lightning**

Flooding

The following is taken from DOE-STD-1020-2002.

Impact on Facilities

In many ways, flood hazards differ significantly from other natural phenomena. As an example, it is often relatively easy to eliminate flood hazards as a potential contributor to

damage at a site through strict siting requirements. Similarly, the opportunity to use warning systems and emergency procedures effectively to limit damage and personnel injury is significantly greater in the case of flooding than it is for seismic or extreme winds and tornadoes.

The damage to buildings and the threat to public health vary depending on the type of flood hazard. In general, structural and nonstructural damage occur if a site is inundated. Depending on the dynamic intensity of onsite flooding, severe structural damage and complete destruction of buildings can result. In many cases, structural failure may be less of a concern than the damaging effects of inundation on building contents and the possible transport of hazardous or radioactive materials.

For hazardous facilities that are not hardened against possible onsite and in-building flooding, simply inundating the site can result in a loss of function of critical components required to maintain safety and breach of areas that contain valuable or hazardous materials.

Structural damage to buildings depends on a number of factors related to the intensity of the flood hazard and the local hydraulics of the site. Severe structural damage and collapse can occur as a result of a combination of hazards such as flood stage level, flow velocity, debris or sediment transport, wave forces, and impact loads. Flood stage is quite obviously the single most important characteristic of the hazard.

In general, the consequences of flooding increases as flooding varies from submergence to rapidly moving water loaded with debris. Submergence results in water damage to a building and its contents, loss of operation of electrical components, and possible structural damage resulting from hydrostatic loads. Structural failure of roof systems can occur when drains become clogged or are inadequate, and parapet walls allow water, snow, or ice to collect. Also, exterior walls of reinforced concrete or masonry buildings can crack and possibly fail under hydrostatic conditions.

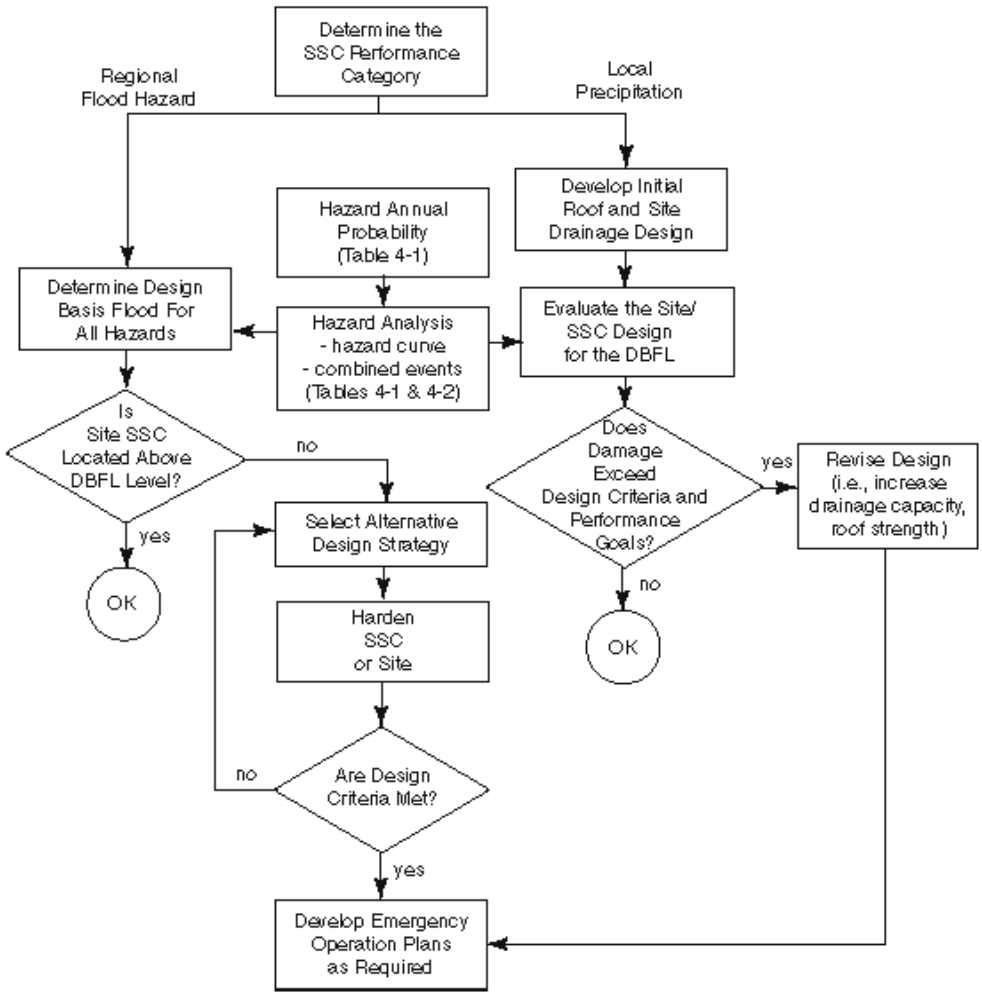
Dynamic flood hazards can cause excessive damage to structures that are not properly designed. Where wave action is likely, erosion of shorelines or river banks can occur. Structures located near the shore are subject to continuous dynamic forces that can break up a reinforced concrete structure and at the same time undermine the foundation. Buildings with light steel frames and metal siding, wooden structures, and unreinforced masonry are susceptible to severe damage and even collapse if they are exposed to direct dynamic forces. Reinforced concrete buildings are less likely to suffer severe damage or collapse.

Mitigating Factors

As part of the flood hazard assessment that is performed for a site, the sources of flooding and the individual flood hazards are identified. A site or individual SSC may be impacted by multiple sources of flooding and flood hazards. For example, many DOE sites must consider the hazards associated with river flooding. In addition, all sites must design a storm water management system to handle the runoff due to local precipitation. Events that contribute to potential river flooding such as spring snowmelt, upstream-dam failure, etc. must be considered as part of a probabilistic flood hazard analysis.

Therefore, at a site there may be multiple design basis floods (DBFLs) that are considered. For sites with potential for river flooding a DBFL is determined for river flooding and for local precipitation which determines the design of the site stormwater management systems. In this instance, various aspects of the design for an SSC may be determined by different flood hazards. As a result, the term DBFL is used in a general sense that applies to the multiple flood hazards that may be included in the design basis.

The flood evaluation process is illustrated in figure 1. It is divided into the consideration of regional flood hazards and local precipitation. For new construction, design practice is to construct the SSC above the DBFL, thus avoiding the flood hazard and eliminating the consideration of flood loads as part of the design. The design of the site storm water management system and structural systems for local precipitation must be adequate to prevent flooding that may damage an SSC or interrupt operations to the extent that the performance goals are not satisfied.



Source: DOE-STD-1020-2002

Figure 1. Flood evaluation process

The basic design strategy for SSCs in performance categories 2 to 4 is to construct the SSC above the DBFL. When this can be done, flood hazards are not considered in the design basis except that possible raised ground water level must be considered. The flood criteria have been established with this basic strategy in mind. Note that local precipitation is an exception since all sites must consider this hazard in the design of the site storm water management system, roof systems, etc.

Since it may not always be possible to construct a new SSC above the DBFL level, alternate design strategies must be considered. The following lists the hierarchy of flood design strategies:

- situate the SSC above the DBFL level,
- modify the flood, or
- harden the site or SSC to mitigate the effects of the DBFL such that the performance goals are satisfied, and
- establish emergency operation plans to safely evacuate employees and secure areas with hazardous, mission-dependent, or valuable materials.

Wind

The following is taken from DOE-STD-1020-2002.

Impact on Facilities

Wind pressures on structures can be classified as external or internal. External pressures develop as air flows over and around enclosed structures. The air particles change speed and direction, which produces a variation of pressure on the external surfaces of the structure. At sharp edges, the air particles separate from contact with the building surface, with an attendant energy loss. These particles produce large outward-acting pressures near the location where the separation takes place. External pressures act outward on all surfaces of an enclosed structure, except on windward walls and on steep windward roofs. External pressures include pressures on windward walls, leeward walls, side walls and roof.

Internal pressures develop when air flows into or out of an enclosed structure through existing openings or openings created by airborne missiles. In some cases natural porosity of the structure also allows air to flow into or out of the building. Internal pressure acts either inward or outward, depending on the location of the opening and the wind direction. If air flows into the structure through an opening in the windward wall, a ballooning effect takes place—pressure inside the building increases relative to the outside pressure. The pressure change produces additional net outward-acting pressures on all interior surfaces. Openings in any wall or roof area where the external pressures are outward acting allow air to flow from inside the structure—pressure inside the structure decreases relative to the outside pressure. The pressure change produces net inward-acting pressure on all interior surfaces. Internal pressures combine with external pressures acting on a structure's surface.

With systems and components, interest focuses on net overturning or sliding forces, rather than the wind pressure distribution. The magnitude of these forces is determined by wind tunnel or full-scale tests. Also, in special cases associated with aerodynamically sensitive SSCs, vortex shedding or flutter may need to be considered in design. Typical wind sensitive

SSCs include stacks, poles, cooling towers, utility bridges, and relatively light-weight structures with large smooth surfaces.

Gusts of wind produce dynamic pressures on SSCs. Gust effects depend on the gust size relative to SSC size and gust frequency relative to the natural frequency of the SSC. Except for tall, slender structures, the gust frequencies and the structure frequencies of vibration are sufficiently different that resonance effects are small, but are not negligible. The size of a gust relative to the size of the SSC contributes to the magnitude of the dynamic pressure. A large gust that engulfs the entire SSC has a greater dynamic effect on the SSC than a small gust that only partially covers the SSC. In any event, wind loads may be treated as quasi-static loads by including an appropriate gust response factor in calculating the magnitude of the wind pressure. Straight wind, hurricane or tornado gusts are not exactly the same, but errors owing to the difference in gust characteristics are believed to be relatively small for those SSCs that are not wind sensitive.

The roughness of terrain surrounding SSCs significantly affects the magnitude of wind speed. Terrain roughness is typically defined in four classes: urban, suburban, open and smooth. Wind speed profiles as a function of height above ground are represented by a power law relationship for engineering purposes. The relationship gives zero wind speed at ground level. The wind speed increases with height to the top of the boundary layer, where the wind speed remains constant with height.

Mitigating Factors

The minimum wind design criteria for each performance category are summarized in table 1. The recommended basic wind speeds for straight wind, hurricanes and tornadoes are contained in table 2 for non-reactor nuclear and other hazardous facilities, reservations, and production facilities. All wind speeds are 3-second gusts, which is consistent with the American Society of Civil Engineers, ASCE 7 approach. Importance factors as given in ASCE 7 should be used where applicable.

Table 1. Summary of minimum wind design criteria

	Performance Category	1	2	3	4
Wind	Hazard Annual Probability Of Exceedance	$2x10^{-2}$	$1x10^{-2}$	$1x10^{-3}$	$1x10^{-4}$
	Importance Factor	1.0	1.00	1.0	1.0
	Missile Criteria	NA	NA	2x4 timber plank 15 lb @50 mph (horiz.); max. height 30 ft.	2x4 timber plank 15 lb @50 mph (horiz.); max. height 50 ft.
Tornado	Hazard Annual Probability of Exceedance	NA	NA	(1) $2x10^{-5}$	(1) $2x10^{-6}$
	Importance Factor	NA	NA	I = 1.0	I = 1.0
	APC	NA	NA	40 psf @ 20 psf/sec	125 psf @ 50 psf/sec
	Missile Criteria	NA	NA	2x4 timber plank 15 lb @100 mph (horiz.); max. height 150 ft.; 70 mph (vert.) 3 in. dia. std. steel pipe, 75 lb @ 50 mph (horiz.); max. height 75 ft, 35 mph (vert.)	2x4 timber plank 15 lb @150 mph (horiz.), max. height 200 ft.; 100 mph (vert.) 3 in. dia. std. steel pipe, 75 lb @ 75 mph (horiz.); max. height 100 ft, 50 mph (vert.) 3,000 lb automobile @ 25 mph, rolls and tumbles

Source: DOE-STD-1020-2002

Degrees of conservatism are introduced in the design process by means of load combinations. The combinations are given in the appropriate material national consensus design standard. Designers will need to exercise judgment in choosing the most appropriate combinations in some situations. Designs or evaluations shall be based on the load combination causing the most unfavorable effect. For performance category 3 and 4, the load combination to be used should invoke either wind or tornado, depending on which speed is specified in table 2.

Table 2. Recommended peak gust wind speeds for straight winds and tornadoes

Current Performance Category	PC1	PC2	PC3 Wind	PC3 Tornado(2)	PC4 Wind	PC4 Tornado(2)
Return period (yrs)	50	100	1000	50000	10000	500000
Annual Probability	2.00E-02	1.00E-02	1.00E-03	2.00E-05	1.00E-4	2.00E-06
Site						
Kansas City Plant, MO	90	96	-	(3)	-	(3)
Los Alamos National Laboratory, NM	90	96	117	-	135	-
Mound Laboratory, OH	90	96	-	(3)	-	(3)
Pantex Plant, TX	90	96	-	195	-	248
Rocky Flats Plant, CO	125	134	163	(1)	188	(1)
Sandia National Laboratories, NM	90	96	117	-	135	-
Sandia National Laboratories, CA	85	91	111	-	128	-
Argonne National Laboratories-East, IL	90	96	-	(3)	-	(3)
Argonne National Laboratories-West, ID	90	96	117	-	135	-
Brookhaven National Laboratory, NY	125	138	178	(1)	219	(1)
Princeton Plasma Physics Laboratory, NJ	110	122	156	(1)	193	(1)
Idaho National Engineering Laboratory , ID	90	96	117	-	135	-
Oak Ridge, X-10, K-25, and Y-12, TN	90	96	-	200	-	255
Paducah Gaseous Diffusion Plant, KY	90	96	-	(3)	-	(3)
Portsmouth Gaseous Diffusion Plant, OH	90	96	-	(3)	-	(3)
Nevada Test Site, NV	90	96	117	-	135	-
Hanford Project Site, WA	85	91	111	-	128	-
Lawrence Berkeley Laboratory, CA	85	91	111	-	128	-
Lawrence Livermore National Laboratory, CA	85	91	111	-	128	-
LLNL, Site 300, CA	95	102	124	-	143	-
Energy Technology & Engineering Center, CA	85	91	-	(3)	-	(3)
Stanford Linear Accelerator Center, CA	85	91	111		128	-
Savannah River Site, SC	100	107	-	169	-	213

Source: DOE-STD-1020-2002

Most loads, other than dead loads, vary significantly with time. When these variable loads are combined with dead loads, their combined effect could be sufficient to reduce the risk of unsatisfactory performance to an acceptably low level. When more than one variable load is considered, it is unlikely that they will all attain their maximum value at the same time.

Accordingly, some reduction in the total of the combined load effects is appropriate. This reduction is accomplished through load combination multiplication factors as given in the appropriate material national consensus standard.

Tornado

The following is taken from DOE-STD-1020-2002.

Impacts on Facilities

In addition to wind effects, tornadoes produce atmospheric pressure change (APC) effects and missile impacts from windborne debris (tornado-generated missiles). APC only affects sealed structures. Natural porosity, openings or breach of the structure envelope permit the inside and outside pressures of an unsealed structure to equalize. Openings of one sq ft per 1000 cu ft volume are sufficiently large to permit equalization of inside and outside pressure as a tornado passes. SSCs that are purposely sealed will experience the net pressure

difference caused by APC. APC, when present, acts outwardly and combines with external wind pressures. The magnitude of APC is a function of the tangential wind speed of the tornado. However, the maximum tornado wind speed and the maximum APC do not occur at the same location within the tornado vortex. The lowest APC occurs at the center of the tornado vortex, whereas the maximum wind pressure occurs at the radius of maximum wind, which ranges from 150 to 500 ft from the tornado center.

The APC is approximately one-half its maximum value at the radius of maximum wind speed. With APC acting on a sealed building, internal pressure need not be considered. The rate of APC is a function of the tornado's translational speed, which can vary from 5 to 60 miles per hour (mph). A rapid rate of pressure change can produce adverse effects on heating, ventilation, and air-conditioning systems.

High winds and tornadoes pick up and transport various pieces of debris, including roof gravel, pieces of sheet metal, timber planks, plastic pipes and other objects that have high surface area to weight ratios. These objects can be carried to heights up to 200 feet in strong tornadoes.

Steel pipes, posts, light-weight beam sections and open web steel joists having smaller area-to-weight ratios are transported by tornado winds, but occur less frequently and normally do not reach heights above 100 feet. Automobiles, storage tanks, and railroad cars may be rolled and tumbled by severe tornado winds. In extremely rare instances, large-diameter pipes, steel wide flange sections and utility poles are transported by very intense tornado winds. These latter missiles are so rare that practicality precludes concern except for SSCs having lower probabilistic performance goals than performance category 4, which are comparable to SSCs found in commercial nuclear power plants.

Effects on Structures, Systems, and Components

A structure is an element or collection of elements that provide support or enclosure of space, e.g., a building. The walls and roof make up the envelope of a structure. Wind pressures develop on the surfaces of a building envelope and produce loads on the support structure, which, in turn, transmits the loads to the foundation. The support structure also must carry dead, live, and other environmental loads.

Element failure is quite rare. More frequently the element connections are the source of failure. A properly conceived wind-force resisting structure should not fail as a result of the failure of a single element or element connection. A multiple degree of redundancy should be provided in a ductile structure that allows redistribution of load when one element or connection of the structure is overloaded. Ductility allows the structure to undergo large deformations without sudden and catastrophic collapse. The structure also must have sufficient strength and stiffness to resist the applied loads without unacceptable deflection or collapse.

Cladding forms the surface of the structure envelope. Cladding includes the materials that cover the walls and roof of a structure. Cladding failure results in a breach of the structure envelope. A breach develops because the cladding itself fails (excessive yielding or fracture); the connections or anchorages are inadequate; or the cladding is perforated by windborne missiles. Cladding is sometimes relied upon to provide lateral support for purlins, girts or

columns. Cladding may be an integral part of shear wall construction. If the cladding or its anchorage fails, this lateral support is lost, leaving the elements with a reduced load-carrying capacity.

Most cladding failures result from failure of the fasteners or the material in the vicinity of the fastener. Cladding failures initiate at locations of high local wind pressures such as wall corners, eaves, ridges, and roof corners. Wind tunnel studies and damage investigations reveal that local pressures can be one to five times larger than overall external pressures.

Breach of structure envelope resulting from cladding failure allows air to flow into or out of the building, depending on where the breach occurs. The resulting internal pressures combine with the external pressures, both overall and local, to produce a worse loading condition. If the structure envelope is breached on two sides of the building, e.g., the windward and leeward walls, a channel of air can flow through the building from one opening to the other.

The speed of flowing air is related to the wind speed outside the building. A high-speed air flow (greater than 40 mph) could collapse interior partitions, pick up small pieces of equipment or transport unconfined toxic or radioactive materials to the environment. A breach can also lead to water damage due to rain.

Systems, consisting primarily of piping, utilities, and distribution configurations, are more susceptible to wind damage when located outdoors. Electrical lines, transformers, overhead pipe bridges, steam lines, and storage tanks are examples of wind-vulnerable systems. Net wind forces are calculated for each element of the system. Channeling and shielding may be a factor in complex facilities. Windborne missiles also pose a threat to systems. Collapse or failure of less vulnerable SSCs could cause damage to more critical ones.

Components, consisting primarily of equipment such as fans, pumps, and switch gear, are less vulnerable to wind than earthquake forces, but can be damaged if exposed to flying debris.

Mitigating Factors

For those sites requiring design for tornadoes, the criteria are based on site-specific studies. An annual exceedance probability of $1x10^{-3}$, which is the same for straight wind, could be justified. A lower value is preferred because the straight wind hazard curve gives wind speeds larger than the tornado hazard curve and a lower hazard probability can be specified without placing undue hardship on the design. The basic tornado wind speed associated with an annual exceedance probability of $2x10^{-5}$ is recommended for performance category 3.

The wind speed obtained from the tornado hazard curve is already converted from peak gust to fastest quarter-mile. Use an importance factor of 1.0 for performance category 3. For the use in DOE-STD-1020-2002, *DOE Standard: Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities*, fastest quarter-mile and 3-second gusts are deemed to be equivalent for all practical purposes.

With the wind speed given in fastest quarter-mile wind and an importance factor of 1.0, the equations in ASCE 7 should be used to obtain design wind pressures on SSCs. Exposure category C should always be used with tornado winds regardless of the actual terrain

roughness. Non-conservative results will be obtained with exposure B. Tornadoes traveling over large bodies of water are waterspouts, which are less intense than land-based tornadoes. Thus, use of exposure category D also is not necessary. The velocity pressure exposure coefficient and gust effect factor are obtained from ASCE 7. External pressure coefficients are used to obtain tornado wind pressures on various surfaces of structures. Net pressure coefficients are applicable to systems and components. On structures, a distinction is made between main wind-force resisting systems and components and cladding.

If a structure is not intentionally sealed to maintain an internal negative pressure for confinement of hazardous materials, or, if openings greater than one square foot per 1000 cubic feet of volume are present, or, if openings of this size can be caused by missile perforation, then the effects of internal pressure should be considered according to the rules of ASCE 7. If a structure is sealed, then APC associated with the tornado vortex should be considered instead of internal pressures.

The maximum APC pressure occurs at the center of the tornado vortex where the wind speed is theoretically zero. A more severe loading condition occurs at the radius of maximum tornado wind speed, which is some distance from the vortex center. At the radius of maximum wind speed, the APC may be one-half its maximum value. Thus, a critical tornado load combination on a sealed building is one-half maximum APC pressure combined with maximum tornado wind pressure. A loading condition of APC alone can occur on the roof of a buried tank or sand filter, if the roof is exposed at the ground surface. APC pressure always acts outward. A rapid rate of pressure change, which can accompany a rapidly translating tornado, should be analyzed to assure that it does not damage safety-related ventilation systems. Procedures and computer codes are available for such analyses.

When using allowable stress design methods, allowable stresses appropriate for the materials shall be used.

Since in this case, the hazard probability satisfies the performance goal, little or no additional conservatism is needed in the design. Thus, for allowable stress design, the tornado wind load combinations are modified to negate the effect of safety factors.

Careful attention should be paid to the details of construction. Continuous load paths shall be maintained; redundancy shall be built into load-carrying structural systems; ductility shall be provided in elements and connections to prevent sudden and catastrophic failures.

Two tornado missiles are specified as minimum criteria for performance category 3.

A 2x4-in. timber plank weighing 15 pounds (lbs) is assumed to travel in a horizontal direction at speeds up to 100 mph. The horizontal speed is effective up to a height of 150 ft above ground level. If carried to great heights by the tornado winds, the timber plank can achieve a terminal vertical speed of 70 mph when falling to the ground. The horizontal and vertical speeds are assumed to be uncoupled and should not be combined. Table 3 describes wall and roof structures that will resist the postulated timber missile. A second missile to be considered is a 3-in. diameter standard steel pipe, which weighs 75 lbs. Design horizontal impact speed is 50 mph; terminal vertical speed is 35 mph. The horizontal speed of the steel pipe is effective up to a height of 75 feet above ground level. Table 3 summarizes certain

barrier configurations that have been successfully tested to resist the pipe missile. Although wind pressure, APC and missile impact loads can occur simultaneously, the missile impact loads can be treated independently for design and evaluation purposes. These are the minimum missile design criteria and should be reviewed for upgrading with the concurrent use of new tornado hazard assessment methodology.

Table 3. Recommended missile barriers for performance category 3

Missile Criteria	Recommended Missile Barrier
Horizontal Component: 2x4 timber plank 15 lb @ 100 mph max. height 150 ft. above ground	8-in. CMU wall with one #4 rebar grouted in each vertical cell and trussed horizontal joint reinforced @ 16 in. on center
	Single width brick veneer attached to stud wall with metal ties
	4 in. concrete slab with #3 rebar @ 6 in. on center each way in middle of slab
Vertical Component: 2x4 timber plank 15 lb @ 70 mph	4 in. concrete slab with #3 rebar @ 6 in. on center each way in middle of slab
Horizontal Component: 3-in. diameter steel pipe 75 lb @ 50 mph max. height 75 ft. above ground	12-in. CMU wall with #4 rebar in each vertical cell and grouted; #4 rebar horizontal @ 8 in. on center
	Nominal 12-in. wall consisting of 8-in. CMU with #4 rebar in each vertical cell and grouted; #4 rebar horizontal @ 8 in. on center; single width brick masonry on outside face; horizontal ties @ 16 in. on center
	9.5- in. reinforced brick cavity wall with #4 rebar @ 8 in. on center each way in the cavity; cavity filled with 2500 psi concrete; horizontal ties @ 16 in. on center
	8-in. concrete slab with #4 rebar @ 8 in. on center each way placed 1.5 in. from each face
Vertical Component: 3-in. diameter steel pipe 75 lb @ 35 mph	6-in. concrete slab with #4 rebar @ 12 in. on center each way 1.5 in. from inside face

Source: DOE-STD-1020-2002

Earthquake and/or Other Seismic Events

The following is taken from DOE-STD-1020-2002.

Impact on Facilities

For most facilities, the primary seismic hazard is earthquake ground shaking. The criteria specifically cover the design and evaluation of buildings, equipment, distribution systems, and other structures for earthquake ground shaking. Other earthquake effects that can be

devastating to facilities include differential ground motion induced by fault displacement, liquefaction, and seismic-induced slope instability and ground settlement. If these latter earthquake effects cannot be avoided in facility siting, the hazard must be eliminated by site modification or foundation design. Existing facilities located on active fault traces, adjacent to potentially unstable slopes, or on saturated, poorly compacted cohesionless soil or fill material pose serious questions as to their usage for critical missions or handling hazardous materials.

While earthquake hazards of potential fault movement or other gross soil movement are typically avoided or mitigated, the earthquake ground shaking hazard is unavoidable. When a structure or component is subjected to earthquake shaking, its foundation or support moves with the ground or with the structural element on which it rests. If the structure or equipment is rigid, it follows the motion of its foundation, and the dynamic forces acting on it are nearly equal to those associated with the base accelerations. However, if the structure is flexible, large relative movements can be induced between the structure and its base. Earthquake ground shaking consists of a short duration of time-varying motion that has significant energy content in the range of natural frequencies of many structures. Thus, for flexible structures, dynamic amplification is possible such that the motions of the structure may be significantly greater than the ground shaking motion. In order to survive these motions, the structural elements must be sufficiently strong, as well as sufficiently ductile, to resist the seismic-induced forces and deformations. The effects of earthquake shaking on structures and equipment depend not only on the earthquake motion to which they are subjected, but also on the properties of the structure or equipment. Among the more important structural properties is the ability to absorb energy (due to damping or inelastic behavior), the natural periods of vibration, and the strength or resistance.

The response of structures to earthquake ground shaking depends on the characteristics of the supporting soil. The amplitude and frequency of the response of massive, stiff structures founded or embedded in a soil media can be significantly affected by soil-structure interaction, including spatial variation of the ground motion. For structures founded on rock media, these effects are much less pronounced. The foundation media is, in effect, another structural element of the structural system and changes the natural frequencies and mode shapes. That is, the structure plus an additional foundation element may have free vibration characteristics that differ from those of the same structure on a rigid foundation and without the additional foundation element. A significant effect of soil-structure interaction is radiation of energy from the structure into the ground (radiation damping). As a result, this foundation element must represent both the stiffness and damping of the foundation media. Spatial variation of earthquake ground motion result in reduced motion at the base of a structure from that recorded by an instrument on a small pad. These reductions are due to vertical spatial variation of the ground motion (reduced motion with depth), horizontal spatial variation of the ground motion (basemat averaging effects), and wave scattering effects (modification of earthquake waves striking a rigid structure foundation).

Earthquake ground shaking generally has lateral, vertical, and rotational components. Structures are typically more vulnerable to the lateral component of seismic motion; therefore, a lateral force-resisting system must be developed. Typical lateral force-resisting systems for buildings include moment-resisting frames, braced frames, shear walls, diaphragms, and foundations. Properly designed lateral force-resisting systems provide a

continuous load path from the top of the structure down to the foundation. Furthermore, it is recommended that redundant load paths exist. Proper design of lateral force-resisting systems must consider the relative rigidities of the elements taking the lateral load and their capacities to resist load. An example of lack of consideration for relative rigidity are frames with brittle unreinforced infill walls that are not capable of resisting the loads attracted by such rigid construction. In addition, unsymmetrical arrangement of lateral force-resisting elements can produce torsional response which, if not accounted for in design, can lead to damage. Even in symmetrical structures, propagating earthquake ground waves can give rise to torsion. Hence, a minimum torsional loading should be considered in design or evaluation.

Earthquake ground shaking causes limited energy transient loading. Structures have energy absorption capacity through material damping and hysteretic behavior during inelastic response. The capability of structures to respond to earthquake shaking beyond the elastic limit without major damage is strongly dependent on structural design details. For example, to develop ductile behavior of inelastic elements, it is necessary to prevent premature abrupt failure of connections. For reinforced concrete members, design is based on ductile steel reinforcement in which steel ratios are limited such that reinforcing steel yields before concrete crushes, abrupt bond or shear failure is prevented, and compression reinforcement includes adequate ties to prevent buckling or spalling. With proper design details, structures can be designed to withstand different amounts of inelastic behavior during an earthquake. For example, if the goal is to prevent collapse, structures may be permitted to undergo large inelastic deformations resulting in structural damage that would have to be repaired or replaced. If the goal is to allow only minor damage such that there is minimal or no interruption to the ability of the structure to function, only relatively small inelastic deformations should be permitted. For new facilities, it is assumed that proper detailing will result in permissible levels of inelastic deformation at the specified force levels, without unacceptable damage. For existing facilities, the amount of inelastic behavior that can be allowed without unacceptable damage must be estimated from the as-is condition of the structure.

Potential damage and failure of SSCs due to both direct earthquake ground shaking and seismic response of adjacent SSCs must be considered. The interaction of SSCs during earthquake occurrence can produce additional damage/failure modes to be addressed during seismic design or evaluation. Examples of interaction include: (1) seismic-induced failure of a relatively unimportant SSC which falls on an SSC which is important to safety or to the mission; (2) displacements of adjacent SSCs during seismic response resulting in the adjacent SSCs pounding together; (3) displacements of adjacent SSCs during seismic response resulting in failure of connecting pipes or cables; (4) flooding and exposure to fluids from vessels or piping systems ruptured as a result of earthquake motion; and (5) effects of seismic-induced fires.

The occurrence of an earthquake affects many or all SSCs in a facility. Hence, it is possible to have multiple seismic-induced failures of SSCs. These common cause effects must be considered in design or evaluation. For example, multiple failures in a tank farm can result in loss of contents greater than that held in any single tank which in turn could overflow a retention berm and/or flood adjacent SSCs. The effects of this large quantity of tank contents on SSCs must be considered.

Earthquake ground shaking also affects building contents and nonstructural features such as windows, facades, and hanging lights. It is common for the structure to survive an earthquake without serious structural damage but to have significant and expensive damage of contents. This damage could be caused by overturned equipment or shelves, fallen lights or ceilings, broken glass, and failed infill walls. Glass and architectural finishes may be brittle relative to the main structure, and they can fail well before structural damage occurs. Windows and cladding must be specially attached in order to accommodate the relative seismic movement of the structure without damage. Building contents can usually be adequately protected against earthquake damage by anchorage to the floor, walls, or ceiling.

Facilities in which radioactive materials are handled are typically designed with redundant confinement barriers between the hazardous material and the environment. Such barriers include:

- The building shell
- Ventilation system filtering and negative pressurization that inhibits outward air flow
- Storage canisters, glove boxes, tanks, or silos for storage or handling within the building.

Release of radioactive material to the environment requires failure of two or more of these barriers. Thus, seismic design considerations for these facilities aim to prevent collapse and control cracks or openings (e.g., failed doors, failed infill walls) such that the building can function as a hazardous materials confinement barrier. Seismic design considerations also include adequate anchorage and bracing of storage canisters, glove boxes, tanks or silos and adequate support of ventilation ducting, filters, and fans to prevent their loss of function during an earthquake. Long-term storage canisters are usually very rugged, and they are not particularly vulnerable to earthquake damage.

Earthquake damage to components of a facility such as tanks, equipment, instrumentation, and distribution systems can also cause injuries, loss of function, or loss of confinement. Many of these items can survive strong earthquake ground shaking with adequate anchorage or restraint. Some items, such as large vertical tanks, must be examined in more detail to assure that there is an adequate lateral force-resisting system for seismic loads. For components mounted within a structure, there are three additional considerations for earthquake shaking. First, the input excitation for structure-supported components is the response motion of the structure (which can be amplified from the ground motion) - not the earthquake ground motion. Second, potential dynamic coupling between the component and the structure must be taken into account if the component is massive enough to affect the seismic response of the structure. Third, large differential seismic motions may be induced on components which are supported at multiple locations on a structure or on adjacent structures.

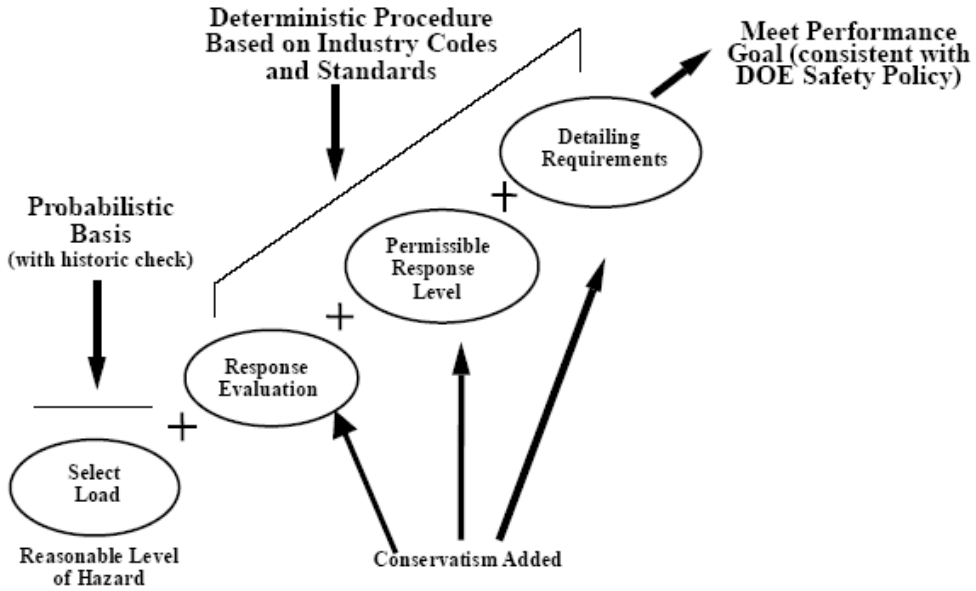
Mitigating Factors

The following paragraphs present the approach upon which the specific seismic force and story drift provisions (as applicable) for seismic design and evaluation of structures, systems, and components in each performance category is based. These provisions include the following steps:

1. Selection of earthquake loading

2. Evaluation of earthquake response
3. Specification of seismic capacity and applicable drift limits
4. Ductile detailing requirements for buildings

The above four elements taken together comprise the earthquake design and evaluation criteria. Acceptable performance can only be reached by consistent specification of all design criteria elements as shown in figure 2. In order to achieve the target performance goals, these seismic design and evaluation criteria specify seismic loading in probabilistic terms. The remaining elements of the criteria (see figure 2) are deterministic design rules which are familiar to design engineers and which have a controlled level of conservatism. This level of conservatism combined with the specification of seismic loading, leads to performance goal achievement.



Source: DOE-STD-1020-2002

Figure 2. Combined probabilistic and deterministic methods to achieve performance goals

Criteria are provided for each of the four performance categories (PCs)1 to 4 as defined in DOE O 420.1B, *Facility Safety*, the accompanying Guide DOE G 420.1-2, *Guide for the Mitigation of Natural Phenomena Hazards for DOE Nuclear Facilities and NonNuclear Facilities*, and DOE-STD-1021-93, *Natural Phenomena Hazards Performance Categorization Guidelines for Structures*, *Systems, and Components*. The criteria for PCs 1 and 2 are similar to those from model building codes. Criteria for PC 3 are similar to those for the Department of Defense (DoD). Criteria for PC 4 approach the provisions for commercial nuclear power plants.

Seismic loading is defined in terms of a site-specific design response spectrum (the design/evaluation basis earthquake). Either a site-specific design response spectrum developed for the site, or a generic design response spectrum that is appropriate or

conservative for the site may be used. Seismic hazard estimates are used to establish the design/evaluation basis earthquake per DOE-STD-1023-95, *Natural Phenomena Hazards Assessment Criteria*.

For each performance category, a mean annual exceedance probability for the design/evaluation basis earthquake is specified from which the maximum ground acceleration (and/or velocity) may be determined from probabilistic seismic hazard curves.

Earthquake input excitation to be used for design and evaluation by these provisions is defined by a median amplification smoothed and broadened design/evaluation response spectrum shape. Such spectra are determined in accordance with DOE-STD-1023-95.

Fire

The following is taken from DOE G 420.1-3.

DOE O 420.1B establishes facility and programmatic safety requirements for a comprehensive fire protection program for DOE sites, facilities, and emergency service organizations to minimize: (1) the potential for occurrence of a fire or related event; (2) fires that cause an unacceptable onsite or offsite release of hazardous or radiological material that could impact the health and safety of employees, the public, or the environment; (3) unacceptable interruption of vital DOE programs as a result of fire and related hazards; (4) property loss from fire exceeding limits established by DOE; and (5) fire damage to critical process controls and safety systems structures and components (as documented by appropriate safety analysis).

A fire hazard analysis (FHA) is required for all hazard category 1, 2 and 3 nuclear facilities, high-hazard facilities, and significant new facilities and facilities that store or process significant quantities of hazardous materials. These examples include planned facilities as well as significant renovations to existing facilities as determined necessary by DOE. Examples of facilities not generally requiring an FHA include small utility buildings, trailers, and office buildings.

The purpose of an FHA is to conduct a comprehensive, qualitative assessment of the risk from fire within individual fire areas in a DOE facility to ascertain whether the DOE fire safety objectives of DOE O 420.1B are met. This should include an assessment of the risk from fire and related hazards (wildland fire exposure, direct flame impingement, hot gases, smoke migration, fire-fighting water damage, etc.) in relation to existing or proposed fire safety features to ensure that the facility can be safely controlled and stabilized during and after a fire.

Analysis of significant planned facilities included in the FHA process should begin early in the design phase to ensure that an acceptable level of protection is being incorporated in the evolving design. This project or preliminary FHA should be updated whenever significant changes occur within an individual fire area and should form the basis for post-construction FHA included in the review and revision schedule.

The following is taken from DOE-STD-1066-99.

When the maximum possible fire loss (MPFL) exceeds $50 million, a redundant fire protection system should be provided that, despite the failure of the primary fire protection system, will limit the loss to acceptable levels as determined by DOE. When the MPFL exceeds $150 million, a redundant fire protection system and a 3-hour fire barrier should be provided to limit the MPFL to acceptable levels as determined by DOE. Where a potential fire would represent an unacceptable risk to the health and safety of the public, workers, the environment, DOE programs or DOE property (as determined by the FHA) fire protection should be provided for special structures, commensurate with the risk.

New permanent structures in excess of 5,000 square feet floor area should be of noncombustible or fire resistive construction if no local building code is enforced. Interior fire barriers should be provided to isolate hazardous occupancies, to minimize the potential for fire spread (including products of combustion) and loss potential, and to help assure the orderly evacuation of facility occupants, consistent with the conclusions of the FHA that is performed in conjunction with the design process. Openings in such barriers should be protected with appropriately fire-rated doors, windows, dampers or penetration seals.

Lightning

The following is taken from DOE-HDBK-1092-2004.

Faults, lightning, or switching transients can cause voltage surges in electrical equipment in excess of normal ratings which in turn can lead to component failures and/or fires.

Lightning protection is required for facilities which will house enclosed electrical/electronic equipment while such equipment is involved with radioactive, explosive, and similarly hazardous materials or for facilities that are considered valuable or house valuable contents.

In addition to facility lightning protection, the effects of surges resulting from lightning strikes to power distribution systems may be lessened by the use of lightning arrestors and suppressors installed at strategic points in the supply system to the facility. An assessment is necessary, addressing the consequences of lightning-induced surges, in order to determine the degree to which protection should be provided.

Specific operations shall be assessed for the risk of detonation of explosives by lightning. When risk is high, as in operations with highly sensitive electrostatic materials or components, operations shall be conducted only in lightning-protected facilities.

Whenever an electrical storm approaches, personnel shall exit any location where a hazard exists from explosives being detonated by lightning. Evacuation may be necessary from locations listed below:

- All outdoor locations, locations in buildings that do not have lightning protection, and locations within inhabited building distance of the hazard. (When an electrical storm is imminent, work with explosives operations shall not be undertaken.); and
- Locations (with or without lightning protection) where operations use electrostatic-sensitive bulk explosives or electro-explosive devices.

b. Briefly describe the safety measures and design features commonly used as safeguards against natural hazards.

The following is taken from DOE-STD-1020-2002.

The natural phenomena hazard (NPH) standard, developed from University of California Radiation Laboratory UCRL-15910, *Natural Phenomena Hazards - Design and Evaluation Criteria for Department of Energy Facilities*, provides criteria for design of new SSCs and for evaluation, modification, or upgrade of existing SSCs so that DOE facilities safely withstand the effects of NPHs such as earthquakes, extreme winds, and flooding.

DOE-STD-1020-2002 provides consistent criteria for all DOE sites across the United States. These criteria are provided as the means of implementing DOE O 420.1B, *Facility Safety*, and the associated guides, and Executive Orders 12699, "Seismic Safety of Federal and Federally Assisted or Regulated New Building Construction," and 12941, "Seismic Safety of Existing Federally Owned or Leased Buildings" for earthquakes.

The design and evaluation criteria presented in this document provide relatively straightforward procedures to evaluate, modify, or upgrade existing facilities or to design new facilities for the effects of NPHs. The intent is to control the level of conservatism in the design/evaluation process such that (1) the hazards are treated consistently, and (2) the level of conservatism is appropriate for SSC characteristics related to safety, environmental protection, importance, and cost.

Prior to applying these criteria, SSCs will have been placed in one of five performance categories (PCs) ranging from PC-0 to PC-4. No special considerations for NPHs are needed for PC-0; therefore, no guidance is provided. Different criteria are provided for the remaining four performance categories, each with a specified performance goal. Design and evaluation criteria aimed at target probabilistic performance goals require probabilistic NPH assessments. NPH loads are developed from such assessments by specifying NPH mean annual probabilities of exceedance. Performance goals may then be achieved by using the resulting loads combined with deterministic design and evaluation procedures that provide a consistent and appropriate level of conservatism. Design/evaluation procedures conform closely to industry practices using national consensus codes and standards so that the procedures will be easily understood by most engineers. Structures, systems, and components comprising a DOE facility are to be assigned to a performance category utilizing the approach described in DOE G 420.1-2, *Guide for the Mitigation of Natural Phenomena Hazards for DOE Nuclear Facilities and Nonnuclear Facilities*, and the performance categorization standard. These design and evaluation criteria are the specific provisions to be followed such that the performance goal associated with the performance category of the SSC under consideration is achieved.

16. Facility maintenance management personnel shall demonstrate a working-level knowledge of DOE's requirements for facility maintenance management as outlined in DOE O 433.1, Maintenance Management Program for DOE Nuclear Facilities.

a. Explain DOE's role in the oversight of contractor maintenance operations.

The following is taken from DOE G 433.1-1.

DOE G 433.1-1 has been prepared to assist DOE employees in the oversight of DOE contractor programs important to nuclear facility maintenance. DOE involvement in the oversight of nuclear facility maintenance programs should include reviews by the DOE facility representative, field and area offices, and Headquarters. Inspections, audits, reviews, investigations and continuous self-assessment are necessary ingredients to achieving excellence in maintenance activities. Whether DOE or contractor, senior managers should periodically review and assess elements of the maintenance program for effectiveness and to identify areas of needed improvement. Such assessments should be aimed at assisting line managers and supervisors to identify and correct deficiencies. A comprehensive assessment of maintenance program elements should be conducted at least every other year and should include input from managers and supervisors from maintenance and other groups such as operations, technical staff, and appropriate corporate departments.

b. Explain the intent of DOE O 433.1, Maintenance Management Program.

[Note: DOE O 433.1 has been superseded by DOE O 433.1A, *Maintenance Management Program for DOE Nuclear Facilities*.]

The intent of DOE O 433.1A is to define the safety management program required for maintenance and the reliable performance of SSCs that are part of the safety basis required by 10 CFR 830, "Nuclear Safety Management," at DOE nuclear facilities. Guidance for compliance with this order is available in DOE G 433.1-1, which references Federal regulations, DOE directives, and industry best practices using a graded approach to clarify requirements and guidance for maintaining DOE-owned Government property.

c. Discuss the Department's policy and objectives for maintenance management.

The following is taken from DOE G 433.1-1.

DOE O 433.1A requires DOE contractors to develop and implement a maintenance management program for each nuclear facility under DOE cognizance. DOE O 433.1A further requires that each DOE contractor develop a MIP defining the safety SSCs the nuclear facility comprises.

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

- that the provisions are sufficient to provide reasonable assurance that the facility safety SSCs are capable of fulfilling their intended function as identified in the SAR; and

- that the maintenance program includes the safety SSCs identified in the SAR, and management systems consistent with the requirements of 10 CFR 830.

d. Describe responsibilities and authorities for maintenance management programs.

The following is taken from DOE G 433.1-1.

It is a primary responsibility of the maintenance manager to ensure implementation of contractor management and facility policies that affect the maintenance organization. Maintenance organization procedures should support contractor management and facility maintenance policies. Responsibilities for implementing these policies, including the responsibilities of maintenance personnel, should be clearly defined. Maintenance personnel should clearly understand their authority, responsibility, accountability, and interfaces with other groups.

The following is taken from DOE O 433.1A.

Authority and implementation guidance for DOE maintenance management programs is from DOE O 433.1A. Nuclear facility maintenance management program MIPs must be reviewed and approved by the DOE approval authority every two years. DOE Secretarial Officers serve as approval authorities, unless otherwise specified.

The NNSA Principal Deputy Administrator and the Undersecretary of Energy serve as central technical authorities and provide authoritative expectations and guidance for implementing DOE O 433.1A.

e. Describe the purpose, scope, and requirements of Maintenance Implementation Plans (MIPs).

The following is taken from DOE G 433.1-1.

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

- all SSCs included in the maintenance program;
- management systems used to control maintenance activities associated with the defined SSCs (these include work control, PMT, material procurement, handling and disposal, control and calibration of M&TE);
- assignment of organizational roles and responsibilities and appropriate maintenance-related training and qualification requirements;
- interfaces between the maintenance organization and other organizations (e.g., operations, engineering, quality, training, industrial health);
- facility/site mission;
- system for assessing maintenance status;
- planned major activities;
- summary of maintenance backlog;
- performance indicators;

- self-assessment program; and
- schedule for periodic inspection of SSCs, and equipment to determine whether deterioration or technical obsolescence that threatens performance and/or safety is taking place.

f. Describe the provisions to allow nuclear facility program elements to include nonnuclear equipment.

The following is taken from DOE Order 4330.4B.

DOE nuclear facility maintenance programs may include facility-related nonnuclear equipment provided the MIP clearly identifies all equipment (or systems) and distinguishes those nonnuclear equipment/systems.

g. Discuss the requirements for the control of Management & Operating (M&O) contractor and subcontractor personnel.

The following is taken from DOE G 433.1-1.

Non-facility contractor and subcontractor personnel (workers not directly employed by the facility operating contractor) who perform maintenance or modifications on facility systems should be trained and qualified for that work they are to perform. These personnel should also receive general employee training and specific training in appropriate facility administration, safety, QC, and radiation protection procedures and practices. Adequate time should be provided for this training. Recognition should be given to individual needs and previous training and experience.

Experienced personnel could be allowed to bypass training by proving proficiency through examination and demonstration. Non-facility contractor and subcontractor personnel who are not fully trained and qualified for the job to be performed should be continuously supervised by qualified personnel.

Non-facility contractor and subcontractor personnel should perform maintenance under the same controls as and to the same high work standards as are expected of facility maintenance personnel. Non-facility contractor and subcontractor managers and supervisors should be held accountable for the work performance of their personnel. Facility supervisors should review the work of these personnel during preparation for work, at the job site, and during PMT and acceptance inspections to the extent needed to enforce these requirements.

Use of subcontractor personnel to perform routine facility maintenance should not be relied upon to the extent that it deters the development of expertise of permanent staff.

h. Describe the relationship between 10 CFR 830.120, DOE Order 5700.6C Chg 1, DOE O 414.1C, Quality Assurance, and DOE O 433.1, Maintenance Management Program for DOE Nuclear Facilities, in relation to work processes and maintenance activities.

[Note: DOE Order 5700.6C was cancelled and subsequently superseded by DOE O 414.1C. DOE O 433.1 was superseded by DOE O 433.1A.]

The following is taken from Government Printing Office, GPO Access, Electronic Code of Federal Regulations.

10 CFR 820.120, "Nuclear Safety Management, Subpart A, Quality Assurance Requirements, Scope," establishes QA requirements for contractors conducting activities, including providing items or services, that affect, or may affect, nuclear safety of DOE nuclear facilities. The contractor responsible for a DOE nuclear facility must submit a Quality Assurance Program (QAP) to DOE for approval, modify the QAP as directed by DOE, annually submit any changes to the DOE-approved QAP to DOE for approval, and conduct work in accordance with the QAP.

The following is taken from DOE O 414.1C.

DOE O 414.1C requires each DOE organization to develop and implement a QAP in accordance with 10 CFR 830, using national or international consensus standards where practicable and consistent with contractual or regulatory requirements.

The graded approach required by 10 CFR 830, is the process of ensuring that the levels of analyses, documentation, and actions used to comply with requirements are commensurate with:

- the relative importance to safety, safeguards, and security;
- the magnitude of any hazard involved;
- the life-cycle stage of a facility or item;
- the programmatic mission of a facility;
- the particular characteristics of a facility or item;
- the relative importance to radiological and non-radiological hazards; and
- any other relevant factors.

The following is taken from DOE O 433.1A.

The intent of DOE O 433.1A is to define the safety management program required for maintenance and the reliable performance of SSCs that are part of the safety basis required by 10 CFR 830 at DOE nuclear facilities. Guidance for compliance with this order is available in DOE G 433.1-1, which references federal regulations, DOE directives, and industry best practices using a graded approach to clarify requirements and guidance for maintaining DOE-owned Government property.

i. Describe the relationship between DOE O 430.1B, Real Property Asset Management, and DOE O 433.1, Maintenance Management Program for DOE Nuclear Facilities, in relation to condition assessment surveys.

The following is taken from DOE O 430.1B.

Each DOE site must have a maintenance program to maintain each real property asset, including plant, property, and equipment, in a condition suitable for its intended use. The maintenance program will include condition assessments of real property assets, a work control system, management of deferred maintenance, a method to prioritize maintenance projects, and cost accounting systems to budget and track maintenance expenditures. In

addition to the maintenance requirements of DOE 430.1B, sites with nuclear facilities must also comply with DOE O 433.1A.

Condition assessments must be performed on all real property assets at least once during any 5-year period.

The following is taken from DOE G 433.1-1.

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

Properly used, a facility condition and housekeeping inspection program is an effective means for identifying and correcting deficiencies. A condition assessment survey can be used to prioritize schedules for repair.

j. Describe the relationship between DOE Order 4320.1B Chg 1, Site Development Planning, and DOE Order 433.1, Maintenance Management Program for DOE Nuclear Facilities.

[Note: DOE Order 4320.1B was canceled by DOE O 430.1. DOE O 430.1B is the current version.]

See item i of competency 16.

k. Describe the relationship between DOE Order 4330.2D, In-House Energy Management, and DOE O 433.1, Maintenance Management Program.

[Note: DOE Order 4330.2D was replaced by DOE O 430.2. DOE O 430.2B is the current version.]

The following is taken from DOE O 430.2B.

The purpose of DOE O 430.2B is to provide requirements and responsibilities for managing DOE energy, buildings, and fleets to meet, lead or exceed the goals of all applicable laws, executive orders, and federal regulations with respect to continuous energy efficiency and water conservation improvements, increased and pervasive use of onsite, distributed renewable and clean energy resources, increased development/deployment of innovative, utility-scale renewable and clean energy sources on DOE and other federal land, increased number of sustainable buildings, optimized utilization of alternative fuel, hybrid, and plug-in electric vehicles, and the expansion and maintenance of an alternative fuel infrastructure at all DOE facilities, laboratories, and sites.

Major facilities contractors managing and operating DOE facilities or subcontracting the operation and maintenance of DOE facilities must have a documented energy management program and an energy management plan.

l. Describe maintenance backlog work and identify criteria used to establish a proper magnitude of maintenance backlog.

See items d, e, and f of competency 5.

m. Discuss the graded approach process by which Department line management determines an appropriate level of coverage by facility maintenance management personnel. Include in this discussion factors that may influence the level of coverage.

The following is taken from DOE G 433.1-1.

The graded approach is the process of assuring that the level of analysis, documentation, and actions used to comply with a requirement are commensurate with:

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

Each WR related to repairs of production equipment should be reviewed by the operations department to determine its impact on facility operations. Meaningful priorities that determine how soon a WR needs to be worked should be set based on operational and industrial safety and reliability. High priority WRs associated with emergencies, or failed systems that cause a severe adverse impact on personnel safety, and/or limit facility operation may require coverage by additional personnel or overtime work.

17. Facility maintenance management personnel shall demonstrate a familiarity-level knowledge of the requirements for a training and qualification program as identified in the following Department of Energy (DOE) Orders:

- **DOE Order 5480.20A, Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities**
- **DOE O 433.1, Maintenance Management Program for DOE Nuclear Facilities**

a. Discuss the meaning of qualification and its importance to maintenance personnel.

The following is taken from DOE G 433.1-1.

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

b. Describe the purpose and scope of DOE Order 5480.20A, Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities.

The purpose of DOE Order 5480.20A is to establish selection, qualification, and training requirements for management and operating (M&O) contractor personnel involved in the operation, maintenance, and technical support of DOE/NNSA category A and B reactors and non-reactor nuclear facilities.

This Order is applicable to all DOE Elements, including the NNSA, and all contractors that are responsible for operable Category A and B reactors and non-reactor facilities. The Director, Naval Nuclear Propulsion Program, is exempt from this Order.

c. Discuss why certain skills or proficiencies should be demonstrated periodically by maintenance personnel.

The following is taken from DOE Order 5480.20A.

Certified reactor operators, senior reactor operators, certified operators, fissionable material handlers, and certified supervisors shall actively perform job functions associated with their certification to maintain proficiency. Actively performing job functions associated with certification means that the certified individual has a position on the shift crew, and that the individual carries out and is responsible for the day-to-day duties of the certified position. If certified operators are absent from activities associated with the certified position for extended periods of time, their ability and readiness to perform at a high level of vigilance can reasonably be expected to decrease. The proficiency requirement is imposed to ensure that certified personnel continue to possess and practice the skills and abilities necessary to operate the systems and equipment for which they are responsible in a safe and reliable manner during both normal and abnormal facility operations and system transients.

d. Using DOE Order 5480.20A, Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities as a reference, describe the general requirements to which an M&O contractor is held at category 1, 2, and 3 facilities in the following areas:
- **Qualification and certification of maintenance personnel**
- **Training and qualification of sub-contractors**
- **Continuing training and requalification of maintenance personnel**
- **Exceptions and alternatives to requirements of DOE Order 5480.20A for maintenance personnel**
- **Maintenance personnel selection**

Qualification and Certification of Maintenance Personnel

Technician and maintenance personnel qualification shall include demonstrated performance capabilities (performance demonstrations) to ascertain their ability to adequately perform assigned tasks. Written examinations should also be administered to personnel in these positions. However, a comprehensive final examination need not be administered to ascertain formal qualification of technicians and maintenance personnel. Participation in continuing training programs is required to maintain and improve their abilities to continue to function safely in the operating organization. Their continued satisfactory performance of assigned

duties and their satisfactory participation in the continuing training program (classroom, OJT, laboratory, etc.) serves as sufficient evidence of maintenance of their qualification.

Certification may be granted only after all qualification requirements (including written and oral examinations and operational evaluations) and other specified requirements (e.g., medical examination) have been satisfactorily completed, and management has assured that the person is capable of safely performing all functions of the position. Satisfactory completion of qualifications which result in certification shall be verified by a person or group other than the candidate's immediate supervisor or the person/group that provided the training. Certification shall be valid for a period not to exceed two years unless revoked for cause (e.g., medical disqualification, performance deficiencies, or failure to maintain proficiency).

Training and Qualification of Sub-Contractors

Subcontractor personnel should meet the qualification requirements for the job function to be performed. In addition, the operating organization should ensure that subcontractor and temporary personnel who perform specialized activities (e.g., radiation protection, maintenance, in-service inspection, radiography, and welding) are qualified to perform their assigned tasks. Personnel should be considered adequately qualified with proper documentation of at least one of the following:

- the satisfactory result of an audit of subcontractor records that relate to qualification of the subcontractor personnel being considered for assignment by the operating organization; or
- the operating organization's previous verification (within 2 years) of the ability of the subcontractor employee to perform assigned tasks safely and efficiently; or
- successful completion by the subcontractor employee of those segments of the operating organization's qualification program that are considered pertinent to accomplishment of the task to be performed.

For subcontractor personnel who do not meet the requirements, work activities on engineered safety features as identified in the facility SAR should be supervised by a person who meets the qualification criteria established by the operating organization for conduct of the activities.

Continuing Training and Requalification of Maintenance Personnel

Continuing training programs should be established to maintain and enhance the knowledge and skills of maintenance personnel who perform functions associated with engineered safety features as identified in the facility SAR. Management should develop continuing training programs that improve the knowledge and skills of operating organization personnel.

These programs should be structured commensurate with specific position needs, and should be administered on a cycle not to exceed two years. Continuing training should include, at a minimum, training in significant facility system and component changes, applicable procedure changes, applicable industry operating experience, selected fundamentals with emphasis on seldom used knowledge and skills necessary to ensure safety, and other training as needed to correct identified performance problems.

Periodic examinations (written and oral examinations, operational evaluations, performance demonstrations, as applicable to the position) should be administered and documented throughout the cycle on material included in the operator training programs (for operators and their immediate supervisors). Periodic examinations (written and/or performance demonstrations) of other members of the operating organization (i.e., maintenance personnel, technicians, technical staff) are also appropriate in some areas during the continuing training program.

Continuing training programs for certified operations personnel shall consist of preplanned classroom-type training, OJT, and operational evaluations on a regular and continuing basis. Continuing training programs for certified operators and certified supervisors should include, at a minimum, the following as related to job performance:

- training and examination covering abnormal facility procedures and emergencies that is required at least annually for maintenance personnel;
- drills conducted in the facility or on a simulator to enable personnel and operating teams to maintain their ability to respond to abnormal or accident situations;
- instruction in the use of facility systems to control or mitigate accidents which includes classroom-type training and training conducted in the facility; and
- training, as applicable to the position, in the following subjects where examinations and experience (industry and facility-specific) or other evidence indicate that additional emphasis in scope and depth of coverage is needed:
    - theory and principles of facility operation
    - general and specific facility operating characteristics
    - facility instrumentation and control
    - facility protection systems
    - engineered safety features
    - normal, abnormal, and emergency procedures
    - radiation control and safety
    - TSRs

Personnel who are responsible for developing and delivering training may be excused from continuing training for the area of primary administrative responsibility. For example, an individual who prepares, administers, and grades a written examination need not take the examination.

Exceptions and Alternatives to Requirements of DOE Order 5480.20A for Maintenance Personnel

The initial training programs that are described in this Order were developed for persons assumed to have the entry-level knowledge and skills required of the positions they would fill on the basis of meeting the education and experience requirements contained in this Order. Some candidates may already possess the knowledge and skills necessary for certain job requirements, and may be excepted from certain areas of training programs on the basis of prior education, experience, training, and/or testing. Testing (i.e., performance demonstrations, written examinations, oral examinations) is the preferred method for excepting persons from specific areas of training.

In all cases, the requisite examinations to establish qualification/certification should be completed.

The operating organization should establish an administrative procedure that describes the methods used to administer and document exceptions to initial training program requirements. The name of the person and the specific subject for which the exception is requested, along with justification for the exception, should be included as part of the documentation. In all cases, the operating organization should ensure that sufficient facility-specific instruction is provided to enable the candidate to perform job requirements. The operating organization should submit the procedure for granting exceptions to the operations office manager for approval.

Personnel placed in the training program that have satisfactorily completed training programs comparable in content and in performance standards may be released (excepted) from portions of training on an individual case basis. Exception from training should be based on a review of previous training records (i.e., transcripts), personal interviews, and on examinations that are based on the objectives stated for the training program.

Exceptions from qualification or certification requirements may be approved by contractor management after approval of the exception procedure by the Operations Office Manager/Field Manager for NNSA Operations.

Persons who believe that they have knowledge or skills equivalent to that which is addressed by the training may challenge the requirement to attend individual portions of the training program. In situations such as these, examinations (written or performance) may be administered by the operating contractor. If challenge examinations are administered, they shall be sufficiently comprehensive to adequately test the learning objective(s) that are stated in the training program. The use of challenge tests is not considered taking an exception to the training and, as such, challenge tests are excluded from the requirements for exceptions. Accordingly, they do not need to be approved on a case-by-case basis.

Maintenance Personnel Selection

The operating contractor shall establish a process for selection and assignment of maintenance personnel. This process should consider factors such as background, experience, and education, and should be based on the ability of the person to meet job performance requirements. Selection of maintenance personnel may involve a selection test.

If an individual does not meet the experience requirements of this Order, consideration may be given to the collective experience of the operating organization. Individuals who do not meet the experience requirements for a position may be assigned to that position provided the overall operating organization is considered balanced and strong and that DOE approval is obtained on a case-by-case basis.

e. Using DOE Order 5480.20A, Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities as a reference, state the entry level requirements for various facility positions.

Entry-level requirements for operating organization personnel are intended to provide reasonable assurance that these personnel have, or can acquire the knowledge and skills to operate and maintain the reactor and related support systems in a safe and reliable manner under all conditions.

DOE Order 5480.20A lists entry level requirements for managers, supervisors, technical staff, trainers, operators, technicians, and maintenance personnel.

Entry level requirements for maintenance personnel include education at the journeyman level and 3 years of related maintenance experience.

f. Describe the purpose and scope of chapter II, section 3, of DOE O 433.1, Training and Qualification of Maintenance Personnel.

[Note: This KSA item actually refers to part III, section 4.2 of DOE G 433.1-1. There is no section on training and qualification of maintenance personnel in DOE O 433.1A.]

The following is taken from DOE G 433.1-1.

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

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

g. Discuss the responsibility of the maintenance organization in the training and qualification of their personnel.

The following is taken from DOE G 433.1-1.

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

h. Discuss the requirements of Chapter II, Section 3, DOE O 433.1, Training and Qualification of Maintenance Personnel, regarding training facilities.

[Note: This KSA item actually refers to part III, section 4.2 of DOE G 433.1-1. There is no section on training facilities in DOE O 433.1A.]

The following is taken from DOE G 433.1-1.

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

for training facilities. Considerations for these facilities and equipment should include the following:

- size of training class
- type of training
- use of mockups
- presence of environmental controls
- availability of services
- access to training equipmen.
- provision of equipment similar to that installed in the plant to be used for practical training

i. Describe the elements of an effective on-the-job training program.

The following is taken from DOE G 433.1-1.

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

Trainee Supervision and Control

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

The trainer should review any information recorded by the trainee on official work and data sheets and should stress to the trainee the importance of maintaining accurate training and

nuclear facility records. In addition, the instructor should discuss with the trainee out-of-specification values and their consequences and the required reporting of such issues.

Number of Trainees

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

Trainee Conduct of Maintenance

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

j. Discuss the maintenance manager's responsibilities in the approval, effectiveness, and feedback cycles of the maintenance training program.`

The following is taken from DOE G 433.1-1.

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

18. Facility maintenance management personnel shall demonstrate a familiarity-level knowledge of the facility maintenance management-related sections and/or requirements of the following related DOE Orders:

- **DOE O 430.1B, Real Property Asset Management**
- **DOE Order 5480.4 Chg 4, Environmental Protection, Safety, and Health Protection Standards**
- **DOE Order 5480.10, Contractor Industrial Hygiene Program**
- **DOE Order 5480.11, Radiation Protection for Occupational Workers**
- **DOE Order 5483.1A, Occupational Safety and Health Program for DOE Contractor Employees at Government-Owned Contractor-Operated Facilities**
- **DOE Order 6430.1A, General Design Criteria**

- **DOE O 440.1A, Worker Protection Management for DOE Federal and Contractor Employees**
- **DOE G 440.1-6, Implementation Guide for Use with Suspect/Counterfeit Items Requirements of DOE O 440.1**

a. Describe the purpose, scope, and application of the requirements detailed in the listed Orders.

DOE O 430.1B, Real Property Asset Management

The objective of this Order is to establish a corporate, holistic, and performance-based approach to real property life-cycle asset management that links real property asset planning, programming, budgeting, and evaluation to program mission projections and performance outcomes. To accomplish the objective, this Order identifies requirements and establishes reporting mechanisms and responsibilities for real property asset management.

DOE Order 5480.4 Chg 4, Environmental Protection, Safety, and Health Protection Standards

This Order was canceled.

DOE Order 5480.10, Contractor Industrial Hygiene Program

This Order was canceled by DOE O 440.1.

DOE Order 5480.11, Radiation Protection for Occupational Workers

This Order was canceled.

DOE Order 5483.1A, Occupational Safety and Health Program for DOE Contractor Employees at Government-Owned Contractor-Operated Facilities

This Order was canceled by DOE O 440.1.

DOE Order 6430.1A, General Design Criteria

This Order was canceled.

DOE O 440.1A, Worker Protection Management for DOE Federal and Contractor Employees

[Note: DOE O 440.1A was superseded by DOE O 440.1B.]

The objective of this Order is to establish the framework for an effective worker protection program that will reduce or prevent injuries, illnesses, and accidental losses by providing DOE, including NNSA, federal workers with a safe and healthful workplace.

DOE G 440.1-6, Implementation Guide for Use with Suspect/Counterfeit Items Requirements of DOE O 440.1

This guide was canceled by DOE G 414.1-3

b. Discuss the impact and/or relationship of the Orders listed to the facility maintenance management functional area.

DOE O 430.1B, Real Property Asset Management

Each DOE site must have a maintenance program to maintain each real property asset, including plant, property, and equipment, in a condition suitable for its intended use. The

maintenance program will include condition assessments of real property assets, a work control system, management of deferred maintenance, a method to prioritize maintenance projects, and cost accounting systems to budget and track maintenance expenditures. In addition to the maintenance requirements of DOE 430.1B, sites with nuclear facilities must also comply with DOE O 433.1A. Condition assessments must be performed on all real property assets at least once during any 5-year period.

DOE O 440.1B, Worker Protection Management for DOE Federal and Contractor Employees

This Order includes the following requirements that impact maintenance:

- reviews must be conducted of safety and health programs developed for site maintenance and operational activities to determine their applicability and cost effectiveness on construction projects.
- procedures must be established for storage, handling, cleaning, and maintenance of firearms and associated ammunition.
- documentation, traceability, and accountability should be maintained for each pressure vessel or system, including descriptions of the design, pressure, testing, operation, repair, and maintenance.
- requirements for motor vehicle maintenance and inspection must be developed.

DOE G 440.1-6, Implementation Guide for Use with Suspect/Counterfeit Items Requirements of DOE O 440.1

[Note: DOE G 440.1-6 was replaced by DOE G 414.1-3, *Suspect/Counterfeit Items Guide for Use with 10 CFR 830 Subpart A, Quality Assurance Requirements, and DOE O 414.1B, Quality Assurance*. DOE O 414.1B was superseded by DOE O 414.1C.]

DOE/NNSA is committed to effective controls for the prevention, detection, and disposition of S/CIs to mitigate any potential safety threat in the DOE/NNSA complex. The principal objectives of S/CI controls are as follows:

- Ensure that items intended for application in safety systems and mission critical facilities comply with design and procurement documents.
- Maintain current, accurate information on S/CIs and associated suppliers using all available sources within the Government and industry and disseminate relevant information on S/CIs to field organizations and contractors.
- Identify, control, and disposition S/CIs that create potential hazards in safety systems and applications.
- Report discoveries of and disseminate information about S/CIs to field organizations, contractors, and government agencies.
- Train and inform managers, supervisors, and workers of S/CI controls and indicators, including prevention, detection, and disposition of S/CIs.

These controls should also include obtaining contractual remedies from suppliers of S/CIs.

DOE G 414.1-3 is for use by all DOE/NNSA organizations and contractors to assist them in developing site-and facility-specific QA policies, processes, and procedures to address the following S/CI controls:

- procurement;
- item inspection and acceptance;

- engineering involvement;
- safety systems, non-safety systems, and critical load paths;
- identification, notification, disposition and disposal;
- reporting;
- trend analysis;
- training; and
- assessment and oversight.

19. Facility maintenance management personnel shall demonstrate a working-level knowledge of the following maintenance management-related Department of Energy Technical Standard and Maintenance Management Program Guide:

- **DOE-STD-1150-2002, Quality Assurance Functional Area Qualification Standard**
- **DOE G 433.1-1, Nuclear Facility Maintenance Management Program Guide for Use with DOE O 433.1**

a. Describe the purpose, scope, and application of the requirements detailed in the listed technical standard and guide.

DOE-STD-1150-2002, Quality Assurance Functional Area Qualification Standard

QA personnel are required to be familiar with applicable portions of DOE O 433.1A and DOE G 433.1-1. Specifically, QA personnel must be able to perform the following:

- Define each of the following maintenance-related terms and explain their relationship to each other:
  - corrective
  - planned
  - preventive
  - predictive

- Describe the elements of an effective work control program and the documentation used to control maintenance.
- Discuss the relationship between maintenance and conduct of operations, QA, and configuration management (CM).
- Discuss the storage and maintenance requirements for parts, materials, and equipment.
- Describe the difference between temporary and permanent repairs/work and the requirements and controls to prevent inadvertent modifications.

QA personnel should also be familiar with procurement processes, control and reporting of S/CIs, and 10 CFR 830.

DOE G 433.1-1, Nuclear Facility Maintenance Management Program Guide for Use with DOE O 433.1

This guide describes a maintenance management program that would be acceptable to DOE for meeting the requirements of DOE O 433.1. An acceptable maintenance management program may be based on existing maintenance programs or on the development of new corrective, preventive, and predictive maintenance programs. This document brings together

in one place the guidance for existing nuclear facility maintenance management program elements that previously resided in separate DOE technical standards. It replaces 15 DOE technical standards relevant to maintenance at DOE nuclear facilities and provides guidance to preserve the designed-in capability of SSCs important to nuclear safety and protection of the environment in accordance with laws, regulations, or DOE directives.

b. Discuss the impact and/or relationship of the listed technical standard and guide to the facility maintenance management functional area.

See item a of competency 19.

20. Facility maintenance management personnel shall demonstrate a familiarity-level knowledge of DOE Order 231.1A, Environment, Safety, and Health Reporting.

a. State the purpose of DOE Manual 231.1-2, Occurrence Reporting and Processing of Operations Information.

This manual provides detailed requirements to supplement DOE O 231.1A, *Environment, Safety, and Health Reporting*.

b. Define the following terms:

- **Event**
- **Condition**
- **Facility**
- **Notification report**
- **Occurrence report**
- **Reportable occurrence**

The following definitions are taken from DOE M 231.1-2.

Event

An event is something significant and real-time that happens (e.g., pipe break, valve failure, loss of power, environmental spill, earthquake, tornado, flood).

Condition

A condition is any as-found state, whether or not resulting from an event that may have adverse safety, health, QA, operational, or environmental implications. A condition is usually programmatic in nature; for example, errors in analysis or calculation, anomalies associated with design or performance, or items indicating a weakness in the management process.

Facility

Facility refers to any equipment, structure, system, process, or activity that fulfills a specific purpose. Examples include accelerators, storage areas, fusion research devices, nuclear reactors, production or processing plants, coal conversion plants, magneto-hydrodynamic experiments, windmills, radioactive waste disposal systems and burial grounds, environmental restoration activities, testing laboratories, research laboratories, transportation activities, and accommodations for analytical examinations of irradiated and un-irradiated components.

Notification Report

A notification report is the initial documented report to DOE of an event or condition that meets the reporting criteria defined in DOE M 231.1-2.

Occurrence Report

An occurrence report is a documented evaluation of an event or condition that is prepared in sufficient detail to enable the reader to assess its significance, consequences, or implications and to evaluate the actions being proposed or employed to correct the condition or to avoid recurrence.

Reportable Occurrence

A reportable occurrence is an occurrence to be reported in accordance with the criteria defined in DOE M 231.1-2.

c. Discuss the Department's policy regarding the reporting of occurrences as outlined in DOE Manual 231.1-2, Occurrence Reporting and Processing of Operations Information.

DOE M 231.1-2 and DOE O 231.1A set forth the minimum set of occurrence reporting requirements for DOE Departmental Elements, including NNSA, and contractors responsible for the management and operation of DOE-owned and DOE-leased facilities, including NNSA facilities. These requirements include categorizing occurrences related to safety, environment, health, or operations ("Reportable Occurrences"); notifying DOE of these occurrences; and developing and submitting documented follow-up reports. These occurrence reporting directives further require that the notifications be timely in accordance with the significance of the occurrence, and that the written reports contain appropriate information describing the occurrence, significance, causal factors, and corrective actions.

d. State the different categories of reportable occurrences and discuss each.

The following is taken from DOE M 231.1-2.

Operational Emergencies

Occurrences that are operational emergencies are the most serious occurrences and require an increased alert status for onsite personnel and, in specified cases, for offsite authorities.

Significance Category 1

Occurrences in significance category 1 are those that are not operational emergencies and that have a significant impact on safe facility operations, worker or public safety and health, regulatory compliance, or public/business interests.

Significance Category R

Occurrences in significance category R are those identified as recurring, as determined from the periodic performance analysis of occurrences across a site.

Significance Category 2

Occurrences in significance category 2 are those that are not operational emergencies and that have a moderate impact on safe facility operations, worker or public safety and health, regulatory compliance, or public/business interests.

Significance Category 3

Occurrences in significance category 3 are those that are not operational emergencies and that have a minor impact on safe facility operations, worker or public safety and health, regulatory compliance, or public/business interests.

Significance Category 4

Occurrences in significance category 4 are those that are not operational emergencies and that have some impact on safe facility operations, worker or public safety and health, or public/business interests.

If the consequences are not fully determined or the event exceeds the threshold of more than one criterion, then the event must be categorized at the higher criteria level being considered. The occurrence criterion must be continuously reevaluated and changed, as needed, when new information becomes available.

e. Discuss the role of facility maintenance personnel in maintenance-related reportable occurrences.

The following is taken from DOE G 433.1-1.

Maintenance personnel should use systematic analysis to determine and correct the root causes of unplanned occurrences related to maintenance. Sections 4.15 and 4.16 of DOE G 433.1-1 provide 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 methods supplement the maintenance history program and provide data, including human error data, which should be reviewed by the analysis program.

An analysis program may be used effectively to reduce recurring maintenance problems by identifying and resolving root causes of problems.

21. Facility maintenance management personnel shall demonstrate a familiarity-level knowledge of DOE Order 414.1C Chg 1, as it pertains to facility maintenance.

- **10 CFR 830 Subpart A, Quality Assurance Requirements**

a. Describe the types of documents related to facility maintenance that should be controlled by a document control system.

The following is taken from DOE G 433.1-1.

The maintenance document control program should ensure technically correct and readily accessible information is provided to support maintenance activities. Technically accurate

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

b. Discuss the requirements for revision and distribution of controlled documents.

The following is taken from DOE G 433.1-1.

Controlled documents include maintenance procedures, technical manuals and drawings, maintenance records and documentation, and facility configuration documents.

Controls should be established for the preparation, review, approval, distribution, and revision of controlled documents. A systematic program should be used to ensure the review and updating of controlled documents at regular intervals that are not to exceed a specified period (normally two years). Guidelines for procedure review should address the scope and depth of the review in areas such as technical and administrative content and human factors.

c. Discuss the determination of calibration frequency for measurement and test equipment.

The following is taken from DOE G 433.1-1.

Frequency of calibration should be determined based on the manufacturers' recommendations, M&TE usage, and M&TE historical reliability. Consideration should be given to the amount and type of M&TE available for use compared with that needed to support periods of peak activity such as outages. This information can help determine calibration frequency and schedule requirements that result in adequate M&TE support for facility needs.

The calibration intervals for M&TE should be established by the cognizant department managers. The initial interval should be based on the inherent stability characteristics of the device, the rate/level and purpose of expected use, manufacturer's recommendation, and historical data for similar equipment. Calibration intervals may be revised based on a review of previous calibration results and maintenance history. Revision of calibration intervals should require the approval of the cognizant department manager. Revisions should be documented on the Calibration Interval Change Authorization form which should be filed in the maintenance history.

d. Describe the effect of using inappropriate calibration standards on test equipment.

The following is taken from NFPA 70B.

Data loss and unsafe work conditions can result from the use of inappropriate calibration standards. All test equipment should be calibrated at regular intervals to ensure the validity of the data obtained. In order to get valid test results, it might be necessary to regulate the power

input to the test equipment for proper waveform and frequency and to eliminate voltage surges.

The following is taken from DOE G 433.1-1.

When a M&TE device is found to be, or suspected to be out of calibration, defective, or otherwise unreliable, an evaluation of the instruments and equipment it has measured or tested since it was last calibrated should be performed promptly to determine whether recalibration or rework is needed. Also, records of the field instruments calibrated by the M&TE should be reviewed to determine whether recalibration is necessary.

When M&TE is suspected or actually found to be inoperable, unreliable, defective, or out of calibration, all data recorded since the previous calibration by affected equipment should be identified through the usage record. A prompt evaluation should be performed to determine the need for corrective action. This evaluation should be documented on a Gross Error Report. The appropriate owner/operator of the affected equipment should evaluate the validity of all applications and data derived since the previous calibration, determine their disposition, and establish the nature and timing of corrective actions, if necessary.

e. Discuss the key elements of the procurement process for facility maintenance as described in DOE Order 5700.6C, Quality Assurance.

[Note: DOE Order 5700.6C has been canceled.]

22. Facility maintenance management personnel shall demonstrate a familiarity-level knowledge of 10 CFR 830.203, Unreviewed Safety Question Process.

a. Discuss the reasons for performing an unreviewed safety question determination.

The following is taken from DOE G 433.1-1.

The contractor responsible for a hazard category 1, 2, or 3 DOE nuclear facility must implement the DOE-approved unreviewed safety question (USQ) procedure in situations where there is a:

- temporary or permanent change in the facility as described in the existing documented safety analysis;
- temporary or permanent change in the procedures as described in the existing documented safety analysis;
- test or experiment not described in the existing documented safety analysis; or
- potential inadequacy of the documented safety analysis because the analysis potentially may not be bounding or may be otherwise inadequate.

b. Define the following terms:

- **Accident analyses**
- **Safety evaluation**
- **TSRs**

The following is taken from DOE-HDBK-1188-2006.

Accident Analyses

The term accident analysis refers to those bounding analyses selected for inclusion in the SAR. These analyses refer to design basis accidents only.

Safety Evaluation

A safety evaluation is the record that is required to document the review of a change. This document records the scope of the evaluation and the logic for determining whether or not an USQ exists.

TSRs

TSRs are the limits, controls, and related actions that establish the specific parameters and requisite actions for the safe operation of a nuclear facility and include, as appropriate for the work and the hazards identified in the documented safety analysis (DSA) for the facility: Safety limits (SLs), operating limits (OLs), surveillance requirements (SRs), administrative and management controls, use and application provisions, and design features, as well as a bases appendix.

c. Describe the situations in which a safety evaluation is required to be performed.

The following is taken from DOE G 424.1-1A.

A safety evaluation is a safety analysis that demonstrates adequate safety with the existing situation so that any interim measures (operational restrictions) to maintain the facility in a safe condition can be removed. If that is not the case (adequate safety), then the analysis should be accompanied by, or followed with, a proposed resolution, also with a safety analysis, that demonstrates adequate safety.

All proposed new or changed processes involving criticality safety that necessitate a new or revised Criticality Safety Evaluation, including those in an experimental facility, undergo a USQ review by the Nuclear Safety Management rule. When the USQ determination is positive indicating the need for DOE review and approval of the change, the safety analyses and controls associated with the approved action become part of the safety basis for the facility. Any changes necessary to the DSA and TSR documents because of the change should be incorporated at the next annual update. The results of the USQ determination define the need for DOE approvals of the supporting criticality safety evaluations and explicit updates of the DSA and TSRs.

d. Define the conditions for an Unreviewed Safety Question.

The following is taken from DOE G 424.1-1A.

The purpose of the USQ process is to alert DOE of events, conditions, or actions that affect the DOE-approved safety basis of the facility or operation and ensure appropriate DOE line management action. If a change is proposed, or a condition is discovered that could increase the risk of operating a facility beyond that established in the current safety basis, DOE line management, including, where applicable, the NNSA, must review and determine the acceptability of that risk through the process of approving a revised safety basis that would be developed and submitted by the contractor.

The following questions should be considered during the USQ process:

- Could the proposed change increase the probability of an accident previously evaluated in the facility's existing safety analyses?
- Could the proposed change increase the consequences (to workers or the public) of an accident previously evaluated in the facility's existing safety analyses?
- Could the proposed change increase the probability of a malfunction of equipment important to safety previously described in the facility's existing safety analyses?
- Could the proposed change increase the consequences of a malfunction of equipment important to safety described in the facility's existing safety analyses?
- Could the proposed change create the possibility of an accident of a different type than any previously evaluated in the facility's existing safety analyses?
- Could the proposed change create the possibility of a malfunction of equipment important to safety of a different type than any previously evaluated in the facility's existing safety analyses?
- Could the proposed change reduce a margin of safety?

If the answer to any of these questions is yes, the change is considered a USQ.

e. Describe the responsibilities of contractors authorized to operate defense nuclear facilities for the performance of safety evaluations.

The following is taken from DOE O 420.1B.

The methodology for conducting criticality safety evaluations must be approved by DOE unless the evaluations are conducted in accordance with the DOE-STD-3007-2007, *Guidelines for Preparing Criticality Safety Evaluations at Department of Energy Non-Reactor Nuclear Facilities*, or successor document, and evaluated in accordance with DOE-STD-1134-1999, *Review Guide for Criticality Safety Evaluations*, or successor document.

f. Describe the actions to be taken by a contractor upon identifying information that indicates a potential inadequacy of previous safety analyses or a possible reduction in the margin of safety as defined in the TSRs.

The following is taken from DOE G 424.1-1A.

Because a safety analysis inadequacy has potential to call into question information on which authorization of operations is based, the contractor is to:

- take appropriate action to place or maintain the facility in a safe condition,
- expeditiously notify DOE when the information is discovered,
- perform a USQ determination and notify DOE of the results promptly, and
- complete evaluation of the safety of the situation and submit it to DOE before removing any operational restrictions implemented to compensate for the discrepancy.

23. Facility maintenance management personnel shall demonstrate a familiarity-level knowledge of the TSRs as described in 10 CFR 830.205, Technical Safety Requirements.

a. Discuss the purpose of the TSRs.

The following is taken from 10 CFR 830.

TSRs comprise the limits, controls, and related actions that establish the specific parameters and requisite actions for the safe operation of a nuclear facility and include, as appropriate for the work and the hazards identified in the DSA for the facility: SLs, OLs, SRs, administrative and management controls, use and application provisions, and design features, as well as a bases appendix.

b. Describe the responsibilities of contractors authorized to operate defense nuclear facilities regarding the TSRs.

The following is taken from 10 CFR 830.

Section 10 CFR 830.205 requires DOE contractors responsible for hazard category 1, 2, and 3 DOE nuclear facilities to develop TSRs. These TSRs identify the limitations to each DOE-owned, contractor-operated nuclear facility based on the DSA and any additional safety requirements established for the facility. The TSR rule requires contractors to prepare and submit TSRs for DOE approval.

c. Define the following terms and discuss the purpose of each:
- **Safety limits**
- **Limiting control settings**
- **Limiting conditions for operation**
- **Surveillance requirements**

The following is taken from 10 CFR 830.

Safety Limits (SLs)

SLs means the limits on process variables associated with those safety class physical barriers, generally passive, that are necessary for the intended facility function and that are required to guard against the uncontrolled release of radioactive materials.

Limiting Control Settings (LCSs)

LCSs means the settings on safety systems that control process variables to prevent exceeding an SL.

Limiting Conditions for Operation (LCOs)

LCO means the limits that represent the lowest functional capability or performance level of safety SSCs required for safe operations.

Surveillance Requirements (SRs)

SRs means requirements relating to test, calibration, or inspection to ensure that the necessary operability and quality of safety SSCs and their support systems required for safe

operations are maintained, that facility operation is within SLs, and that LCSs and LCO are met.

d. Describe the general content of each of the following sections of the TSRs:
- **Use and application**
- **Safety limits (SLs)**
- **Operating limits (OLs)**
- **Surveillance requirements (SRs)**
- **Administrative controls (ACs)**
- **Basis**
- **Design features**

The following is taken from DOE G 423.1-1.

Use and Application

This section should contain basic information and instructions for using and applying the TSR. Operational modes (operation, startup, shutdown, warm standby, repair, refueling, etc.) of the facility are also listed.

Safety Limits (SLs)

SLs should describe as precisely as possible the process variables or the parameters being limited, and should state the limit in measurable units (pressure, temperature, flow, etc.). In general, SLs should be monitored continuously.

SLs should be based on, and specified in terms of, three basic rules:

1. Exceeding an SL is a TSR violation for each applicable mode. Upon exceeding an SL, the following steps should be taken:
   - The affected parameter must be immediately brought within the SL.
   - Place the facility in the most stable, safe condition attainable, including shutdown if appropriate.
   - Reactors are required to shut down immediately (e.g., scram). At nonreactor nuclear facilities, the TSR should specify actions to be taken that place the involved process in the most stable, safe condition attainable, including shutdown if appropriate.
   - All other action requirements should be met.

2. Each SL should have a mode applicability statement. This statement should consist of a simple list of modes or other conditions for which the SL is applicable.
3. Action statements should describe the actions to be taken in the event that the SL is not met. First, these actions should place the facility in a safe, stable condition, or should verify that the facility already is safe and stable and will remain so. Second, an action statement should establish the steps and time limits to correct the out-of-specification condition. The actions should bring the affected parameter immediately within the SL and should affect a shutdown of the facility, within a justified facility-specific time frame, normally less than an hour. Other actions required after exceeding an SL, including reporting requirements and an evaluation of possible damage caused by exceeding the SL, may be included in the action statement. A statement prohibiting restart of the facility after a SL violation without DOE approval

should be included in the action statement of each SL, in section 5 of the TSR, or in both.

Operating Limits (OLs)

This section contains LCSs and LCOs. Mode and location applicability statements, action statements, and SRs should also be included for each LCO or LCS, as appropriate. The most conservative value for each parameter or process variable contained in the safety analyses makes up the envelope within which the facility must operate to ensure that the DSA analyses bound safe operation.

LCSs should describe, as precisely as possible, the parameter or process variable being controlled or equipment being actuated and its limit, or the limiting setting of the device to control it.

The LCO statement should describe, as precisely as possible, the lowest functional capability or performance level of equipment required for safe operation of the facility. Each separate limiting condition should have an LCO with associated mode applicability, action statements, and SRs.

Surveillance Requirements (SRs)

SR statements consist of short descriptions of the type of surveillance required and its frequency of performance. These statements should be as brief as possible but should identify those requirements needed to ensure compliance with the LCS or LCO.

Administrative Controls (ACs)

The AC section should impose administrative requirements necessary to control operation of the facility such that it meets the TSR. The following topics should be included:

- Contractor responsibility. The facility or plant manager is responsible for overall operation of the nuclear facility and should delegate in writing the succession to this responsibility during his or her absence.
- Contractor organization. Onsite and offsite organizations should be described for facility operation and contractor management.
- Procedures. Operations procedures should provide sufficient direction to ensure that the facility is operated within its design basis and supports safe operation.
- Programs. Programs developed to ensure the safe operation of the facility should be discussed in this section and thereby committed to by reference.
- Minimum operations shift complement. This section of the ACs should include the maximum daily working hours and maximum number of consecutive days on duty.
- Operating support. A list of facility support personnel that includes name, title, and work and home telephone numbers should be maintained.
- Facility staff qualifications and training. Minimum qualifications for members of the facility staff in positions affecting safety should conform to the requirements of DOE Order 5480.20A, or a successor document, and should be provided in the AC section.
- Record keeping. Records need to be kept of all information supporting the implementation of the TSR, including operational logs of modes changes, entering actions, surveillances, deviations, procedures, programs, meetings, recommendations, etc.

- Reviews and audits. The methods established to conduct independent reviews and audits should be described.
- Deviations from TSRs. The actions and reporting required when there are deviations from TSRs should be explained.

Basis

This appendix provides summary statements of the reasons for the SLs, LCSs, LCOs, and associated SRs. The bases show how the numeric values, the conditions, the surveillances, and the action statements fulfill the purpose derived from the safety documentation. The primary purposes for describing the bases of each requirement are to ensure future changes to the requirement will not affect its original intent or purpose by invalidating the safety analysis and to aid in understanding why the requirement exists. The bases appendix should reference the more specific detailed safety analyses related to the TSR and the derivation of TSR section of the DSA for other related analyses discussed in the DSA.

Design Features

A design features section should be included with the TSR. The purpose of the design features section is to describe in detail those features not covered elsewhere in the TSRs that, if altered or modified, would have a significant effect on safety. The following two areas should be addressed in this section:

- vital passive safety SSCs such as piping, vessels, supports, structures (such as confinement), and containers;
- configuration or physical arrangement including dimensions, the parameter(s) being controlled, and the reasoning behind the design should be provided as identified in the safety analysis. Examples of such situations are where criticality avoidance is dependent on physical separation and where equipment configuration is used to minimize radiation levels.

24. Facility maintenance management personnel shall demonstrate a familiarity-level knowledge of nuclear safety analysis reports as described in 10 CFR 830.204, Documented Safety Analysis Reports.

a. Discuss the basic purposes and objectives of Nuclear Safety Analysis Reports.

[Note: The information provided here refers to documented safety analyses.]

The following is taken from DOE G 421.1-2.

Development of a DSA or a preliminary documented safety analysis (PDSA) is the process whereby facility hazards are identified, controls to prevent and mitigate potential accidents involving those hazards are proposed, and commitments are made for design, construction, operation, and disposition so as to assure adequate safety at DOE nuclear facilities. DOE, in its review and approval role, may require modification or addition to these commitments by the responsible contractor. Throughout the life of the facility, from design and construction to mission-oriented operations, through deactivation, long-term surveillance and maintenance, to decontamination and decommissioning, there must be a safety basis in place that is appropriate to the activities (operations) occurring during each of those phases.

b. Describe the responsibilities of contractors authorized to operate defense nuclear facilities regarding the development and maintenance of a Nuclear Safety Analysis Report.

[Note: The information provided here refers to documented safety analyses.]

The following is taken from DOE G 421.1-2.

Title 10 CFR 830.200, "Safety Basis Requirements, Scope," states that a contractor responsible for a DOE hazard category 1, 2, or 3 nuclear facility must:

- establish and maintain a safety basis for the facility;
- perform work in accordance with the safety basis and, in particular, with the hazard controls that ensure adequate protection of workers, the public, and the environment;
- pending issuance of a safety evaluation report in which DOE approves a safety basis for an existing DOE nuclear facility, continue to perform work in accordance with the safety basis for the facility in effect on October 10, 2000, or as approved by DOE at a later date, and maintain the existing safety basis consistent with the rule requirements.

In establishing the safety basis for a hazard category 1, 2, or 3 DOE nuclear facility, the contractor responsible for the facility must:

- define the scope of the work to be performed;
- identify and analyze the hazards associated with the work;
- categorize the facility consistent with DOE-STD-1027-92, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports*;
- prepare a DSA for the facility;
- establish the hazard controls upon which the contractor will rely to ensure adequate protection of workers, the public, and the environment.

[Note: DOE Order 5480.23 was cancelled.]

c. Define the following terms and discuss the purpose of each:

- **Design basis**
- **Authorization basis**
- **Engineered safety features**
- **Safety analysis**

The following is taken from DOE-HDBK-1188-2006.

Design Basis

Design basis is composed of design inputs, the design constraints, and the design analysis and calculations. It includes topical areas such as seismic qualification, fire protection, and safe shutdown. It encompasses consideration of such factors as plant availability, plant efficiency, costs, and maintainability, and that subset that relates to safety and the authorization basis.

Authorization Basis

Those aspects of the facility design basis and operational requirements relied upon by DOE to authorize operation. These aspects are considered to be important to the safety of facility

operations. The authorization basis is described in documents such as the facility SAR and other safety analyses; hazard classification documents, the TSRs, DOE-issued safety evaluation reports, and facility-specific commitments made in order to comply with DOE Orders or policies.

Engineered Safety Features

Engineered safety features are SSCs that prevent and/or mitigate the consequences of potential accidents described in the final SAR including the bounding design basis accidents.

Safety Analysis

Safety analysis is a documented process: (1) to provide systematic identification of hazards within a given DOE operation; (2) to describe and analyze the adequacy of measures taken to eliminate, control, or mitigate identified hazards; and (3) to analyze and evaluate potential accidents and their associated risks.

d. Describe the requirements for the scope and content of a Nuclear Safety Analysis Report and discuss the general content of each of the required sections of a Nuclear Safety Analysis Report.

[Note: The information provided here refers to documented safety analyses.]

The following is taken from DOE-STD-3009-94.

Content is usually governed by DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses*, which identifies the following chapters:

Chapter One: Site Characteristics

This chapter provides a description of site characteristics necessary for understanding the facility environs important to the safety basis. Information is provided to support and clarify assumptions used in the hazard and accident analyses to identify and analyze potential external and natural event accident initiators and accident consequences external to the facility.

Chapter Two: Facility Description

This chapter provides descriptions of the facility and processes to support assumptions used in the hazard and accident analyses. These descriptions focus on all major facility features necessary to understand the hazard analysis and accident analysis, not just safety SSCs.

Chapter Three: Hazard and Accident Analyses

The purpose of this chapter is to provide information that will satisfy the requirements of 10 CFR 830 to evaluate normal, abnormal, and accident conditions, including consideration of natural and man-made external events, identification of energy sources or process that might contribute to the generation or uncontrolled release of radioactive and other hazardous materials, and consideration of the need for analysis of accidents which may be beyond the design basis of the facility.

Chapter Four: Safety Structures, Systems, and Components

This chapter provides details on those facility structures, systems, and components that are necessary for the facility to protect the public, provide defense in depth, or contribute to worker safety.

Chapter Five: Derivation of Technical Safety Requirements

This chapter builds upon the control functions determined to be essential in chapter 3, and chapter 4, to derive TSRs. This chapter is meant to support and provide the information necessary for the separate TSR document required by 10 CFR 830.205.

Chapter Six: Prevention of Inadvertent Criticality

The purpose of this chapter is to provide information that will support the development of a safety basis in compliance with the provisions of 10 CFR 830.204(b) (6) regarding the definition of a criticality safety program.

Chapter Seven: Radiation Protection

This chapter summarizes provisions for radiation protection. Summaries focus on radiation protection based on facility hazards to provide a basic understanding of the scope of the radiation protection program.

Chapter Eight: Hazardous Material Protection

This chapter summarizes provisions for hazardous material protection other than radiological hazards. Summaries focus on hazardous material protection based on facility hazards to provide a basic understanding of the scope of the hazardous material protection program.

Chapter Nine: Radioactive and Hazardous Waste Management

This chapter describes the provisions for radioactive and hazardous waste management. Expected products of this chapter, as applicable, based on the graded approach, include:

- description of the overall radioactive and hazardous waste management program and organization;
- description of the site-specific radioactive, mixed, and hazardous material waste management policy, objectives, and philosophy;
- identification of hazardous waste streams, including types, sources, and quantities; and
- description of the waste management process, and waste treatment and disposal systems, including design and administrative controls.

Chapter Ten: Initial Testing, In-Service Surveillance, and Maintenance

This chapter describes the essential features of the testing, surveillance, and maintenance programs. Expected products of this chapter, as applicable based on the graded approach, include:

- description of the facility initial testing program.
- description of the facility in-service surveillance program.
- description of the planned, predictive, preventive, and corrective facility maintenance programs.

Chapter Eleven: Occupational Safety

This chapter discusses general aspects of operational safety. It specifically focuses on the bases for the conduct of operations program specified by DOE 5480.19.

Chapter Twelve: Procedures and Training

This chapter describes the processes by which the technical content of the procedures and training programs are developed, verified, and validated. These processes will ensure that the facility is operated and maintained by personnel who are well qualified and competent to carry out their job responsibilities using procedures and training elements that have been well developed and are kept current by the use of feedback and continuous improvement.

Chapter Thirteen: Human Factors

This chapter focuses on human factors engineering, its importance to facility safety, and the design of the facility to optimize human performance.

Chapter Fourteen: Quality Assurance

This chapter describes the provisions for a quality assurance program. Expected products of this chapter, as applicable based on the graded approach, include:

- description of quality assurance program and organization;
- description of document control and records management; and
- description of the quality assurance process ensuring that performed safety related work meets requirements.

Chapter Fifteen: Emergency Preparedness Program

This chapter summarizes the emergency preparedness functions and response at the facility. Expected products of this chapter, as applicable based on the graded approach, include:

- identification of the scope of the facility Emergency Preparedness Plan (EPP) (i.e., spectrum of emergencies encompassed); and
- description of the philosophy, objectives, organization, and emergency response of facility emergency preparedness.

Chapter Sixteen: Provisions for Decontamination and Decommissioning

This chapter describes provisions that facilitate future decontamination and decommissioning of a facility. Design of significant modifications to an existing facility must consider provisions for decontamination and decommissioning. This chapter also contains guidance on the description of the conceptual decontamination and decommissioning plan for existing facilities.

Chapter Seventeen: Management, Organization, and Industrial Safety Provisions

This chapter presents information on management, technical, and other organizations that support safe operation. This chapter also enumerates the requirements used to develop the safety management programs, includes descriptions of the responsibilities of and relationships between the non-operating organizations having a safety function and their interfaces with the line operating organization, and presents sufficient information on the safety management policies and programs to demonstrate that the facility operations are embedded in a safety conscious environment.

Appendix A: Evaluation Guideline

This appendix specifies a numerical radiological dose value to be used in identifying safety class SSCs. Calculation methods and assumptions needed to provide general consistency in dose estimation are also described, with relevant background and interpretation discussions included as appropriate.

e. Discuss the ways that contractor management makes use of nuclear safety analysis reports.

[Note: The information provided here refers to documented safety analyses.]

The following is taken from 10 CFR 830.

The DSA for a hazard category 1, 2, or 3 DOE nuclear facility must, as appropriate for the complexities and hazards associated with the facility:

- describe the facility (including the design of SSCs and the work to be performed);
- provide a systematic identification of both natural and man-made hazards associated with the facility;
- evaluate normal, abnormal, and accident conditions, including consideration of natural and man-made external events, identification of energy sources or processes that might contribute to the generation or uncontrolled release of radioactive and other hazardous materials, and consideration of the need for analysis of accidents which may be beyond the design basis of the facility;
- derive the hazard controls necessary to ensure adequate protection of workers, the public, and the environment, demonstrate the adequacy of these controls to eliminate, limit, or mitigate identified hazards, define the process for maintaining the hazard controls current at all times, and control their use;
- define the characteristics of the safety management programs necessary to ensure the safe operation of the facility, including where applicable, QA, procedures, maintenance, personnel training, conduct of operations, emergency preparedness, fire protection, waste management, and radiation protection;
- define a criticality safety program that ensures that operations with fissionable material remain sub-critical under all normal and credible abnormal conditions, identifies applicable nuclear criticality safety standards, and describes how the program meets applicable nuclear criticality safety standards.

25. Facility maintenance management personnel shall demonstrate a familiarity-level knowledge of DOE -STD-1073-93, Configuration Management.

[Note: DOE-STD-1073-93 was superseded by DOE-STD-1073-2003.]

a. Describe the purpose and objectives of the operational configuration management program.

The following is taken from DOE-STD-1073-2003.

The purpose of DOE-STD-1073-2003 is to define the objectives of a CM process for DOE nuclear facilities (including activities and operations), and to provide detailed examples and

supplementary guidance on methods of achieving those objectives. CM is a disciplined process that involves both management and technical direction to establish and document the design requirements and the physical configuration of the nuclear facility and to ensure that they remain consistent with each other and the documentation.

The size, complexity, and missions of DOE nuclear facilities vary widely and CM processes may need to be structured to individual facilities, activities, and operations. It would generally be inappropriate to apply the same CM standards to widely different activities, for example, a reactor facility and a small, simple laboratory. The detailed examples and methodologies in this standard are provided to aid those developing their CM processes; however, they are provided for guidance only and may not be appropriate for application to all DOE nuclear activities. The individuals defining the CM process for a particular nuclear activity will need to apply judgment to determine if the examples and methods presented in this standard are appropriate for the activity.

Nevertheless, the basic objectives and general principles of CM are the same for all activities. The objectives of CM are to:

- establish consistency among design requirements, physical configuration, and documentation (including analysis, drawings, and procedures) for the activity, and
- maintain this consistency throughout the life of the facility or activity, particularly as changes are being made.

b. Discuss what constitutes acceptable contractor compliance consistent with the requirements of DOE-STD-1073-93, Configuration Management, for the following elements of the contractor's configuration management plan:

- **Program planning**
- **Equipment scope criteria**
- **Concepts and terminology**
- **Interfaces**
- **Databases**
- **Procedures**

[Note: DOE-STD-1073-93 was superseded by DOE-STD-1073-2003.]

The following is taken from DOE-STD-1073-2003.

Program Planning

The contractor must formally document and implement the CM process to be used for the activity in a CM plan. The CM plan must address:

- how each of the key elements of CM will be implemented;
- what are the systems, structures, and components to be included in the CM process and what is the basis/justification for the selection;
- what CM training is provided;
- who is assigned key responsibilities and authorities for CM;
- how interfaces are controlled; and
- what programs and procedures must incorporate CM.

Where appropriate, a graded approach should be used to implement CM. The CM plan should identify how the graded approach will be applied. For example, if the contractor

applies different schedules for updating documents through the document control process based on the importance of the document type to operations, the schedules should be documented in the CM plan.

The DOE ISMS is defined in DOE Policy 450.4, *Safety Management System Policy*. DOE contractors are expected to use ISMS to integrate safety into all aspects of work planning and execution. All safety management systems and programs should be designed to fit together to permit safe and efficient performance. Consistent with that goal, CM should function as an integrated process that marries seamlessly with other safety management processes at the facility or activity, not as a separate and distinct program. In addition, the contractor must flow down the CM process to subcontractors and suppliers as appropriate to the work and ensure subcontractors and suppliers are implementing it appropriately.

Equipment Scope Criteria

In order to assess the impact a change will have to an activity, the contractor must first understand the design requirements of the activity. These design requirements must be identified and documented, and changes to them must be controlled.

The first set of SSCs that must be included in the CM SSCs for hazard category 1, 2, and 3 nuclear facilities is the set of Safety SSCs identified in the DSA as required by 10 CFR 830. Safety SSCs are defined as the combination of Safety-Class SSCs and Safety-Significant SSCs, and they include those SSCs whose preventive or mitigative functions are considered to be major contributors to defense-in-depth and worker safety. “Defense-in-depth” refers to the various layers of protection provided to ensure public safety, worker safety, and protection of the environment. The safety SSCs identified in the DSA constitute the baseline set of SSCs that must be included in the CM process.

In addition, contractors should include in the set of CM SSCs the SSCs whose functions are considered to be important to defense-in-depth or worker safety, but are not already included in the Safety SSCs. The combination of the Safety SSCs and the other defense-in-depth SSCs should encompass the “vital safety systems.” The vital safety systems include the safety significant systems, the safety class systems, and other systems that perform an important defense-in-depth safety function.

The contractor should also review the activity to determine if it is appropriate to include other SSCs in the set of CM SSCs. Other categories of SSCs that should be considered include the following:

- Mission critical SSCs - SSCs whose failure could cause substantial interruption to the mission of the facility or activity;
- Environmental protection SSCs - SSCs that could have a significant impact on the environment if they failed to perform their function;
- Costly SSCs - SSCs that would be expensive to fix or replace or whose failure could result in problems that could be expensive to fix;
- Critical Software - Software whose proper performance is critical to the expected performance of a safety SSC, a defense-in-depth SSC, or the safety of the nuclear facility;
- MEL SSCs – SSCs that are included in the maintenance program; and

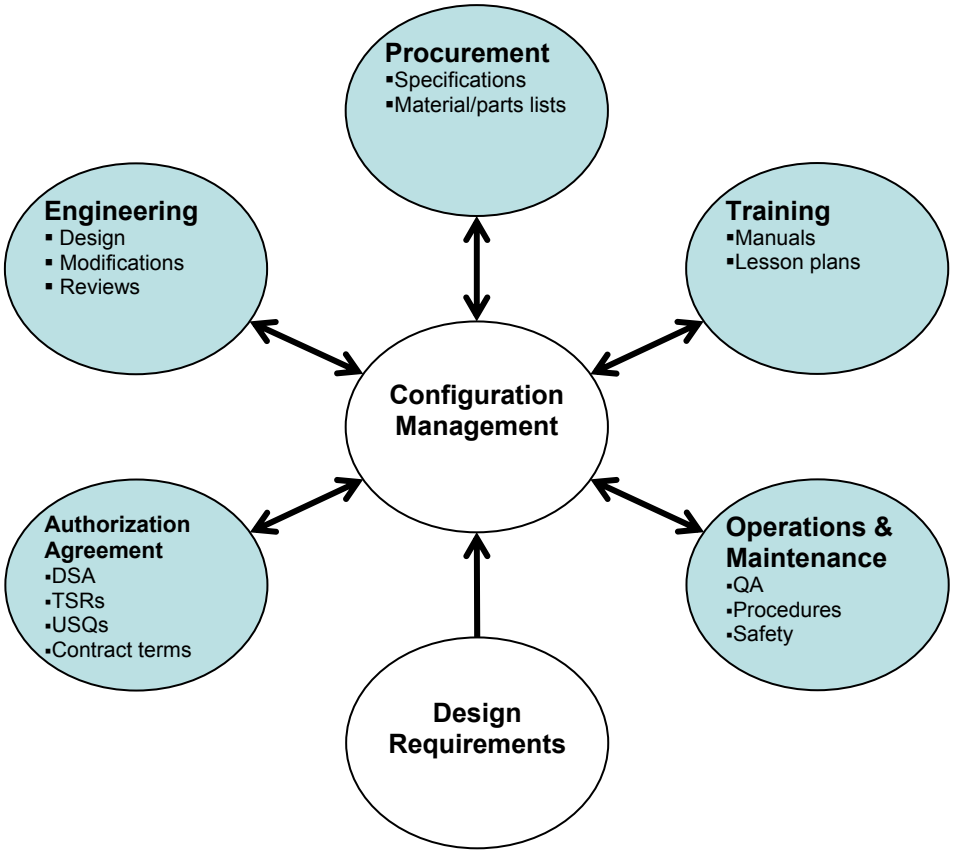
- Adjacent SSCs - SSCs that are located adjacent to the safety or defense-in-depth SSCs such that changes to these SSCs could negatively impact the safety or mission of the activity.

Concepts and Terminology

Contractors with existing processes that satisfy the CM criteria should continue to use those processes, modifying them only as necessary. This standard should not be used to justify repackaging existing processes that are already adequate. For example, if a facility has an adequate document control process, there would be little benefit in requiring that facility to repackage the process for the sole purpose of matching the format or terminology in this standard.

Interfaces

CM supports a number of contractor organizations and initiatives by ensuring conformance with the established design requirements. Figure 3 illustrates some of these interfaces.



Source: DOE-HDBK-1073-2003.

Figure 3. Configuration management interfaces

Databases

Contractors must develop CM equipment databases that cross-reference SSCs with their design requirements, design basis, and associated documents. These databases will be the primary information source for design requirements. Contractors should use the best available design information to fill the database fields.

The CM equipment database can be used to contain and correlate key information, such as:

- system designators;
- component designators;
- component descriptive information such as type, manufacturer, model, and size;
- grades/priority/classification;
- design requirements or references to design requirements;
- design basis references;
- design topical area references (e.g., seismic, environmental qualification, fire protection);
- range of acceptable setpoints;
- facility document references (e.g., drawings, procedures, DSAs);
- TSR references;
- MELs;
- other desired system and component information.

Linking the management equipment database with other equipment databases with other databases, such as the MEL or other databases listed above, will not only result in greater efficiency because there are fewer databases to maintain, it will also facilitate CM as changes will be more thoroughly reviewed and coordinated.

Procedures

The contractor must incorporate CM requirements into its procedures and other work processes, and, consistent with 10 CFR 830, perform work in accordance with those procedures and work processes. Furthermore, personnel must be trained to establish and maintain proficiency in meeting the CM process. Training should include:

- instruction on the objectives of CM;
- instruction on the implementation of CM, including applicable procedures; and
- update and refresher training (e.g., annually).

c. Discuss the following elements of the Configuration Management Program:

- **Design requirements**
- **Document control**
- **Change control**
- **Assessments**
- **Design reconstitution adjunct**
- **Material condition and aging adjunct**

The following is taken from DOE-STD-1073-2003.

Design Requirements

The objective of the design requirements element of CM is to document the design requirements. The design requirements define the constraints and objectives placed on the

physical and functional configuration. The design requirements to be controlled under CM will envelope the safety basis and, typically, the authorization basis. Consequently, proper application of the CM process should facilitate the contractor's efforts to maintain the safety basis and the authorization basis. Contractors must establish procedures and controls to assess new facilities and activities and modifications to facilities and activities to identify and document design requirements.

Document Control

Document control ensures that only the most recently approved versions of documents are used in the process of operating, maintaining, and modifying the nuclear facility. Document control helps ensure that

- important facility documents are properly stored;
- revisions to documents are controlled, tracked, and completed in a timely manner;
- revised documents are formally distributed to designated users;
- information concerning pending revisions is made available.

As controlled documents are updated to reflect changes to the requirements and/or physical installation, the contractor must ensure that (1) each updated document is uniquely identified and includes a revision number and date, and (2) each outdated document is replaced by the latest revision.

Change Control

Contractors must establish and use a formal change control process as part of the CM process. The objective of change control is to maintain consistency among design requirements, the physical configuration, and the related facility documentation, even as changes are made. The change control process is used to ensure changes are properly reviewed and coordinated across the various organizations and personnel responsible for activities and programs at the nuclear facility.

Through the change control process, contractors must ensure that

- changes are identified and assessed through the change control process;
- changes receive appropriate technical and management review to evaluate the consequences of the changes;
- changes are approved or disapproved;
- waivers and deviations are properly evaluated and approved or denied, and the technical basis for the approval or the denial is documented;
- approved changes are adequately and fully implemented, or the effects of the partial implementation are evaluated and accepted;
- implemented changes are properly assessed to ensure the results of the changes agree with the expectations;
- documents are revised consistent with the changes, and the revised documents are provided to the users.

Assessments

The QA criteria of 10 CFR 830, subpart A, require DOE contractors for nuclear facilities (including activities and operations) to assess management processes and measure the

adequacy of work performance. Furthermore, the assessment criteria require the persons performing the assessments to

- have sufficient authority and freedom from line management
- be qualified to perform the assessments

The maintenance criteria of DOE O 433.1 also require periodic assessments to verify the condition of systems and equipment.

Periodic assessments help ensure that work processes continue to function properly or problems are identified, root causes are determined, and problems are corrected. DOE-STD-1073-2003 provides guidance on performing assessments directly related to CM. While contractors may perform these assessments of the CM process separate from other assessments, it may be more efficient to combine these assessments with other periodic assessments of the activity. All or part of the assessment of the adequacy of CM for an activity may be integrated into broader management and performance assessments, such as QA, maintenance, or integrated safety management assessments. If the contractor decides to fold the assessment of CM into a broader assessment, it must consider the criteria in DOE-STD-1073-2003 when developing the assessment criteria for the broader assessment.

The five specific types of assessments discussed in DOE-STD-1073-2003 are:

- construction assessments, which are performed to ensure configuration is managed throughout the construction process for new construction or major modifications;
- physical configuration assessments, which are conducted to evaluate the consistency between the physical configuration and the facility documentation;
- design assessments, which are done to ensure that design documents have been updated to reflect changes and accurately reflect the physical configuration of the nuclear facility;
- post-construction, post-modification, or post-installation inspections and tests, which are performed either after construction, modification, or installation to verify operation is as expected;
- periodic performance assessments, which are conducted to verify that systems and components continue to meet design and performance requirements in their current configurations.

Design Reconstitution Adjunct

Design reconstitution adjunct is an adjunct program to the CM process that accomplishes the one-time effort of identifying, retrieving, extracting, evaluating, verifying, validating, and regenerating missing critical design requirements and basis. Design reconstitution encompasses the following functions: developing associated program plans and procedures; identifying and retrieving design information from identified source documents; evaluating, verifying, and validating the design information; resolving discrepancies; regenerating missing critical design information; and preparing and issuing design information summaries.

Material Condition and Aging Adjunct

The discussion on material condition and aging was deleted from DOE-STD-1073-2003.

d. Discuss the purpose, concepts, and general process for applying the graded approach to operational configuration management.

DOE defines the graded approach as a process of ensuring that the level of analysis, documentation, and actions used to comply with a requirement are commensurate with:

- the relative importance to safety, safeguards, and security;
- the magnitude of any hazard involved;
- the life cycle stage of a facility;
- the programmatic mission of a facility;
- the particular circumstances of a facility;
- the relative importance of radiological and non-radiological hazards;
- any other relative hazard.

The main purpose of using a graded approach is to determine and apply a level of resources that is appropriate when implementing a program. The goal is to apply the highest level of resources to the most important equipment in the most important facilities and to avoid such expenditures where they are not warranted. For a highly hazardous facility such as a large nuclear reactor, which could potentially have serious offsite personnel safety consequences, a significant investment of resources is appropriate for the systems that prevent, detect, or mitigate such consequences. At the other extreme, for a low-hazard facility — a glovebox operation, for example — where the greatest hazard is localized (i.e., offsite persons and workers at other collocated facilities are not affected), the same investment of resources may not be necessary. The grading system should take into account both facility grades and SSC grades in determining the appropriate level of resources to be applied.

26. Facility maintenance management personnel shall demonstrate a familiarity-level knowledge of DOE O 413.3, Program and Project Management for the Acquisition of Capital Assets.

[Note: DOE O 413.3 was superseded by DOE O 413.3A, *Program and Project Management for the Acquisition of Capital Assets*.]

a. Discuss the purpose, scope, and application of DOE Order 4700.1, Project Management System. Include in this discussion the key terms, essential elements, and personnel responsibilities and authorities.

[Note: DOE Order 4700.1 has been canceled.]

b. Discuss the project management terminology for which definitions are provided in DOE Order 4700.1.

[Note: DOE Order 4700.1 has been canceled.]

The following partial list of terminology/definitions is taken from DOE 413.3A.

Acquisition Strategy

An acquisition strategy is a high-level business and technical management approach designed to achieve project objectives within specified resource constraints. It is the framework for

planning, organizing, staffing, controlling, and leading a project. It provides a master schedule for activities essential for project success, and for formulating functional strategies and plans.

Capital Assets

Capital assets are land, structures, equipment, intellectual property (e.g., software), and information technology used by the federal government and having an estimated useful life of two or more years. Capital assets include environmental restoration (decontamination and decommissioning) of land to make useful leasehold improvements and land rights, and assets whose ownership is shared by the federal government with other entities.

Critical Decision

A formal determination made by the Secretarial Acquisition Executive/Acquisition Executive at a specific point in a project's life cycle that allows the project to proceed to the next phase or critical decision (CD).

Earned Value

Earned value (EV) is the budgeted value of work actually accomplished in a given time. Simply defined, EV represents the value of work accomplished during the period.

Earned Value Management

EV management is a program and project management methodology of which organization, planning, progressing, tracking, management control, reporting, and communication are essential elements.

External Independent Review

A project review conducted by individuals outside DOE. The Office of Engineering and Construction Management selects an appropriate contractor to perform these reviews.

Final Design

Completion of the design effort and production of all the approved design documentation necessary to permit procurement, construction, testing, checkout, and turnover to proceed. Final design occurs between CD-2 and CD-3.

Independent Cost Estimate

A "bottoms-up" documented, independent cost estimate that has the express purpose of serving as an analytical tool to validate, crosscheck, or analyze cost estimates developed by project proponents.

Independent Project Review

Independent project reviews are important project management tools and serve to verify the project's mission, organization, development, processes, technical requirements, baselines, progress, etc. Independent project reviews are performed by reviewers from within or outside the Program, but having no association with the project being reviewed.

Integrated Project Team

An integrated project team is a cross-functional group of individuals organized for the specific purpose of delivering a project to an external or internal customer.

Key Performance Parameters (KPPs)

A KPP is a vital characteristic of a project or facility mission. A characteristic, function, requirement, or design basis, that if changed, would have a major impact on the facility or system performance, scope, schedule, cost and/or risk, or the ability of an interfacing project to meet its mission requirements.

Major System

A project with a total project cost (TPC) of greater than or equal to $750 million or an Environmental Management TPC of $1 billion, or designated by the Deputy Secretary of DOE.

Non-Major System

Any project with a total project cost less than $750 million or an Environmental Management total project cost less than $1 billion.

Performance Baseline

Performance baselines are the collective key performance, scope, cost, and schedule parameters, which are defined for all projects. Performance baseline includes the entire project budget (total cost of the project including contingency) and represents DOE's commitment to Congress.

Project

A unique effort that supports a program mission having defined points for starting and ending, undertaken to create a product, facility, or system and containing interdependent activities planned to meet a common objective or mission. A project is a basic building block (in relation to a program) that is individually planned, approved, and managed.

Total Project Cost

DOE has traditionally identified project costs in two categories: (1) total estimated cost (TEC), and (2) other project cost (OPC). The sum of the TEC and OPC make up the TPC.

- TEC includes project costs incurred after CD-1 such as costs associated with the acquisition of land and land rights; engineering, design, and inspection; direct and indirect construction/fabrication; and the initial equipment necessary to place the plant or installation in operation. TEC may be funded as an operating or capital expense.
- OPCs include all project costs that are not identified as total estimated cost costs. Generally, OPCs are costs incurred during the initiation and definition phases for planning, conceptual design, research and development, and during the execution phase for startup and operation. OPCs are always operating funds.

Value Management

Value management is an organized effort directed at analyzing the functions of systems, equipment, facilities, services, and supplies for achieving the essential functions at the lowest life cycle cost consistent with required performance, quality, reliability, and safety. Value management encompasses value engineering.

Value Engineering

Value engineering is a planned, detailed review/evaluation of a project to identify alternative approaches to providing the needed assets.

Variance

A variance is a deviation from the approved scope, cost, or schedule performance. Variances must be tracked and reported. Variances should be mitigated through corrective actions and not eliminated through baseline change control unless valid rationale can be presented to justify a change in baseline. Baseline changes are submitted for changes in technical, work scope, funding, or directed changes.

c. Discuss in detail the roles played by various management levels within the Department as they relate to the project management system.

The following is taken from DOE O 413.3A.

The DOE Deputy Secretary serves as the Secretarial Acquisition Executive for DOE and promulgates DOE-wide policy and direction. The CD authorities, thresholds and delegations are identified in table 4.

Table 4. Critical decision authority thresholds

Critical Decision Authority	Total Project Cost Thresholds*	Life Cycle Clean-Up Project Cost Thresholds*
Secretarial Acquisition Executive	≥ $750M (or any project on an exception basis when designated by the Secretarial Acquisition Executive) **No delegation authority**	≥ $1B (or any Clean-Up Project on an exception basis when designated by the Secretarial Acquisition Executive) **Delegation authority to Program Secretarial Office on an exception basis**
Under Secretaries	≥ $100M and < $750M (or any project on an exception basis when designated by the Under Secretaries) **Delegation authority to Program Secretarial Officer for projects < $400M**	Not Applicable
Program Secretarial Officer	≥ $20M** and < $100M **Delegation authority to a Program Manager or field organization manager. CD-0 may not be delegated below the Program Secretarial Officer.**	<$1B **Delegation authority to Headquarters or field Senior Executive Service manager. CD-0 may not be delegated below the Program Secretarial Officer.**
Chief Information Officer	> $5M and < $750M Departmental Information Technology Projects **No delegation authority**	Not Applicable

Source: DOE O 413.3A.

d. Discuss the purpose of critical decisions. Include in this discussion the responsible authorities for critical decisions.

The following is taken from DOE O 413.3A.

The five CDs are major milestones approved by the secretarial acquisition executive or acquisition executive that establish the mission need, recommended alternative, acquisition strategy, the performance baseline, and other essential elements required to ensure that the project meets applicable mission, design, security, and safety requirements. Each CD marks an increase in commitment of resources by the department and requires successful completion of the preceding phase or CD. Collectively, the CDs affirm the following:

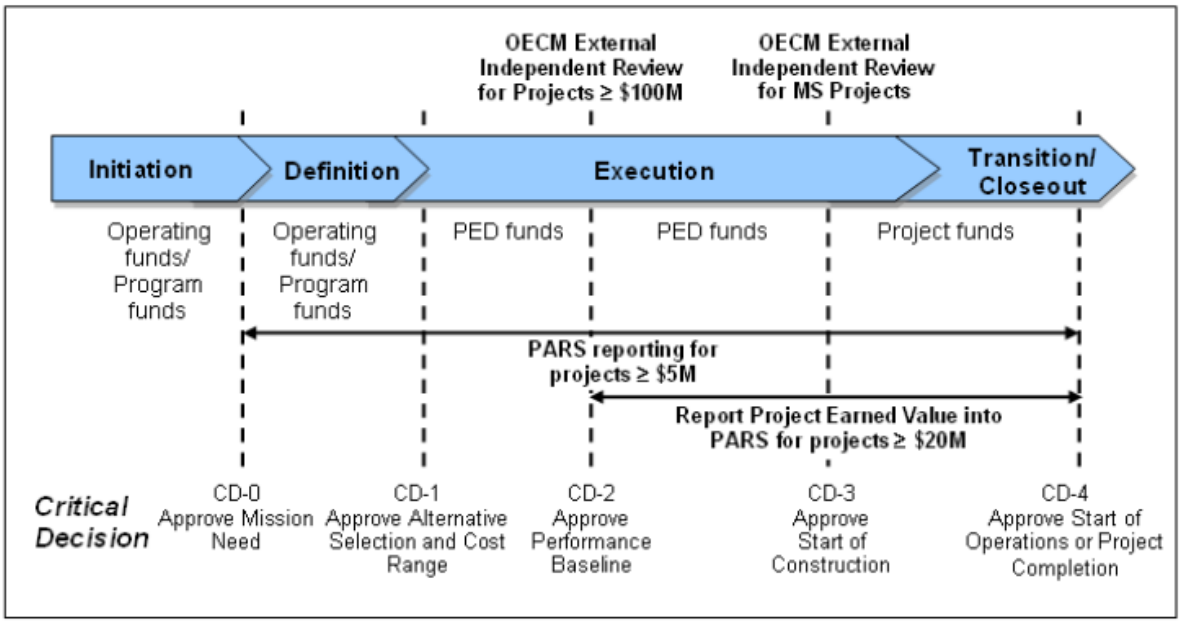
- There is a need that cannot be met through other than material means;
- The selected alternative and approach is the optimum solution;
- Definitive scope, schedule and cost baselines have been developed;
- The project is ready for implementation; and
- The project is ready for turnover or transition to operations.

CDs for traditional construction projects are shown in figure 4 and include the following:

- CD-0, Approve Mission Need
- CD-1, Approve Alternative Selection and Cost Range
- CD-2, Approve Performance Baseline
- CD-3, Approve Start of Construction

- CD-4, Approve Start of Operations or Project Completion

The DOE Deputy Secretary serves as the Secretarial Acquisition Executive for DOE and promulgates DOE-wide policy and direction. The CD authorities, thresholds and delegations are identified in table 4.



Source: DOE O 413.3A.

Figure 4. Typical DOE acquisition management system

e. Describe the process by which projects are designated.

The following is taken from DOE O 413.3A.

Major System Projects

Projects with a total project cost greater than or equal to $750 million or Environmental Management clean-up projects with an Environmental Management total project cost of $1 billion are major system projects. All major system project CDs must be proposed by the appropriate program secretarial officer and approved by the Deputy Secretary as DOE's designated secretarial acquisition executive before proceeding to the next project phase or CD.

Non-Major System Projects

Projects with a total project cost less than $750 million or Environmental Management Clean-Up Projects with an Environmental Management total project cost less than $1 billion are non-major system projects. The designated acquisition executive must approve all non-major system project CDs, except for CD-0, which cannot be delegated below the program secretarial officer.

The Chief Information Officer will function as the acquisition executive for all information technology capital assets deemed by the Deputy Secretary to be DOE-wide with total project Development, Modernization, and Enhancement funding of $20 million and greater, and Development, Modernization, and Enhancement funding of $5 million or more in current year or budget year. DOE information technology capital assets will be defined by the Deputy Secretary and are characterized by: 1) their widespread and continuous use among multiple DOE organizational units; 2) their vital importance to accomplishing DOE's business functions; and 3) their special importance to agency senior management.

27. Facility maintenance management personnel shall demonstrate a familiarity-level knowledge of the following DOE technical standards and Order related to natural phenomena hazards:

- **DOE-STD-1020-2002, Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities**
- **DOE-STD-1021-93, Natural Phenomena Hazards Performance Categorization Guidelines for Structures, Systems, and Components**
- **DOE-STD-1022-94, Natural Phenomena Hazards Characterization Criteria**
- **DOE Order 5480.28, Natural Phenomena Hazards Mitigation**

a. Describe the purpose, scope, and application of the requirements detailed in the listed standards and Order.

DOE-STD-1020-2002, Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities

This NPH standard, developed from University of California Research Laboratory-15910, provides criteria for the design of new SSCs and for evaluation, modification, or upgrade of existing SSCs so that DOE facilities safely withstand the effects of NPHs such as earthquakes, extreme winds, and flooding.

DOE-STD-1020 provides consistent criteria for all DOE sites across the United States. These criteria are provided as the means of implementing DOE O 420.1B and the associated guides, and Executive Orders 12699 and 12941 for earthquakes.

DOE-STD-1021-93, Natural Phenomena Hazards Performance Categorization Guidelines for Structures, Systems, and Components

This standard provides guidelines to be used for NPH performance categorization of SSCs, and recommends systematic procedures to implement these guidelines. It applies to all DOE facilities that are covered by DOE O 420.1B. Title 10 CFR 830 requires the use of a graded approach in performing safety analysis and evaluation of DOE facilities for normal operating and accident conditions, including accidents caused by NPH events. The NPH guide to DOE O 420.1B (DOE G 420.1-2, *Guide for the Mitigation of Natural Phenomena Hazards for DOE Nuclear Facilities and NonNuclear Facilities*) uses this graded approach and requires, for the purpose of NPH design and evaluation, placing the SSCs comprising the DOE facilities into five NPH performance categories.

NPH performance categorization guidelines provided in this technical standard are based on the system safety classification and hazard categorization/classification data obtained from the application of 10 CFR 830, DOE-STD-3009-94, and DOE-STD-1027-92.

DOE-STD-1022-94, Natural Phenomena Hazards Characterization Criteria

The purpose of DOE-STD-1022-94 is to provide criteria for site characterization to provide site-specific information needed for implementing DOE O 420.1B requirements. Additionally, the purpose of this standard is to develop a site-wide database related to NPH that should be obtained to support individual DSAs. Appropriate approaches are outlined to ensure that the current state-of-the-art methodology is being used in the site characterization.

The criteria and recommendations in this standard apply to site characterization for the purpose of mitigating NPHs in all DOE facilities covered by DOE O 420.1B. Criteria for site characterization not related to NPHs are generally not included in this document unless they are deemed necessary for clarification. General and detailed site characterization requirements are provided in the areas of meteorology, hydrology, geology, seismology, and geotechnical studies.

DOE Order 5480.28, Natural Phenomena Hazards Mitigation

This Order has been canceled.

b. Discuss the graded approach process that Department line management uses to determine an appropriate level of coverage by facility maintenance systems personnel. Include in this discussion the factors that may influence the level of coverage.

The following is taken from DOE-STD-1021-93.

Following the graded approach, the level of effort directed toward performance categorization, using the procedural steps presented in DOE-STD-1021-93, should be in proportion to the safety, mission, and cost significance of the SSC being categorized and the facility to which the SSC belongs. Hazard is used as only one consideration in the graded approach concept. Categorization of safety-class and safety-significant SSCs shall heavily rely on accident analysis of the facility if available. Whenever questions concerning appropriate categorization arise, a margin of error should be provided by selecting the higher category.

c. Determine contractor compliance with the listed documents as they apply to contract design requirements and facility maintenance management system activities at a defense nuclear facility.

This is a performance-based KSA. The Qualifying Official will evaluate its completion.

28. Facility maintenance management personnel shall demonstrate a familiarity-level knowledge of methods to maintain communication with Headquarters, field elements, and the public.

a. Describe the Department's organization and discuss the procedures for communicating between elements.

The following is taken from DOE, Organization.

DOE contributes to the future of the nation by ensuring energy security, maintaining the safety, security and reliability of the nuclear weapons stockpile, cleaning up the environment from the legacy of the Cold War, and developing innovations in science and technology.

These various missions are managed by the following program offices:

- Office of Civilian Radioactive Waste Management
- Office of Electricity Delivery and Energy Reliability
- Office of Energy Efficiency and Renewable Energy
- Office of Environmental Management
- Office of Fossil Energy
- Office of Legacy Management
- Office of Nuclear Energy
- Office of Science

DOE Staff and Support Offices provide administrative, management, and oversight support to the DOE's Program Offices to assist them in the successful accomplishment of their respective missions. A list of staff and support offices follows:

- Chief Financial Officer
- Chief Human Capital Officer
- Chief Information Officer
- Office of Congressional and Intergovernmental Affairs
- Office of Economic Impact and Diversity
- Office of General Counsel
- Office of Health, Safety, and Security
- Office of Hearings and Appeals
- Office of Inspector General
- Office of Intelligence and Counterintelligence
- Office of Management
- Office of Policy and International Affairs
- Office of Public Affairs

The following is taken from DOE O 226.1A.

Sites must have effective processes for communicating issues up the management chain to senior management, using a graded approach that considers hazards and risks. The processes must provide sufficient technical basis to allow managers to make informed decisions and must include provisions for communicating and documenting dissenting opinions. Processes for resolving disputes about oversight findings and other significant issues must be implemented. The processes must include provisions for independent technical reviews of significant issues.

Formal programs must be established to communicate lessons learned during work activities, process reviews, and event analyses to potential users and applied to future work activities. Contractors must identify, apply, and exchange lessons learned with the rest of the DOE complex. Contractors must review and apply lessons learned identified by other DOE organizations and external sources to prevent similar occurrences. DOE's lessons learned program is presented in DOE-STD-7501-99, *The DOE Corporate Lessons Learned Program.*

DOE line management must set expectations and communicate them to contractors. This will be implemented through formal contract mechanisms and direct communication between DOE and contractor managers.

b. Describe the Department's procedures and policy for communicating with the Environmental Protection Agency and other regulatory agencies.

The following is taken from U.S. Environmental Protection Agency (EPA), *Federal Facilities Restoration and Reuse, Final Guidance on Improving Communication to Achieve Collaborative Decision-Making at DOE Sites*.

This document was developed through a joint effort by the DOE and the EPA with substantive input from state regulators.

A variety of factors led to the development of this guidance. First, independent observers highlighted the need for improved communications both within, and between, the respective organizations. Second, given increasing fiscal constraints, DOE and EPA must facilitate greater regulator involvement in budget planning. Lastly, DOE and EPA must jointly identify the necessary work that will be undertaken to achieve the most suitable remedy. This will save money, focus effort on the appropriate actions, and accelerate cleanup.

This guidance describes a communication framework that should improve compliance, accelerate environmental work, and increase efficiencies. Improving communications is critical to achieving the DOE's goal of completing cleanup at most sites within a decade.

Early regulator participation in project scoping provides opportunities for discussion and incorporation of improvements which are necessary to meet each party's objectives. A team approach brings together people with diverse skills and organizational perspectives required for accountability. Sites must develop collaborative procedures such as project teams which jointly solve the technical and statutory challenges. Empowered teamwork establishes mutual needs to resolve differences and provide quick issue resolution and elevation.

The team responsible for day-to-day execution is generally called the Project Team. In establishing the membership of the Project Team, it is necessary for each agency to identify its appropriate representatives. The goal of any Project Team meeting is to promote mutual understanding and determine actions necessary to keep the project moving forward. Minutes of these meetings should record the nature and extent of discussion and decisions reached among the Team members. Issues should be resolved at the lowest level possible. When conflict cannot be resolved by the Project Team, there should be prompt elevation of the disagreement to supervisors of the team members to avoid the loss of forward project momentum.

The Interagency group responsible for the oversight of project execution is generally called the Supervisory Team. Members of this team should meet regularly with their counterparts. The Project and Supervisory Team members should mutually develop and agree on a charter, empowerment boundaries, and methods for resolving disagreements. The Supervisory Team will monitor progress of project execution, provide advice and management direction, and

resolve disagreements elevated for resolution by the Project Team. Both Teams are accountable for project completion.

When addressing complex technical and programmatic issues, conflict is unavoidable. Handled constructively, conflict leads to a discussion of alternatives that may result in program improvements. Conflict becomes counterproductive when issues remain unresolved and the working relationship and trust between the parties deteriorate.

In general, DOE, EPA, and state interagency agreements allow 30 days for informal dispute resolution before entering into a more prescriptive formal dispute resolution process. This guidance recommends a framework that can be used to resolve most disputes informally. Informal dispute resolution saves time by avoiding the more lengthy formal dispute resolution process. It is important for Project and Supervisory Teams to identify effective informal dispute resolution options that can be used within the 30 day window.

As previously stated, the preferred option of resolving disputes is to find mutually agreeable solutions at the Project Team level. Teams should use constructive conflict resolution tools such as facilitation and mediation. When a disagreement cannot be resolved in the 30 day informal dispute resolution period, formal dispute resolution should be initiated quickly. The goal of either form of dispute resolution is to reach a mutually agreeable conclusion to the disagreement and proceed with project execution.

Where issues in dispute have national implications of precedence, budget consideration, regulatory consistency, or intra-agency execution or communication, the Supervisory Team will contact their appropriate Headquarters' representative. Headquarters DOE and EPA will develop a collaboration process similar to that outlined above for the sites and Regions. Each Headquarters will identify individuals who will serve on the Interagency Headquarters Team. The Interagency Headquarters Team is responsible for working issues of national precedence, policy, and scope in a collaborative framework and providing guidance to the field that aids in the resolution of the dispute.

The following is taken from DOE G 481.1-1.

DOE has major national programs in fundamental scientific research; energy research and development; and nuclear weapons research, development, and production. Much of the work in these programs is conducted through an extensive network of government-owned, contractor-operated (GOCO) laboratories and facilities under performance-based contracts. Through the Work for Others Program, DOE can make the highly specialized or unique expertise and capabilities of this network available to support the missions of other federal agencies and non-federal customer needs on a fully reimbursable basis.

By performing Work for Others, DOE benefits by increasing its opportunities to transfer technology that originates in DOE facilities to private industry for further development or commercialization. Other benefits DOE receives from Work for Others include (1) the financial support of mutual-interest scientific and technical programs and (2) improved and more continuous use of its facilities and contractor personnel, both of which help support DOE's fixed and variable costs.

29. Facility maintenance management personnel shall demonstrate a familiarity-level knowledge of facility maintenance management-related data management requirements.

a. Describe the local file plan and procedure and the authorized disposition requirements for facility maintenance management-related records contained in DOE Order 1324.2A Chg 1, Records Disposition.

[Note: DOE Order 1324.2A was cancelled by DOE Order 1324.5B, Records Management Program. DOE Order 1324.5B was superseded by DOE O 200.1, *Information Management Program*. DOE O 200.1A, *Information Technology Management*, subsequently superseded DOE O 200.1. DOE O 200.1A requires that a records management program is maintained, consistent with DOE O 243.1, *Records Management Program*.]

The following is taken from DOE O 243.1.

DOE O 243.1 sets forth requirements and responsibilities for implementing and maintaining a cost-effective records management program throughout DOE and provides for:

- awareness that records management is a part of the job of every DOE employee and contractor (i.e., documentation of activities is essential to ensuring that DOE's performance and accomplishments can be preserved and made available to the citizens of the United States and DOE's staff);
- adequate and proper documentation of DOE activities, organization, functions, policies, decisions, procedures, and essential transactions;
- maintenance and use of records supporting DOE activities;
- proper records disposition; and
- economy and efficiency in the execution of the DOE Records Management Program.

This is a performance-based KSA. The Qualifying Official will evaluate its completion.

b. Describe the reporting requirements for occurrence reports categorized as Personnel Safety and Health Occurrence Reports per DOE Manual 231.1-2, Occurrence Reporting and Processing of Operations Information.

The following is taken from DOE M 231.1-2.

There are ten major groups of categorized occurrences. Personnel safety and health occurrence reports are in group 2. The criteria for this type of occurrence report are:

- any occurrence due to DOE operations resulting in a fatality or terminal injury/illness (For fatalities caused by overexposures, the intent of this criterion is to report those caused by acute rather than chronic effects.);
- any single occurrence requiring in-patient hospitalization of three or more personnel;
- any single occurrence resulting in three or more personnel having days away, restricted, or transferred cases;
- personnel exposure to chemical, biological or physical hazards above limits established by the Occupational Safety and Health Administration ; or the American Conference of Governmental Industrial Hygienists, whichever is lower, and that requires the

administration of medical treatment beyond simple first aid on the same day as the exposure;
- personnel exposure to chemical, biological or physical hazards above limits established by the Occupational Safety and Health Administration or the American Conference of Governmental Industrial Hygienists;
- any single occurrence resulting in a serious occupational injury. A serious occupational injury is an occupational injury that:
  - requires hospitalization for more than 48 hours, commencing within 7 days from the date the injury was received;
  - results in a fracture of any bone (except simple fractures of fingers, toes, or the nose, or a minor chipped tooth);
  - causes severe hemorrhages or severe damage to nerves, muscles, or tendons;
  - damages any internal organ;
  - causes second- or third-degree burns, affecting more than five percent of the body surface.

c. Describe the reporting requirements outlined in DOE O 231.1A, Environment, Safety and Health Reporting.

The following is taken from DOE O 231.1A.

Unless otherwise indicated, the reports listed below will be submitted in accordance with the most recent versions of DOE M 231.1-1A, *Environment, Safety and Health Reporting Manual,* and DOE M 231.1-2. These manuals, which are mandatory for ensuring compliance with parts of this order, specify in detail the reports that must be filed, the persons or organizations responsible for filing the reports, the recipients of the reports, the formats in which the reports must be prepared, and the time schedules for filing the reports. The following reports and information are required:
- occupational injury and illness reports
- fatality and catastrophe reports
- work hours reports
- occupational radiation exposure data to individuals (and visitors)
- annual individual occupational radiation exposure data to the radiation exposure monitoring system
- National Environmental Policy Act reporting
- annual site environmental reports
- excess injury and illness reports
- information requested by external organizations for epidemiological studies
- annual fire protection summaries
- occurrence reports
- environmental protection program reports

d. Discuss the record keeping requirements of DOE O 433.1, Maintenance Management Program for DOE Nuclear Facilities.

[Note: DOE O 433.1 was superseded by DOE O 433.1A.]

DOE O 433.1A requires a maintenance history and trending program to document historical information for maintenance planning and support maintenance and performance trending of nuclear facility systems and components. All records and documentation are to be maintained according to an approved site-specific records retention and disposition schedule.

30. Facility maintenance management personnel shall demonstrate a working-level knowledge of contractor and Department organization and structure as they relate to maintenance management responsibilities and authority.

a. Define the maintenance organizational structure.

The following is taken from DOE G 433.1-1.

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

Each facility should develop an integrated approach to maintenance that encourages working relationships among all organizational units that support the maintenance function [e.g., operations, health physics, stores, QC, engineering, procurement, and modifications].

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

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

b. Describe the responsibilities of individuals in the organization and their authority.

The following is taken from DOE-STD-1051-93.

Maintenance Division Manager

The maintenance division manager is responsible for all aspects of maintenance operations, including the safety and well-being of maintenance personnel working at the plant. The maintenance division manager should be aware of day-to-day maintenance activities. The maintenance division manager reports to the plant manager, although he/she retains full

responsibility for safe and reliable operation of the maintenance division. Responsibilities of the maintenance division manager should include the following:

- establishing high standards for the conduct of maintenance activities and ensuring uniform adherence to those standards;
- holding line managers accountable for performance in their areas of responsibility;
- establishing goals and objectives that promote safe, reliable, and efficient maintenance operations;
- ensuring the safety and well-being of assigned maintenance division personnel;
- ensuring that the plant is maintained in accordance with corporate and plant policies and procedures and applicable regulatory requirements;
- ensuring maintenance division personnel are properly trained and qualified;
- developing personnel for key supervisory and management positions;
- monitoring maintenance performance by performing activities such as:
  - observing personnel performing their duties;
  - promoting personal involvement and continuing assessments by key subordinates;
  - communicating frequently with subordinates;
  - reviewing performance monitoring trend reports, reports from the quality program, and reports from other groups or activities.
- reviewing assessments performed by outside organizations;
- identifying root causes of problems, initiating corrective actions, and tracking actions to completion;
- ensuring incorporation of industry operating experience into appropriate aspects of maintenance operations.

Staff Assistants

Staff assistants may be designated within the maintenance organization to fulfill certain staff functions for the maintenance division manager. When designated, the staff assistant's duties, responsibilities, and reporting relationship should be clearly defined in position descriptions approved by the maintenance division manager. Staff assistants should not perform functions that are the responsibility of line management.

Department Managers

The managers of the line operations and support departments generally report to, and receive instructions from, the maintenance division manager. Department managers should be responsible for the activities of personnel assigned to their department. In addition, department managers should be held accountable for ensuring that plant policies and procedures are carried out.

When onsite support departments report to someone other than the maintenance division manager, they should be responsive to direction from the maintenance division manager. The relationships between maintenance management and support groups located onsite should be clearly defined and understood.

Committees and Task Forces

Committees and task forces can be used effectively to bring together personnel from multiple disciplines to review or investigate a specific issue or problem. Committees and task forces

should have a clearly defined charter and objective and should be chaired by a senior individual with proven leadership capabilities and appropriate experience in the area under investigation.

Recommendations from committees or task forces should be provided to line management. Line management is responsible for evaluating and appropriately acting on recommendations made by committees. The use of committees and task forces to manage or coordinate responsibilities that should be assigned to individual managers can dilute authority and accountability; therefore, committees should be used with prudence.

c. Describe the relationship and interface of the maintenance organization with other organizational structures.

The following is taken from DOE G 433.1-1.

Senior management can achieve a high level of performance in facility maintenance by establishing high standards, by communicating these standards to personnel who perform maintenance, by selecting and training high-quality personnel, by providing sufficient resources to the maintenance organization, by setting goals and objectives, by closely observing and assessing performance, by effectively coordinating maintenance activities with operations and other facility organizations, and by holding workers and their supervisors accountable for their performance.

Performance in maintenance should be closely monitored by operations office personnel and facility managers through direct observation and development of maintenance reports.

Each facility should develop an integrated approach to maintenance that encourages working relationships among all organizational units that support the maintenance function [e.g., operations, health physics, stores, QC, engineering, procurement, and modifications].

Each WR related to repairs of production equipment should be reviewed by the operations department to determine its impact on facility operations. Meaningful priorities that determine how soon a WR needs to be worked should be set based on operational and industrial safety and reliability. Communication among cognizant groups should be established to enable proper priorities to be set. A method should be established that avoids congesting the work control system with jobs that are not important to safe and reliable operation.

The planning group or maintenance supervisors should maintain the status of all open WRs and PM items that are overdue or coming due and should recommend assignments from this list based on job priority. Meetings involving scheduling of routine jobs need to be held frequently to ensure proper communication concerning priorities, current problems, job interferences, and requests for support among facility organizations. These meetings should be chaired by a designated individual from the operations department. Supervisors or responsible spokespersons from all maintenance disciplines, safety, environmental protection, QC, radiological protection, technical support, and the warehouse should attend these meetings. Other personnel should be invited as needed.

31. Facility maintenance management personnel shall demonstrate a working-level knowledge of assessment techniques (such as the planning and use of observations, interviews, and document reviews) to assess facility performance, report results of assessments, and follow-up on actions taken as the result of assessments.

a. Describe the role of facility maintenance management personnel with respect to oversight of Government-Owned Contractor-Operated (GOCO) facilities.

The following is taken from DOE G 433.1-1.

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

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

Management involvement in control of maintenance activities should ensure that maintenance practices are effective in maintaining safe and reliable facility operation. This control should extend to all facility, contractor, and subcontractor personnel involved in maintenance activities. Rigorous control of maintenance activities should be directed toward achieving high-quality work performance, personnel safety (including radiological protection), equipment and system protection, and facility safety and reliability.

Rules, responsibilities and accountability between DOE and contractor and facility managers should be clearly delineated and communicated to all levels of the maintenance organization. DOE managers should be responsible and accountable for the management and maintenance of DOE assets in accordance with federal regulations, DOE directives, and contractual agreements. DOE contractors should be responsible for the operation, management, and maintenance of DOE nuclear facilities in accordance with commitments and agreements for satisfactory deliverables under the contract. DOE, contractor corporate, and facility managers should periodically review the maintenance programs to verify that they are effectively accomplishing their intended objectives and are upgraded as needed.

Contractors operating DOE nuclear facilities should integrate environment, safety, and health (ES&H) requirements into maintenance work planning and execution. The contractors should ensure that ES&H functions and activities become an integral, but visible, part of the contractor's work planning and execution process.

b. Describe the assessment requirements and limitations associated with the interface with contractor employees.

As assessment requirements and limitations associated with the interface of contractor employees vary from site to site, the Qualifying Official will evaluate the completion of this competency.

c. Discuss the essential elements of a performance-based assessment including:

- **Investigation**
- **Fact finding**
- **Exit interview**
- **Reporting**
- **Follow-up**
- **Closure**

Investigation

The following is taken from DOE G 414.1-5.

Types of assessment activities may range from major topical site-wide oversight inspections and investigations to individual worker safety concerns.

Identifying and reporting problem findings from a variety of sources to include a specific operational event, internal or external assessment or investigation, observation during daily work performance, and worker safety concern is the first generalized step for the feedback and improvement core safety function. All workers should be encouraged to evaluate performance and safety of workers, products, services, and processes; identify potential and actual problems (e.g, deficiencies, incidents, malfunctions, weaknesses, failures, etc.) at the earliest possible time before they become more significant; and immediately report these problems. This first step should be formally defined and fully integrated with the site/organization continuous performance and safety improvement strategy.

Fact Finding

The following is taken from DOE G 414.1-5.

The site/organization responsible for the function/activity where the problem finding was identified should have a clear understanding and description of the finding supported by the facts and causal factors in order to develop the most appropriate, timely corrective actions to resolve the finding and prevent recurrence.

All information to determine the facts of what actually occurred should be reviewed. These facts should be continuously validated and analyzed individually and together for relevance and accuracy in telling the story of what happened and how. Any missing information or inconsistencies identified during analysis of the finding should be reviewed and followed up.

The review participants may conduct both formal and informal interviews throughout all phases of the review. The interviews should include a representative cross section of managers, workers, and support personnel at various levels. Interview questions should be open, not leading.

Exit Interview

The following is taken form DOE G 414.1-1B.

This meeting is used primarily by the assessment team to present the assessment summary. Reasonable time should be allowed to discuss any concerns, but this meeting should not be used to argue the assessment findings or methodology. There should be no surprises during the exit meeting since the assessment team should have taken every effort possible during the conduct of the assessment to ensure that the assessed organization was aware of the team's findings and concerns. Prior to the exit meeting the assessment team should consider combining related findings into a small number of well-supported findings to help focus management's opportunities for improvement.

Reporting

The following is taken form DOE G 414.1-1B.

Assessment reports are required for documentation of assessment results. Assessment team leaders have the overall responsibility for preparing the report and obtaining appropriate approval for its release as applicable. The report may be formal (e.g., distributed by memorandum) or informal (e.g., letter to file or email), depending on the level of assessment performed, but should provide a clear picture of the results in terms of the programs, systems, and processes assessed. The assessment report should be clear, concise, accurate, and easy to understand, and should include only facts that directly relate to assessment observations and results. It should include sufficient information to enable the assessed organization to develop and implement appropriate improvement plans.

Follow Up

The following is taken form DOE G 414.1-1B.

Managers responsible for the activities assessed are also responsible for the development of effective corrective actions for the problem areas/deficiencies discovered during the assessment. At a minimum, these corrective actions should include the following:

- measures to correct each deficiency;
- identification of all root causes for significant deficiencies;
- determination of the existence of similar deficiencies or underlying causes (i.e., extent of condition, extent of cause);
- actions to preclude recurrence of like or similar deficiencies;
- assignment of corrective action responsibility; and
- completion dates for each corrective action.

Managers should verify that corrective actions are likely to fully address the identified deficiency and when actions are completed, validate that the actions have corrected the deficiency.

Closure

The following is taken from DOE G 414.1-5.

Upon completion and implementation of corrective actions the next step consists of verifying the completion of corrective actions for each finding, and determining effectiveness of the corrective actions in successfully resolving and preventing recurrence of each finding.

One of the most significant problems and most frequently cited weakness in the QAP is the lack of follow-up to determine the effectiveness of corrective actions in successfully resolving and preventing recurrence of identified problem findings.

A follow-up assessment with special focus may be performed and should be completed in accordance with applicable corrective action documents. Particularly, this follow-up assessment should evaluate the effectiveness of corrective actions. A reasonable subset of corrective actions should be reviewed for effectiveness.

d. Describe the following assessment methods and the advantages or limitations of each method:
- **Document review**
- **Observation**
- **Interview**

The following is taken form DOE G 414.1-1B.

Document Review

Document reviews provide the objective evidence to substantiate compliance with applicable requirements. A drawback is that the accuracy of the records cannot be ascertained by review alone. This technique should be combined with interviews, observation, inspection, and/or performance testing to complete the performance picture. Records and documents should be selected carefully to ensure that they adequately characterize the program, system, or process being assessed.

Observation

Observation, the viewing of actual work activities is often considered the most effective technique for determining whether performance is in accordance with requirements. Assessors should understand the effect their presence has on the person being observed and convey an attitude that is helpful, constructive, positive, and unbiased. The primary goal during observation is to obtain the most complete picture possible of the performance, which should then be put into perspective relative to the overall program, system, or process.

Interview

Interviews provide the means of verifying the results of observation, document review, inspection, and performance testing; allow the responsible person to explain and clarify those results; help to eliminate misunderstandings about program implementation; and provide a venue where apparent conflicts or recent changes can be discussed and organization and program expectations can be described.

e. Describe the action(s) to be taken if the contractor challenges the assessment findings and explain how such challenges can be avoided.

The following is taken from DOE G 414.1-5.

Disputes between assessed and assessing employees or organizations concerning corrective action plan development, implementation, or completion should be resolved at the lowest possible organizational level. If informal discussions successfully resolve the dispute, the resolution should be documented in a mutually agreeable way. If the dispute cannot be resolved in informal discussions, it should be elevated to the minimum extent necessary to reach resolution through the organizational level of management hierarchy.

32. Facility maintenance management personnel shall demonstrate a working-level knowledge of lessons learned and problems impacting the Department's maintenance activities across the complex.

a. Describe the documentation of the Department's and industry's lessons learned and current events.

The following is taken from DOE O 210.2.

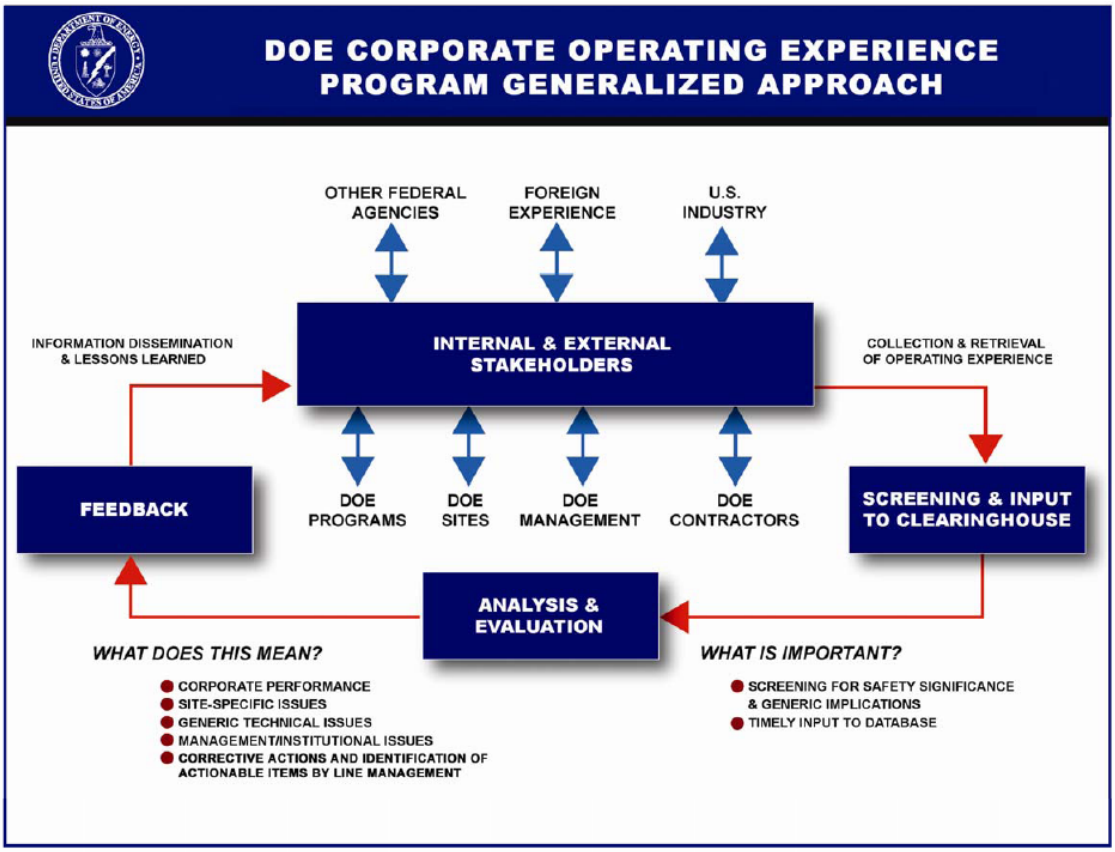
The objectives of DOE O 210.2, *DOE Corporate Operating Experience Program,* are to:

- institute a DOE wide program for the management of operating experience to prevent adverse operating incidents and to expand the sharing of good work practices among DOE sites;
- provide the systematic review, identification, collection, screening, evaluation, and dissemination of operating experience from U.S. and foreign government agencies and industry, professional societies, trade associations, national academies, universities, and DOE and its contractors;
- reinforce the core functions and guiding principles of DOE's ISMS to enhance mission safety and reliability;
- provide mutual integration with the lessons learned requirements in other DOE directives.

Operating experience must be collected, stored, and retrieved through a central clearinghouse that allows ready access to, and communication about, collected information on a timely, unimpeded basis by all DOE elements.

Operating experience must be screened daily by each organization's operating experience program, in particular the designated Corporate Operating Experience Program Lead Office, for safety significance, generic technical implications or management considerations. When data suggests a significant near-term safety risk or vulnerability, those issues must be prioritized, communicated, and resolved.

Lessons learned must be incorporated into training, maintenance and work planning, operations, design, and construction. Figure 5 illustrates the described approach.



Source: DOE O 210.2

Figure 5. DOE corporate operating experience approach

The following is taken from DOE G 413.3-11.

The goal of this Guide is to encourage compiling and disseminating project management lessons learned as part of effective project management practices encompassing the project lifecycle, CD-0 to CD-4, as a viable method of identifying issues and opportunities that influence successful project execution. This information should be collected, reviewed and promptly distributed to all affected programs throughout DOE to aid in achieving the goal of improving overall project management performance.

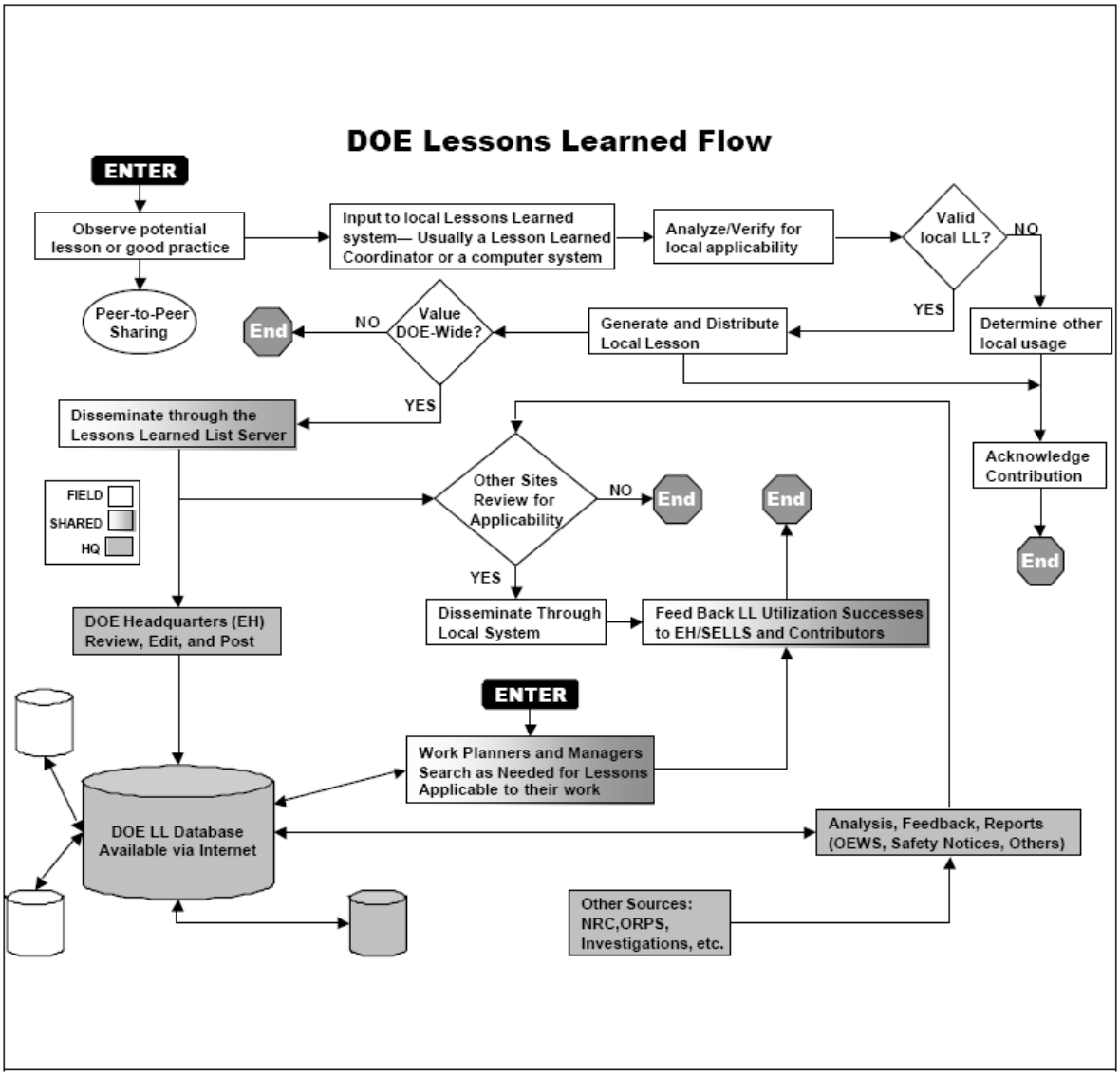
DOE G 413.3-11, *Project Management Lessons Learned,* is not intended to duplicate or conflict with DOE O 210.2. This guide is specifically for project management lessons learned associated with the non-operational phase of a facility during construction. Lessons learned that fall within the applicable category of DOE O 210.2 should follow requirements of that order.

The following is taken from DOE-STD-7501-99.

The DOE Corporate Lessons Learned Process is illustrated in figure 6. It is composed of a number of DOE and contractor local lessons learned programs supported by and coordinated

through the Lessons Learned Lead Office. The operating concept begins at the local levels where individuals observe adverse outcomes, potential good work practices or applicable information gathered from external sources. These are contributed to the local lessons learned program that supports further review and analysis to verify that a lesson has been learned that has further local applicability. The contributors should be acknowledged for identifying the potential lesson. If a local lesson learned is developed, it is distributed to appropriate individuals through local practices. Actions are then taken at the local level for inclusion into management systems and work practices.

The next step is to determine if the lesson has potential DOE-wide implications. If broader DOE applicability is determined, then the local lesson learned is distributed to a select list of recipients through a subscription list server. At the various DOE local levels, determinations of local applicability will be made in accordance with local lessons learned processes. At the Headquarters level, the Lessons Learned Lead Office is available to assist the contributing organization to formulate a lessons learned appropriate for posting on the publicly accessible DOE Corporate Lessons Learned database. The corporate database is accessible through an information portal which links all the local programs as well as providing links with external lessons learned information sources. Each local DOE and contractor organization should identify an infrastructure for supporting this operation.



Source: DOE-STD-7501-99

Figure 6. DOE lessons learned flow

b. Discuss recent events that impact maintenance management activities.

c. Discuss current efforts by the Department and the contractor to address issues and recent events.

d. Discuss recent issues identified by external groups (e.g., Defense Nuclear Facilities Safety Board, Environmental Protection Agency, Occupational Safety and Health Act) and Department oversight groups (Environmental Health and Operational Readiness Reviews) that impact facility maintenance.

Elements b through d are performance-based KSAs. The Qualifying Official will evaluate their completion.

e. Explain the intent of a maintenance problem analysis program and discuss a maintenance problem where this program has recently been employed.

This is a performance-based KSA. The Qualifying Official will evaluate its completion.

The following is taken from DOE G 433.1-1.

Systematic analysis should be used to determine and correct root causes of unplanned occurrences related to maintenance. Maintenance management provides guidance for collecting and trending maintenance history to reduce recurring or persistent equipment failures that should be reviewed by the analysis program. Incident reports, post-trip reviews, and other similar operating experience review documents and methods supplement the maintenance history program and provide data, including human error data, which should be reviewed by the analysis program. An analysis program may be used effectively to reduce recurring maintenance problems by identifying and resolving their root causes.

33. Facility maintenance management personnel shall demonstrate a working-level knowledge of the requirements of a maintenance management program.

a. Describe the SSCs included in a maintenance management program.

The following is taken from DOE G 433.1-1.

DOE O 433.1A requires DOE contractors to develop and implement a maintenance management program for each nuclear facility under DOE cognizance. DOE O 433.1A further requires that each DOE contractor develop a MIP defining the safety SSCs the nuclear facility comprises.

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

- that the provisions are sufficient to provide reasonable assurance that the facility safety structures, systems, and components are capable of fulfilling their intended function as identified in the SAR; and
- that the maintenance program includes the safety structures, systems, and components identified in the SAR, and management systems consistent with the requirements of 10 CFR 830.

The MIP should include both safety-related and non-safety related SSCs in the maintenance program. Failures of certain non-safety-related SSCs can lead to challenges, failure or undesirable consequences to safety-related SSCs.

b. Discuss line management's responsibilities for the maintenance management program.

See items a, b, and c of competency 13.

c. Define the term "graded approach" and discuss its application to a maintenance management program.

See item m of competency 16.

d. Discuss the application of TSRs in a maintenance management program.

See item d of competency 2.

e. Discuss the management systems that control maintenance activities.

The following is taken from DOE G 433.1-1.

Management systems are used to control maintenance activities associated with the defined SSCs. These include work control, PMT, material procurement, handling and disposal, control and calibration of M&TE.

A computerized maintenance history engineering database is a set of computer software modules and equipment databases containing facility data and the capability to process the data for facilities maintenance management functions. Computer software modules provide historical data, report writing capabilities, job analyses, and more. The data describe equipment, parts, jobs, crafts, costs, step-by-step instructions, and other information involved in the maintenance effort. This information may be stored, viewed, analyzed, reproduced and updated with just a few keystrokes. The maintenance-related functions typically include the following:

- maintenance cost and reliability data,
- facility/equipment inventories
- facility/equipment histories,
- work input controls,
- job estimating,
- work scheduling and tracking,
- preventive and predictive maintenance,
- facility inspections and assessments,
- material management, and
- utilities management.

A computerized maintenance history engineering database can emphasize SSC maintenance needs, costs, and reliability at DOE nuclear facilities, principally through the feedback of maintenance experience and SSC condition data to DOE contractor facility planners, designers, maintenance managers, craftsmen, and manufacturers, and to DOE for prioritization and allocation of funds for maintenance. This information is instrumental for continually upgrading the SSC specifications for increased reliability. Increased reliability leads to fewer SSC failures and, therefore, greater availability for mission support and lower maintenance costs.

The Facility Information Management System is DOE's corporate database management system with the universe of DOE real property information, its status, and funds needed and requested for maintenance. This system is used for real property management and for reporting to the General Services Administration, Congress, and the public.

f. Describe the mechanisms for feedback of relevant information, such as trend analysis and instrumentation performance/reliability data, to identify necessary program modifications.

The following is taken from DOE G 433.1-1.

A key element of management involvement is the establishment of a system where feedback and communication are encouraged. This system should include planners, engineers, crafts workers, warehouse personnel, appropriate line management, and others so that participation in improvement is promoted at all levels of the maintenance and management organizations. Project teams (for such purposes as discussing proposed modifications to the facility, prioritizing industrial safety actions, and improving facility condition) should include representatives from the affected crafts.

Feedback and update processes need to be incorporated into the PM program to ensure that the program effectively addresses changing facility and equipment conditions. These processes should be routine functions of appropriate organizations.

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

- equipment failure trending;
- root-cause analysis of component failures resulting in facility events;
- craft feedback reports;
- predictive maintenance analysis;
- facility and system performance monitoring;
- preventive and corrective maintenance history;
- surveillance test optimization studies;
- radiation exposure history of PM performances;
- equipment design modifications.

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

- adequacy of PM procedures as deemed by craftsperson feedback;
- QA audit reports and self assessment findings;
- failure trend reports for facility and industry equipment;
- occurrence reports;
- nonconformance reports;
- material deficiency reports; and
- causes for deferrals.

g. Discuss the role of configuration management as it relates to maintenance management.

The following is taken from DOE G 433.1-1.

Management should ensure that plant configuration, including the manner in which the facility is maintained, conforms to the established design basis requirements. Many routine activities, if carried out improperly, can have an adverse impact on facility configuration and cause eventual equipment damage or increase the probability or consequences of a significant event.

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

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

34. Facility maintenance management personnel shall demonstrate the ability to conduct independent assessments of a contractor's compliance with the requirements of DOE O 433.1, Maintenance Management Program for DOE Nuclear Facilities.

a. Establish the criteria to be used as a basis for conducting the evaluation.

b. Establish the points of contact with the field organization being evaluated.

c. Gather information pertinent to the evaluation by interviewing personnel, observing maintenance activities and reviewing maintenance records.

d. Document the results of data collection in field notes.

e. Compare the results of the review phase with the criteria established for the evaluation and determine if deficiencies exist.

f. Document the results of the overall evaluation in a formal written report which includes the status of meeting the established criteria, identifies deficiencies or good practices, and suggests recommendations for improvement.

g. Resolve conflicting or inconclusive observations or findings obtained from other evaluators on an evaluation team.

h. Verbally report the results of the evaluation to contractor facility management and Department management.

i. Perform follow-up activities as applicable to ensure implementation of corrective actions, including tracking and close-out.

Elements a through i are performance-based KSAs. The Qualifying Official will evaluate their completion.

35. Facility maintenance management personnel shall demonstrate a working-level knowledge of problem analysis principles and techniques necessary to identify maintenance problems, determine potential causes of problems, and identify corrective action(s).

a. Discuss the elements of an analysis program.

The following is taken from DOE G 433.1-1.

Systematic analysis should be used to determine and correct root causes of unplanned occurrences related to maintenance. Maintenance management provides guidance for collecting and trending maintenance history to reduce recurring or persistent equipment failures that should be reviewed by the analysis program. Incident reports, post-trip reviews, and other similar operating experience review documents and methods supplement the maintenance history program and provide data, including human error data, which should be reviewed by the analysis program. An analysis program may be used effectively to reduce recurring maintenance problems by identifying and resolving their root causes.

The analysis program should include the methodical collection of facts describing the unplanned occurrence. These facts should then be reviewed from the standpoint of management controls and engineering and human performance perspectives to pinpoint probable causes for the unplanned occurrence. Seldom does one single root cause exist by itself. A combination of such factors as supervision, workmanship, procedures, manufacturing flaws, training and qualification, improper tool use, and design may contribute to an unplanned occurrence. Corrective action follow-up should then be performed to help verify that the problem is resolved.

b. Discuss the guidelines for information collecting.

The following is taken from DOE G 433.1-1.

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.

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.

c. Discuss event causal factors for human performance problems.

The following is taken from DOE G 433.1-1.

The following are the event causal factors for human performance problems with explanatory examples:

- Verbal communication—Inadequate information exchange face-to-face or by telephone.
- Written procedures and documents—Inappropriate maintenance, operating, or special test procedures/instructions; inappropriate drawing(s), equipment manual(s), technical specification(s).
- Human-machine interface—Insufficient or incorrect label, gauge, annunciator, control device.
- Environmental conditions—Inadequate lighting, workspace, clothing; noise; high radiation, ambient temperature.
- Work schedule—Excessive overtime; insufficient time to prepare for or accomplish the task.
- Work practices—Lack of self-check; failure to follow procedures.
- Work organization/planning—Insufficient time to prepare or to perform unscheduled maintenance.
- Supervisory methods—Inadequate direction, supervisor interface; overemphasis on schedule.
- Training/qualification—Insufficient technical knowledge; lack of training; inadequate training materials; improper use of tools; insufficient practice; ineffective OJT.
- Change management—Inappropriate plant modification; lack of change-related retraining, procedures, documents.
- Resource management—Unavailability of tools, information, personnel, supervision.
- Managerial methods—Insufficient/lack of accountability, policy, goals, schedule; failure to ensure previous problem was resolved; insufficient use of operating experience; lack of proper assignment of responsibility; lack of communication or non-enforcement of high standards; lack of safety awareness.

d. Discuss event causal factors for equipment performance problems.

The following is taken from DOE G 433.1-1.

The following are the event causal factors for equipment performance problems, with explanatory examples:

- Design configuration and analysis—inappropriate layout of system or subsystem; inappropriate component orientation; component omission; errors in assumptions, methods, or calculations during design or while establishing operational limits; improper selection of materials, components; failure to consider operating environment in original design.
- Equipment specification, manufacture, and construction—improper heat treatment, machining, casting, onsite fabrication, installation.
- Maintenance/testing—inadequate PM; insufficient PMT; inadequate QC.
- Facility/system operation—changes in operating parameters, performance.
- External—storm, flood, earthquake, fire.

Of the above categories, one or more may be primary causes, one or more may be secondary, and others may be possible. In all cases, the reason why a category is chosen is known and documented.

e. Describe and explain the application of problem analysis techniques, including the following:
- **Root cause analysis**
- **Causal factor analysis**
- **Change analysis**
- **Barrier analysis**
- **Management Oversight Risk Tree analysis**

The following is taken from DOE G 433.1-1.

Root Cause and Causal Factor Analysis

The actual or probable causes of a problem should be evaluated by one or more techniques or methodologies to establish a root cause. The root cause should meet three criteria: (1) its correction should prevent recurrence of the unplanned occurrence; (2) its correction should be feasible; and (3) its correction should not adversely impact safety, reliability, or operational goals. Examples of a number of proven and accepted techniques for analyzing information to determine causes of problems include the following:
- event and causal factor charting
- walk-through task analysis
- change analysis
- barrier analysis
- fault tree analysis

Event and causal factor charting uses a block diagram to depict cause and effect. This technique is most effective for solving complicated problems because it provides a means to organize the data, provides a concise summary of what is known and unknown about the event, and results in a detailed sequence of facts and activities. The first block on the chart is the primary effect. For each effect, there is a cause that becomes the effect in the next block to the right. For each cause (effect), two reasons that are known to be true are listed in a block just below the cause (effect). If only one reason is known or the reason is uncertain, then all possible causes should be evaluated as potential causes. When this process gets to the point where a cause can be corrected to prevent recurrence of the event, the root cause has been found.

A walk-through task analysis may be used to supplement other techniques described here. This task analysis is a method in which personnel that actually do the task where the problem occurred conduct for the observer a step-by-step reenactment of their actions, without carrying out the actual function. The objective is to determine how a task was really performed and identify problems in human factors design, discrepancies in procedural steps, or inadequacies in training.

Change Analysis

Change analysis is used when the problem is obvious. It is generally used for a single event and looks at a problem by analyzing the discrepancy between what is expected and what actually happened. The evaluator essentially asks what differences occurred in this task or activity to make its outcome different this time from all other times. This technique consists of asking What? When? Where? Who? and How? The answers should provide direction toward answering the root-cause-determination question, “Why?”

Barrier Analysis

Barrier analysis is a systematic questioning process that can be used when the problem appears to be programmatic. It identifies physical, administrative, and procedural controls, and other controls or barriers that should have prevented an event from happening. This technique should be used to assess why existing barriers, both physical and administrative, failed and what additional barriers are needed to prevent recurrence. Secondary questions in this technique ask "Why?" and "How do you know?"

Management Oversight Risk Tree Analysis

Fault tree analysis is a systematic approach, similar to the management oversight and risk tree process, which may be used when the problem is known but the cause is not clear. Questions are used to determine what was less than adequate and why. A flowchart is created by the use of "AND" and "OR" gates to record what was less than adequate.

f. Describe and explain the application of the following root cause analysis processes in the performance of occurrence investigations:
- **Events and causal factors charting**
- **Root cause coding**
- **Recommendation generation**

The following definitions are taken from DOE-NE-STD-1004-92.

Events and Causal Factors Charting

Events and Causal Factor Analysis is used for multi-faceted problems or long, complex causal factor chains. The resulting chart is a cause and effects diagram that describes the time sequence of a series of tasks and/or actions and the surrounding conditions leading to an event. The event line is a time sequence of actions or happenings while the conditions are anything that shapes the outcome and ranges from physical conditions (such as an open valve or noise) to attitude or safety culture. The events and conditions as given on the chart describe a causal factor chain.

Root Cause Coding

Cause codes are letters and/or numbers that represent specific cause descriptions related to categories such as equipment/material problems, procedural problems, personnel error, or training deficiencies.

Recommendation Generation

After root cause analysis is completed, effective corrective actions can be determined, recommended, and implemented to reduce the probability that a problem will recur, thereby improving reliability and safety.

g. Compare and contrast immediate, short term, and long term actions taken as the result of a problem identification or an occurrence.

The following is taken from DOE G 225.1A-1.

[Note: Corrective actions are no longer classified as short term and long term.]

The final report is submitted by the appointing official to senior managers of organizations identified in the judgments of need in the report, with a request for the organizations to prepare corrective action plans. These plans contain actions for addressing judgments of need identified in the report and include milestones for completing the actions.

Corrective actions fall into four categories:

- Immediate corrective actions that are taken by the organization managing the site where the accident occurred to prevent a second or related accident.
- Corrective actions required to satisfy judgments of need identified by the board in the final report. These corrective actions are developed by the heads of field elements and/or contractors responsible for the activities resulting in the accident and are designed to prevent recurrence and correct system problems.
- Corrective actions determined by the appointing official to be appropriate for DOE-wide application. The appointing official recommends these corrective actions when the report is distributed.
- DOE Headquarters corrective actions that result from discussions with senior management. These actions usually address DOE policy.

h. Describe various data gathering techniques and the use of trending/history when analyzing problems.

The following is taken from DOE G 414.1-5.

Identified problem findings and their associated causes should also be analyzed to determine the existence of trends to identify the same or similar occurrences, generic problems, vulnerabilities, and cross functional weaknesses at the lowest level before significant problems result. Trending typically identifies problem categories, responsible organizations, and specific activities or conditions. Benefits of trending include:

- the ability to document historical data consistently in measurable, visible terms;
- identify changes in performance as they occur; and
- develop leading indicators that identify degrading trends.

A consistent trend coding system would assist in analyzing the problem findings. This trending data should be constantly analyzed, updated and summarized; and the results should be reported to management.

The following is taken from DOE G 433.1-1.

A maintenance history and trending program should be maintained to document data, provide historical information for maintenance planning, and support maintenance and performance trending of facility systems and components. The documentation of complete, detailed, and usable history will be increasingly important as plant-life extension becomes an issue. Trending should be directed toward identifying improvements for the maintenance program and needed equipment modifications.

In addition to maintenance history files, information pertinent to the most recent occurrence is valuable during problem analysis and may be obtained from:

- WRs,

- shop floor activity logs,
- strip-chart and other recording devices,
- operator statements (facts and symptoms),
- troubleshooting results,
- crafts worker statements, and/or
- industry experience.

36. Facility maintenance management personnel shall demonstrate the ability to apply problem analysis techniques necessary to identify maintenance problems, determine potential causes, and identify corrective action(s).

a. Given an event and/or occurrence data, apply problem analysis techniques and identify the problems and how they could have been avoided.

b. Participate in a contractor or Departmental problem analysis and critique the findings and results.

c. Using appropriate data, interpret two fault tree analyses.

Elements a through c are performance-based KSAs. The Qualifying Official will evaluate their completion.

37. Facility maintenance management personnel shall demonstrate the ability to trend facility maintenance management-related data.

a. Discuss the key processes used in the trending and analysis of operations information and their relationship to facility maintenance management activities.

See item h of competency 35.

b. Discuss the importance and key items of a maintenance history.

The following is taken from DOE G 433.1-1.

A maintenance history and trending program should be maintained to document data, provide historical information for maintenance planning, and support maintenance and performance trending of facility systems and components.

The documentation of complete, detailed, and usable history will be increasingly important as plant-life extension becomes an issue. Trending should be directed toward identifying improvements for the maintenance program and needed equipment modifications.

The maintenance history program should clearly define the safety systems and equipment that require documentation and retention of historical data according to the MEL for which maintenance provides support. In addition, non-safety equipment requiring repeated maintenance should be considered for inclusion. The MEL can provide much of the information for the system. Alternatively, if the MEL is computerized, the history files should be cross-referenced to it.

The maintenance history program should define the type of data that should be collected and recorded to effectively support the use of the program. Some examples of data that should be included or cross-referenced in the program are:

- corrective maintenance records;
- appropriate PM records;
- modification packages;
- vendor repair information (e.g., correspondence on component repairs and modification bulletins);
- start-up tests and other baseline data;
- appropriate surveillance test data;
- calibration data; and
- applicable industry experience information.

The specific data to be collected should include:

- details of the work performed,
- special equipment and tools used,
- procedures or drawings needed,
- spare parts installed,
- personnel safety and radiation protection requirements,
- PMT results, and
- any other information that may be useful later.

c. Given appropriate data, demonstrate the ability to analyze the data.

d. Given DOE Order 5480.26, Trending and Analysis of Operations Information Using Performance Indicators, discuss the key elements of the Order and how they are applied.

[Note: DOE Order 5480.26 was cancelled.]

e. Given incident/occurrence report data for a specified period, analyze the information for safety trends or compliance problems.

Elements c through e are performance-based KSAs. The Qualifying Official will evaluate their completion.

38. Facility maintenance management personnel shall demonstrate a familiarity-level knowledge of financial management practices and the application of contractor resources to meet commitments to the quality, safety, cost, and schedule of systems.

a. Describe the process for preparing cost estimates and budgets.

The following is taken from DOE G 430.1-1.

Cost Estimates

Several techniques are available to help the estimator estimate the cost of a project. Based on the project's scope, the purpose of the estimate, and the availability of estimating resources,

the estimator can choose one or a combination of techniques when estimating an activity or a project.

Bottom-up Technique

Generally, a work statement and set of drawings or specifications are used to "take off" material quantities needed to perform each discrete task that is required to accomplish a given operation or produce an equipment component. From these quantities, direct labor, equipment, and overhead costs are derived and added. This technique is used as the level of detail increases as the project develops.

Specific Analogy Technique

Specific analogies depend upon the known cost of an item used in prior systems as the basis for the cost of a similar item in a new system. Adjustments are made to known costs to account for differences in relative complexities of performance, design, and operational characteristics.

Parametric Technique

Parametric estimating requires historical databases on similar systems or subsystems. Statistical analysis is performed on the data to find correlations between cost drivers and other system parameters, such as design or performance parameters. The analysis produces cost equations or cost-estimating relationships, which can be used individually or grouped into more complex models.

Cost Review and Update Technique

An estimate is constructed by examining previous estimates of the same project for internal logic, completeness of scope, assumptions, and estimating methodology and updating them with any changes.

Trend Analysis Technique

A contractor efficiency index is derived by comparing originally projected contract costs against actual costs on work performed to date. The index is used to adjust the cost estimate of work not yet completed.

Expert Opinion Technique

This technique may be used when other techniques or data are not available. Several specialists can be consulted reiteratively until a consensus cost estimate is established.

The following is taken from DOE O 130.1.

Budgets

DOE's annual budget formulation process consists of four distinct phases. Detailed reporting requirements for each phase are contained in DOE Budget Formulation Instructions.

The field budget process is the first phase of DOE's annual budget formulation process. It is the process through which Field Offices prepare and submit field budget data to Headquarters Elements for use in the corporate review budget process.

The corporate review budget process is the second phase of DOE's annual budget formulation process. It is the process whereby Headquarters organizations use, among other budget related information, field budget data and spring planning decisions to develop initial organizational budget requests that are jointly evaluated and considered in the DOE's internal budget review, resulting in corporate review budget allowances.

The Office of Management and Budget (OMB) budget review process is the third phase of DOE's annual budget formulation process. It is the principal mechanism for preparing DOE's annual budget submission to the OMB. DOE's OMB request is based on the Secretary's final budget allowances resulting from the corporate review budget process.

The congressional budget review process is the final phase of DOE's annual budget formulation process. It is based on final Presidential funding and policy determinations resulting from the OMB budget review process.

b. Describe and contrast direct and indirect costs. List ways to reduce indirect costs.

The following is taken from DOE G 430.1-1, chapter 7.

Direct costs are costs that can be specifically identified with a particular project or activity, including salaries, travel, equipment, and supplies directly benefiting the project or activity.

Indirect costs are costs incurred by an organization for common or joint objectives and cannot be identified with a particular project or activity. Examples are insurance and taxes.

Chapter 7 of DOE G 430.1-1 contains a table listing numerous categories of indirect costs. Examples include utilities, motor pool operations, medical and first aid, and consumables. Utility costs can be reduced by utilizing energy efficient practices and equipment. Motor pool operation costs can be reduced by eliminating excess and inefficient vehicles. Medical and first aid costs can be reduced by encouraging and supporting improvements in employee fitness. Consumable costs can be reduced by creating an accountability program for consumable items such as office supplies to reduce fraud, waste, and abuse.

c. Define and explain the relationship between the following terms:
- **Budgeted cost of work scheduled (BCWS)**
- **Budgeted cost of work performed (BCWP)**
- **Actual cost of work performed (ACWP)**
- **Earned value (EV)**

The following is taken from DOE M 413.3-1.

BCWS is the sum of budgets for all work packages and planning packages scheduled to be accomplished (including work packages that are in progress), plus the amount of level of effort and apportioned effort scheduled to be accomplished within a given period.

BCWP is a measurement of the work completed. BCWP is the value of work performed, or earned, when compared to the original plan, that is, the BCWS. The BCWP is called the EV.

ACWP is the total cost incurred (direct and indirect) in accomplishing an identified element or scope of work during a given time period.

EV is a method for measuring project performance. It compares the value of work performed (BCWP) with the value of work scheduled (BCWS) and the cost of performing the work (ACWP) for the reporting period and/or cumulative to date.

d. Describe the types of earned value, and how they are measured.

The following is taken from DOE G 413.3-10.

The earned value management system (EVMS) is an integrated set of policies, procedures, and practices to support program and project management as a decision enhancing tool and a critical component of risk management.

An EVMS reliably tracks:

- planned value of work to be performed or the BCWS,
- EV of actual work performed or the BCWP, and
- ACWP.

EVMS measures actual performance of work scope and the associated cost and schedule versus an agreed to baseline plan, while using disciplined means of baseline change control for documenting any changes to the agreed to baseline plan.

EVMS should be implemented as early as possible in a project's life cycle. By no later than CD-2, the performance baseline must cover the entire project life cycle, i.e., through CD-4 or through the near-term baseline for DOE Environmental Management cleanup projects. DOE O 413.3A requires its use for projects with a total project cost greater than or equal to $20M, and its EVMS data be entered into the DOE Project Assessment and Reporting System after CD-2.

e. Describe the types of data required to forecast cost and schedule performance.

The following is taken from DOE G 430.1-1, chapter 19.

Cost estimating relationships or parametric equations are mathematical statements that indicate that the cost is proportional to a physical commodity. Parametric estimating requires that statistical analysis be performed on data points to correlate the cost drivers and other system parameters. The basis of the data points is collected from databases or is developed by building a model of a project or scenario.

When developing forecasts from historical data, it is important to consider the different sources available. Some examples of sources include published reports; adopted and draft regulations; local, commercial, and DOE databases; past and current estimates; and bid documents. The information extracted from these sources will provide the estimator an understanding of the steps that are necessary to perform the work for a project so the cost drivers can be identified.

Sometimes an analyst will be required to develop estimates pertaining to projects for which there is no historical data. In this situation, the analyst can develop a conceptual design of the project (a model) and can estimate the cost of the model. This estimate is a more comprehensive effort than ordinary estimates. The project must be designed and then estimated for three to five cases or sizes differing from one another with respect to the parameter expected to drive the cost or schedule.

f. Define the term "estimate at completion" (EAC).

The following is taken from DOE M 413.3-1.

EAC is the current estimated cost for program authorized work.

The following is taken from DOE G 413.3-10.

Whereas the performance management baseline is important to measure a contractor's performance against a plan, an EAC is necessary to understand what the anticipated total funding requirements are to complete the project. Although most contractors have a process for identifying the development of trends and revising specific control account EACs to address individual issues, oftentimes there is no defined frequency for the development of a revised bottoms-up EAC. Real-time updates of EAC at individual control account is important, and individual changes are often non-linear (i.e., their algebraic sum may not reflect the total impact). To better understand the EAC, a bottoms-up EAC should be required on some defined frequency. An annual update is usually adequate.

g. Discuss the importance of formal change control in relation to project management.

The following is taken from DOE, *Management Model for Delivering High Performance and Leadership Class Computing Systems for Scientific Discovery*.

Project changes can be classified into two broad categories. First are those changes that directly impact the performance baseline. Second are those that occur within the performance baseline, such as changes to project sub-element costs and milestones. Changes within the performance baseline are routinely accomplished during the development process as the design, engineering, execution or construction and risk management efforts continue. Establishing a formal change control process permits all changes to be managed to integrate the cost, schedule, and technical parameters that are affected by each change. Change control approval thresholds should be developed in a tiered manner, from the acquisition executive to the deputy administrator level down to the project director and the contractor, commensurate with the size and significance of the proposed change. Project changes shall be identified, controlled, and managed through a traceable, documented change control process that is defined in the project execution plan. Project changes caused by congressional action, such as a funding shortfall or the addition of new requirements, shall be called directed changes. Directed changes shall follow the change control process and shall be approved by the appropriate acquisition executive.

The following is taken from DOE G 413.3-10.

Many project corrective action requests are related to change control. It is important for the change control process to provide visibility to the type of change (e.g., scope change, versus a contractor initiated re-plan of future work) and that budget has been taken from the appropriate account (i.e., reserve/contingency funds). This is essential to ensure that the total project scope, cost, and schedule are managed by DOE and the contractor.

All project work must be performed against a planned budget. Therefore, if there is a large proposed scope change for which a significant amount of time is required prior to DOE approval, mechanisms should exist to provide "a not to exceed budget" while contract negotiations continue to resolve the final outcome.

Although the issue of budget control (which is a part of baseline change control) and funds control are often inter-related, the contractor EVMS description and implementing procedures oftentimes use the terms interchangeably, when in fact they are two separate processes.

When describing a baseline change, the TPC and schedule impacts need to be addressed up through CD-4 and not just the cost and schedule impacts to the annual work plan, or the current project phase (e.g., design phase).

39. Facility maintenance management personnel shall demonstrate the ability to perform project management duties as required to provide facility maintenance management technical support to a project.

a. Support the preparation of a project execution plan.

b. Evaluate a work breakdown structure (WBS).

c. Evaluate a project's critical path schedule.

d. Using the results from an analysis of contractor noncompliance, determine the potential implications and describe how to communicate the results to contractor and Department management.

Elements a through d are performance-based KSAs. The Qualifying Official will evaluate their completion.

40. Facility maintenance management personnel shall demonstrate a familiarity-level knowledge of the DOE project management system, including the application of contractor resources to meet commitments to quality, safety, cost, and schedule.

a. Explain the purpose of project management and describe the phases of a typical project.

The following is taken from DOE O 413.3A.

Fundamental project management principles provide a framework for successful project execution. The requirements set forth in DOE O 413.3A are established to ensure adherence to the following principles:

- line management accountability;
- sound disciplined up-front planning;
- development and implementation of sound acquisition strategies;
- well-defined and managed performance baselines;
- effective project management systems (e.g., QA, risk management, change control, performance management);
- implementation of an ISMS; and
- effective communication among all project stakeholders.

Project phases:

Initiation Phase

During this phase, preconceptual planning activities focus on the program's strategic goals and objectives. User needs are analyzed for consistency with DOE's strategic plan, congressional direction, administration initiatives, and political and legal issues. One outcome of the analysis could be a determination that a user need exists that cannot be met through other than material means. This outcome leads to the development and approval of a mission need statement. The information developed during this phase also provides the basis for the project engineering and design budget request when preliminary design activities are planned.

Definition Phase

Upon approval of mission need, the project enters the definition phase where alternative concepts, based on user requirements, risks, costs, and other constraints, are analyzed to arrive at a recommended alternative. This is accomplished using systems engineering and other techniques and tools such as alternatives analysis and value management/value engineering. This ensures the recommended alternative provides the essential functions and capability at optimum life cycle cost, consistent with required performance, scope, schedule, cost, security, and ES&H considerations. During this phase, the required value management assessment is completed, and more detailed planning is accomplished which further defines required capabilities. The products produced by this planning provide the detail necessary to develop a range of estimates for the project cost and schedule.

Execution Phase

Following the definition phase, preliminary design activities mark the beginning of the execution phase. Systems engineering continues to balance requirements, cost, schedule, and other factors to optimize the design, cost, and capabilities that satisfy the mission need. Engineering and design continue until the project has a sufficiently mature design that can be implemented successfully within a firm performance baseline. During this phase, the initial design concepts and the preliminary design are developed into detailed and final designs and plans. These plans are used to procure or manufacture components, fabricate subsystems, or construct, remediate, decommission or demolish facilities. Major activities in this phase include:

- establishing performance measurement baselines and implementing change control procedures;
- satisfying environmental and safety requirements;
- obtaining approved National Environmental Policy Act documentation, if required, prior to the start of detail or final design;
- continuing to refine and optimize cost estimates, schedules, and designs;
- approving the final design for procurement and implementation; and
- identifying and addressing security concerns.

Execution comprises the longest and most costly phase of a project. Value management and value engineering are implemented throughout the project execution phase to ensure the most effective solutions are implemented. If the delivery method is design-build versus design-bid-build and a single contract is awarded for both design and construction, it may be necessary to tailor the project's execution process to allow the project team to propose cost-effective innovative approaches that reduce project duration and cost.

Transition/Closeout Phase

When the project nears completion and has progressed into formal transition and commissioning, which generally includes final testing, inspection, and documentation, the project is prepared for operation, long-term care, or closeout. The nature of the transition and its timing depends on the type of project and the requirements that were identified subsequent to the mission need.

b. Describe typical documents and data sources utilized by facility maintenance management personnel in project management.

The following is taken from DOE G 433.1-1.

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

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

maintenance, warehousing, purchasing, accounting, engineering and production in such a way that all parties work together and share current information.

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

Responsibilities should be assigned for collection and analysis of data for each indicator. A coordinator should be assigned overall responsibility for development, production, and distribution of the report. Reports tailored to the needs and desires of responsible company management, including the facility manager and appropriate division managers, should be distributed.

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

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

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

c. Identify and explain the major elements of a project and discuss their relationship.

The following is taken from DOE O 413.3A.

The five CDs are major milestones approved by the secretarial acquisition executive or acquisition executive that establish the mission need, recommended alternative, acquisition

strategy, the performance baseline, and other essential elements required to ensure that the project meets applicable mission, design, security, and safety requirements. Each CD marks an increase in commitment of resources by the department and requires successful completion of the preceding phase or CD. Collectively, the CDs affirm the following:

- There is a need that cannot be met through other than material means;
- The selected alternative and approach is the optimum solution;
- Definitive scope, schedule and cost baselines have been developed;
- The project is ready for implementation; and
- The project is ready for turnover or transition to operations.

CDs for traditional construction projects are shown in figure 2 and include the following major elements:

- CD-0, Approve Mission Need
- CD-1, Approve Alternative Selection and Cost Range
- CD-2, Approve Performance Baseline
- CD-3, Approve Start of Construction
- CD-4, Approve Start of Operations or Project Completion

CD-0, Approve Mission Need

The initiation phase begins with the identification of a mission-related need. A program identifies a credible performance gap between its current capabilities and capacities and those required to achieve the goals articulated in its strategic plan.

Approval of CD-0 formally establishes a project and begins the process of conceptual planning and design used to develop alternative concepts and functional requirements. Additionally, CD-0 approval allows the program to request funds for use in preliminary design, final design, and baseline development.

CD-1, Approve Alternative Selection and Cost Range

CD-1 approval marks the completion of the project definition phase, during which time the conceptual design is developed. This is an iterative process to define, analyze, and refine project concepts and alternatives. This process uses a systems methodology that integrates requirements analysis, risk identification and analysis, acquisition strategies, and concept exploration to evolve a cost-effective, preferred solution to meet a mission need. Approval of CD-1 provides the authorization to begin the project execution phase.

CD-2, Approve Performance Baseline

Completion of preliminary design is the first major milestone in the project execution phase. Preliminary design is complete when it provides sufficient information for development of the performance baseline in support of CD-2. The performance baseline is developed based on a mature design, a well-defined and documented scope, a resource-loaded detailed schedule, a definitive cost estimate, and defined KPPs. Approval of CD-2 authorizes submission of a budget request for the total project cost.

CD-3, Approve Start of Construction

With design and engineering essentially complete, a final design review performed, all environmental and safety criteria met, and all security concerns addressed, the project is

ready to begin construction, implementation, procurement, or fabrication. CD-3 provides authorization to complete all procurement and construction and/or implementation activities and initiate all acceptance and turnover activities. Approval of CD-3 authorizes the project to commit all the resources necessary, within the funds provided, to execute the project.

CD-4, Approve Start of Operations or Project Completion

CD-4 marks the achievement of the completion criteria defined in the project execution plan and approval of transition to operations. This decision is predicated on the readiness to operate and/or maintain the system, facility, or capability. Transition and turnover does not necessarily terminate all project activity. Rather, it marks a point at which the operations organizations assume responsibility for operation and maintenance. All projects must have a project transition/closeout plan that clearly defines the basis for attaining initial or full operating capability or meeting performance criteria as required for project closeout, as applicable. The key attributes in turnover are the government's readiness to operate, the ability to assume operational responsibility, and the acceptance of the asset.

See item a of competency 40 for a discussion of project phases associated with these CDs.

d. Explain the purpose and use of a project execution plan.

The following is taken from DOE O 413.3A.

The project execution plan is the core document for management of a project. The Federal project director is responsible for the preparation of this document. It establishes the policies and procedures to be followed to manage and control project planning, initiation, definition, execution, and transition/closeout, and uses the outcomes and outputs from all project planning processes, integrating them into a formally approved document. A project execution plan includes an accurate reflection of how the project is to be accomplished, resource requirements, technical considerations, risk management, CM, and roles and responsibilities. A preliminary project execution plan is required to support CD-1. This document continues to be refined throughout a project's life cycle and revisions are documented through the CM process.

e. Discuss the role of configuration management as it relates to project management.

The following is taken from DOE O 413.3A.

A CM process must be established that controls changes to the physical configuration of project facilities, structures, systems, and components. This process must also ensure that the configuration is in agreement with the performance objectives identified in the technical baseline and the approved QA plan.

The technical baseline is part of the performance baseline developed to support CD-1.

f. Explain the use of safety plans in the management of projects.

The following is taken from DOE M 413.3A.

DOE is committed to performing all work so missions can be accomplished with adequate controls in place to protect the public, workers, and the environment. The fundamental premise of ISMS is that accidents are preventable through early and close attention to planning, design, and physical execution of a project. The ISMS is designed to ensure that safety is appropriately addressed throughout the life cycle of a project. Identification of potential hazards must begin early in project planning and continue throughout the life cycle of the project. DOE policy requires safety management systems be used to systematically integrate safety into management and work processes at all levels.

At CD-1, for hazard category 1, 2, and 3 nuclear projects, a conceptual safety design report is developed to document and establish a preliminary inventory of hazardous materials, including radioactive materials and chemicals; and to document and establish the preliminary hazard categorization of the facility. At CD-2, a preliminary safety design report is developed from the conceptual safety design report to reflect more refined analyses based on the evolving design and safety integration activities during preliminary design. The preliminary safety design report should include the results of process hazards analyses and confirm or adjust, as appropriate, the items included in the conceptual safety design report. At CD-3, a PDSA report is prepared and updates the safety information in the preliminary safety design report and identifies and justifies changes from the design approach described in the preliminary safety design report. At CD-4, a DSA report is developed based on information from the PDSA report and the safety evaluation report. TSRs are developed to document and establish specific parameters and requisite actions for safe facility operation.

For CD-1, projects involving facilities that are below hazard category 3 thresholds must prepare a preliminary hazard analysis report to identify and evaluate all potential hazards and establish a preliminary set of safety controls. For CD-2, a hazard analysis report is developed by updating the preliminary hazard analysis report to include any new or revised information on facility hazards and safety design. For CD-3 and -4, hazard analysis and controls are updated in the hazard analysis report.

All projects must comply with environmental protection requirements including National Environmental Policy Act documentation, anticipated permitting requirements, and cost-effective environmental stewardship-high performance sustainable building principles. A construction project safety and health plan is prepared prior to construction activities.

g. Discuss the relationship between WBS and cost and schedule.

The following is taken from DOE G 430.1-1, chapter 5.

A work breakdown structure (WBS) is a numerical, graphic representation that completely defines a project by relating elements of work in that project to each other and to the end product. The WBS is comprised of discrete work packages, called elements that describe a specific item of hardware, service, or data. Descending levels of the WBS provide elements of greater and greater detail. The number of levels of a WBS depends on the size and complexity of the project. The DOE WBS Guide presents a structure that may be used as a guideline when developing the project/program WBS.

A WBS is the result of project/program planning that establishes the physical work packages or elements and the activities within those packages that completely define a project. It organizes the physical work packages into levels that can be developed into a summary.

A WBS shows the relationship of all elements of a project. This provides a sound basis for cost and schedule control. During that period of a project's life from its inception to a completed project, a number of diverse financial activities must take place. These activities include cost estimating, budgeting, accounting, reporting, controlling and auditing. A WBS establishes a common frame of reference for relating job tasks to each other and relating project costs at the summary level of detail.

Since the WBS divides the package into work packages, it can also be used to interrelate the schedule and costs. The work packages or their activities can be used as the schedule's activities. This enables resource loading of a schedule, resource budgeting against time, and the development of a variety of cost budgets plotted against time.

h. Describe the purpose and use of work packages and/or planning packages.

See item a of competency 3.

The following is taken from DOE-STD-1120-2005, volume 2.

Work packages are prepared during the planning of specific work tasks, using first-line supervisors, workers, and safety personnel. Work packages provide details regarding proposed work scope and methods; identify task hazards; specify required training, necessary work permits, and appropriate controls for worker protection; and specific appropriate emergency response actions. Work packages should be screened against the approved facility safety basis.

i. Describe the purpose of schedules, and discuss the use of milestones and activities.

The following is taken from DOE G 433.1-1.

An effective system for planning, scheduling, and coordinating maintenance activities should be implemented to ensure maintenance is accomplished in a timely manner, ensure worker safety, improve maintenance efficiency, reduce radiation exposure, and increase equipment availability. Planning and scheduling involves assigning priorities that reflect the importance of maintenance work relative to safe and reliable facility operation; personnel safety; identification of logistics, personnel support; and other preparation; and minimizing any adverse impact that the maintenance activity has on facility operation. Coordination of work ensures that needed support (e.g., lockouts/tagouts, RWPs, QC) is available.

The processes of planning, scheduling, and coordinating work are discrete tasks that are closely related and that are usually delegated to one of several functional groups. Planning, scheduling, and coordinating work usually involves a planning group, a scheduling system (work control system), a scheduling group (which may be a part of the planning group), and a coordination group (which may also be a part of the planning group). Outage planning,

scheduling, and coordination are usually managed by a dedicated group of individuals in order to control this significant effort.

Milestones should be defined for the completion of logical collections of tasks. Use of these intermediate milestones may provide an overall measure of the progress of maintenance activities and identify tasks significantly behind schedule.

j. Describe the critical path method of scheduling.

The following is taken from DOE G 413.3-5.

The critical path is the longest path through a project/network schedule that consequently defines the shortest possible duration for completing a project. This path and its duration are determined by performing forward and backward passes through the network diagram based on the defined activity sequence and estimated activity durations.

The basic scheduling computations performed on a network diagram provide the earliest and latest allowable start and finish times for each activity and as a byproduct, indicate the amount of slack or float time associated with each noncritical path. This information form the basis of the project management plan and subsequently is used for performance measurement and EV reporting, baseline change control, milestone tracking, and schedule contingency management.

Critical path computations performed during the network analysis determine the slack along each path in the project schedule. Based on the length and location of this slack, certain activities can be moved forward or backward in time without affecting the completion date of the project. Consequently, this movement can be used to develop a schedule that satisfies external constraints placed on the type and quantity of resources available during various phases of the project.

The duration of the project critical path determines the shortest possible schedule for a given baseline. Results provided by the critical path method are accurate only when everything goes according to plan. A project, on occasion, may provide very optimistic duration estimates and plan parallel work without full considerations for the unique scheduling and work execution complexities posed by parallel activities. The project schedule therefore should contain some amount of contingency to account for the potential impacts of risk and uncertainty.

k. Explain the concept of a project management baseline and describe the four baselines used in project management.

The following is taken from DOE G 413.3-5.

Baselining is a central feature of the DOE project management system and reflects the adaptation of diverse management philosophies and practices borrowed from industry and other Federal agencies. Principal drivers of performance baselines are the changing nature of project management philosophies (e.g., degree of Federal oversight/involvement); reliance on performance-based acquisition policies; and incorporation of new baselining concepts

brought to DOE project management support organizations by managers and staff with experience or knowledge of baselining practices in other Federal agencies.

Regardless of type or sources of funding, a performance baseline needs to be developed for each individual project. The project performance baseline documents the high-level, summary statement of the project's key technical, schedule, cost, and performance parameters.

The performance baseline is comprised of three other baselines and a list of KPPs. These four components are listed in table 5.

Table 5. DOE project lifecycle phases

PERFORMANCE BASELINE COMPONENT	PROJECT LIFECYCLE PHASES			
	Initiation	Definition	Execution	Transition/ Closeout
Technical Baseline	Preliminary functions and requirements from pre-conceptual design	Preliminary design requirements baseline	Final design requirements, configuration baseline	As-built configuration baseline
Key Performance Parameters	Preliminary KPPs derived from technical goals from the mission need	Preliminary KPPs	Final KPPs	Demonstration of KPPs
Schedule Baseline	Order of magnitude project duration and forecast need date	Preliminary schedule and milestones	Complete schedule hierarchy	Actual completion date
Cost Baseline	Order of magnitude cost estimate	Preliminary cost estimates	Final TPC estimate	Actual project costs

Source: DOE G 413.3-5

Technical Baseline

The technical baseline defines technical goals, objectives, and scope and provides the basis for estimating project cost and schedule. Development should encompass project team actions necessary to identify, define, integrate, and document the project mission, functional objectives, design requirements, and detailed specifications in order to define, execute, and control the technical method of accomplishing the project's scope of work.

A well-defined and documented technical baseline is a key tool for ensuring project success. It should be established in such a way that technical requirements can be understood, broadly communicated, and effectively controlled throughout the life of the project. The technical baseline should include design requirements, criteria, and characteristics that provide the basis for project definition.

Key Performance Parameters (KPPs)

Traditionally, in DOE a project baseline was comprised of three components; technical, cost, and schedule, each of which is intimately related to the others. Recently the requirement to establish KPPs has become a prominent feature of DOE project management.

KPPs include a characteristic, function, requirement, or design basis, that if changed, would have a major impact on the facility or system performance scope, schedule, cost and/or risk, or the ability of an interfacing project to meet its mission requirements.

A KPP may be a performance, design, or interface requirement. Parameters that are appropriate for KPPs should express performance in terms of accuracy, capacity, throughput, quantity, process rate, purity, or other elements that define how well a system, facility, reliability, or other project will perform.

Key parameters are often defined in terms of what is desired and what is required. Stated another way, the parameters are values that have desired objectives and minimum thresholds. The objective value is the desired performance, scope, cost, or schedule that the completed asset should achieve, whereas the threshold value is more conservative and represents the minimum acceptable performance, scope, cost, or schedule that an asset must achieve.

Schedule Baseline

The schedule baseline establishes the overall project duration and completion date and should clearly identify critical path activities and key project milestones. A tailored approach should be used to determine how much detail to include in the schedule. The number of activities should not be so few as to prevent suitable progress tracking and not so numerous that the number of activities overwhelms the system and its users.

All known project and contract requirements, major procurements, milestones, and constraints should be identified during the planning and scheduling process. Activities external to the project that could reasonably be expected to impact the project should also be considered.

Cost Baseline

The cost baseline supports the development of the total project cost and is established to ensure that costs and budgets for labor, services, and materials are defined and time-phased based. While the technical baseline ensures that technical requirements are focused on achieving the project mission, the cost baseline supports corporate planning, budgeting, and reporting processes. For instance, estimates provide the basis for formulating annual budget requests, establishing the project and activity resources, hours and quantities that are used to develop the schedule and quantitative units to be measured, evaluating contract bids and proposals, providing a sense of scale that often aids in understanding the overall scope of a project, and evaluating the impact of change to the performance baseline.

41. Facility maintenance management personnel shall demonstrate a familiarity-level knowledge of the DOE/facility contract provisions necessary to provide oversight of a contractor's performance.

a. Describe the role of facility maintenance management personnel in contractor oversight.

The following is taken from DOE G 433.1-1.

Management should conduct periodic inspections of safety equipment and facilities to ensure excellent facility condition and housekeeping. The involvement of facility managers and supervisors in periodic walk-downs and inspections clearly displays management standards to all personnel and can significantly improve the condition of the facility. Establishing a program for identification and dispositioning of condition deficiencies and housekeeping discrepancies is an important step in maintaining facilities and equipment in a condition of maximum safety, reliability, and availability.

b. Compare and contrast the following:
- **DOE's expectations of an M&O contractor**
- **M&O contractor's expectations of DOE**

DOE's Expectations of an M&O Contractor

The following is taken from DOE Acquisition Regulations, subchapter I, 970 – DOE Management and Operating Contracts, section 970.0470, Department of Energy Directives.

The contractor is required to comply with the requirements of applicable Federal, state and local laws and regulations, unless relief has been granted by the appropriate authority.

The DOE directives program is a system of instructions, including orders, notices, manuals, guides, and standards, for DOE elements. In certain circumstances, requirements contained in these directives may apply to a contractor through operation of a contract clause. Program and requirements personnel are responsible for identifying requirements in the directives program which are applicable to a contract, and for developing a list of applicable requirements and providing it to the contracting officer for inclusion in the contract.

ES&H requirements appropriate for work conducted under a M&O contract may be determined by a DOE approved process to evaluate the work and the associated hazards, and identify an appropriately tailored set of standards, practices, and controls.

The following is taken from Defense Acquisition University, CON 214, Business Decisions for Contracting course.

There are seven general standards that a prospective contractor must meet in order to be determined "responsible":
1. have adequate financial resources to perform the contract or the ability to obtain them;
2. be able to comply with the required or proposed delivery or performance schedule, taking into consideration all existing commercial and governmental business
3. have a satisfactory performance record;
4. have a satisfactory record of integrity and business ethics;
5. have the necessary organization, experience, accounting and operational controls, and technical skills, or the ability to obtain them;

6. have the necessary production, construction, and technical equipment and facilities, or the ability to obtain them; and
7. be otherwise qualified and eligible to receive an award under applicable laws and regulations.

M&O Contractor's Expectations of DOE

The following is taken from Defense Acquisition University, CON 214, Business Decisions for Contracting course.

Some companies, as a matter of corporate policy, do not do business with the government or certain government agencies. Other companies have quit doing business with the government as a result of poor government business practices. Quality contractors affected by abusive demands beyond the contract requirements, late payments, a low bid environment not based on value, etc. can find many business opportunities with other Federal agencies and in the commercial market place.

Each party can demonstrate its commitment to maintaining and strengthening the relationship by:

- enhancing cooperation between the parties;
- providing opportunities and benefits that are better than those available from other sources;
- maintaining corporate values that are compatible with those of the other party;
- providing honest performance feedback, especially the negative, to the other party so that can take appropriate action quickly;
- sharing information that will enhance the other party's market knowledge; and
- upholding the implicit and explicit promises made.

c. Discuss the key elements and features of an effective DOE and M&O contractor relationship.

The following is taken from Defense Acquisition University, CON 214, Business Decisions for Contracting course.

Creating and maintaining positive, mission-focused business relationships between the government and contractors plays a critical role in supporting the customer's contract requirements.

The most fundamental characteristics of a strong relationship are trust in the other party and commitment to the relationship. Trust can help both entities shape more flexible contract strategies and create a relationship based on value. When both parties are committed to the relationship they will put forth extraordinary efforts to ensure that the relationship survives.

The following are some proven strategies that can help build a successful business relationship:

- Structure the relationship in a way that maximizes the chance of a successful win-win partnership. Traditional contracting processes may lack the collaboration required to mutually achieve program goals necessary to produce a win-win partnership.

- Ensure that there is a clear understanding of the goals and motivations of all parties so they can be aligned to the maximum extent possible.
- Ensure that all parties work to create a cooperative atmosphere. This is critical in the early stages of the relationship.
- Develop a shared ability to find mutually beneficial solutions for achieving goals.
- Openly discuss differences, such as, cultural, structural, financial, contractual, programmatic, political, etc., to provide insight into each other's motivations and to develop mutual understandings.
- Balance the risks and rewards available to the parties.
- All parties need to plan, execute, and deliver on their respective responsibilities in order to achieve the individual and shared goals and objectives.

42. Facility maintenance management personnel shall demonstrate the ability to conduct independent assessments of the contractor's maintenance training and qualification program(s) in accordance with DOE Order 433.1, Maintenance Management Program for DOE Nuclear Facilities, and DOE Order 5480.20A, Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities.

a. Conduct an evaluation of a contractor training and qualification program to verify that qualification requirements have been specified for job categories.

b. Given a work activity that requires special skills or abilities, verify that personnel are qualified prior to performing the work.

c. Assess a work activity requiring specific qualifications to verify that sub-contractors performing the work are qualified to the same level as contractor personnel.

d. Assess the instructor qualifications for a selected maintenance training program to verify that instructors have the necessary credentials and skills to provide the training.

Elements a through d are performance-based KSAs. The Qualifying Official will evaluate their completion.

Selected Bibliography and Suggested Reading

***Code of Federal Regulations* (CFR)**

10 CFR 830, "Nuclear Safety Management." January 1, 2009.
10 CFR 830, subpart A, "Quality Assurance Requirements." January 1, 2009.
10 CFR 830.120, "Scope." January 1, 2009.
10 CFR 830.200, "Scope." January 1, 2009.
10 CFR 830.203, "Unreviewed Safety Question Process." January 1, 2009.
10 CFR 830.204, "Documented Safety Analysis." January 1, 2009.
10 CFR 830.205, "Technical Safety Requirements." January 1, 2009.

American Society of Civil Engineers, ASCE 7, *Minimum Design Loads for Buildings and Other Structures*. January 2006.

ANSI/ASQ Z1.4 - 2008, *Sampling Procedures and Tables for Inspection by Attributes*. 2008.

Defense Acquisition University, CON 214, Business Decisions for Contracting course.

Executive Order 12699. "Seismic Safety of Federal and Federally Assisted or Regulated New Building Construction." January 1990.

Executive Order 12941. "Seismic Safety of Existing Federally Owned or Leased Buildings." December 1994.

National Fire Protection Association. NFPA 70B, *Recommended Practice for Electrical Equipment Maintenance*. 2006.

U.S. Department of Energy Handbooks and Standards

DOE-HDBK-1028-2009, *Human Performance Improvement Handbook, volume 2: Human Performance Tools for Individuals, Work Teams, and Management*. June 2009.
DOE-HDBK-1092-2004, *Electrical Safety*. December 2004.
DOE-HDBK-1188-2006, *Glossary of Environment, Safety and Health Terms*. January 2006.
DOE-NE-STD-1004-92, *Root Cause Analysis Guidance Document*. February 1992. (Archived)
DOE-STD-1020-2002, *Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities.* January 2002.
DOE-STD-1021-93, *Natural Phenomena Hazards Performance Categorization Guidelines for Structures, Systems, and Components*. July 1993.
DOE-STD-1022-94, *Natural Phenomena Hazards Site Characterization Criteria*. March 1994.
DOE-STD-1023-95, *Natural Phenomena Hazards Assessment Criteria*. March 1995
DOE-STD-1027-92, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports*. December 1992.
DOE-STD-1036-93, *Guide to Good Practices for Independent Verification*. January 1993.
DOE-STD-1051-93, *Guideline to Good Practices for Maintenance Organization and Administration at DOE Nuclear Facilities*. March 1993. (Archived)

DOE-STD-1066-99, *Fire Protection Design Criteria*. July 1999.
DOE-STD-1073-93, *Guide for Operational Configuration Management Program*. November 1993. (Archived)
DOE-STD-1073-2003, *Configuration Management*. October 2003.
DOE-STD-1120-2005, *Integration of Environment, Safety, and Health into Facility Disposition Activities, Volume 2 of 2, Appendices*. April 2005.
DOE-STD-1134-1999, *Review Guide for Criticality Safety Evaluations.* September 1999.
DOE-STD-1150-2002, *Quality Assurance Functional Area Qualification Standard*. April 2002.
DOE-STD-1181-2004, *Facility Maintenance Management Functional Area Qualification Standard*. March 2004.
DOE-STD-3007-2007, *Guidelines for Preparing Criticality Safety Evaluations at Department of Energy Non-Reactor Nuclear Facilities.* February 2007.
DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses*. July 1994.
DOE-STD-7501-99, *The DOE Corporate Lessons Learned Program.* December 1999.

U.S. Department of Energy Directives (Guides, Manuals, Orders, and Policies)

DOE Guide 225.1A-1, *Implementation Guide for use with DOE Order 225.1A, Accident Investigations*. November 26, 1997.
DOE Guide 413.3-5, *Performance Baseline Guide*. September 12, 2008.
DOE Guide 413.3-10, *Earned Value Management System (EVMS)*. May 6, 2008.
DOE Guide 413.3-11, *Project Management Lessons Learned*. August 5, 2008.
DOE Guide 414.1-1B, *Management and Independent Assessments Guide for use with 10 CFR Part 830, Subpart A, and DOE O 414.1C, Quality Assurance; DOE M 450.4-1, Integrated Safety Management System Manual; and DOE O 226.1A, Implementation of Department of Energy Oversight Policy*. September 27, 2007.
DOE Guide 414.1-2A, *Quality Assurance Management System Guide.* June 17, 2005.
DOE Guide 414.1-3, *Suspect/Counterfeit Items Guide for Use with 10 CFR 830 Subpart A, "Quality Assurance Requirements,"* and DOE O 414.1B, *Quality Assurance.* November 3, 2004.
DOE Guide 414.1-5, *Corrective Action Program Guide.* March 2, 2006.
DOE Guide 420.1-2, *Guide for the Mitigation of Natural Phenomena Hazards for DOE Nuclear Facilities and NonNuclear Facilities.* March 28, 2000.
DOE Guide 420.1-3, *Implementation Guide for DOE Fire Protection and Emergency Services Programs for use with DOE O 420.1B, Facility Safety*. September 27, 2007.
DOE Guide 421.1-2, *Implementation Guide for use in Developing Documented Safety Analyses to Meet Subpart B of 10 CFR 830*. October 24, 2003.
DOE Guide 423.1-1, *Implementation Guide for use in Developing Technical Safety Requirements*. October 24, 2001.
DOE Guide 424.1-1A, *Implementation Guide for use in Addressing Unreviewed Safety Question Requirements*. July 24, 2006.
DOE Guide 430.1-1, *Cost Estimating Guide*. March 28, 1997.
DOE Guide 433.1-1, *Nuclear Facility Maintenance Management Program Guide for Use with DOE O 433.1*. September 5, 2001.
DOE Manual 231.1-2, *Occurrence Reporting and Processing of Operations Information*. August 19, 2003.

DOE Manual 413.3-1, *Project Management for the Acquisition of Capital Assets*. March 28, 2003. (Archived)
DOE Order 130.1. *Budget Formulation*. September 29, 1995.
DOE Order 200.1A, *Information Technology Management*. December 23, 2008.
DOE Order 210.2, *DOE Corporate Operating Experience Program*. June 12, 2006.
DOE Order 231.1A, *Environment, Safety, and Health Reporting.* August 19, 2003.
DOE Order 243.1, *Records Management Program*. February 2, 2006.
DOE Order 414.1C, *Quality Assurance*. June 17, 2005.
DOE Order 420.1B, *Facility Safety.* December 22, 2005.
DOE Order 430.1B, *Real Property Asset Management*. February 8, 2008.
DOE Order 430.2B, *Departmental Energy, Renewable Energy and Transportation Management*. February 27, 2008.
DOE Order 433.1A, *Maintenance Management Program For DOE Nuclear Facilities*. February 13, 2007.
DOE Order 4330.4B, *Maintenance Management Program*. February 10, 1994. (Archived)
DOE Order 5480.19, *Conduct Of Operations Requirements For DOE Facilities*. July 9, 1990.
DOE Order 5480.20A, *Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities*. July 12, 2001.
DOE Policy 450.4, *Safety Management System Policy.* October 15, 1996.

U.S. Department of Energy Other References

DOE Acquisition Regulations, subchapter I, 970 – DOE Management and Operating Contracts, section 970.0470, Department of Energy Directives. August 20, 2009.
Management Model for Delivering High Performance and Leadership Class Computing Systems for Scientific Discovery. December 2006.

U.S. Environmental Protection Agency, Federal Facilities Restoration and Reuse, Final Guidance on Improving Communication to Achieve Collaborative Decision-Making at Department of Energy Sites. March 26, 2007.

University of California Radiation Laboratory (UCRL) UCRL-15910, Natural Phenomena Hazards - Design and Evaluation Criteria for Department of Energy Facilities. June 1990.

Facility Maintenance Management
Qualification Standard
Reference Guide
NOVEMBER 2009